SUPPLY CHAIN MANAGEMENT
THIRUVANANTHAPURAM

SPECIFICATION

220/110KV 200MVA & 160MVA, THREE PHASE AUTO TRANSFORMER

APPLICABLE TO KSEBL	**Rev#0**	DOC. NO.: **SCM-SPEC/XT/ 160 & 200MVA Transformer**
		EFF. DATE: **01/09/2021**

Number of Pages: 197

Technical Specification and Evaluation Committee for Transmission Material

(i) Document Approval & Control Status

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Date	27/08/2021	31/08/2021	01/09/2021
Signature	**Sd/-**	**Sd/-**	**Sd/-**

(ii) Amendments and History

Sec. #	*Rev. #*	*Date*	*History of Change*

1. PURPOSE:

Purpose of this document is to document updates & history, upkeep and publish the specifications related to **220/110kV 200MVA & 160MVA, Three Phase Auto Transformer** in a professional manner

2. SCOPE:

The Scope of this document is to inform and alert all relevant stakeholders including KSEBL. Public, KSERC etc regarding the current specifications and historical changes adopted in specifications of **220/110kV 200MVA & 160MVA, Three Phase Auto Transformer** used in field by KSEBL

3. RESPONSIBILITY:

The Executive Engineer (T), Office of Chief Engineer, Supply Chain Management shall compile and take necessary steps to publish the specification in KSEBL website and shall inform relevant stakeholders regarding updates and revisions

4. PROCEDURE FOR REVISION:

Modifications if any, in the technical specification will be incorporated as **Revisions.** Any changes in values, minor corrections in pages, incorporation of small details etc. will be considered as Minor Modification. **The Revisions due to minor modifications will be assigned as Rev. No.0.1, 0.2 etc.**

A complete updation of the technical specification will be considered as Major modification. **The Revisions due to major modifications will be assigned as Rev. No.1.0, 2.0 etc.**

All the details of regarding the revisions (both minor and major) will be incorporated in **"(ii)-Amendments and history"** above.

The concerned officers, in consultation with the Technical Committee will review and suggest changes required and the revision suggestion will be approved by **Chief Engineer (SCM).** Those who notice any discrepancy or have any suggestion regarding revision, may bring the matter to the attention of Chief Engineer (SCM) in writing or through e-mail id:**cescm@kseb.in**

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TECHNICAL SPECIFICATION FOR 220/110KV 200MVA THREE PHASE AUTO TRANSFORMER

1. SCOPE:- This specification covers the design, manufacture, inspection, testing at supplier's works and delivery, installation assistance and commissioning at destination stations of 200MVA 220/110kV Three Phase Autotransformer with 11kV Tertiary winding for stabilization connected in YNa0d1 as detailed in the Technical parameters and its guarantee for satisfactory performance as specified elsewhere. **The transformers shall be delivered at the transformer plinth if the plinth is ready at the time of delivery or at any desired site, anywhere in the state of Kerala as mentioned by the Board.**

1.2. The transformers shall in general have constant ohmic impedance between HV and IV on all taps and it shall be possible to operate in parallel with each other.

1.3. External or internal reactors shall not be used to achieve the specified HV/LV and IV/LV impedances. Further, matching of physical orientation shall be done to facilitate inter-changeability.

1.4. All drawings, schedules and annexure appended to this specification shall form part of the specification and supplement the requirements specified. The equipment / materials offered by the Bidder shall be complete in all respects and, whether called for specifically or not, all accessories, hardware and services required for normal satisfactory operation of the system shall be deemed to be included in unit rates quoted. Design and manufacture shall also be such that equipment / accessories of the same type and rating would be interchangeable.

Specific reference in this specification and documents to any material by trade name, make or catalogue number shall be construed as establishing standard of quality and performance and not as limiting competition. All equipment / accessories offered shall also be of proven design and manufacture. The make of all accessories and hardware shall be subject to purchaser's approval

1.5. It is not the intent to specify completely herein all details of the design and construction of equipment. However, the equipment shall conform in all respects to standards of engineering, design and workmanship 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 equipment offered shall be complete with all components necessary for their effective and trouble free operation. Such components shall be deemed to be within the scope of supplier's

supply, irrespective of whether those are specifically brought out in this specification and/or the commercial order or not.

2. Transportation:-

2.1. The Supplier shall be responsible to select and verify the route, mode of transportation and make all necessary arrangement with the appropriate authorities for the transportation of the equipment. The dimension of the equipment shall be such that when packed for transportation, it will comply with the requirements of loading and clearance restrictions for the selected route. It shall be the responsibility of the supplier to coordinate the arrangement for transportation of the transformer for all the stages from the manufacturer's work to site.

2.2. The supplier shall carry out the route survey along with the transporter and finalize the detailed methodology for transportation of transformer and based on route survey. If any bottlenecks are observed in the route proposed, it shall be the responsibility of the supplier to ensure hassle free transportation of the equipment through the route.

2.3. The main tank of the transformer shall be inland transported on low bed trailers. There should be provision for tracking the location of consignment at all times during transportation from manufacturer's works to designated site. The supplier shall intimate KSEB Limited about the details of transporter engaged for transportation of the Transformer for tracking the Transformer during transit.

2.4. All metal blanking plates and covers which are specifically required to transport and storage of the transformer shall be considered part of the transformer and handed over to the Purchaser after completion of the erection. Bill of quantity of these items shall be included in the relevant drawing/document.

2.5. The Supplier shall despatch the transformer filled with Nitrogen gas with necessary arrangement to take care of pressure drop of nitrogen during transit and storage till completion of oil filling during erection. A N2 cylinder with regulator, gas pressure testing valve with necessary pressure gauge and adaptor valve shall be provided. As the packing is liable to be stored in the open, the packing shall be suitable for outdoor storage under humid atmospheric conditions. All parts shall be adequately marked to facilitate erection at site.

Each consignment shall be accompanied by a detailed packing list. Any material found short/damaged in the consignment shall be supplied or made good by the supplier without any extra cost to KSEB Limited

In case, turrets are having insulation assembly and is transported separately then the same shall also be filled with Nitrogen.

2.6. Transformer shall also be fitted with sufficient number of Electronic impact recorders (Minimum 2 numbers -on returnable basis) during transportation to measure the magnitude and duration of the impact in all three directions. The impact recorders shall be of different make for reliability .The acceptance criteria and limits of impact, which can be withstood by the equipment during transportation and handling in all three directions, shall not exceed "3g" for 50 mSec (20Hz) or as per supplier standard, whichever is lower.

3. CODES & STANDARDS:- The transformer shall be manufactured and tested according to the latest revisions of IS 2026 /IEC 60076.

The Material, equipment and methods used in the manufacture of power transformer shall conform to the latest edition of following.

Standard Name / No	Standard's Description
Indian Standard	
IS 335	Insulating oil
IS 1271	Thermal evaluation and classification of electrical insulation
IS 2099	Bushing for Alternating voltage above 1000V
IS 2705	Current Transformers
IS 3347	Dimensions for porcelain Transformer bushing
IS 3637	Gas operated relays
IS 3639	Fitting & Accessories for power transformers
IS 4201	Application guide for CT's
IS 6600	Guide for loading of oil immersed transformers
IS 8478	Application guide for On-load tap changer
IS 8468	On-load tap changer
IS 10028	Code of practice for selection, installation & maintenance of transformers
IS 13947	LV switchgear and control gear part-1
IS 2026	Power transformers
IS 6272	Industrial Cooling Fans
IS 5	Colours for ready mix paints
IS5561	Electrical power connectors
	Indian electricity act & CEA Regulations.

	CBIP manual on transformers- Publication 295
IEC Standards	
IEC 34	Rotating Electrical Machines. (E.g. For Cooler Fan , Motors.)
IEC 38	Standard Voltages.
IEC 71	Co-ordination of Insulation.
IEC 76	Power transformers
IEC 137	Insulating bushings for alternating voltages above 1000V
IEC 156	Method for Determination of the Electric Strength for Insulating Oils.
IEC 185	Current Transformers.
IEC 214	On-Load Tap- Changers
IEC 233	Tests on hollow insulators for use in electrical equipment.
	Standard Frequencies for Centralized Network Control Installations.
IEC 296	Specification for Unused Mineral Insulating Oils for Transformer and switchgear.
IEC 354	Loading Guide for Oil-Immersed Power Transformers.
IEC 445	Identification of Equipment Terminals and of Terminations of Certain Designated Conductors, Including General Rules for an Alphanumeric
IEC 529	Degrees of Protection Provided by Enclosures (IP Code)
IEC 542	Application Guide for On-Load Tap- changers.
IEC 551	Determination of Transformer and Reactor Sound Levels.
IEC 606	Application Guide for Power Transformer.
IEC 616	Terminal and Tapping Markings for Power Transformers.
IEC 947	Low- Voltage Switchgear and Control gear.
British Standards	
BS 148	Unused Mineral Insulation Oils for Transformers and Switchgear.
BS 223	Bushings for alternating Voltages above 1000 V.
BS 2562	Cable Boxes for Transformers and Reactors.
BS 6435	Unfilled enclosures for the Dry Termination of HV Cables for Transformers and Reactors.

In the event of direct conflict between various order documents, the precedence of authority of documents shall be as follows:

1. Guaranteed Technical Particulars (GTP)
2. This Specification
3. Referred Standards
4. Approved Vendor Drawings
5. Other documents.

4. Performance:-

4.1. The transformers shall be suitable for bi-directional flow of rated power. The major technical parameters of the transformers are defined in the ***Standard Technical Parameters (STP)*** at **Annexure – A.**

4.2. Transformers shall be capable of operating under natural cooled condition up to 120 MVA load. The forced cooling equipment shall come into operation by pre-set contacts of winding temperature indicator and the transformer shall operate as a forced cooling unit initially as ONAF up to 160 MVA load and then as ODAF. Cooling shall be so designed that during total failure of power supply to cooling fans and oil pumps, the transformer shall be able to operate at full load for at least ten (10) minutes without exceeding the calculated winding hot spot temperature. Transformers fitted with two coolers, each capable of dissipating 50 per cent of the loss at continuous maximum rating, shall be capable of operating for 20 minutes in the event of failure of the oil circulating pump or blowers associated with one cooler without exceeding the calculated winding hot spot temperature at continuous max rating. The supplier shall submit supporting calculations for the above and the same shall be reviewed during design review.

4.3. The transformer shall be free from any electrostatic charging tendency (ECT) under all operating conditions when all oil circulation systems are in operation. In general, oil flow speed shall not exceed 1.0 m/sec within winding in the oil flow system of the transformers. The manufacturer shall ensure that there is no electrostatic charging tendency in the design.

4.4. The transformers shall be capable of being continuously operated at the rated MVA without danger, at any tapping with voltage variation of 10% corresponding to the voltage of that tapping.

4.5. The transformers shall be capable of being over loaded in accordance with IS 6600-latest amendments. There shall be no limitation imposed by bushings, tap changers etc. or any other associated equipment.

4.5.1. Tank hot spot shall not exceed 130 Deg. Celsius. Maximum ambient temperature shall be considered as 50 Deg. C.

4.6. The transformer and all its accessories including bushing/ built in CTs etc. shall be designed to withstand without damage, the thermal and mechanical effects of any external short circuit to earth and of short circuits at the terminals of any winding for a period of 3 secs. The short circuit level of the HV & IV System to which the transformers will be connected is as follows:

220kV system	-	50 kA (sym, rms, 3 phase fault)
110kV system	-	31.5 kA (sym, rms, 3 phase fault)
33 & 11kV system	-	25 kA (sym, rms, 3 phase fault)

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

4.7. Transformer shall be capable of withstanding thermal and mechanical stresses caused by symmetrical or asymmetrical faults on any terminals. Mechanical strength of the transformer shall be such that it can withstand 3-phase and 1- phase through fault for transformer rated voltage applied to HV and / or IV terminals of transformer. The short circuit shall alternatively be considered to be applied to each of the HV, IV and tertiary (LV) transformer terminals as applicable. The tertiary terminals shall be considered not connected to system source. For short circuit on the tertiary terminals, the in-feed from both HV & IV system shall be limited by the transformer self-impedance only and the rated voltage of HV and IV terminals shall be considered. The maximum short circuit output current at the tertiary terminals shall be limited to a safe value to make the transformer short circuit proof.

The transformer shall be designed to withstand for short circuit duration of 3 seconds for thermal stress and the same shall be verified during design review.

4.8. The maximum flux density in any part of the core and yoke at the rated MVA, voltage and frequency shall be such that under 10 % continuous over-voltage condition it does not exceed 1.8 Tesla at all tap positions. Maximum current density on any portion of the winding (HV/LV) shall not exceed 2.80 Amp/Sq.mm.

4.9. Transformers shall withstand without damage, heating due to the combined voltage and frequency fluctuations which produce the following over fluxing conditions:

110 % for continuous
125 % for 1 minute
140 % for 5 seconds.

4.10. The transformers will be evaluated against no load and load losses guaranteed by the bidders with capitalization of losses as per CBIP guidelines for loss capitalization. The corresponding capitalization

figures for no load, load losses and cooler aux. loads shall be as per clause 16.1, 16.2 & 16.3 of **STP** respectively. In the event of measured loss figures during testing exceeding the guaranteed loss figures of the successful bidder penalty shall be levied at a rate of 1.25 times the figures mentioned above for no load, load loss and cooler aux. losses. The quoted losses shall be considered as maximum without any positive tolerance.

The continuous rating of transformers shall be 60% (ie 120 MVA with ONAN),80% (ie 160 MVA with ONAF) and 100% (ie 200MVA with ODAF). The required fans, oil pumps and cooler control cubicle shall be provided. The temperature rise of the transformer shall be within the values specified at 20.1, 20.2 of the **STP.**

5) Tertiary Winding:-

Each transformer shall be provided with a tertiary winding connected in delta for stabilizing purpose. All three terminals of the stabilizing winding shall be brought out.

This stabilizing winding shall be capable of carrying continuously the rated load as specified under S.T.P. The design of the stabilizing winding shall be such that to take care of the effect of transfer surge. Tertiary winding shall be designed to withstand mechanical and thermal stresses due to dead short circuit on its terminals.

6) Radio Interference and Noise Level:-

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

The noise level of transformer, when energized at normal voltage and frequency with fans and pumps running shall not exceed the values specified at Annexure - A, when measured under standard conditions as stipulated in NEEMA TR-1.

7) Dynamic Short Circuit Test requirement:-

Bidder / Manufacturer should have successfully carried out Dynamic Short Circuit Test on the transformer as on the originally scheduled date of bid opening and shall enclose the relevant Test Report / Certificate along with bid. In case the bidder has not successfully tested for Dynamic Short Circuit Test, their bid shall be considered technically non-responsive. Further design review of offered transformers shall be carried out based on design of short circuit tested 220 kV or above voltage class transformer.

8) Transformer Losses and Bid acceptance:-

The transformers will be evaluated against no load, load losses and auxiliary losses with capitalization of losses as per CBIP guidelines for loss capitalization.

Following shall be the losses.

i) Guaranteed Maximum No Load Loss on principal tap at Rated Voltage and frequency, in KW (Without any positive tolerance: As per clause 15.1 of STP.

ii) Guaranteed Maximum Load Losses (Copper + stray loss) at rated current on principal tap at 75 ^{o}C, without any positive tolerance : As per clause 15.2 of STP.

iii) Guaranteed Maximum Auxiliary/Cooler Loss in KW : As per clause 15.3 of STP.

a) The Transformers are to be designed with maximum permissible losses as indicated above.

b) The bidder must clearly specify that the offered losses are "Maximum"(including IS/IEC tolerance) and no further positive tolerance as per IS/IEC shall be applicable on the offered values during evaluation as well as during testing of transformer.

c) Bids offering with losses beyond the maximum limits mentioned above shall be treated as non-responsive and rejected.

d) Loss Capitalization shall be done with the accepted bids with loss values within specified limit. For the purpose of evaluation of bids, the capitalized cost of iron loss, load loss and auxiliary loss (KW) shall be added to the quoted price of the transformer at the following rates:

i) Capitalized value of No Load loss per KW – As per clause 16.1 of STP

ii) Capitalized value of load loss per KW - As per clause 16.2 of STP

iii) Capitalized value of Auxiliary loss per KW- As per clause 16.3 of STP

e) However once a bidder becomes successful on the basis of loss capitalization with certain declared loss value, they have to strictly achieve the same loss value during the course of testing of transformers, offered for supply. No tolerance as per IS/IEC will be applicable.

f) If they fail to do so, the offered transformer will be rejected and only replaced transformer with declared loss value will be accepted.

g) In this process, the delay so occurred will be on the vendor's account.

h) If the vendor fails to achieve the declared loss during second time, the contract will be terminated at the vendor's risk and cost.

9) Measurable Defects:- The following shall constitute a Measurable Defects for the purpose of Defect Liabilities.

a) Repair, inside the Transformer and OLTC (including oil migration) either at site or at factory is carried out after commissioning.

b) The concentration of any fault gas is more than values of condition-1 indicated in clause no 6.5 of IEEE-C57.104-2008, which are as detailed below.

H2	CH4	C2H2	C2H4	C2H6	CO	CO2	TDCG
100	120	1	50	65	350	2500	720

c) The winding tan delta goes beyond 0.005 or increase more than 0.001 within a year w.r.t. pre-commissioning values.

d) The moisture content goes above 12 ppm at any temperature during operation including full load.

10) Design review:-

10.1. The transformer shall be designed, manufactured and tested in accordance with the best international engineering practices under strict quality control to meet the requirement stipulated in the technical specification. The manufacturer will be required to demonstrate the adequate safety margin w.r.t thermal, mechanical, dielectric and electrical stress etc. shall be maintained during design, selection of raw material, manufacturing process etc. in order to achieve long life of transformer with least maintenance and to take into account the uncertainties of his design and manufacturing processes. The scope of such design review shall include but not limited to the requirement as mentioned at **Annexure - C**

10.2 Raw material and sub-vendors used by transformer manufacturer shall be declared before commencement of manufacturing. The validity of Type tests (except dynamic short circuit test) of Transformer shall be 5 years as on the originally scheduled date of bid opening, provided that offered transformer design is identical to the type tested transformer and same active materials (CRGO, Conductor and Insulation) of same grade & from the same sub-vendors are used. In case of any change of either active materials or sub-vendors, the type tests shall be carried out by the supplier at no extra cost to Purchaser. Transformer type test report from the same manufacturing plant only shall be acceptable. With regard to Validity of Dynamic short circuit test, refer clause 7.0 above.

10.3. Design reviews shall be conducted by Purchaser during the procurement process for transformers; however the entire responsibility of design shall be with the manufacturer. Purchaser may also visit the manufacturer's works to inspect design, manufacturing and test facilities at any time.

10.4. The design review will commence after placement of award with the successful bidder and shall be finalized before commencement of manufacturing activity. These design reviews shall be carried out in detail to the specific design with reference of the transformer under the scope of this specification. It shall be conducted generally following the "Guidelines for conducting design reviews for transformers - 100 MVA and 123 kV and above" prepared by CIGRE SC 12 with latest amendments thereof.

10.5. The manufacturer shall also provide all necessary information and calculations to demonstrate that the transformer meets the requirements for short circuit strength and durability. The latest recommendations of IS/IEC and CIGRE SC 12 shall be applied for short circuit withstand evaluation.

11) Construction Details:- The construction details and features of transformer shall be in accordance with the requirement stated hereunder. The components and fitting associated with transformers are subject to Purchaser's approval.

11.1. Tank

11.1.1. Tank shall be of bolted construction and fabricated from tested quality low carbon steel of adequate thickness. Unless otherwise approved, metal plate, bar and sections for fabrication shall comply with BS-4360 / IS 2062. Material Samples, technical literature, drawings, test reports and list of the names of the principal users with experience gained shall be supplied on request.

11.1.2. All seams and joints which are not required to be opened at site, shall be factory welded, and wherever possible they shall be double welded. Welding shall conform to BS-5135/IS 9595. After fabrication of tank and before painting, dye penetration test shall be carried out on welded parts of jacking bosses, lifting lugs and all load bearing members. The requirement of post weld heat treatment of tank / stress relieving shall be based on recommendation of BS-5500 table 4.4.3.1/IS 10801.

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

11.1.4. The tank shall be of proven design either bell type with bolted joint or conventional type with bolted top cover. The welded joint shall be provided with flanges suitable for repeated welding. The joint shall be provided with a suitable gasket to prevent weld splatter inside the tank. Proper tank shielding shall be done to prevent excessive temperature rise at the joint.

11.1.5. Tank shall be provided with:

a) Lifting lugs: Four symmetrically placed lifting lugs shall be provided so that it will be possible to lift the complete transformer when filled with oil without structural damage to any part of the transformer. The factor of safety at any one point shall not be less than 2.

b) A minimum of four jacking pads in accessible position to enable the transformer complete with oil to be raised or lowered using hydraulic jacks.

c) Each jacking pad shall be designed to support with an adequate factor of safety at least half of the total mass of the transformer filled with oil allowing in addition to maximum possible misalignment of the jacking force to the centre of the working surface.

d) Suitable haulage holes shall be provided.

e) Provision of 4 nos. of Gate valves for UHF sensors for PD Measurements at various locations. Location of valves shall be finalized during detailed engineering.

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

11.1.6. The tank shall be designed in such a way that it can be mounted on rollers.

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

11.2. Tank Cover:-

11.2.1. The tank cover shall be designed to prevent retention of water and shall not distort when lifted. The internal surface of the top cover shall be shaped to ensure efficient collection and direction of free gas to the buchholz relay.

11.2.2. At least two adequately sized inspection openings one at each end of the tank, shall be provided for easy access to bushings and earth connections. The inspection covers shall not weigh more than 25 kg. Handles shall be provided on the inspection cover to facilitate lifting.

11.2.3. The tank cover shall be provided with pockets for oil and winding temperature indicators. The location of pockets (for OTI, WTI & RTDs including two spare pockets) shall be in the position where oil reaches maximum temperature. Further, it shall be possible to remove bulbs of OTI/WTI/RTD without lowering the oil in the tank. The thermometer shall be fitted with a captive screw to prevent the ingress of water.

11.2.4. Bushing turrets, covers of inspection openings, thermometer pockets etc. shall be designed to prevent ingress of water into or leakage of oil from the tank.

11.2.5. To allow for the effect of possible induced and capacitive surge current flow, the tank cover and bushing turret shall be fixed to the transformer in such a way that good electrical contact is maintained around the perimeter of the tank and turrets.

11.2.6. The transformer shall be provided with a suitable diameter pipe flange, butterfly valve, bolted blanking plate and gasket shall be fitted at the highest point of the transformer for maintaining vacuum in the tank.

11.2.7. **Gas venting:**- The transformer cover and generally the internal spaces of the transformer and all pipe connections shall be designed so as to provide efficient venting of any gas in any part of the transformer to the Buchholz relay. The space created under inspection / manhole covers shall be filled with suitable material to avoid inadvertent gas pockets. The Covers shall be vented at least at both longitudinal ends. The design for gas venting shall take into accounts the slopes of the plinth (if any) on which the transformer is being mounted.

11.3. Gasket for tank & cover:-

All gasketed joints shall be designed, manufactured and assembled to ensure long-term leak and maintenance free operation. All gasketed joints shall preferably of O-ring and groove type. The Gaskets / O-Ring in contact with oil shall be Nitrile rubber or any other better approved quality.

All bolted connections shall be fitted with weather proof, hot oil resistant, resilient gasket in between for complete oil tightness. If gasket is compressible, metallic stops/other suitable means shall be provided to prevent over-compression.

The properties of all the above gaskets / O-Rings shall comply with the requirements of IS-11149. Gaskets and O-rings shall be replaced every time whenever the joints are opened.

11.4. Roller Assembly and Anti Earthquake Clamping Device:- The roller mounted transformers are to be provided with flanged bi-directional wheels and axles. This set of wheels and axles shall be suitable for fixing to the under carriage of transformer to facilitate its movement on rail track. Suitable locking arrangement along with foundation bolts shall be provided for the wheels to prevent accidental movement of transformer. The rail track gauge shall be 1676m with 2 rails for longer axis and for shorter axis 2rails or 3 rails as required (as per Standard KSEB Practice).

All wheels should be detachable and shall be provided with suitable bearings which shall be rust and corrosion resistant. Fittings for lubrication shall also be provided. The flanged wheels shall be suitable for use on gauge track and shall be so placed that pinch bar can be used to move the transformer.

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

11.5. Conservator:-

11.5.1. Main tank conservator shall have air cell type constant oil pressure system to prevent oxidation and contamination of oil due to contact with moisture. Conservator shall be fitted with magnetic oil level gauge with potential free high and low oil level alarm contacts and prismatic oil level gauge.

11.5.2. Conservator tank shall have adequate capacity with highest and lowest visible-levels to meet the requirements of expansion of total cold oil volume in the transformer and cooling equipment from minimum ambient temperature to top oil temperature of 110 deg C. The capacity of the conservator tank shall be such that the transformer shall be able to carry the specified overload without overflowing of oil.

11.5.3. The conservator shall be fitted with lifting lugs in such a position so that it can be removed for cleaning purposes. Suitable provision shall be kept to replace air cell and cleaning of the conservator as applicable.

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

11.5.5. The connection of air cell to the top of the conservator is by air proof seal preventing entrance of air into the conservator. The main conservator tank shall be stenciled on its underside with the words **"Caution: Air cell fitted".** Lettering of at least 150 mm size shall be used in such a way to ensure clear legibility from ground level when the transformer is fully installed. To prevent oil filling into the air cell, the oil filling aperture shall be clearly marked. The transformer rating and diagram plate shall bear a warning statement that the **"Main conservator is fitted with an air cell".**

11.5.6. Contact of the oil with atmosphere is prohibited by using a flexible air cell of nitrile rubber reinforced with nylon cloth. The temperature of oil in the conservator is likely to

raise up to 110°C during operation. As such air cell used shall be suitable for operating continuously at this temperature.

11.5.7. The transformer manual shall give full and clear instructions on the operation, maintenance, testing and replacement of the air cell. It shall also indicate shelf life, life expectancy in operation, and the recommended replacement intervals.

11.5.8. The conservator tank and piping shall be designed for complete vacuum / filling of the main tank and conservator tank. Provision must be made for equalizing the pressure in the conservator tank and the air cell during vacuum / filling operations to prevent rupturing of the air cell.

11.5.9. The bidder shall furnish the leakage rates of the rubber bag / air cell for oxygen and moisture. It is preferred that the leakage rate for oxygen from the air cell into the oil will be low enough so that the oil will not generally become saturated with oxygen. Air cells with well proven long life characteristics shall be preferred.

11.5.10. OLTC shall have conventional type conservator (without aircell) with magnetic oil level gauge with potential free oil level alarm contact and prismatic oil level gauge.

11.5.11. **Piping works for conservator:**

11.5.11.1. Pipe work connections shall be of adequate size preferably short and direct.

11.5.11.2. The feed pipe to the transformer tank shall enter the transformer cover plate at its highest point and shall be straight for a distance not less than five times its internal diameter on the transformer side of the Buchholz relay, and straight for not less than three times that diameter on the conservator side of the relay. Gas-venting pipes shall be connected to the final rising pipe between the transformer and Buchholz relay as near as possible in an axial direction and preferably not less than five times pipe diameters from the Buchholz relay.

11.5.11.3. This pipe shall rise towards the oil conservator, through the Buchholz relay, at an angle between 5(five) degrees to 7 (seven) degrees to horizontal.

11.5.11.4. A double flange valve of preferably 50 mm and 25 mm size shall be provided to fully drain the oil from the main tank conservator and OLTC conservator tank respectively.

11.5.11.5. The feed pipe diameter for the main conservator shall be not less than 80mm.

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

11.5.11.7. Fittings and accessories on the Main Conservator tank.

1) Prismatic oil gauge with NORMAL, MINIMUM and MAXIMUM marking
2) End cover
3) Oil filling hole with cap
4) Magnetic oil gauge with LOW LEVEL Alarm contact.
5) Silica Gel dehydrating breather with Oil seal and dust filter with clear acrylic single piece clearly transparent cover resistant to UV rays.

6) Drain cum filling valve (gate valve) with locking rod and position Indicator made of Brass, 25 mm with Cover plate.
7) Shut off valve (gate valve) with Position indicator made of Brass Located before and after Bucholz relay, 50mm.
8) Flange for breather connection.
9) Air release valve on conservator (gate valve) made of Brass, 25 mm with cover plate.
10) Air release plug as required.
11) Valve on the breather pipe near to conservator tank for filling /Nitrogen to the air cell.
12) Provision to fix one pressure gauge in between the conservator tank and the valve mentioned above (item 11).

11.5.11.8. Fittings and Accessories on OLTC Conservator.

1) Prismatic oil gauge with NORMAL, MINIMUM and MAXIMUM marking.
2) End cover.
3) Oil filling hole with cap.
4) Magnetic oil gauge with LOW LEVEL Alarm contact.
5) Silica gel dehydrating breather with oil seal and dust filter with clear acrylic single piece clearly transparent cover resistant to UV rays.
6) Drain valve (gate valve)With locking rod and position Indicator made of Brass, 25 mm with cover plate.
7) Shut off valve (gate valve) with Position indicator made of Brass located before oil surge relay, 25 mm.
8) Flange for breather connection.
9) Air release plug as required.

11.6. Dehydrating Silica gel Filter Breather:- Conservator of Main Tank and OLTC shall be fitted with a dehydrating silica gel filter breather. Connection shall be made to a point in the oil conservator not less than 50 mm above the maximum working oil level by means of a pipe with a minimum diameter of 25 mm. Breathers and connecting pipes shall be securely clamped and supported to the transformer, or other structure supplied by the supplier, in such a manner so as to eliminate undesirable vibration and noise. The design shall be such that:

a) Passage of air is through silica gel.
b) Silicagel is isolated from atmosphere by an oil seal.
c) Moisture absorption indicated by a change in colour of the crystals.
d) Breather is mounted approximately 1200 mm above rail top level.

11.7. Pressure Relief Device:- Minimum two number of pressure relief devices shall be provided at suitable locations. These shall have opening diameter of at least 100 mm for

rapid release of any pressure that may be generated in the tank and which may result in damage to equipment. The device shall maintain its oil tightness under static oil pressure equal to the static operating head of oil plus 20 kPa. The device shall operate and attain its full opening in not more than 2.5 ms when subject to an internal pressure impulse equal to static operating head of oil plus 50 kPa. It shall be capable of withstanding full internal vacuum at mean sea level. It shall be mounted directly on the tank. One set of potential free contacts (**suitable for 2.5sq.mm control cable)** per device shall be provided for tripping. Following routine tests shall be conducted on PRD:

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

11.8. **Buchholz Relay:-** One double float, reed type Buchholz relay shall be provided in the connecting pipe between the oil conservator and the Transformer. Any gas evolved in the Transformer shall be collected in this relay. The relay shall be provided with a test cock suitable for a flexible pipe connection for checking its operation and taking gas sample. A copper tube shall be connected from the gas collector to a valve located about 1200 mm above ground level to facilitate sampling while the Transformer in service. Each device shall be provided with two potential free contacts **(suitable for 2.5sq.mm control cable),** one for alarm and other for trip on gas accumulation and on sudden rise of pressure.

The Buchholz relay shall not operate during starting/ stopping of the transformer oil circulation under any oil temperature conditions. The pipe or relay aperture baffles shall not be used to decrease the sensitivity of the relay. The relay shall not mal-operate for through fault conditions or be influenced by the magnetic fields around the transformer during the external fault conditions. Pressurised water ingress test for Terminal Box (routine tests) shall be conducted on Buchholz relay.

11.10. Oil Temperature Indicator (OTI):- All transformers shall be provided with a dial type thermometer of around 150 mm diameter for top oil temperature indication. It shall have adjustable, potential free alarm and trip contacts **(suitable for 2.5sq.mm control cable)** besides that required for control of cooling equipment, if any. A temperature sensing element suitably located in a pocket on top oil shall be provided. This shall be connected to the OTI by means of capillary tubing. Temperature indicator dials shall have linear gradations to clearly read at least every 2 deg C. Accuracy of OTI shall be 2.0 deg C or better for a temperature of 100 deg C.

The setting of alarm and tripping contacts shall be adjustable at site.

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

a) **Temperature transducer with Pt100 sensor:-** RTD shall be provided with Pt100 temperature sensor having nominal resistance of 100 ohms at zero degree centigrade. The Pt100 temperature sensor shall have three wire ungrounded system. The calibration shall be as per IEC 60751-2 or equivalent. The Pt100 sensor may be placed in the pocket containing temperature sensing element. RTD shall provide dual output 4-20mA for remote OTI and SCADA system individually. The transducer shall be installed in the Individual Marshalling Box. Any special cable required for shielding purpose, for connection between Pt-100 temperature sensor and transducer, shall be in the scope of Supplier.

11.11. **Winding Temperature Indicator (WTI):-** All Transformers shall be provided with a device for measuring the hot spot temperature of each winding (HV, IV and LV) with dial type thermometer of 150 mm diameter for winding temperature indication and shall have adjustable potential free alarm and trip contacts **(suitable for 2.5sq.mm control cable**) besides that required for control of cooling equipment if any. WTI shall have Temperature sensing element, Image coil and Auxiliary CTs, if required to match the image coil, shall be mounted in the cooler control cabinet. Temperature indicator dials shall have linear gradations to clearly read at least every 2 deg C. Accuracy of WTI shall be 2.0 deg C or better for a temperature of 100 deg C.

The setting of alarm and tripping contacts shall be adjustable at site.

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

a) **Temperature transducer with Pt100 sensor for each winding:-** RTD shall be provided with Pt100 temperature sensor having nominal resistance of 100 ohms at zero degree centigrade. The Pt100 temperature sensor shall have three wire ungrounded system. The calibration shall be as per IEC 60751-2 or equivalent. The Pt100 sensor may be placed in the pocket containing temperature sensing element. RTD shall include image coil, Auxiliary CTs, if required to match the image coil, for WTI system and shall provide dual output 4-20mA for remote WTI and SCADA system individually. The transducer, Auxiliary CT shall be installed in the Individual Marshalling Box. Any special cable required for shielding purpose, for connection between Pt100 temperature sensor and transducer, shall be in the scope of Supplier.

The temperature indicators (OTI & WTI) shall be so mounted that the dials are about 1200 mm from ground level. Glazed door of suitable size shall be provided for convenience of reading.

11.12. **Earthing Terminals:**

11.12.1. Two (2) earthing pads (each complete with two (2) nos. holes, M16 bolts, plain and spring washers) suitable for connection to 75 x 12 mm galvanised steel grounding flat shall be provided each at position close to earth of the two (2) diagonally opposite bottom corners of the tank.

11.12.2. Two earthing terminals suitable for connection to 75 x 12 mm galvanised steel flat shall also be provided on each cooler, marshalling box, Cooler Control Cabinet and any other equipment mounted separately. For the tank-mounted equipment like online drying/ Online DGA/ Optical Sensor Box etc. double earthing shall be provided through the tank for which provision shall be made through tank and connected through two flexible insulated copper link.

11.12.3. Equipotential flexible copper link of suitable size at least 4 Nos. for Tank mounted turret with tank and tank with cover and or Bell shall be provided. For other components like – pipes, conservator support etc. Connected to tank shall also be provided with equipotential flexible copper link.

11.13. **Core:-**

11.13.1. The core shall be constructed from high grade, non-ageing, cold rolled, super grain oriented silicon steel laminations (HI-B or better grade). Indian transformer manufacturers shall use core material as per above specification with BIS certification.

11.13.2. The design of the magnetic circuit shall be such as to avoid static discharges, development of short circuit paths within itself or to the earthed clamping structure and production of flux component at right angles to the plane of laminations which may cause local heating.

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

11.13.4. Core and winding shall be capable of withstanding the shock during transport, installation and service. Adequate provision shall be made to prevent movement of core and winding relative to tank during these conditions.

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

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

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

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

11.13.9. The core shall be earthed to the core clamping structure at one point only, through a removable external link of minimum size of 80 sq. mm copper suitably located and protected to facilitate testing after installation of the transformer. The removable links shall have adequate section to carry ground fault current. Separate identification name plate/labels shall be provided for the 'Core' and 'Core clamp' on the outside of tank cover.

11.13.10. In case core laminations are divided into sections by insulating barriers or cooling ducts parallel to the plane of the lamination, tinned copper bridging strips shall be inserted to maintain electrical continuity between sections.

11.14. **Windings:-**

11.14.1. The Supplier shall ensure that windings of all transformers are made in dust proof and conditioned atmosphere.

11.14.2. The conductors shall be of electrolytic grade copper free from scales and burrs.

11.14.3. The insulation of transformer windings and connections shall be free from insulating compounds which are liable to soften, ooze out, shrink or collapse and shall be non-catalytic and chemically inactive in transformer oil during service.

11.14.4. Coil assembly and insulating spacers shall be so arranged as to ensure free circulation of oil and to reduce the hot spot of the winding.

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

11.14.6. The conductor shall be transposed at sufficient intervals in order to minimize eddy currents and to equalize the distribution of currents and temperature along the winding.

11.14.7. The windings shall be designed to withstand the dielectric tests specified. The type of winding used shall be of time tested. An analysis shall be made of the transient voltage distribution in the windings, and the clearances used to withstand the various voltages. Margins shall be used in recognition of manufacturing tolerances and considering the fact that the system will not always be in the new factory condition.

11.14.8. The barrier insulation including spacers shall be made from high- density pre-compressed pressboard (1.1 gm/cc minimum for load bearing and 1 to 1.3 gm/cc minimum for non-load bearing) to minimize dimensional changes.

11.14.9. The conductor insulation shall be made from high-density (at least 0.75 gm/cc) paper having high mechanical strength. The characteristics for the paper will be reviewed at the time of design review.

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

11.14.11. All winding insulation shall be processed to ensure that there will be no detrimental shrinkage after assembly. All windings shall be pre-sized before being clamped.

11.14.12. Windings shall be provided with clamping arrangements which will distribute the clamping forces evenly over the ends of the winding.

11.14.13. The bracing of the windings and connections shall be such that these parts shall safely withstand the cumulative effects of stresses which may occur during handling, transportation, installation and service including line-to–line and line-to–ground faults.

11.14.14. **Current carrying connections:-** The mating faces of bolted connections shall be appropriately finished and prepared for achieving good long lasting, electrically stable and effective contacts. All lugs for crimping shall be of the correct size for the conductors. Connections shall be carefully designed to limit hot spots due to circulating eddy currents.

11.15. **Winding terminations into bushings:-**

11.15.1. Winding termination interfaces with bushings shall be designed to allow for repeatable and safe connection under site conditions to ensure the integrity of the transformer in service.

11.15.2. The winding end termination, insulation system and transport fixings shall be so designed that the integrity of the insulation system generally remains intact during repeated work in this area.

11.15.3. Allowances shall be made on the winding ends for accommodating tolerances on the axial dimensions of the set of bushings and also for the fact that bushings may have to be rotated to get oil level inspection gauges to face in a direction for ease of inspection from ground level.

11.15.4. In particular, rotation or straining of insulated connections shall be avoided during the fastening of conductor pads (or other methods) on the winding ends onto the termination surfaces of the bushing.

11.15.5. Suitable inspection and access facilities into the tank in the bushing oil-end area shall be provided to minimize the possibility of creating faults during the installation of bushings.

11.16. **Paint system and procedures:-** The typical painting details for transformer main tank, pipes, conservator tank, radiator, control cabinet / marshalling box / oil storage tank etc... shall be as given in **Annexure-D.** The proposed paint system shall generally be similar or better than this. The quality of paint should be such that its colour does not fade during drying process and shall be able to withstand temperature up to 120 deg C.

12. **Insulating Oil:-** The oil for first filling together with 10% extra shall be supplied with each transformer. The oil shall comply in all respects with **Annexure- A** of the specification. Particular attention shall be paid to deliver the oil free from moisture

having uniform quality throughout. The quantity of oil for first filling & 10% extra of each transformer shall be stated in the tender.

12.1. The supplier of transformer shall furnish test certificates of the insulating oil supplied against their acceptance norms, prior to dispatch.

Subsequently oil samples shall be drawn

i) At manufacturer's works before and after heat run test, the following shall be tested at CPRI.
   a) BDV in kVrms
   b) Moisture content
   c) Dissolved Gas Analysis – samples for DGA shall be taken from sampling device within 24 hrs prior to commencement of heat run test and immediately after this test. The acceptance norms shall be as per IS:10593 (based on IEC-599)

ii) Prior to filling in main tank at site the following shall be tested.
   1) BDV in kV rms
   2) Moisture content

iii) Prior to energisation at site following shall be tested.
   a) BDV in kVrms
   b) Moisture content
   c) Tan Delta at 90 deg cen.
   d) Resistivity at 90 deg cen.
   e) Interfacial Tension.

12.3. **Transportation of Oil:-** The insulating oil for the transformer shall be delivered at site with prior information to the Employer.

Insulating oil shall be delivered to the site in non returnable oil drums. The drums shall be suitable for storing the oil for long period

14. Bushings:-

14.1 Bushing shall have high factor of safety against leakage to ground and shall be so located as to provide adequate electrical clearances between bushing and grounded parts. Bushings of identical voltage rating shall be interchangeable. All bushings shall be equipped with suitable terminals of approved type and size and shall be suitable for bimetallic connection, if necessary. The insulation class of the high voltage neutral bushing shall be properly coordinated with the insulation class of the neutral of the high voltage winding.

All main windings, tertiary windings and neural leads shall be brought out to outdoor through bushings which shall be so located that the full flashover strength will

be utilised and phase to phase and phase to earth clearance shall be more than minimum value specified below. Location and arrangement of bushing shall follow Indian Standards.

Each bushing shall be so coordinated with the transformer insulation that flashovers will occur outside the tank.

All porcelain used in the bushings shall be made of the wet process, be homogeneous and free from cavities or other flaws. The glazing shall be uniform in colour and free from blisters, burns, and other defects. Upper portion of Bushing made of Porcelain & lower portion made of Epoxy / porcelain is also acceptable.

Bushings for 245 KV and 145 KV voltage class shall be Oil Filled Condenser type and shall be hermetically sealed. HV Neutral bushing shall be of 36 KV class for 220 KV class transformers. Bushing for 11 KV delta tertiary winding shall be of 36 KV class and of plain porcelain type and shall be hermetically sealed. All OIP bushing shall have provision of measurement of capacitance and tan-delta without dismantling of the bushing. Rating plate of bushing shall be provided near each type of bushing with terminal marking and physical position as per IS:2026. Bushing for 36KV shall be Solid porcelain or oil communicating type.

The electrical and mechanical characteristic of bushings shall conform to IS:2099 and IS:3347. The characteristic of the oil used in the bushing shall be the same as that of the oil in the transformer.

Main terminals shall be solder less and “Terminal Connectors” shall be as per cl. No. 12 of this technical specification. The spacing between the bushings must be adequate to prevent flashover between phases under all conditions of operation.

All bushings shall be suitable for heavily polluted atmosphere and minimum creepage distance shall be taken as 25 mm per KV.

Where Bushing mounted Current Transformers are specified, the bushing shall be removable without disturbing the current transformers.

The voltage and current rating of the bushings shall be as follows :

Highest System Voltage (kV)	**Rated Current in Amp.**
245kV	800 A
145kV	2000A
36kV (Tertiary)	3150 A
36kV (Neutral)	2000 A

15) Terminations:-

15.1. **220kV Terminations:-** The 220kV terminations shall be made through 245kV class, 800Amp. OIP condenser bushing of appropriate without arcing horns. Bushings shall be provided with TEST TAP rated for 2kV.

15.2. **110kV Terminations:-** The 110kV terminations shall be made through 145kV class 2000A–. OIP condenser bushing of appropriate without arcing horns. Bushings shall be provided with TEST TAP rated for 2kV.

15.3. **Neutral Termination:-** The neutral point shall be brought out through an Oil/Air solid porcelain bushing of suitable rating.

15.4. **Tertiary Winding Terminations:-** The three ends of the internally formed delta of the tertiary winding shall be brought out through solid porcelain bushings having voltage class as mentioned in the STP. These bushings shall be suitably positioned that proper protection/ grounding can be done as required.

15.5**.** **Terminal Connections:-**

15.5.1. General:

i) The bushing shall be equipped with suitable terminals for connector as specified herein.

ii) Each terminal (including the neutral) shall be distinctly marked on both the primary and secondary side in accordance with the diagram of connection supplied with the transformers.

iii) Vertical/horizontal/universal type bi-metallic, rigid connector for bushing stud shall be provided.

iv) Clamp and connector shall be made from Cold forged Aluminium Alloy Plate i.e Extruded Aluminium Clamp and Connector shall be processed through Cold forging for 220KV, 132KV, 52KV & 36KV Bushings.

v) The Nuts & Bolts associated with equipment of connector pieces shall be MS Hot dip galvanized. Quality of Nuts & bolts shall conform to relevant IS of latest edition.

vi) Minimum thickness at any point of current carrying part of any clamp & connector shall not be less than 12mm.

vii) From outermost hole edge to nearest edge of any clamp & connector the distance shall not be less than 10mm.

15.5.2. **HV Terminal:-** The HV Terminal connectors (TC) shall be suitable to connect between transformer HV bushing and double ACSR MOOSE conductor. Proper bimetallic (ALCO) shall be provided. Shall have proper bolts to get proper connection and shall be easily removable on requirement. The contact area between bushing & TC and TC & conductor shall be suitable for carrying 120% of the rated current continuously and fault currents as per standards.

15.5.3. **IV Terminal:-** The HV Terminal connectors (TC) shall be ssuitable to connect between transformer IV bushing and double ACSR KUNDAH conductor. Proper bimetallic (ALCO) shall be provided. Shall have proper bolts to get proper connection and shall be easily removable on requirement. The contact area between bushing & TC and TC &

conductor shall be suitable for carrying 120% of the rated current continuously and fault currents as per standards.

15.5.4. Neutral Terminal:- The Neutral Terminal Connector shall be suitable to connect between transformer Neutral bushing and ACSR KUNDAH / earthing GI strip. Proper bimetallic (ALCO) shall be provided. Shall have proper bolts to get proper connection and shall be easily removable on requirement. The contact area between bushing & TC and TC & conductor shall be suitable for carrying the fault current as per standards.

15.5.5. Tertiary Terminal:- The tertiary Terminal connectors shall be suitable to connect between transformer tertiary bushings - and ACSR KUNDAH conductor / earthing GI. The contact area between bushing & TC and TC & conductor shall be suitable for carrying the fault current as per standards.

16) Cooling Equipment and its Control:-

16.1. **Cooling Equipment for Radiator Bank**

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

16.1.2. In case of separately mounted radiator bank arrangement, the main tank shall have provision such that cooler banks can be placed on either side of the main tank ithout the need of any extra member/pipe maintaining the electrical clearances.

16.1.3. The radiator shall be of sheet steel in accordance with IS 513 and minimum thickness 1 mm. Each radiator bank shall be provided with the following accessories:

(a) Cooling Fans, Oil Pumps, Oil Flow Indicator (as applicable)
(b) Top and bottom shut off valve
(c) Drain Valve and sampling valve
(d) Top and bottom oil filling valves
(e) Air release plug
(f) Two grounding terminals for termination of two(2) Nos. 75x12mm galvanized steel flats.
g) Thermometer pockets with captive screw caps at cooler inlet and outlet.
(h) Lifting lugs

16.1.4. Each radiator bank shall be detachable and shall be provided with flanged inlet and outlet branches. Expansion joint shall be provided on top and bottom cooler pipe connection.

16.1.5. Required number of standby fans of approximately 20% capacity shall also be provided with each radiator bank.

16.1.6. Cooling fans shall not be directly mounted on radiator bank which may cause undue vibration. These shall be located so as to prevent ingress of rain water. Each fan shall be suitably protected by galvanized wire guard. The exhaust air flow from cooling fan shall not be directed towards the main tank in any case.

16.1.7. Two (2), 100% centrifugal or axial in line oil pumps, if applicable, (out of which one pump shall be standby) shall be provided with each radiator bank. Measures shall be taken to prevent mal-operation of Buchholz relay when all oil pumps are simultaneously put into service. The pump shall be so designed that upon failure of power supply to the pump motor, the pump impeller will not limit the natural circulation of oil.

16.1.8. An oil flow indicator shall be provided for each pump, for the confirmation of the oil pump operating in a normal state. An indication in the flow indicator and potential free contacts for remote alarm shall be provided.

16.1.9. Valves shall be provided across the pump and oil flow indicator to avoid oil drain and long outage during maintenance / replacement of pump and oil flow indicator.

16.1.10. Cooling fans and oil pump motors shall be suitable for operation from 415 volts, three phase 50 Hz power supply and shall conform to IS: 325. Each cooling fan and oil pump motors shall be provided with starter thermal overload and short circuit protection. The motor winding insulation shall be conventional class 'B' type. Motors shall have hose proof enclosure equivalent to IP: 55 as per IS: 4691.

16.1.11. The cooler pipes, support structure including radiators and its accessories shall be hot dip galvanized or corrosion resistant paint should be applied to external surface of it.

16.1.12. Air release device and oil plug shall be provided on oil pipe connections. Drain valves shall be provided in order that each section of pipe work can be drained independently.

16.2. **Cooling Equipment Control for Radiator banks**

16.2.1. Manual and Automatic operation control of fans/pumps shall be provided (with temperature change) from contacts of winding temperature indicator. The manufacturer shall recommend the setting of WTI for automatic changeover of cooler control over entire cooling option. The setting shall be such that hunting i.e. frequent start-up operations for small temperature differential do not occur.

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

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

16.2.4. Following lamp indications shall be provided in cooler control cabinet:

a) Cooler Supply failure (main)
b) Cooler supply changeover
c) Cooler Supply failure (standby)
d) Control Supply failure
e) Cooling fan failure for each bank
f) Cooling pump failure for each pump
g) Common thermal overload trip

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

16.2.5. The cooler control cabinet / Marshalling box shall have all necessary devices meant for cooler control and local temperature indicators. All the contacts of various protective devices mounted on the transformer and all the secondary terminals of the bushing CTs shall also be wired up to the terminal board in the cooler control cabinet/ Marshalling box. All CT secondary terminals in the cooler control cabinet shall have provision for shorting to avoid CT open circuit while it is not in use.

16.2.6. All necessary terminations for remote connection to Purchaser's panel shall be wired up to the Marshalling box.

16.2.7. The manufacturer shall derive AC power for Cooler Control Circuitry from the AC feeder.

16.3. **Auxiliary Power Supply for OLTC, Cooler Control and Power Circuit:-**

16.3.1. 415 volt, three phase 50Hz four (4) wire AC supply shall be provided by the Purchaser at cooler control cabinet.

16.3.2. For each circuit, suitably rated power contactors, MCBs/MCCBs as required for entire auxiliary power supply distribution scheme including distribution to DM boxes, Fibre optic sensor Box etc. (as applicable), shall be provided by supplier in cooler control cabinet.

16.3.3. Auxiliary power supply distribution scheme shall be submitted for approval. Supply and laying of Power, Control and special cables from marshalling box to all accessories is in the scope of the supplier.

17) **Valves:-**

17.1. All valves up to and including 100 mm shall be of gun metal or of cast steel/cast iron.

Larger valves except radiator shut off valves may be of gun metal or may have cast iron bodies with gun metal fittings. They shall be of full way type with internal screw and shall open when turned counter clock wise when facing the hand wheel. All

hardware used shall be hot dip galvanized / stainless steel.

17.2. Suitable means shall be provided for locking the valves in the open and close positions which can be operated with special tools only. Provision is not required for locking individual radiator valves.

17.3. Each valve shall be provided with the indicator to show clearly the position (open/close) of the valve.

17.4. All valves flanges shall have machined faces.

17.5. All valves in oil line shall be suitable for continuous operation with transformer oil at 15 deg C.

17.6. The oil sampling point for main tank shall have two identical valves put in series. Oil sampling valve shall have provision to fix rubber hose of 10 mm size to facilitate oil sampling.

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

18) Cabling:-

All interconnecting control and power cables between various parts of Transformers like turret CT, MBs, Fans, pumps, Buchholz, PRD etc. shall be routed through covered cable tray or GI conduit and shall be properly dressed. All cables shall be armoured type. Un-armoured cables (if provided) in any circuitry, shall be through GI conduit and no part shall be exposed. Cable terminations shall be through stud type TB and ring type lugs. Typical Technical specification for cables is attached at **Annexure-G.** Supplier shall provide type tested cables from approved sources. No type testing for cables is envisaged. Both ends of all the wires (control & power) shall be provided with proper ferrule numbers for tracing and maintenance. Further, any special cables (if required) shall also be considered included in the scope. All cable accessories such as glands, lugs, cable tags / numbers etc as required shall be considered included in the scope of supply.

19) Tap Changing Equipment:-

Each transformer shall be provided with On Load Tap changing equipment as specified elsewhere. The OLTC offered shall be suitable for bi directional power flow and shall comprise tap selectors and high speed transition diverter switch.

19.1. **ON Load Tap Changing (OLTC) Equipment**

19.1.1. **Main OLTC Gear Mechanism**

19.1.1.1. Each transformer shall be provided with an on load tap changing Mechanism. ***The tap changer shall be suitable for bidirectional power flow. The OLTC shall be comprising tap selectors and diverter switch of high speed transition.*** This shall be designed suitable for remote operation from the remote tap changer control (RTCC) panel in the control room in addition to being capable of local manual as well as local electric al operation.

The tapings shall be controlled by a high speed resistor transition type gear in which tap change is carried out virtually under 'no volt' 'no ampere' condition and the selector switches do not make and break any current, main current is never interrupted and a resistor is provided to limit the arching at diverter contacts to a minimum. Shall be suitable for outdoor mounting and continuously rated for operating at all position including positions in the middle of tap change. In particulars, the tap change gear shall be suitable for delivering the full output plus permissible overload and operating the lowest voltage tap on the HV side.

The value of the transition resistor shall be indicated on the rating plate of the OLTC with continuous current rating with reference to design ambient temperature specified.

Each transformer shall be provided with On Load Tap changer units for controlling the voltage.

191.1.2. OLTC shall be motor operated suitable for local as well as remote operation. The diverter switch or arcing switch shall be designed so as to ensure that its operation once commenced shall be completed independently of the control relays or switches, failure of auxiliary supplies etc. To meet any contingency which may result in incomplete operation of the diverter switch, adequate means shall be provided to safeguard the transformer and its ancillary equipment. The current diverting contacts shall be housed in a separate oil chamber not communicating with the oil in main tank of the transformer. The contacts shall be accessible for inspection without lowering oil level in the main tank and the contacts shall be replaceable.

191.1.3. Necessary safeguards shall be provided to avoid harmful arcing at the current diverting contacts in the event of operation of the OLTC gear under overload conditions of the transformer.

191.1.4. The OLTC oil chamber shall have oil filling and drain valve, oil sampling valve, relief vent and level glass. Oil sampling valve of minimum size, accessible from ground, shall be provided to take sample of oil from the OLTC chamber. It shall also be fitted

with an oil surge relay which shall be connected between OLTC oil chamber and OLTC conservator tank.

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

19.2. **Local OLTC Control Cabinet (Drive Mechanism Box):-** Each transformer unit of OLTC gear shall have following features:

19.2.1 OLTC shall be suitable for manually handle operated and electrically motor operated.

For local manual operation from Local OLTC Control cabinet (Drive Mechanism Box), an external handle shall be provided.

19.2.2. OLTC's Local control cabinet shall be mounted on the tank in accessible position. The cranking device/ handle for manual operation for OLTC gear shall be removable and suitable for operation by a man standing at ground level. The mechanism shall be complete with the following:

Mechanical tap position indicator which shall be clearly visible from near the transformer. A mechanical operation counter of at least five digits shall be fitted to indicate the number of operations completed and shall have no provision for resetting. Mechanical stops to prevent over-cranking of the mechanism beyond the extreme tap positions.

The manual control considered as back up to the motor operated on load tap changer control shall be interlocked with the motor to block motor start-up during manual operation.

The manual operating mechanism shall be labeled to show the direction of operation for raising the voltage and vice-versa.

An electrical interlock to cut-off a counter impulse for reverse step change being initiated during a progressing tap change and until the mechanism comes to rest and resets circuits for a fresh position.

19.2.3. For electrical operation from local as well as remote, motor operated mechanism shall be provided. It shall not be possible to operate the electric drive when the manual operating gear is inserted. It shall not be possible for any two controls to be in operation at the same time. Thermal device or other means shall be provided to protect the motor and control circuit.

19.2.4. The Local OLTC Drive Mechanism Box shall house all necessary devices meant for OLTC control and indication. It shall be complete with the followings:

i. A circuit breaker / contactor with thermal overload devices for controlling the AC Auxiliary supply to the OLTC motor.
ii. Emergency Push Button to stop OLTC operation.
iii. Cubicle light with door switch.
iv. Provided with anti-condensation metal clad heaters to prevent condensation of moisture.
v. Padlocking arrangement for hinged door of cabinet.
vi. All contactors relay coils and other parts shall be protected against corrosion deterioration due to condensation, fungi etc.
vii. The cabinet shall be tested at least IP 55 protection class.

19.2.5. All relays and operating devices shall operate correctly at any voltage within the limits specified in this specification In case auxiliary power supply requirement for OLTC DM Box is different than station auxiliary AC supply, then all necessary converters shall be provided by the Supplier.

19.2.6. Operating mechanism for on load tap changer shall be designed to go through one step of tap change per command only, until the control switch is returned to the off position between successive operations / repeat commands.

19.2.7. Limit switches shall be provided to prevent overrunning of the mechanism and shall be directly connected in the control circuit of the operating motor provided that a mechanical de-clutching mechanism is incorporated. In addition, a mechanical stop shall be provided to prevent over-running of the mechanism under any condition. An interlock to cut-out electrical control when it tends to operate the gear beyond either of the extreme tap positions.

19.2.8. OLTC local control cabinet shall be provided with tap position indication for the transformer. Drive Mechanism shall be equipped with a fixed resistor network capable of providing discrete voltage steps or provide 4-20mA transducer outputs for tap position indication in MB/ Cooler Control Cabinet and input to RTCC/SCADA system.

19.2.9. 'Local-remote' selector switch shall be provided in the local OLTC control cabinet. In Local mode, all electrical commands from remote (RTCC, SCADA etc.) shall be cut-off/blocked. Electrical operations to change tap positions shall be possible by using raise/lower push buttons under local mode from DM Box. In remote mode electrical commands from RTCC/SCADA etc. shall be executed. The remote-local selector switch shall be having at-least two spare contacts per position.

19.2.10. Following minimum contacts shall be available in DM Box, which shall be wired to Digital RTCC panel:

a) INCOMPLETE STEP which shall not operate for momentary loss of auxiliary power.
b) OLTC motor overload protection
c) Supply to DM Motor fail
d) OLTC IN PROGRESS
e) Local / Remote Selector switch position
f) OLTC upper/lower limits reached.
g) Facility to trip the OLTC DM motor from remote during any emergency

19.2.11. All relays, switches, fuses etc. shall be mounted in the OLTC local control cabinet and shall be clearly marked / labelled for the purpose of identification.

19.2.12. A permanently legible lubrication chart if required shall be fitted within the OLTC local control cabinet.

19.3. **RTCC Panel:**

The supplier shall supply one indoor cubicle for each transformer (RTCC panel) for installation in the purchaser's control room for the remote operation of the tap change from control room and from remote (viz. Load dispatch centre through SCADA).

The RTCC panel shall be made of CRCA sheet steel of thickness minimum 2.5 mm for load as well as non load bearing member.

The RTCC panel shall be provided with suitable size Min. 3 mm thick detachable gland plate.

The following control switches/ push buttons shall be provided in the RTCC panel.

Push button for 'RAISE"

Push button for "LOWER"

"EMERGENCY STOP" button to stop TC operation.

"Control Supply ON/OFF" switch.

"OFF/MASTER/FOLLOWER/INDEPENDENT" Mode Selector Switch.

The RTCC panel shall be provided with an annunciation window having minimum the following indications.

The RTCC panel shall be provided with an annunciation Relay system having TEST, ACCEPT & RESET facilities. The relay shall be suitable for TRIP and NON-TRIP alarms. In the event of any contact initiates, the corresponding window shall glow and an audible alarm shall be operated. The TRIP window shall have Black text in Red background and

Non-Trip alarm window shall have black text in white background.

There shall be minimum two nos. each of TRIP & NON TRIP windows as SPARES.

The relay shall be suitable for the following TRIP and NON-TRIP alarms.

WTI alarm and trip

OTI alarm and trip

Bucholz relay alarm and trip for main tank

OSR trip.

MOG low level alarm for main tank and OLTC

PRV main tank trip

PRV OLTC Trip

Sudden pressure relay trip

Main fan in GR-1 fail

Main fan in GR-2 fail

Drive Motor Auto trip

Out of step alarm

Following bunched LED indications shall be provided on the RTCC panel.

Supply ON- Green

Tap Change in Progress- Amber

OLTC control supply On- Green

DC Supply ON- Green

TC Upper limit reached- Yellow

TC Lower limit reached- Red

TC in LOCAL mode- Red

TC in REMOTE mode- Blue

4- to 20 mA signals for WTI, OTI repeater and tap positions for SCADA use.

Further the the RTCC panel shall be provided with

1) Remote Oil & winding temperature indicators
2) Remote tap position indicators etc.

Following signals /controls shall be available for connecting to remote from RTCC through SCADA.

1) TAP positions
2) Winding and Oil temperatures
3) Tap changer LOW and RAISE controls.
4) And all protection alarm and trip signals from transformer to RTCC panel for

extending to elsewhere (Load dispatch Centre) through SCADA.

4 to 20mA signal for SCADA for tap positions for connecting from RTCC

The welding of the panel shall be continuous on joints. Welding at regular intervals on joints and filling of gaps with use of Mseal is not accepted.

All cables shall be bottom entry and access from rear side. The auxiliary supply to the panel is 240 V AC, single phase, 50 Hz / 110 V DC. Following shall be provided in the RTCC panel.

1) Cubicle lamp with door switch and separate fuse / MCB.
2) Approved space heaters controlled by thermostat and separate fuse / MCB
3) Incoming fuse switch / MCB for the incoming supply.
4) A table showing voltages on each tap position engraved in stainless steel plate shall be fixed on the front of the panel by rivet.
5) Stainless steel door handle with lock & additional facility for padlock.
6) Earthing strip inside the panel for connecting to the substation grounding.
7) Single phase power plug industrial type 15/5 Amp. With MCB.
8) All hinged parts (doors etc) shall be properly grounded.

The RTCC Panel shall be provided with Raise / Lower push buttons, Master / Follower / Independent / Off mode selection features and emergency stop Push Button for control of OLTC.

19.4. **Master / Follower / Independent / Off mode**

Master Position: If the selector switch is in master position, it shall be possible to control the OLTC units of other parallel operating transformers in the follower mode by operation from the master unit.

Follower Position: If the selector switch is in Follower position control of OLTC shall be possible only from panel where master mode is selected.

Independent Position: In independent position of selector switch, control of OLTC shall be possible only from the panel where independent mode is selected. Suitable interlock arrangement shall be provided to avoid unwanted/inconsistent operation of OLTC of the transformer

Raise / Lower control: The remote OLTC scheme offered shall have provision to raise or lower taps for the Transformers.

The relays shall ensure positive completion of lowering/raising of the OLTC tap, once the command is issued from the relay. "Step-by-Step" operation shall be ensured so that only one tap change from each tap changing pulse shall be effected. If the command remains in the "operate" position, lock-out of the mechanism is to be

ensured.

20) Constructional features of Cooler Control Cabinet / Individual Marshalling Box / and RTCC Panel

20.1. Each transformer unit shall be provided with local OLTC Drive Mechanism Box, cooler control cabinet /individual marshalling box and RTCC panel.

20.2. The cooler control cabinet, Marshalling Box, RTCC panel etc. shall be made of CRCA sheet of minimum thickness of 2.5mm and shall be painted suitably as per **Annexure-D.**

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

20.4. All doors, removable covers and plates shall be gasketed all around with suitably profiled. All gasketed surfaces shall be smooth straight and reinforced if necessary to minimize distortion to make a tight seal. For Control cubicle / Marshalling Boxes etc. which are outdoor type, all the sealing gaskets shall be of EPDM rubber or any better approved quality, whereas for all indoor control cabinets / RTCC panel, the sealing gaskets shall be of neoprene rubber or any better approved quality. The gaskets shall be tested in accordance with approved quality plan, IS: 1149 and IS: 3400.

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

20.6. The size of all cabinets shall be suitable for fixing all required accessories. All accessories shall be easily accessible inspection and maintenance. All cabinets except RTCC shall be tank mounted. The RTCC panel shall be suitable for mounting indoor.

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

a) Conservator for main tank with air cell, oil filling hole and cap, isolating valves, drain valve, magnetic oil level gauge with low & high level alarm contacts, prismatic oil level gauges and dehydrating breather

b) Conservator for OLTC with drain valve, oil surge Relay, filling hole with cap, prismatic oil level gauge and dehydrating breather.

c) Pressure relief devices.

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

e) Air release plug

f) Inspection openings and covers

g) Bushing with metal parts and gaskets to suit the termination arrangement

h) Winding & Oil temperature indicators for local and remote mounting.

i) Cover lifting eyes, transformer lifting lugs, jacking pads, towing holes and core and winding lifting lugs.

j) Protected type mercury or alcohol in glass thermometer or magnetic or micro- switch type dial type temperature indicator.

k) Bottom and top filter valves with threaded male adaptors, bottom sampling valve and drain valve.

l) Rating and diagram plates (in English) on transformers and auxiliary apparatus.

m) On load tap changing gear, OLTC DM Box, Cooler control cabinet, Fibre optic sensor box and RTCC Panel (indoor type) as applicable

n) Cooling equipment

o) Bushing current transformers for winding temperature imaging.

p) Oil flow indicator

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

r) Terminal marking plates t. Valves schedule plate

s) Ladder to climb up to the Transformer tank cover with suitable locking arrangement to prevent climbing during charged condition

t) Suitable Platform for buchholz relay shall be provided, in case these are not accessible from transformer top.

u) Haulage lugs

v) Flow sensitive conservator isolation valve.

w) Flanged bi-directional wheels

22) **Bushing Current Transformer:-** Bushing CTs shall be used for HV, IV winding temperature imaging on required phases. Test windings shall be provided for bushing CTs for testing purposes.

22.1. Current transformers shall comply with IS 2705/IEC-60044-1.

22.2. It shall be possible to remove the turret mounted current transformers from the Transformer tank without removing the tank cover. Necessary precautions shall be taken to minimize eddy currents and local heat generated in the turret.

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

23) General warranty:- The bidder shall among other things guarantee the following:

i) Quality and strength of materials used.

ii) The tenderer shall give guarantee for satisfactory working of the complete transformer for **114 months** from the date of commissioning of equipment or **120 months** from the date of receipt of transformer at site, whichever is earlier.

Guarantee period will be reckoned from the date of receipt of 100 % accessories and not from the date of receipt of main tank only.

Defects any noticed during this period due to faulty design/ workmanship, inferior raw materials or non adherence to the relevant standards shall be made good by way of replacement on all free of cost to KSEB Ltd

24) Hand Tools:- One set of hand tools of reputed make packed in a carry bag/box broadly comprising of double ended spanners (open jaws, cranked ring, tubular with Tommy bar each of sizes 9mm to 24mm, one set each), adjustable wrenches (8 &12 inch one set), gasket punches (of different sizes used - one set), pliers (flat nose, round nose & side cutting one of each type), hammer with handle (one), files with handle (two), knife with handle (one), adjustable hacksaw (one), and cold chisel (one), Hole punching tools for punching holes on gaskets (of all required sizes for the offered transformer) etc. shall be supplied per lot.

25) Centre of Gravity:- The centre of gravity of the assembled transformer shall be low and as near the vertical centre line as possible.

The transformer shall be stable with or without oil. If the centre of gravity is eccentric relative to track either with or without oil, its location shall be shown on the outline drawing.

26) Inspection and Testing:- The manufacturer should have a well established Quality Assurance System in place and the QAP should be submitted for review and approval of KSEB Limited within 30 days from the date of purchase order. The manufacturer shall carry out a comprehensive inspection and testing program during manufacture of the equipment. The inspection envisaged by the Purchaser is given below. This is however not intended to form a comprehensive program as it is Supplier's

responsibility to draw up and carry out such a program in the form of detailed quality plan duly approved by Purchaser for necessary implementation.

26.1. **Inspection**

26.1.1. **Tank and Conservator**

a) Check for flatness

b) Welder's qualification and welding procedure

c) Inspection of major weld preparation

d) Crack detection of major strength weld seams by dye penetration test

e) Measurement of film thickness of:

I) Oil insoluble varnish

ii) Zinc chromate paint

iii) Finished coat

f) Check correct dimensions between wheels, demonstrate turning of wheels through 90 degree and further dimensional check.

g) Check for physical properties of materials for lifting lugs, jacking pads, etc. All load bearing welds including lifting lug welds shall be subjected to Non Destructive Testing.

h) Leakage test of the conservator

I) Certification of all test results

j) Test for proper and effective shielding of tank

26.1.2. **Core:-**

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

b. Check on the quality of varnish if used on the stampings:

i) Measurement of thickness and hardness of varnish on stampings

ii) Solvent resistance test to check that varnish does not react in hot oil

iii) Check overall quality of varnish by sampling to ensure uniform shining colour, no bare spots, no over burnt varnish layer and no bubbles on varnished surface

c. Check on the amount of burrs

d. Bow check on stampings

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

f. Visual and dimensional check during assembly stage

g. Check for inter-laminar insulation between core sectors before and after pressing

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

i. High voltage test (2 kV for one minute) between core and Yoke clamps, Yoke clamps to tank and Core to Tank

j. Certification of all test results

26.1.3. **Insulation Material**

a. Sample check for physical properties of materials b.
Check for dielectric strength

c. Visual and dimensional checks

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

e. Dimension stability test at high temperature for insulating material f.
Tracking resistance test on insulating material

g. Certification of all test results

26.1.4. **Winding**

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

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

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

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

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

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

g. Check for absence of short circuit between parallel strands h.
Check for brazed joints wherever applicable

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

j. Conductor enamel test for checking of cracks, leakage and pin holes k.
Conductor flexibility test

l. Heat shrink test for enameled wire m.
Certification of all test results

26.1.5. **Checks Before Drying Process**

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

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

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

d. Insulation of core shall be tested at 2 kV/minute between c o r e and Yoke clamps, Yoke clamps to tank and Core to Tank

e. Check for proper cleanliness and absence of dust etc.

f. Certification of all test results

26.1.6. **Checks During Drying Process**

a. Measurement and recording of temperature, vacuum and drying time during drying process

b. Check for completeness of drying by periodic monitoring of dryness c. Certification of all test results

26.1.7. **Assembled Transformer**

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

b. Jacking test of Transformer in oil-filled condition (excluding separately mounted cooler bank)

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

26.1.8. **Bought Out Items:-** The makes of all major bought out items shall be subject to Purchaser's approval for 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/ Individual Marshalling box and common marshalling box as applicable
h) Cooling equipment
i) Oil pumps
j) Fans/Air Blowers k) Tap change gear
l) Pressure relief device.

The above list is not exhaustive and the Supplier shall also include other bought-out items in his program .

26.2. **Factory Tests:-** The manufacturer shall be fully equipped to perform all the required tests as specified. Bidder shall confirm the capabilities of the proposed

manufacturing plant in this regard when submitting the bid. Any limitations shall be clearly stated in.

The supplier shall bear all additional costs related to tests which are not possible to carry out at his own works.

The supplier shall submit an Inspection and test plan (ITP) for approval. A typical test plan is indicated in "**Annexure-E".**

All tests shall be done in line with IS 2026/IEC-60076 and the test procedures as mentioned in "**Annexure-E".** Complete test report shall be submitted to purchaser after proper scrutiny and signing on each page by the testing engineer of the supplier.

26.3 Type Tests on fittings:

The following fittings shall conform to type tests as per relevant IS/IEC and the type test reports shall be furnished by the supplier along with the drawings of equipment/ fittings.

1) OLTC
2) Buchholz relay
3) Cooler Control cabinet, O L T C D M box
4) Pressure Relief device Test

   The pressure Relief Device of each size shall be subjected to increase in oil/ air pressure. It shall operate before reaching the test pressure specified in transformer tank pressure test above. 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 of IS 13947/Equivalent IEC standard.
5) Magnetic Oil Level gauge & Terminal Box.
6) Air Cell (Flexible air separator) - Oil side coating, Air side under Coating, Air side outer coating and coated fabric as per IS: 3400/ BS: 903/ IS: 7019
7) OTI & WTI
8) Oil pump
9) Cooling fan and motor assembly
10) Bushings

26.4. Pre-Shipment Checks at Manufacturer's Works

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

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

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

26.4.4. Gas tightness test to confirm tightness and record of dew point of gas inside the tank.

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

27) Packing:- The packing may be in accordance with the supplier's standard practice but full particulars of packing shall be submitted for the approval of the purchaser. Special arrangement should be made to facilitate handling and to protect and projecting connections from damage in transit. Vibration monitoring device shall be fitted on the transformer to monitor the vibration during transit. The transformer shall be shipped in Nitrogen filled condition. All parts shall be adequately marked to facilitate field erection. Boxes and crates shall be marked with the contact number and shall have a packing list enclosed showing the parts contained therein, weight and special lifting and storing instruction if any.

As the equipment is liable to be stored in the open, packing shall be suitable for outdoor storage under humid atmospheric conditions.

28) Receipt and Storage Checks

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

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

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

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

29) Supervision of Erection & Commissioning:- Supervision of erection of the transformers and commissioning of the transformers are in the scope of the supplier as already stated in clause 1.1.

Annexure – A

Standard Technical Particulars / Parameters.

(220/110/11kV, 200MVA 3-Phase Auto Transformer)

Cl. No.	Description	Unit	TECHNICAL PARAMETERS
1	Rated Capacity		
1.1	HV	MVA	200
1.2	IV	MVA	200
1.3	LV (Tertiary: For Stabilizing)	MVA	66.67
2	Voltage ratio	kV	220/110/11
3	Single / Three Phase Design		Three
4	Applicable Standard		IS 2026/IEC 60076
5	Frequency	Hz	50
6	Cooling & Percentage Rating at different cooling		ONAN / ONAF / ODAF 60% / 80% / 100%
7.1	Type of Transformer		Outdoor Type Interconnection Power Transformer
7.2	Type of Transformer		Constant Ohmic impedance type (Refer Note1)
8	Polarity		Subtractive
9	Voltage variation on supply side		+ / - 10%
10	Frequency variation on supply side		+ / - 5%
11	Transient condition.		- 20% or + 10% combined variation of voltage and frequency
12	Radio interference Voltage		Maximum 250 µV.
13	HV-IV Impedance at 75 Deg C at Principal Tap	%	% impedance at principal tap at rated voltage, frequency at 200 MVA Base shall be **10.2%,** (Match with existing transformer with % impedance for parallel operation as below: Tap-1 – 9.16 Tap-5 – 10.227
14	Type of insulating media		Immersed in mineral Oil
15	Losses		
15.1	No load losses in kW		Maximum no load loss at rated condition allowed without any positive tolerance shall be 40 kW

15.2	Load loss at principal tap		Maximum load loss at rated condition @ 75°C and principal tap allowed without any positive tolerance shall be **285** kW	
15.3	Auxilliary losses		Maximum guaranteed auxiliary losses at rated voltage and frequency of aux. supply shall be **9** kW.	
16	Loss Capitalization formula		As per CBIP manual section-AA (Publication No.317, 2013)	
16.1	Capitalized value of No load loss per kW (in Indian Rupees)		Rs. **4,72,003**/-per kW	
16.2	Capitalized value of load loss per kW (in Indian Rupees)		Rs. **2,51,106**/-per kW	
16.3	Capitalized value of auxiliary load loss per kW (in Indian Rupees)		Rs. **1,88,801**/-per kW	
17	Service		OUTDOOR	
18	Duty		CONTINUOUS	
19	Overload Capacity		IS 6600/IEC 60076-7, IEC 354	
20	Temperature rise over 50 deg C Ambient Temp			
20.1	Top oil measured by thermometer	Deg. C	45	
20.2	Average winding temperature measured by Thermometer	Deg. C	50	
23	Design Clearances in mm.		Phase to Earth	Phase to Phase
	Highest System voltage of 245kV	mm.	1800	2000
	Highest System voltage of 145kV	mm.	1050	1220
	Highest System voltage of 33kV	mm.	320	350
	Highest System voltage of 11kV	mm.	140	280
24	Windings			
24.1	System Fault level			
	HV	kA	50	
	IV	kA	31.5	
	LV	kA	25	
24.2	Lightning Impulse withstand Voltage			
	HV	kVp	1050	
	IV	kVp	650	

	LV	kVp	170
	Neutral	kVp	95
24.3	One Minute Power Frequency withstand Voltage		
	HV	kVrms	460
	IV	kVrms	275
	LV	kVrms	95–
	Neutral	kVrms	38
25	Neutral Grounding		Solidly grounded
26	Insulation		
	HV		GRADED
	IV		GRADED
	LV		UNIFORM
27	Tertiary Connection		DELTA
28	Tan delta of winding	%	< 0.5%
29	Vector Group (3 –ph) (unless specified differently elsewhere)		YNa0d11
30	Tap Changer		OLTC. Shall be suitable for bi-directional power flow.
30.1	Tap Range & No. of steps		+2.5% to -12.5% of HV variation in the step of 1.25%,
30.2	Location of Tap changer		On the HV winding.
30.3	Design		Constant flux voltage variation type as per IS 2026
30.4	Tap control		Full capacity - on load tap changer suitable for group / independent, remote / local electrical and local manual operation and bi- directional power flow
31	Bushings		
31.1	Rated voltage		
	HV	kV	245
	IV	kV	145
	LV	kV	36
	Neutral	kV	36
31.2	Rated current (Min.)		
	HV	A	800
	IV	A	2000
	LV	A	3150

	Neutral	A	2000
31.3	Lightning Impulse withstand Voltage		
	HV	kVp	1050
	IV	kVp	650
	LV	kVp	170
	Neutral	kVp	95
31.4	One Minute Power Frequency withstand Voltage		
	HV	kVrms	460
	IV	kVrms	275
	LV	kVrms	95
	Neutral	kVrms	38
31.5	Minimum total creepage distances		
	HV	mm	6125
	IV	mm	3625
	LV	mm	900
	Neutral	mm	900
31.6	Tan delta of bushing		
	HV	%	<0.5%
	IV	%	<0.5%
	LV	%	N.A
	Neutral	%	N.A
31.7	Max Partial discharge level at Um		
	HV	pC	10
	IV	pC	10
	Max Partial discharge level at 1.5Um/√3	pC	100
32	Max Noise level at rated voltage and at principal tap on full load and all cooling active	dB	Shall not exceed limits as per NEMA TR1 with all accessories running, measured as per standard.
33	Auxiliary supply to OLTC, oil pumps and cooler fans		3 Phase, 415V ± 10%
34	Auxiliary DC supply for alarm and tripping (volt)		110V DC
35	Width of rail gauge		1676 mm

Notes:

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

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

3) Tan delta of Winding & Bushing shall be measured at ambient temperature.

Annexure-B

Specification for Transformer Insulating Oil.
(IS 335)

TRANSFORMER OIL:

Sl. No.	Characteristics.	Requirement	Methods of Test.
1.	Appearance	The oil shall be clear and transparent and free from suspended matter or sediment.	A representative sample of oil shall be examined in a 100 mm thick layer at ambient temperature.
2.	Density at 20oC Max.	0.89 g/cm3	IS.1448,ISO 3675/12185
3.	Kinematic Viscosity at 27oC Max.	27 CST	IS.1448
4.	Interfacial tension at 27oC Min.	0.04 N/m	IS.6104,ISO 6295
5.	Flash point (Penskey Marten – closed cup)	140oC(Min.)	IS.1448,ISO2719
6.	Pour point	-6 (Max.)	IS.1448,IEC 60296, ISO 3016
7.	Neutralization value (total acidity) Max.	0.03 mg KOH/g	IS.335 Appx.A. IEC62021-1
8.	Corrosive sulphur (in term of classification of copper strip)	Non-corrosive	IS.335 Appx.B. DIN51353, BS2000 PART373
9.	Electric strength (break down voltage) Min.		
	a) New untreated oil	30KV(rms) (if the above value is not attained, the oil shall be treated.	IS.6792 IEC 60814
	b)After treatment	60KV(rms)	IS.6792. IEC 60814
10.	Dielectric dissipation factor (tan delta) at 90oC Max.	0.002	IS.6262 IEC60247/61620

11	Specific resistance (resistivity)		
	a)at 90°C Min.	$35x10^{12}$ ohm-cm	IS.6103
	b)at 27°C Min.	$1500x10^{12}$ ohm-cm	
12	Oxidation stability		IEC 61125 part C
	a) Neutralization value after oxidation (Max.)	0.40 mg/KOH/g	
	b) Total sludge after Oxidation Max.	0.10 percent by weight.	
13.	Presence of oxidation inhibitor.	The oil shall not contain anti-oxidant inhibitors.	IS.335 Appendix .D
14	Water contents Max.	50 ppm	IS.2362.IEC 60814
15	Ageing characteristics After 96 hrs. with catalyst (copper)		
	a) Resistivity		As per ASTM –D 1934.
	i) 27°C	$2.5x10^{12}$ ohm cm.	
	ii) 90°C	$0.2x10^{12}$ ohm cm.	
	b) Tan delta at 90°C	0.2 (Max.)	
	c) Total acidity	0.05 mg/KOH/gm (Max.)	
	d) Total Sludge content % by mass	0.05% (Max.)	

Annexure- C
Design Details

Sr. No.	Description
1.	Core and Magnetic Design
2.	Over-fluxing characteristics up to 1.7Um
3.	Inrush-current characteristics while charging from HV & IV respectively.
4.	Winding and tapping design
5.	Short-circuit withstand capability including thermal stress for min. 2 Sec.
6.	Thermal design including review of localized potentially hot area.
7.	Cooling design
8.	Overload capability
9.	Eddy current losses
10.	Seismic design, as applicable
11.	Insulation co-ordination
12.	Tank and accessories
13.	Bushings
14.	Tap changers
15.	Protective devices
16.	Fans, pumps and radiators
17.	Sensors and protective devices– its location, fitment, securing and level of redundancy
18.	Oil and oil preservation system
19.	Corrosion protection
20.	Electrical and physical Interfaces with substation
21.	Earthing (Internal & External)
22.	Processing and assembly
23.	Testing capabilities & Detailed test procedure.
24.	Inspection and test plan
25.	Transport and storage
26.	Sensitivity of design to specified parameters

27.	Acoustic Noise
28.	Spares, inter-changeability and standardization
29.	Maintainability
30.	PRD and SPR (number & locations)
31.	Conservator capacity calculation
32.	Winding Clamping arrangement details with provisions for taking it “in or out of tank”
33.	Conductor insulation paper details
34.	Location of Optical temperature sensors
35.	The design of all current connections
36.	Location & size of the Valves

Annexure – D
Painting Procedure

Painting	Surface preparation	Primer coat	Intermediate undercoa	Finish coat	Total dry film thick-ness (DFT)	Colour shade
Main tank, pipes, conservator tank, oil storage tank& DM Box etc. (external surfaces)	Shot Blast cleaning Sa 2 ½*	Epoxy base Zinc primer (30-40 m)	Epoxy high build Micaceous iron oxide (HB MIO) (75 m)	Aliphatic polyurethane (PU) (Minimum 50 m)	Minimum 155 m	Shade no.631 of IS 5 or equivalent
Main tank, pipes (above 80 NB), conservator tank, oil storage tank & DM Box etc. (Internal surfaces)	Shot Blast cleaning Sa 2 ½*	Hot oil proof, low viscosity varnish or Hot oil resistant, non- corrosive Paint	--	--	Minimum 30 m	Shade no.631 of IS 5 or equivalent
Radiator (external surfaces)	Chemical / Shot Blast cleaning Sa 2 ½*	Epoxy base Zinc primer (30- 40 m)	Epoxy base Zinc primer (30-40 m)	PU paint (Minimum 50 m)	Minimum 100 m	Shade no.631 of IS 5 or equivalent
	supplier may also offer Radiators with hot dip galvanized in place of painting with minimum thickness of 40 m (min)					
Radiator and pipes up to 80 NB (Internal surfaces)	Chemical cleaning, if required	Hot oil proof, low viscosity varnish or Hot oil resistant, non- corrosive Paint	--	--	--	--
Digital RTCC Panel	Seven tank process as per IS:3618 & IS:6005	Zinc chromate primer (two coats)	--	EPOXY paint with PU top coat or POWDER coated	Minimum 80 m / for powder coated minimum 100 m	Shade no.631 of IS 5 or equivalent

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

Annexure -E

Test Plan

No.	Test	
1.	Measurement of winding resistance	Routine
2.	Voltage ratio measurement	Routine
3.	Polarity test	Routine
4.	No-load loss and excitation current measurement	Routine
5.	Magnetic balance test (for three phase Transformer only)	Routine
6.	Impedance and load loss measurement	Routine
7.	Measurement of insulation resistance & Polarization Index	Routine
8.	Measurement of insulation power factor and capacitance between	Routine
9.	Chopped wave lightning impulse test for the line terminals	Routine
10.	Full wave lightning impulse test for the line terminals (LI)	Routine
11.	Measurement of transferred surge on LV (Tertiary) as applicable	Type
12.	Induced voltage withstand test (IVW) with PD	Routine
13.	Applied voltage test (AV)	Routine
14.	On-load tap changer test(Ten complete cycle before LV test)	Routine
15.	Gas-in-oil analysis	Routine
16.	Core assembly dielectric and earthing continuity test	Routine
17.	Oil leakage test on transformer tank	Routine
18.	Appearance, construction and dimension check	Routine
19.	Measurement of no load current & Short circuit Impedance with	Routine
20.	High voltage with stand test on auxiliary equipment and wiring after	Routine
21.	Tank vacuum test	Routine
22.	Tank pressure test	Routine
23.	Lightning impulse test for the neutral terminals (LIN)	Type
24.	Temperature rise test	Type
25.	Measurement of Zero seq. reactance (for three phase Transformer only)	Type
26.	Measurement of harmonic level in no load current	Type
27.	Measurement of acoustic noise level	Type
28.	Measurement of power taken by fans and oil pumps (Not applicable for ONAN)	Type
29.	Dynamic Short circuit withstand test	Type
30.	DGA tests before and after conducting the Temperature Rise	Type
31.	Pressure Relief Device Test	Type

Annexure - G

1.1 KV GRADE POWER & CONTROL CABLES

1) Approval shall be obtained for all Power & Control cables used for cabling purposes.

2) Separate cables shall be used for AC & DC.

3) At least one (1) core shall be kept as spare in each copper control cable of 4C, 5C or 7C size whereas minimum no. of spare cores shall be two (2) for control cables of 10 core or higher size.

4) Copper wires used for manufacturing the cables shall be true circular in shape before stranding and shall be uniformly good quality, free from defects.

5) The fillers and inner sheath shall be of non-hygroscopic, fire retardant material, shall be softer than insulation and outer sheath shall be suitable for the operating temperature of the cable.

6) Progressive sequential marking of the length of cable in metre at every one metre shall be provided on the outer sheath of all cables.

7) Strip wire armouring method (a) mentioned in Table 5, Page-6 of IS: 1554 (Part 1) – 1988 shall not be accepted for any of the cables. For control cables only round wire armouring shall be used.

8) The cables shall have outer sheath of a material with an oxygen index of not less than 29 and a temperature index of not less than 250°C.

9) All the cables shall conform to fire resistance test as per IS: 1554 (Part – I).

10) The normal current rating of all PVC insulated cables shall be as per IS: 3961.

11) Repaired cables shall not be accepted.

12) Allowable tolerance on the overall diameter of the cables shall be plus or minus 2 mm.

13) PVC Power Cables

13.1) The PVC (70°C) insulated 1100V grade power cables shall be of FR type, C1 category, conforming to IS: 1554 (Part-I) and its amendments read along with this specification and shall be suitable for a steady conductor temperature of 70°C. The conductor shall be stranded copper. The Insulation shall be extruded PVC to type-A of IS: 5831. A distinct inner sheath shall be provided in all multi core cables. For multi core armoured cables, the inner sheath shall be of extruded PVC. The outer sheath shall be extruded PVC to Type ST-1 of IS:5831 for all cables.

14) PVC Control Cables

14.1 The 1100V grade control cables shall be of FR type C1 category conforming to IS: 1554 (Part-1) and its amendments, read along with this specification. The conductor shall be

stranded copper. The insulation shall be extruded PVC to type A of IS: 5831. A distinct inner sheath shall be provided in all cables whether armoured or not. The over sheath shall be extruded PVC to type ST-1 of IS: 5831 and shall be grey in colour except where specifically advised by the Employer to be black.

14.2 Cores shall be identified as per IS: 1554 (Part-1) for the cables up to five (5) cores and for cables with more than five (5) cores the identification of cores shall be done by printing legible Hindu Arabic Numerals on all cores as per clause 10.3 of IS : 1554 (Part - 1).

STANDARD TECHNICAL DATA SHEET - 1.1kV kV GRADE PVC CONTROL CABLES

SN	Description	Parameters							
1a	Cable Sizes	2 c x 2.5	3c c x 2.5	5c x 2.5	7 c x 2.5	10 c x 2.5	14 c x 2.5	19 c x 2.5	27 c x 2.5
1b	Manufacturer's type designation	YWY	YWY	YWY	YWY	YWY	YWY	YWY	YWY
2	Applicable standard	IS: 1554/PT-I/1988 & its referred standards							
3	Rated Voltage(volts)	1100 V grade							
4	Type & Category	FR & C1							
5	Suitable for earthed or unearthed system	for both							
6	Continuous current rating when laid in air in a ambient temp. of 50°C and for maximum conductor temp. of 70°C of PVC Cables [For information only]	22	19	19	14	12	10.5	9.7	8
7	Rating factors applicable to the current ratings for various conditions of installation:	As per IS-3961-Pt-II-67							
8	Short circuit Capacity								
a)	Short Circuit Amp.(rms) KA for 1 sec duration	0.285	0.285	0.285	0.285	0.285	0.285	0.285	0.285

b)	Conductor temp. allowed for the short circuit duty (°C.)	160 C							
9	Conductor								
a)	Material	annealed High Conductivity stranded Copper (as per IS:8130/84)							
b)	Grade	Electrolytic							
c)	Cross Section area (Sq.mm.)	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5
d)	Number of wires(No.)	as per Table 2 of IS 8130							
e)	Form of Conductor	Non-compacted Stranded circular shaped conductor							
f)	Direction of lay of stranded layers	Outermost layer shall be R.H lay							
10	Conductor resistance (DC) at 20 °C per km-maximum	7.41	7.41	7.41	7.41	7.41	7.41	7.41	7.41
11	Insulation								
a)	Composition of insulation	Extruded PVC type A as per IS-5831-84							
b)	Nominal thickness of insulation(mm)	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9
c)	Minimum thickness of insulation	0.71	0.71	0.71	0.71	0.71	0.71	0.71	0.71
12	Inner Sheath								
a)	Material	Extruded PVC type ST-I as per IS-5831-84							
b)	Calculated diameter over the laid up cores,(mm)	7.2	7.8	9.7	10.8	14.4	15.9	18	22.1
c)	Thickness of Sheath (minimum)mm	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3
13	Armour	as per IS 3975/99							

a)	Type and material of armour	Gal. Steel Wire							
b)	Direction of armouring	left hand							
c)	Calculated diameter of cable over inner sheath (under armour), mm	7.8	8.4	10.3	11.4	15	6.5	18.6	22.7
d)	Nominal diameter of round armour wire/strip	1.4	1.4	1.4	1.4	1.6	1.6	1.6	1.6
e)	Number of armour wires/strips	Armouring shall be as close as practicable							
f)	Short circuit capacity of the armour along for 1 sec-for info only	0.05 x A√t (K Amp)(where A = total area of armour in mm2 & t = time in seconds)							
g)	DC resistance at 20 °C (Ω/Km) & Resistivity	As per IS 1554 Part (1), wherever applicable and IS 3975-1999							
14	Outer Sheath								
a)	Material (PVC Type)	ST-1& FR							
b)	Calculated diameter under the sheath	10.6	11.2	13.1	14.2	18.2	19.7	21.8	25.9
c)	Min. thickness of sheath(mm)	1.24	1.24	1.24	1.24	1.4	1.4	1.4	1.56
d)	Guaranteed value of minimum oxygen index of outer sheath at 27°C	Min 29.0	Min 29.0	Min 29.0	Min 29.0	Min 29.0	Min 29.0	Min 29.0	Min 29.0
e)	Guaranteed value of minimum temperature index at 21 oxygen index	Min 250	Min 250	Min 250	Min 250	Min 250	Min 250	Min 250	Min 250
f)	colour of sheath	Grey	Grey	Grey	Grey	Grey	Grey	Grey	Grey

15a)	Overall diameter of cable	$							
b)	Tolerance on overall diameter (mm)	+2/-2 mm							
16	Cable Drums	shall conform to IS 10418 and technical specification							
a)	Max./ Standard length per drum for each size of cable (single length) with ±5% Tolerance (mtrs)	1000/500							
b)	Non standard drum lengths	Maximum one(1) non standard lengths of each cable size may be supplied in drums only over & above the standard lengths as specified above.(if required for completion of project)							
17	Whether progressive sequential marking on outer sheath provided								
18	Identification of cores	Yes							
a)	colour of cores	R & Bk	R, Y & Bl	Red R,Y,Bl	Grey	Grey	Grey	Grey	Grey
b)	Numbering	N.A	N.A	N.A	Numerals in black ink				
19	Whether Cables offered are ISI marked	YES							
20	Whether Cables offered are suitable for laying as per IS 1255	YES							

$'- As per manufacturer design data.

Sd/-
Chief Engineer(SCM)

BIDDING SCHEDULE
(To be filled in and signed by the Bidder) SCHEDULE 'A'
SCHEDULE OF GUARANTEED TECHNICAL PARTICULARS FOR 220/110/11kV, 200MVA THREE PHASE AUTO TRANSFORMERS

No.	Particulars	Offered
A	**General Data of Bidder**	
1	Name of Manufacturer	
2	Country of Origin	
3	Business Type of Company (eg. Manufacturer/ Supplier / Transporter etc.)	
B	**General Data of the Transformer**	
1	Conforming Applicable Standards (including Bushing & other)	
2	Conceptual Design of Transformer (e.g. Outdoor oil immersed core type /Indoor dry core type/etc)	
3	Type of Operation of the Transformer (e.g. Interconnection / Distribution / Generator step-up) * Interconnection means used in Transmission Grid SS	
4	Rated Frequency (in Hz)	
5	Rated Frequency (in Hz)	

6	Rated MVA Capacity Of the Transformer – Rated capacity 80% / 100% ONAN / ONAF i) HV ii) IV iii) LV (Tertiary)	
7	Rated No-load Voltage of the Transformer 1. HV 2. IV 3. LV (Tertiary)	
8	No Load Current in percent of Full Load current at rated KV & rated frequency at Normal Tap	
9	Vector Group	
10	Type of Cooling	
11	Method of Neutral Grounding	
12	Rated No load Voltages of windings in kV a) HV Winding b) IV Winding c) LV – Tertiary winding	
13	Normal ratio of transformation	
14	Rated Current in Ampere. a) HV Winding b) IV Winding c) LV- Tertiary winding	
15	Overload capacity	
16	Width of Track gauge (in mm)	

C	**Thermal Data**	
1	Temperature rise of top oil (in ° C) above ambient temperature of 50 °C measured by thermometer with ONAN/ONAF/ODAF cooling	
2	Temperature rise of winding measured by resistance : With ONAN/ONAF/ODAF cooling, in ° C	
3	Limit of hot spot temperature in ° C for which the transformer is designed	
4	Temperature gradient between Oil & Winding.	
5	Limit for hot spot temperature for which transformer is designed.	
D	**Impedance Data**	
1	Percentage Impedance at rated current and frequency at 75 ° C(with tolerance) 1) At maximum tap 2) At Normal tap 3) At Lowest tap	
2	Reactance of windings in ohm at 75 ° C a) At maximum tap b) At Normal tap c) At Lowest tap	
3	Resistance of windings in ohm at 75 ° C a) At maximum tap b) At Normal tap c) At Lowest tap	
4	Zero Sequence Impedance at 75 ° C at 100% rating a. At maximum tap b. At Normal tap c. At Lowest tap	

E	**Guaranteed Loss**	
1	Guaranteed no load loss (KW) on principal tap at rated voltage and Frequency & tolerance, if any	
2	No load loss at rated voltage and frequency at highest tap (max.)	
3	Guaranteed load loss at rated current at rated voltage, rated frequency and 75° C average winding temperature, kW (excluding aux. losses). At principal tap a.For ONAN cooling b.For ONAF cooling c.For ODAF cooling At maximum tap a.For ONAN cooling b.For ONAF cooling c.For ODAF cooling At minimum tap a.For ONAN cooling b.For ONAF cooling c.For ODAF cooling	
4	Guaranteed copper loss (KW) on principal tap at rated voltage and Frequency & tolerance, if any	
5	Maximum Auxiliary Loss (KW)	
6	Total losses at normal ratio, rated output, rated voltage, rated frequency and maximum attainable temperature at site including auxiliary losses.	

7	Time for which the transformer can be run at full load without exceeding the max. permissible temperature at reference temperature when power supply to fans is cut off (in minutes)	
8	Exciting current and power factor	
F	**Efficiency & Regulation**	
1	Efficiency (in percent) at unity power factor at 75°C	
	At 110% Load	
	At 100% Load	
	At 75% Load	
	At 50% Load	
	At 25% Load	
2	Efficiency (in percent) at 0.85 power factor (Lag) at 75°C	
	At 110% Load	
	At 100% Load	
	At 75% Load	
	At 50% Load	
	At 25% Load	

3	Maximum Efficiency %	
4	% Load and power factor at which Max efficiency occurs	
5	Regulation at Unity Power factor	
6	Regulation at 0.8 lagging Power factor	
G	**Radiators**	
1	Overall dimensions l x b x h ,mm	
2	Total weight with oil, Kg	
3	Total weight without oil	
4	Vacuum withstand capacity, *tor*	
5	Capacity of cooling units	
6	Mounting of radiators	
7	Number of radiators	
8	Type & size of individual radiator valve	
9	Total radiating surface, sq.mm	
10	Thickness of radiator tubes, mm	
11	Oil drain plug and air release plug provided on each radiator Yes/No	
12	Schematic flow diagram of the cooling system furnished (Yes/No)	

H	**Cooling System**	
	Cooling Fans	
1	Make and type	
1.1	No. of fans in each group excluding standby fans	
1.2	No. of connected units	
1.3	No. of standby units	
1.4	Rated power input, watts	
1.5	Capacity (cum/minute)	
1.6	Rated voltage,	
1.7	Locked rotor current,	
1.8	Efficiency of motor at full load, %	
1.9	Temp.rise of motor at full load, °C	
1.10	Temperature range over which the control is adjustable, °C	
1.11	Whether fans suitable for continuous operation	
1.12	Period of continuous working at full load without fan for ONAN/ONAF	
1.13	Continuous MVA rating without fan for ONAN/ONAF	
2	**Cooling Oil pumps**	
2.1	Make and type	

2.2	No. of oil pumps on each group excluding standby pump	
2.3	No. of connected units in each group.	
2.4	No. of standby units for each group.	
2.5	No. of radiator / cooling groups	
2.6	Rated power input of each pump, watts	
2.7	Capacity (cum/minute)	
2.8	Rated voltage,	
2.9	Locked rotor current,	
2.10	Efficiency of motor at full load, %	
2.11	Temp.rise of motor at full load, °C	
2.12	Temperature range over which the control is adjustable, °C	
2.13	Whether oil pumps suitable for continuous operation	
2.14	Estimated time constant in hours for 1. Natural cooling (ONAN) 2. Forced air cooling (ONAF) 3. Forced oil cooling (ODAF)	
2.15	Period of continuous working at full load without fan or oil pump.	
3	**Cooling Calculations shall be submitted**	
I	**Core**	
1	Type of core construction	

2	Type of core joints	
3	Net core area in sq. metre	
4	Core material & grade of sheet HIB or better	
5	Thickness of lamination mm	
6	Insulation of core lamination, mm	
7	Specific loss of core material (Watts/Kg)	
8	Whether core construction is without core bolts	
9	Insulation of core bolt washers	
10	Insulation between core laminations	
11	Core bolt insulation power frequency withstand test voltage for 1 mt.	
12	Are the core bolts grounded, if so how?	
13	Details of oil duct	
14	Whether in the plane and at right angle to the plane of winding	
15	Across the plane of laminations	
16	Design flux density of the core at rated voltage & frequency at principal tap, Tesla	
16.1	1. Core	

16.2	2. Yoke	
17	Maximum flux density allowed in the core at extreme over excitation / over fluxing , Tesla	
17.1	Power factor of Magnetizing current at normal ratio and frequency	
17.2	85 % of rated voltage	
17.3	100 % of rated voltage	
17.4	105 % of rated voltage	
17.5	110 % of rated voltage	
18	Power factor of Mag. Current at normal voltage ratio and frequency	
19	Over Excitation withstand time (secs) at 110% / 125% /140%	
20	Materials of core clamping plate	
21	Thickness of core clamping plate	
22	Insulation of core clamping plate	
23	Describe Location/ method of core grounding	
24	Details of oil ducts in core	
25	Equivalent cross section area of core, mm2	
26	Guaranteed No load current at 90% /100% / 110% rated voltage & frequency(Amp)	

26.1	HV	
26.2	IV	
26.3	LV	
27	Noise level (in db) when energized at normal voltage and normal frequency at no load.	
J	**Winding**	
1	No. of windings	
2	Type of Winding (eg. Helical / Disc/ layer /pancake) HV IV LV	
3	Arrangement of main winding & Geometrical sequence	
4	Winding material HV IV LV	
5	Maximum current density allowed, Amp per mm2 HV IV LV	
6	Whether windings are Interleaved (HV/IV/LV)	
7	Whether HV windings are Preshrunk (HV/IV/LV)	
8	Whether electro-static shields are provided to obtain uniform voltage distribution in the windings	

9	Gauge/area of cross section of conductor, mm2 HV IV LV	
10	Maximum current density achieved in winding Amps/ mm2 1) HV 2) IV 3) LV	
11	Insulating material used for: HV turn IV turn Tap winding to earth LV turn LV to core Between HV & IV Between IV & LV Between HV & LV (as applicable)	
12	Insulation material thickness in mm used for: HV turn IV turn Tap winding to earth LV turn LV to core Between HV & IV Between IV & LV Between HV & LV (as applicable)	
13	Type of coil axial support 1) HV winding 2) IV winding 3) LV winding	

14	Type of coil radial support a) HV winding b) IV winding c) LV winding	
15	Weight of support insulators including insulation cylinders	
16	Maximum allowable torque on coil clamping bolts	
17	Inter-turn insulation	
18	Extent of extreme end turns reinforcement	
19	Extent of end turns reinforcement	
20	Extent of turns adjacent to tappings	
21	Test voltage for 10 Seconds 50 cycles inter turn insulation test for Cl.J16, kV rms	
22	Test voltage for 10 Seconds 50 cycles inter turn insulation test for Cl. J 17, (28.17.2), kV rms	
23	Test voltage for 10 Seconds 50 cycles inter turn insulation test for Cl.J 18, kV rms	
24	Test voltage for 10 Seconds 50 cycles inter turn insulation test on main body of the winding, kV rms	
K	**Tertiary Winding**	
1	Whether delta is formed internally	
2	Whether all three bushings are taken outside (YES/ NO)	

3	Design value of surges transferred on tertiary terminals	
3.1	For 1050 kVp, 1.2/ 50 µs surge striking on HV terminal and with a)Both tertiary terminals open b)One terminal earthed.	
3.2	For 650 kVp, 1.2/ 50 µs surge striking on IV terminal and with a) Both tertiary terminals open b) One terminal earthed.	
L	**Minimum design clearance , mm**	
1	HV to earth in air	
2	HV to earth in oil	
3	IV to earth in air	
4	IV to earth in oil	
5	LV to earth in air	
6	LV to earth in oil	
7	Between HV & IV in Air	
8	Between HV & IV in Oil	
9	Between IV & LV in Air	
10	Between IV & LV in Oil	

11	Between HV & LV in Air	
12	Between HV & LV in Oil	
13	Top winding & Yoke	
14	Bottom winding & Yoke	
M	**Insulating Oil**	
1	Governing standard	
2	Type of oil	
3	Spec. resistance (ohmscm) at 27°C /90° C	
4	Tan delta	
5	Water content , ppm	
6	Dielectric strength (BDV), kV	
7	Characteristics of oil after ageing test	
8	Sludge content	
9	Neutralisation number	
10	Quantity of oil Ltrs	
11	In the transformer tank	
12	In each radiator	
13	Total quantity	

14	10% excess oil furnished?	
N	**Conservator**	
1	Details of oil preservation equipment offered	
2	Oil preservation system provided (Yes/No)	
3	Total volume of conservator (Ltr)	
4	Volume between highest and lowest visible oil levels (Ltr)	
5	Details of Air cell 1) Make 2) Type 3) Material 4) Capacity	
O	**Bushing Particulars**	
1	Manufacturer i) HV ii) IV iii) LV (Tertiary) iv) Neutral	
2	Type of bushings 1) HV 2) IV 3) LV (Tertiary) 4) Neutral	
3	Reference Standard 1 HV 2 IV 3 LV (Tertiary) 4 Neutral	
4	Rated Voltage in kV	HV IV LV Neutral

5	Rated Current in Amp.	
6	Lightning impulse voltage(1.20/50µSec.) in kVp	
7	Switching impulse voltage in kV	
8	Power Frequency Withstand Voltage (Dry)	
9	Power Frequency Withstand Voltage (Wet)	
9.1	Wet Flash over voltage, kV	
9.2	Dry Flash over voltage, kV	
10	Partial discharge level	
11	Creepage distance in mm	
12	Creepage distance (protected)	
13	Whether test tap is provided? If so, power frequency withstand test voltage of test tap,	
14	Quantity of oil used in bushing & specification of oil used.	
15	Weight of assembled bushing, Kg	
16	Minimum clearance height for removal of bushings, mm	

17	Recommended gap setting for Arcing horn	
18	Cantilever strength	
19	Terminal connections	
P	**Details of bushing CT**	
1	Purpose	
2	Installed on which bushing HV/IV	
3	No. of bushing CTs installed	
4	Type	
5	Make	
6	Reference standard	
7	No. of cores	
8	Whether TEST winding provided or not	
9	CT ratio	
10	Burden, VA	
11	Class of accuracy	
Q	**On Load Tap Changer**	
1	Make	
2	Type	

3	Total Tap Range (+) percent to (-) percent of Voltage	
4	Percent of Voltage per tap step	
5	No. of steps	
6	Time (in second) for total tap change	
7	Diverter selector switch transient time, cycles	
8	Power flow-uni directional/ bidirectional/restricted bi directional	
9	Rated voltage to earth, kV	
10	Rated currents, Amp	
11	Control – Manual/Local electrical/ Remote electrical	
12	Is suitable for Parallel operation	
13	Protective devices	
14	Auxiliary supply details	
15	Value of maximum short circuit current, kA	
16	Maximum impulse withstand test voltage with 1.2/50µS, full wave between switch assembly and ground, kV peak	
17	Maximum Power frequency test voltage between switch assembly and earth, kV rms	
18	Maximum impulse withstand test voltage with 1.2/50µs, across the tapping range, kV peak	
19	Approx. overall dimensions of the tap changer (in case of separate tank type),	

	mm	
20	Approx. overall weight, (in case of separate tank type), Kg	
21	Approx. mass of oil ((in case of separate tank type), Kg	
22	Particulars of the OLTC control panel for installation in the control room (RTCC panel)	
23	Driving Mechanism box	
24	Make and Type	
25	Details of apparatus proposed	
R	**Details of protective devices**	
1	Pressure release device	
1.1	Make & Type	
1.2	Minimum pressure the device is set to rupture.	
1.3	Rain hood provided or not	
2	Explosion vent	
2.1	Type & make	
2.2	Minimum pressure the device is set to rupture.	
3	Bucholz relay of main tank	
3.1	Type & make	
3.2	No. of contacts	
4	Oil Surge relay	

4.1	Type & make	
4.2	No. of contacts	
5	OTI	
5.1	Make & Type	
5.2	No. of contacts	
5.3	Setting range	
6	WTI	
6.1	Make & Type	
6.2	No. of contacts	
6.3	Setting range	
7	Oil Level guage	
7.1	Type & make	
7.2	No. of contacts	
S	**Lifting Jacks**	
1	No. of jacks in one set	
2	Type and make	
3	Capacity (tonnes)	
4	Pitch, mm	
5	Lift, mm	
6	Height in closed position, mm	
7	Mean dia. of thread, mm	

T	**Alarm and trip contact ratings of protective devices**	
1	Rated/making/ breaking currents , Amp & voltage for	
1.1	PRV for main tank and OLTC tank	
1.2	Bucholz relay	
1.3	OTI	
1.4	WTI	
1.5	Magnetic oil level gauge	
U	**Fittings accessories for each transformer are furnished as per different clauses in the specification (separate sheet giving details, make and bill of materials to be attached)**	
V	**Painting: as per annexure –D for the transformer, radiator, marshalling box, etc (Yes/No)**	
W	**Details of Tank**	
1	Material	
2	Approximate thickness of sheet	
3	Sides, mm	
4	Bottom, mm	
5	Cover (Top), mm	
6	Radiators, mm	
7	Pressure mm of Hg	
8	Vacuum recommended for Hot oil Circulation	

9	Vacuum to be maintained during oil filling in transformer tank	
10	Vacuum to which the tank can be subjected without distortion as per specification	
11	Confirmation of tank designed and tested for vacuum pressure (Ref: CBIP manual) (Yes/No)	
12	Is the tank lid slopped?	
13	Inspection cover provided(Yes/No)	
14	Location of inspection cover (Yes/No)	
15	Min. dimensions of inspection cover (provide list of all inspection cover with dimension), mm x mm	
16	No. of bi-directional wheels provided	
17	Track gauge required for the wheels in transverse axis	
18	Track gauge required for the wheels in longitudinal axis	
19	Type of pressure relief device/ explosion vent and the pressure at which it operates	
20	Minimum clearance height for lifting core and winding from tank, mm	
21	Minimum clearance height for lifting tank cover, mm	
22	**Over all transformer dimensions**	
22.1	Length , mm	
22.2	Breadth , mm	
22.3	Height , mm	

23	Transformer tank dimensions	
23.1	Length , mm	
23.2	Breadth , mm	
23.3	Height , mm	
24	Marshalling box dimensions	
24.1	Length , mm	
24.2	Breadth , mm	
24.3	Height , mm	
25	Weight data	
25.1	Core, Kg	
25.2	Frame parts, Kg	
25.3	Core and frame, Kg	
25.4	Weight of core clamp kg	
25.5	Weight of winding kg HV IV LV	
25.6	Total winding Kg	
25.7	Core and frame winding, Kg	
25.8	Tank, Kg	
25.9	Tank lid, Kg	

25.10	Empty conservator tank, Kg	
25.11	Each radiator empty , Kg	
25.12	Total weight of all radiator empty , Kg	
25.13	Weight of oil in tank , Kg	
25.14	Weight of oil in each conservator, Kg	
25.15	Weight of oil in each radiators, Kg	
25.16	Total weight of oil in radiator, Kg	
25.17	OLTC gear including oil , Kg	
25.18	Total transport weight of the transformer , Kg	
25.19	Total transport weight of the transformer with OLTC and all accessories, Kg	
26	Volume data	
26.1	Volume of oil in main tank, litres	
26.2	Volume of oil between highest and lowest levels of main conservator, litres	
26.3	Volume of oil between highest and lowest levels of OLTC conservator, litres	
26.4	Volume of oil in each radiator, litres	
26.5	Total volume of oil in radiators, litres	
26.6	Volume of oil in OLTC, litres	
26.7	Transformer total oil volume , litres	
27	Shipping data	
27.1	Weight of heaviest package, kG	

27.2	Dimensions of the largest package (L xB x H) mm	
X	**Tests**	
1	All in process tests confirmed as per Cl.25.1 & Annexure-F (Yes /No)	
2	All types tests confirmed as per Cl. 25.2 and Annexures E,F (Yes /No)	
3	All routine tests confirmed as per 25.2 and Annexures E,F (Yes /No)	
3	All special tests confirmed as per Annexure E and Cl. 25.2 (Yes /No)	
Y	**Others**	
1	Transformer will be transported with oil/gas/dry air	
2	Quality Assurance Plan:	
3	An outline of quality assurance plan used by the bidder To be submitted attached	
4	General warranty for the transformer	
5	Test procedure	
Z	**Important design parameters**	
1	Maximum no load loss at rated condition allowed without any positive tolerance (kW).	
2	Maximum load loss at rated condition @ 75°C and principal tap allowed without any positive tolerance (kW).	
3	Grade of core sheet, Hi-B or better	
4	Type of winding for HV	
5	Design value of flux density	
6	Design value of current density	

7	Weight of HV winding	
8	Weight of LV winding	
9	Weight of support insulators including insulation cylinders	
10	Weight of core(kg)	
11	Weight of core clamp	
12	Per turn voltage	
13	Conductor cross section HV LV	
14	Winding stack height(mm)	
15	Confirm that the weight of copper in winding and CRGO in core during detailed design and manufacturing and supply of the transformer is not less than the values mentioned above.	
16	Transformer tank dimensions(mm)(lxbxh)	
17	Weight of tank (kg)	
18	Total volume of oil in tank (Litres)	
19	Weight of core, winding and frame(kg)	
20	Overall dimensions of the transformer(mm)(lxbxh)	

SCHEDULE 'B'

SCHEDULE OF GUARANTEED TECHNICAL PARTICULARS

ON LOAD TAPCHANGING GEAR (To be filled by the Bidder)

Sl. No	ITEM	Offered
1	Make	
2	Type designation	
3	Suitable for auto/manual Operation (Yes / No)	
4	Rated voltage (KV)	
5	Rated current (Amps)	
6	Step voltage (Volts)	
7	Number of steps	
8	Rated voltage of drive motor (V)	
9	List of routine tests to be carried out	
10	Location of the taps with respect to the terminals of the tapped winding	
11	Drawing or pamphlet-number of the technical and descriptive particulars of the OLTC, enclosed with the Bid.	
12	Is suitable for bi directional power flow? Yes/ No	
13	Drawing number of the complete control schematic drawing enclosed with the Bid, along with a write-up of the scheme provided. YES / NO	
14	Separate conservator and oil surge relay provided (YES / NO)	

15	Local outdoor cabinet general arrangement drawing number (enclosed with the Bid).	
16	Remote indoor control cabinet arrangement drawing number (enclosed with the Bid.)	
17	Quantity of oil in the OLTC chamber (Ltrs)	
18	Capacity of OLTC conservator tank in Cu.mtr.	

SCHEDULE 'C'

SCHEDULE OF GUARANTEED TECHNICAL PARTICULARS

CONTROL CABINETS **(To be filled in and signed by the Bidder)**

No.	Item	MK Box	Cooler Control	RTCC
1	Manufacturer's name and Country			
2	Indoor/ outdoor application			
3	Design ambient air temperature (^{0}C)			
4	Thickness of sheet steel for outdoor & indoor panels (mm)			
5	Degree of protection provided (as per IS:13947 or equivalent)			
6	Bill of material for various equipment giving make, type, ratings etc. enclosed(YES/NO)			
7	Colour of finish paint			
	1) Outside			
	2) Inside			
8	Temperature rise at rated current over specified ambient temp of 50°C			
9	Temperature rise at rated current over specified ambient temp of 50° C			
10	Continuous current rating (Amp)			
11	Three second current rating (KA) (short time)			
12	Control wiring			
	1) Material of conductor for various circuits			

	ii)Size of conductor For various circuits mm2			
	iii)Conductor – Solid / Stranded			
13	Terminal Blocks			
	i) Make			
	ii) Current rating			
14	Power terminals (Amp)			
15	Other terminals (Amp)			
16	All tests as specified in Section-D (ii) DATA SHEET A1 Specification for the control panel will be carried out Yes / No.			
17	Space heater rating (Watts)			

Bidders Name

Name

Designation

Date

Part-2

TECHNICAL SPECIFICATION FOR 220/110kV 160MVA, THREE PHASE AUTO TRANSFORMER

1. SCOPE

This specification covers the design, manufacture, inspection, testing at supplier's works and delivery, installation assistance and commissioning at destination stations of 160MVA 220/110kV Three Phase Autotransformer with 11kV Tertiary winding for stabilization connected in YNa0d1 as detailed in the Technical parameters and its guarantee for satisfactory performance as specified elsewhere. **The transformers shall be delivered at the transformer plinth if the plinth is ready at the time of delivery or at any desired site, anywhere in the state of Kerala as mentioned by the Board. The % impedance shall be matched with the existing 160MVA Bank parallel at Brahmapuram.**

1.2. The transformers shall in general have constant ohmic impedance between HV and IV on all taps and it shall be possible to operate in parallel with each other.

1.3. External or internal reactors shall not be used to achieve the specified HV/LV and IV/LV impedances. Further, matching of physical orientation shall be done to facilitate inter-changeability.

1.4. All drawings, schedules and annexure appended to this specification shall form part of the specification and supplement the requirements specified. The equipment / materials offered by the Bidder shall be complete in all respects and, whether called for specifically or not, all accessories, hardware and services required for normal satisfactory operation of the system shall be deemed to be included in unit rates quoted. Design and manufacture shall also be such that equipment / accessories of the same type and rating would be interchangeable.

Specific reference in this specification and documents to any material by trade name, make or catalogue number shall be construed as establishing standard of quality and performance and not as limiting competition. All equipment/ accessories offered shall also be of proven design and manufacture. The make of all accessories and hardware shall be subject to purchaser's approval.

1.5. It is not the intent to specify completely herein all details of the design and construction of equipment. However, the equipment shall conform in all respects to standards of engineering, design and workmanship 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 equipment offered shall be complete with all components necessary for their effective and trouble free operation. Such components shall be deemed to be within the scope of supplier's supply, irrespective of whether those are specifically brought out in this specification and/or the commercial order or not.

2. Transportation

2.1. The Supplier shall be responsible to select and verify the route, mode of transportation and make all necessary arrangement with the appropriate authorities for the transportation of the equipment. The dimension of the equipment shall be such that when packed for transportation, it will comply with the requirements of loading and clearance restrictions for the selected route. It shall be the responsibility of the supplier to coordinate the arrangement for transportation of the transformer for all the stages from the manufacturer's work to site.

2.2. The supplier shall carry out the route survey along with the transporter and finalize the detailed methodology for transportation of transformer and based on route survey. If any bottlenecks are observed in the route proposed, it shall be the responsibility of the supplier to ensure hassle free transportation of the equipment through the route.

2.3. The main tank of the transformer shall be inland transported on low bed trailers. There should be provision for tracking the location of consignment at all times during transportation from manufacturer's works to designated site. The supplier shall intimate KSEB Limited about the details of transporter engaged for transportation of the Transformer for tracking the Transformer during transit.

2.4. All metal blanking plates and covers which are specifically required to transport and storage of the transformer shall be considered part of the transformer and handed over to the Purchaser after completion of the erection. Bill of quantity of these items shall be included in the relevant drawing/document.

2.5. The Supplier shall despatch the transformer filled with Nitrogen gas with necessary arrangement to take care of pressure drop of nitrogen during transit and storage till completion of oil filling during erection. A N2 cylinder with regulator, gas pressure testing

valve with necessary pressure gauge and adaptor valve shall be provided. As the packing is liable to be stored in the open, the packing shall be suitable for outdoor storage under humid atmospheric conditions. All parts shall be adequately marked to facilitate erection at site.

Each consignment shall be accompanied by a detailed packing list. Any material found short/damaged in the consignment shall be supplied or made good by the supplier without any extra cost to KSEB Limited

In case, turrets are having insulation assembly and is transported separately then the same shall also be filled with Nitrogen.

2.6. Transformer shall also be fitted with sufficient number of Electronic impact recorders (Minimum 2 numbers -on returnable basis) during transportation to measure the magnitude and duration of the impact in all three directions. The impact recorders shall be of different make for reliability .The acceptance criteria and limits of impact, which can be withstood by the equipment during transportation and handling in all three directions, shall not exceed "3g" for 50 mSec (20Hz) or as per supplier standard, whichever is lower.

3. CODES & STANDARDS:

The transformer shall be manufactured and tested according to the latest revisions of IS 2026 /IEC 60076.

The Material, equipment and methods used in the manufacture of power transformer shall conform to the latest edition of following.

Standard Name / No	Standard's Description
Indian Standard	
IS 335	Insulating oil
IS 1271	Thermal evaluation and classification of electrical insulation
IS 2099	Bushing for Alternating voltage above 1000V
IS 2705	Current Transformers
IS 3347	Dimensions for porcelain Transformer bushing
IS 3637	Gas operated relays

IS 3639	Fitting & Accessories for power transformers
IS 4201	Application guide for CT's
IS 6600	Guide for loading of oil immersed transformers
IS 8478	Application guide for On-load tap changer
IS 8468	On-load tap changer
IS 10028	Code of practice for selection, installation & maintenance of transformers
IS 13947	LV switchgear and control gear part-1
IS 2026	Power transformers
IS 6272	Industrial Cooling Fans
IS5	Colours for ready mix paints
IS5561	Electrical power connectors
	Indian electricity act & CEA Regulations.
	CBIP manual on transformers- Publication 295
IEC Standards	
IEC 34	Rotating Electrical Machines. (E.g. For Cooler Fan , Motors.)
IEC 38	Standard Voltages.
IEC 71	Co-ordination of Insulation.
IEC 76	Power transformers
IEC 137	Insulating bushings for alternating voltages above 1000V
IEC 156	Method for Determination of the Electric Strength for Insulating Oils
IEC 185	Current Transformers.
IEC 214	On-Load Tap- Changers
IEC 233	Tests on hollow insulators for use in electrical equipment.
IEC 343	Standard Frequencies for Centralized Network Control Installations
IEC 296	Specification for Unused Mineral Insulating Oils for Transformer and switchgear
IEC 354	Loading Guide for Oil-Immersed Power Transformers.
IEC 445	Identification of Equipment Terminals and of Terminations of Certain Designated Conductors, Including General Rules for an Alphanumeric System.

IEC 529	Degrees of Protection Provided by Enclosures (IP Code)
IEC 542	Application Guide for On-Load Tap- changers.
IEC 551	Determination of Transformer and Reactor Sound Levels.
IEC 606	Application Guide for Power Transformer
IEC 616	Terminal and Tapping Markings for Power Transformers.
IEC 947	Low- Voltage Switchgear and Control gear.
British Standards	
BS 148	Unused Mineral Insulation Oils for Transformers and Switchgear.
BS 223	Bushings for alternating Voltages above 1000 V.
BS 2562	Cable Boxes for Transformers and Reactors.
BS 6435	Unfilled enclosures for the Dry Termination of HV Cables for Transformers and Reactors.

In the event of direct conflict between various order documents, the precedence of authority of documents shall be as follows:

1) Guaranteed Technical Particulars (GTP)
2) This Specification
3) Referred Standards
4) Approved Vendor Drawings
5) Other documents.

4. Performance

4.1. The transformers shall be suitable for bi-directional flow of rated power. The major technical parameters of the transformers are defined in the ***Standard Technical Parameters (STP)*** at **Annexure - A**

4.2. Transformers shall be capable of operating under natural cooled condition up to 96 MVA load. The forced cooling equipment shall come into operation by pre-set contacts of winding temperature indicator and the transformer shall operate as a forced cooling unit initially as ONAF up to 128 MVA load and then as ODAF. Cooling shall be so designed that during total failure of power supply to cooling fans and oil pumps, the transformer shall be able to operate at full load for at least ten (10) minutes without exceeding the calculated winding hot spot temperature. Transformers fitted with two coolers, each capable of dissipating 50 per cent of the loss at continuous maximum

rating, shall be capable of operating for 20 minutes in the event of failure of the oil circulating pump or blowers associated with one cooler without exceeding the calculated winding hot spot temperature at continuous max rating. The supplier shall submit supporting calculations for the above and the same shall be reviewed during design review.

4.3. The transformer shall be free from any electrostatic charging tendency (ECT) under all operating conditions when all oil circulation systems are in operation. In general, oil flow speed shall not exceed 1.0 m/sec within winding in the oil flow system of the transformers. The manufacturer shall ensure that there is no electrostatic charging tendency in the design.

4.4. The transformers shall be capable of being continuously operated at the rated MVA without danger, at any tapping with voltage variation of 10% corresponding to the voltage of that tapping.

4.5. The transformers shall be capable of being over loaded in accordance with IS 6600- latest amendments. There shall be no limitation imposed by bushings, tap changers etc. or any other associated equipment.

4.5.1. Tank hot-spot shall not exceed 130 Deg. Celsius. Maximum ambient temperature shall be considered as 50 Deg. C.

4.6. The transformer and all its accessories including bushing/ built in CTs etc. shall be designed to withstand without damage, the thermal and mechanical effects of any external short circuit to earth and of short circuits at the terminals of any winding for a period of 3 secs. The short circuit level of the HV & IV System to which the transformers will be connected is as follows:

220kV system	-50 kA (sym, rms, 3 phase fault)
110kV system	- 31.5 kA (sym, rms, 3 phase fault)
33 & 11kV system	- 25 kA (sym, rms, 3 phase fault)

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

4.7. Transformer shall be capable of withstanding thermal and mechanical stresses caused by symmetrical or asymmetrical faults on any terminals. Mechanical strength of the transformer shall be such that it can withstand 3-phase and 1- phase through fault for transformer rated voltage applied to HV and / or IV terminals of transformer. The short circuit shall alternatively be considered to be applied to each of the HV, IV and tertiary (LV) transformer terminals as applicable. The tertiary terminals shall be considered not connected to system source. For short circuit on the tertiary terminals, the in-feed from both HV & IV system shall be limited by the transformer self-impedance only and the rated voltage of HV and IV terminals shall be considered. The maximum short circuit output current at the tertiary terminals shall be limited to a safe value to make the transformer short circuit proof.

The transformer shall be designed to withstand for short circuit duration of 3 seconds for thermal stress and the same shall be verified during design review.

4.8. The maximum flux density in any part of the core and yoke at the rated MVA, voltage and frequency shall be such that under 10 % continuous over-voltage condition it does not exceed 1.8 Tesla at all tap positions. Maximum current density on any portion of the winding (HV/LV) shall not exceed 2.80 Amp/Sq.mm

4.9. Transformers shall withstand without damage, heating due to the combined voltage and frequency fluctuations which produce the following over fluxing conditions:

110 % for continuous
125 % for 1 minute
140 % for 5 seconds.

4.10 The transformers will be evaluated against no load and load losses guaranteed by the bidders with capitalization of losses as per CBIP guidelines for loss capitalization. The corresponding capitalization figures for no load, load losses and cooler aux. loads shall be as per clause 16.1, 16.2 & 16.3 of **STP** respectively. In the event of measured loss figures during testing exceeding the guaranteed loss figures of the successful bidder penalty shall be levied at a rate of 1.25 times the figures mentioned above for no load, load loss and cooler aux. losses. The quoted losses shall be considered as maximum without any positive tolerance.

The continuous rating of transformers shall be 60% (ie 96 MVA with ONAN), 80% (ie 128 MVA with ONAF) and 100% (ie 160 MVA with ODAF). The required fans, oil pumps and cooler control cubicle shall be provided. The temperature rise of the transformer shall be within the values specified at 20.1, 20.2 of the **STP.**

5 Tertiary Windings.

Each transformer shall be provided with a tertiary winding connected in delta for stabilizing purpose. All three terminals of the stabilizing winding shall be brought out.

This stabilizing winding shall be capable of carrying continuously the rated load as specified under S.T.P. The design of the stabilizing winding shall be such that to take care of the effect of transfer surge. Tertiary winding shall be designed to withstand mechanical and thermal stresses due to dead short circuit on its terminals.

6 Radio Interference and Noise Level.

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

The noise level of transformer, when energized at normal voltage and frequency with fans and pumps running shall not exceed the values specified at Annexure - A, when measured under standard conditions as stipulated in NEEMA TR-1

7 Dynamic Short Circuit Test requirement

Bidder / Manufacturer should have successfully carried out Dynamic Short Circuit Test on the transformer as on the originally scheduled date of bid opening and shall enclose the relevant Test Report / Certificate along with bid. In case the bidder has not successfully tested for Dynamic Short Circuit Test, their bid shall be considered technically non-responsive. Further design review of offered transformers shall be carried out based on design of short circuit tested 220 kV or above voltage class transformer.

8. Transformer Losses and Bid acceptance

The transformers will be evaluated against no load, load losses and auxiliary losses with capitalization of losses as per CBIP guidelines for loss capitalization.

Following shall be the losses.

1)Guaranteed Maximum No Load Loss on principal tap at Rated Voltage and frequency, in KW (Without any positive tolerance: As per clause 15.1 of STP

2)Guaranteed Maximum Load Losses (Copper + stray loss)at rated current on principal tap at 75 ^{o}C, without any positive tolerance : As per clause 15.2 of STP.

3)Guaranteed Maximum Auxiliary/Cooler Loss in KW : As per clause 15.3 of STP.

a) The Transformers are to be designed with maximum permissible losses as indicated above.

b) The bidder must clearly specify that the offered losses are "Maximum"(including IS/IEC tolerance) and no further positive tolerance as per IS/IEC shall be applicable on the offered values during evaluation as well as during testing of transformer.

c) Bids offering with losses beyond the maximum limits mentioned above shall be treated as non-responsive and rejected.

d)Loss Capitalization shall be done with the accepted bids with loss values within specified limit. For the purpose of evaluation of bids, the capitalized cost of iron loss, load loss and auxiliary loss (KW) shall be added to the quoted price of the transformer at the following rates:

i) Capitalized value of No Load loss per KW – As per clause 16.1 of STP

ii) Capitalized value of load loss per KW - As per clause 16.2 of STP

iii) Capitalized value of Auxiliary loss per KW- As per clause 16.3 of STP

e) However once a bidder becomes successful on the basis of loss capitalization with certain declared loss value, they have to strictly achieve the same loss value

during the course of testing of transformers, offered for supply. No tolerance as per IS/IEC will be applicable.

f) If they fail to do so, the offered transformer will be rejected and only replaced transformer with declared loss value will be accepted.

g) In this process, the delay so occurred will be on the vendor's account.

h) If the vendor fails to achieve the declared loss during second time, the contract will be terminated at the vendor's risk and cost.

9) Measurable Defects.

The following shall constitute a Measurable Defects for the purpose of Defect Liabilities.

a) Repair, inside the Transformer and OLTC (including oil migration) either at site or at factory is carried out after commissioning.

b) The concentration of any fault gas is more than values of condition-1 indicated in clause no 6.5 of IEEE-C57.104-2008, which are as detailed below.

H2	CH4	C2H2	C2H4	C2H6	CO	CO2	TDCG
100	120	1	50	65	350	2500	720

c) The winding tan delta goes beyond 0.005 or increase more than 0.001 within a year w.r.t. pre-commissioning values.

d) The moisture content goes above 12 ppm at any temperature during operation including full load.

10. Design review

10.1. The transformer shall be designed, manufactured and tested in accordance with the best international engineering practices under strict quality control to meet the

requirement stipulated in the technical specification. The manufacturer will be required to demonstrate the adequate safety margin w.r.t thermal, mechanical, dielectric and electrical stress etc. shall be maintained during design, selection of raw material, manufacturing process etc. in order to achieve long life of transformer with least maintenance and to take into account the uncertainties of his design and manufacturing processes. The scope of such design review shall include but not limited to the requirement as mentioned at **Annexure - C**

10.2

Raw material and sub-vendors used by transformer manufacturer shall be declared before commencement of manufacturing. The validity of Type tests (except dynamic short circuit test) of Transformer shall be 5 years as on the originally scheduled date of bid opening, provided that offered transformer design is identical to the type tested transformer and same active materials (CRGO, Conductor and Insulation) of same grade & from the same sub-vendors are used. In case of any change of either active materials or sub-vendors, the type tests shall be carried out by the supplier at no extra cost to Purchaser. Transformer type test report from the same manufacturing plant only shall be acceptable. With regard to Validity of Dynamic short circuit test, refer clause 7.0 above.

10.3. Design reviews shall be conducted by Purchaser during the procurement process for transformers; however the entire responsibility of design shall be with the manufacturer. Purchaser may also visit the manufacturer's works to inspect design, manufacturing and test facilities at any time.

10.4. The design review will commence after placement of award with the successful bidder and shall be finalized before commencement of manufacturing activity. These design reviews shall be carried out in detail to the specific design with reference of the transformer under the scope of this specification. It shall be conducted generally following the "Guidelines for conducting design reviews for transformers - 100 MVA and 123 kV and above" prepared by CIGRE SC 12 with latest amendments thereof.

10.5. The manufacturer shall also provide all necessary information and calculations to demonstrate that the transformer meets the requirements for short circuit strength and durability. The latest recommendations of IS/IEC and CIGRE SC 12 shall be applied for short circuit withstand evaluation.

11. Construction Details

The construction details and features of transformer shall be in accordance with the requirement stated hereunder. The components and fitting associated with transformers are subject to Purchaser's approval.

11.1 Tank

11.1.1. Tank shall be of bolted construction and fabricated from tested quality low carbon steel of adequate thickness. Unless otherwise approved, metal plate, bar and sections for fabrication shall comply with BS-4360 / IS 2062. Material Samples, technical literature, drawings, test reports and list of the names of the principal users with experience gained shall be supplied on request.

11.1.2. All seams and joints which are not required to be opened at site, shall be factory welded, and wherever possible they shall be double welded. Welding shall conform to BS-5135/IS 9595. After fabrication of tank and before painting, dye penetration test shall be carried out on welded parts of jacking bosses, lifting lugs and all load bearing members. The requirement of post weld heat treatment of tank/stress relieving shall be based on recommendation of BS-5500 table 4.4.3.1/IS 10801.

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

11.1.4. The tank shall be of proven design either bell type with bolted joint or conventional type with bolted top cover. The welded joint shall be provided with flanges suitable for repeated welding. The joint shall be provided with a suitable gasket to prevent weld splatter inside the tank. Proper tank shielding shall be done to prevent excessive temperature rise at the joint.

11.1.5. Tank shall be provided with:

a. Lifting lugs: Four symmetrically placed lifting lugs shall be provided so that it will be possible to lift the complete transformer when filled with oil without structural damage to any part of the transformer. The factor of safety at any one point shall not be less than 2.

b. A minimum of four jacking pads in accessible position to enable the transformer complete with oil to be raised or lowered using hydraulic jacks.

c. Each jacking pad shall be designed to support with an adequate factor of safety at least half of the total mass of the transformer filled with oil allowing in addition to maximum possible misalignment of the jacking force to the centre of the working surface.

d. Suitable haulage holes shall be provided.

e. Provision of 4 nos. of Gate valves for UHF sensors for PD Measurements at various locations. Location of valves shall be finalized during detailed engineering.

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

11.1.6. The tank shall be designed in such a way that it can be mounted on rollers.

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

11.2. Tank Cover

11.2.1. The tank cover shall be designed to prevent retention of water and shall not distort when lifted. The internal surface of the top cover shall be shaped to ensure efficient collection and direction of free gas to the buchholz relay.

11.2.2. At least two adequately sized inspection openings one at each end of the tank, shall be provided for easy access to bushings and earth connections. The inspection covers shall not weigh more than 25 kg. Handles shall be provided on the inspection cover to facilitate lifting.

11.2.3. The tank cover shall be provided with pockets for oil and winding temperature indicators. The location of pockets (for OTI, WTI & RTDs including two spare pockets) shall be in the position where oil reaches maximum temperature. Further, it shall be possible to remove bulbs of OTI/WTI/RTD without lowering the oil in the tank. The thermometer shall be fitted with a captive screw to prevent the ingress of water.

11.2.4. Bushing turrets, covers of inspection openings, thermometer pockets etc. shall be designed to prevent ingress of water into or leakage of oil from the tank.

11.2.5. To allow for the effect of possible induced and capacitive surge current flow, the tank cover and bushing turret shall be fixed to the transformer in such a way that good electrical contact is maintained around the perimeter of the tank and turrets.

11.2.6. The transformer shall be provided with a suitable diameter pipe flange, butterfly valve, bolted blanking plate and gasket shall be fitted at the highest point of the transformer for maintaining vacuum in the tank.

11.2.7. **Gas venting** - The transformer cover and generally the internal spaces of the transformer and all pipe connections shall be designed so as to provide efficient venting of any gas in any part of the transformer to the Buchholz relay. The space created under inspection /manhole covers shall be filled with suitable material to avoid inadvertent gas pockets. The Covers shall be vented at least at both longitudinal ends. The design for gas venting shall take into accounts the slopes of the plinth (if any) on which the transformer is being mounted.

11.3. Gasket for tank & cover

All gasketed joints shall be designed, manufactured and assembled to ensure long-term leak and maintenance free operation. All gasketed joints shall preferably of O-ring and groove type. The Gaskets / O-Ring in contact with oil shall be Nitrile rubber or any other better approved quality.

All bolted connections shall be fitted with weather proof, hot oil resistant, resilient gasket in between for complete oil tightness. If gasket is compressible, metallic stops/other suitable means shall be provided to prevent over-compression.

The properties of all the above gaskets / O-Rings shall comply with the requirements of IS-11149. Gaskets and O-rings shall be replaced every time whenever the joints are opened.

11.4. Roller Assembly and Anti Earthquake Clamping Device

The roller mounted transformers are to be provided with flanged bi-directional wheels and axles. This set of wheels and axles shall be suitable for fixing to the under carriage of transformer to facilitate its movement on rail track. Suitable locking arrangement along with foundation bolts shall be provided for the wheels to prevent accidental movement of transformer. The rail track gauge shall be 1676m with 2 rails for longer axis and for shorter axis 2rails or 3 rails as required (as per Standard KSEB Practice)..

All wheels should be detachable and shall be provided with suitable bearings which shall be rust and corrosion resistant. Fittings for lubrication shall also be provided. The flanged wheels shall be suitable for use on gauge track and shall be so placed that pinch bar can be used to move the transformer.

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

11.5. Conservator

11.5.1. Main tank conservator shall have air cell type constant oil pressure system to prevent oxidation and contamination of oil due to contact with moisture. Conservator shall be fitted with magnetic oil level gauge with potential free high and low oil level alarm contacts and prismatic oil level gauge.

11.5.2. Conservator tank shall have adequate capacity with highest and lowest visible-levels to meet the requirements of expansion of total cold oil volume in the transformer and cooling equipment from minimum ambient temperature to top oil temperature of 110 deg C. The capacity of the conservator tank shall be such that the transformer shall be able to carry the specified overload without overflowing of oil.

11.5.3. The conservator shall be fitted with lifting lugs in such a position so that it can be removed for cleaning purposes. Suitable provision shall be kept to replace air cell and cleaning of the conservator as applicable.

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

11.5.5. The connection of air cell to the top of the conservator is by air proof seal preventing entrance of air into the conservator. The main conservator tank shall be stenciled on its

underside with the words **"Caution: Air cell fitted".** Lettering of at least 150 mm size shall be used in such a way to ensure clear legibility from ground level when the transformer is fully installed. To prevent oil filling into the air cell, the oil filling aperture shall be clearly marked. The transformer rating and diagram plate shall bear a warning statement that the **"Main conservator is fitted with an air cell".**

11.5.6. Contact of the oil with atmosphere is prohibited by using a flexible air cell of nitrile rubber reinforced with nylon cloth. The temperature of oil in the conservator is likely to raise up to 110 ^{O}C during operation. As such air cell used shall be suitable for operating continuously at this temperature.

11.5.7. The transformer manual shall give full and clear instructions on the operation, maintenance, testing and replacement of the air cell. It shall also indicate shelf life, life expectancy in operation, and the recommended replacement intervals.

11.5.8. The conservator tank and piping shall be designed for complete vacuum / filling of the main tank and conservator tank. Provision must be made for equalizing the pressure in the conservator tank and the air cell during vacuum / filling operations to prevent rupturing of the air cell.

11.5.9. The bidder shall furnish the leakage rates of the rubber bag/ air cell for oxygen and moisture. It is preferred that the leakage rate for oxygen from the air cell into the oil will be low enough so that the oil will not generally become saturated with oxygen. Air cells with well proven long life characteristics shall be preferred.

11.5.10. OLTC shall have conventional type conservator (without aircell) with magnetic oil level gauge with potential free oil level alarm contact and prismatic oil level gauge.

11.5.11 **Piping works for conservator**

11.5.11.1 Pipe work connections shall be of adequate size preferably short and direct.

11.5.11.2 The feed pipe to the transformer tank shall enter the transformer cover plate at its highest point and shall be straight for a distance not less than five times its internal diameter on the transformer side of the Buchholz relay, and straight for not less than three times that diameter on the conservator side of the relay. Gas-venting

pipes shall be connected to the final rising pipe between the transformer and Buchholz relay as near as possible in an axial direction and preferably not less than five times pipe diameters from the Buchholz relay.

11.5.11.3. This pipe shall rise towards the oil conservator, through the Buchholz relay, at an angle between 5(five) degrees to 7 (seven) degrees to horizontal.

11.5.11.4. A double flange valve of preferably 50 mm and 25 mm size shall be provided to fully drain the oil from the main tank conservator and OLTC conservator tank respectively.

11.5.11.5. The feed pipe diameter for the main conservator shall be not less than 80mm.

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

11.5.11.7 Fittings and accessories on the Main Conservator tank.

1) Prismatic oil gauge with NORMAL, MINIMUM and MAXIMUM marking
2) End cover
3) Oil filling hole with cap
4) Magnetic oil gauge with LOW LEVEL Alarm contact
5) Silica Gel dehydrating breather with Oil seal and dust filter with clear acrylic single piece clearly transparent cover resistant to UV rays
6) Drain cum filling valve (gate valve) with locking rod and position Indicator made of Brass, 25 mm with Cover plate
7) Shut off valve (gate valve) with Position indicator made of Brass Located before and after Bucholz relay, 50mm
8) Flange for breather connection.
9) Air release valve on conservator (gate valve) made of Brass, 25 mm with cover plate
10) Air release plug as required.
11) Valve on the breather pipe near to conservator tank for filling /Nitrogen to the air cell.
12) Provision to fix one pressure gauge in between the conservator tank and the valve mentioned above (item 11).

11.5.11.8 Fittings and Accessories on OLTC Conservator.

1) Prismatic oil gauge with NORMAL, MINIMUM and MAXIMUM marking
2) End cover
3) Oil filling hole with cap
4) Magnetic oil gauge with LOW LEVEL Alarm contact
5) Silica gel dehydrating breather with oil seal and dust filter with clear acrylic single piece clearly transparent cover resistant to UV rays
6. Drain valve (gate valve)With locking rod and position Indicator made of Brass, 25 mm with cover plate
7) Shut off valve (gate valve) with Position indicator made of Brass located before oil surge relay, 25 mm
8) Flange for breather connection
9) Air release plug as required

11.6 Dehydrating Silica gel Filter Breather

Conservator of Main Tank and OLTC shall be fitted with a dehydrating silica gel filter breather. Connection shall be made to a point in the oil conservator not less than 50 mm above the maximum working oil level by means of a pipe with a minimum diameter of 25 mm. Breathers and connecting pipes shall be securely clamped and supported to the transformer, or other structure supplied by the supplier, in such a manner so as to eliminate undesirable vibration and noise. The design shall be such that:

a) Passage of air is through silica gel.
b) Silicagel is isolated from atmosphere by an oil seal.
c) Moisture absorption indicated by a change in colour of the crystals.
d) Breather is mounted approximately 1200 mm above rail top level.

11.7. Pressure Relief Device

Minimum two number of pressure relief devices shall be provided at suitable locations. These shall have opening diameter of at least 100 mm for rapid release of any pressure that may be generated in the tank and which may result in damage to equipment. The device shall maintain its oil tightness under static oil pressure equal

to the static operating head of oil plus 20 kPa. The device shall operate and attain its full opening in not more than 2.5 ms when subject to an internal pressure impulse equal to static operating head of oil plus 50 kPa. It shall be capable of withstanding full internal vacuum at mean sea level. It shall be mounted directly on the tank. One set of potential free contacts (**suitable for 2.5sq.mm control cable)** per device shall be provided for tripping. Following routine tests shall be conducted on PRD:

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

11.8. Buchholz Relay

One double float, reed type Buchholz relay shall be provided in the connecting pipe between the oil conservator and the Transformer. Any gas evolved in the Transformer shall be collected in this relay. The relay shall be provided with a test cock suitable for a flexible pipe connection for checking its operation and taking gas sample. A copper tube shall be connected from the gas collector to a valve located about 1200 mm above ground level to facilitate sampling while the Transformer in service. Each device shall be provided with two potential free contacts **(suitable for 2.5 sq.mm control cable),** one for alarm and other for trip on gas accumulation and on sudden rise of pressure.

The Buchholz relay shall not operate during starting/ stopping of the transformer oil circulation under any oil temperature conditions. The pipe or relay aperture baffles shall not be used to decrease the sensitivity of the relay. The relay shall not mal-operate for through fault conditions or be influenced by the magnetic fields around the transformer during the external fault conditions. Pressurised water ingress test for Terminal Box (routine tests) shall be conducted on Buchholz relay.

11.10. Oil Temperature Indicator (OTI)

All transformers shall be provided with a dial type thermometer of around 150 mm diameter for top oil temperature indication. It shall have adjustable, potential free alarm and trip contacts **(suitable for 2.5 sq.mm control cable)** besides that required for control of cooling equipment, if any. A temperature sensing element suitably

located in a pocket on top oil shall be provided. This shall be connected to the OTI by means of capillary tubing. Temperature indicator dials shall have linear gradations to clearly read at least every 2 deg C. Accuracy of OTI shall be 2.0 deg C or better for a temperature of 100 deg C.

The setting of alarm and tripping contacts shall be adjustable at site.

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

a) Temperature transducer with Pt100 sensor

RTD shall be provided with Pt100 temperature sensor having nominal resistance of 100 ohms at zero degree centigrade. The Pt100 temperature sensor shall have three wire ungrounded system. The calibration shall be as per IEC 60751-2 or equivalent. The Pt100 sensor may be placed in the pocket containing temperature sensing element. RTD shall provide dual output 4-20mA for remote OTI and SCADA system individually. The transducer shall be installed in the Individual Marshalling Box. Any special cable required for shielding purpose, for connection between Pt100 temperature sensor and transducer, shall be in the scope of Supplier.

11.11. Winding Temperature Indicator (WTI)

All Transformers shall be provided with a device for measuring the hot spot temperature of each winding (HV, IV and LV) with dial type thermometer of 150 mm diameter for winding temperature indication and shall have adjustable potential free alarm and trip contacts **(suitable for 2.5sq.mm control cable**) besides that required for control of cooling equipment if any. WTI shall have Temperature sensing element, Image coil and Auxiliary CTs, if required to match the image coil, shall be mounted in the cooler control cabinet. Temperature indicator dials shall have linear gradations to clearly read at least every 2 deg C. Accuracy of WTI shall be 2.0 deg C or better for a temperature of 100 deg C.

The setting of alarm and tripping contacts shall be adjustable at site.

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

a) Temperature transducer with Pt100 sensor for each winding

RTD shall be provided with Pt100 temperature sensor having nominal resistance of 100 ohms at zero degree centigrade. The Pt100 temperature sensor shall have three wire ungrounded system. The calibration shall be as per IEC 60751-2 or equivalent. The Pt100 sensor may be placed in the pocket containing temperature sensing element. RTD shall include image coil, Auxiliary CTs, if required to match the image coil, for WTI system and shall provide dual output 4-20mA for remote WTI and SCADA system individually. The transducer, Auxiliary CT shall be installed in the Individual Marshalling Box. Any special cable required for shielding purpose, for connection between Pt100 temperature sensor and transducer, shall be in the scope of Supplier.

The temperature indicators (OTI & WTI) shall be so mounted that the dials are about 1200 mm from ground level. Glazed door of suitable size shall be provided for convenience of reading.

11.12. **Earthing Terminals**

11.12.1. Two (2) earthing pads (each complete with two (2) nos. holes, M16 bolts, plain and spring washers) suitable for connection to 75 x 12 mm galvanised steel grounding flat shall be provided each at position close to earth of the two (2) diagonally opposite bottom corners of the tank.

11.12.2. Two earthing terminals suitable for connection to 75 x 12 mm galvanised steel flat shall also be provided on each cooler, marshalling box, Cooler Control Cabinet and any other equipment mounted separately. For the tank-mounted equipment like online drying/ Online DGA/ Optical Sensor Box etc. double earthing shall be provided through the tank for which provision shall be made through tank and connected through two flexible insulated copper link.

11.12.3. Equipotential flexible copper link of suitable size at least 4 Nos. for Tank mounted turret with tank and tank with cover and or Bell shall be provided. For other components like - pipes, conservator support etc. Connected to tank shall also be provided with equipotential flexible copper link.

11.13. **Core**

11.13.1. The core shall be constructed from high grade, non-ageing, cold rolled, super grain oriented silicon steel laminations (HI-B or better grade). Indian transformer manufacturers shall use core material as per above specification with BIS certification.

11.13.2. The design of the magnetic circuit shall be such as to avoid static discharges, development of short circuit paths within itself or to the earthed clamping structure and production of flux component at right angles to the plane of laminations which may cause local heating.

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

11.13.4. Core and winding shall be capable of withstanding the shock during transport, installation and service. Adequate provision shall be made to prevent movement of core and winding relative to tank during these conditions.

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

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

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

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

11.13.9. The core shall be earthed to the core clamping structure at one point only, through a removable external link of minimum size of 80 sq. mm copper suitably located and

protected to facilitate testing after installation of the transformer. The removable links shall have adequate section to carry ground fault current. Separate identification name plate/labels shall be provided for the 'Core' and 'Core clamp' on the outside of tank cover.

11.13.10. In case core laminations are divided into sections by insulating barriers or cooling ducts parallel to the plane of the lamination, tinned copper bridging strips shall be inserted to maintain electrical continuity between sections.

11.14. **Windings**

11.14.1. The Supplier shall ensure that windings of all transformers are made in dust proof and conditioned atmosphere.

11.14.2. The conductors shall be of electrolytic grade copper free from scales and burrs.

11.14.3. The insulation of transformer windings and connections shall be free from insulating compounds which are liable to soften, ooze out, shrink or collapse and shall be non-catalytic and chemically inactive in transformer oil during service.

11.14.4. Coil assembly and insulating spacers shall be so arranged as to ensure free circulation of oil and to reduce the hot spot of the winding.

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

11.14.6. The conductor shall be transposed at sufficient intervals in order to minimize eddy currents and to equalize the distribution of currents and temperature along the winding.

11.14.7. The windings shall be designed to withstand the dielectric tests specified. The type of winding used shall be of time tested. An analysis shall be made of the transient voltage distribution in the windings, and the clearances used to withstand the various voltages. Margins shall be used in recognition of manufacturing tolerances and considering the fact that the system will not always be in the new factory condition.

11.14.8. The barrier insulation including spacers shall be made from high- density pre-compressed pressboard (1.1 gm/cc minimum for load bearing and 1 to 1.3 gm/cc minimum for non-load bearing) to minimize dimensional changes.

11.14.9. The conductor insulation shall be made from high-density (at least 0.75 gm/cc) paper having high mechanical strength. The characteristics for the paper will be reviewed at the time of design review.

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

11.14.11. All winding insulation shall be processed to ensure that there will be no detrimental shrinkage after assembly. All windings shall be pre-sized before being clamped.

11.14.12. Windings shall be provided with clamping arrangements which will distribute the clamping forces evenly over the ends of the winding.

11.14.13. The bracing of the windings and connections shall be such that these parts shall safely withstand the cumulative effects of stresses which may occur during handling, transportation, installation and service including line-to–line and line-to–ground faults.

11.14.14. **Current carrying connections**

The mating faces of bolted connections shall be appropriately finished and prepared for achieving good long lasting, electrically stable and effective contacts. All lugs for crimping shall be of the correct size for the conductors. Connections shall be carefully designed to limit hot spots due to circulating eddy currents.

11.15. **Winding terminations into bushings**

11.15.1. Winding termination interfaces with bushings shall be designed to allow for repeatable and safe connection under site conditions to ensure the integrity of the transformer in service.

11.15.2. The winding end termination, insulation system and transport fixings shall be so designed that the integrity of the insulation system generally remains intact during repeated work in this area.

11.15.3. Allowances shall be made on the winding ends for accommodating tolerances on the axial dimensions of the set of bushings and also for the fact that bushings may have to be rotated to get oil level inspection gauges to face in a direction for ease of inspection from ground level.

11.15.4. In particular, rotation or straining of insulated connections shall be avoided during the fastening of conductor pads (or other methods) on the winding ends onto the termination surfaces of the bushing.

11.15.5. Suitable inspection and access facilities into the tank in the bushing oil-end area shall be provided to minimize the possibility of creating faults during the installation of bushings.

11.16. Paint system and procedures

The typical painting details for transformer main tank, pipes, conservator tank, radiator, control cabinet/ marshalling box / oil storage tank etc. shall be as given in **Annexure-D.** The proposed paint system shall generally be similar or better than this. The quality of paint should be such that its colour does not fade during drying process and shall be able to withstand temperature up to 120 deg C.

12. Insulating Oil

The oil for first filling together with 10% extra shall be supplied with each transformer. The oil shall comply in all respects with **Annexure- A** of the specification. Particular attention shall be paid to deliver the oil free from moisture having uniform quality throughout. The quantity of oil for first filling & 10% extra of each transformer shall be stated in the tender.

12.1 The supplier of transformer shall furnish test certificates of the insulating oil supplied against their acceptance norms, prior to dispatch.
Subsequently oil samples shall be drawn

i) At manufacturer's works before and after heat run test, the following shall be tested at CPRI.
a) BDV in kVrms
b) Moisture content
c) Dissolved Gas Analysis – samples for DGA shall be taken from sampling device within 24 hrs prior to commencement of heat run test and immediately after this test. The acceptance norms shall be as per IS:10593 (based on IEC-599)

ii) Prior to filling in main tank at site the following shall be tested.
a)BDV in kV rms
b)Moisture content

iii) Prior to energisation at site following shall be tested.
a) BDV in kVrms
b) Moisture content
c) Tan Delta at 90 deg cen.
d) Resistivity at 90 deg cen.
e) Interfacial Tension.

12.3. **Transportation of Oil**

The insulating oil for the transformer shall be delivered at site with prior information to the Employer.

Insulating oil shall be delivered to the site in non returnable oil drums. The drums shall be suitable for storing the oil for long period

14. Bushings

14.1 Bushing shall have high factor of safety against leakage to ground and shall be so located as to provide adequate electrical clearances between bushing and grounded parts. Bushings of identical voltage rating shall be interchangeable. All bushings shall be equipped with suitable terminals of approved type and size and shall be suitable for bimetallic connection, if necessary. The insulation class of the high voltage neutral

bushing shall be properly coordinated with the insulation class of the neutral of the high voltage winding.

All main windings, tertiary windings and neural leads shall be brought out to outdoor through bushings which shall be so located that the full flashover strength will be utilised and phase to phase and phase to earth clearance shall be more than minimum value specified below. Location and arrangement of bushing shall follow Indian Standards.

Each bushing shall be so coordinated with the transformer insulation that flashovers will occur outside the tank.

All porcelain used in the bushings shall be made of the wet process, be homogeneous and free from cavities or other flaws. The glazing shall be uniform in colour and free from blisters, burns, and other defects. Upper portion of Bushing made of Porcelain & lower portion made of Epoxy/porcelain is also acceptable.

Bushings for 245 KV and 145 KV voltage class shall be Oil Filled Condenser type and shall be hermetically sealed. HV Neutral bushing shall be of 36 KV class for 220 KV class transformers. Bushing for 11 KV delta tertiary winding shall be of 36 KV class and of plain porcelain type and shall be hermetically sealed. All OIP bushing shall have provision of measurement of capacitance and tan-delta without dismantling of the bushing. Rating plate of bushing shall be provided near each type of bushing with terminal marking and physical position as per IS:2026. Bushing for 36KV shall be Solid porcelain or oil communicating type.

The electrical and mechanical characteristic of bushings shall conform to IS:2099 and IS:3347. The characteristic of the oil used in the bushing shall be the same as that of the oil in the transformer.

Main terminals shall be solder less and “Terminal Connectors” shall be as per cl. No. 12 of this technical specification. The spacing between the bushings must be adequate to prevent flashover between phases under all conditions of operation.

All bushings shall be suitable for heavily polluted atmosphere and minimum creepage distance shall be taken as 25 mm per KV.

Where Bushing mounted Current Transformers are specified, the bushing shall be removable without disturbing the current transformers.

The voltage and current rating of the bushings shall be as follows :

Highest System Voltage (kV)	**Rated Current in Amp.**
245kV	800 A
145kV	1250A

36kV (Tertiary)	3150 A
36kV (Neutral)	2000 A

15 Terminations

15.1 220kV Terminations

The 220kV terminations shall be made through 245kV class, 800Amp. OIP condenser bushing of appropriate without arcing horns. Bushings shall be provided with TEST TAP rated for 2kV.

15.2 110kV Terminations

The 110kV terminations shall be made through 145kV class 2000A-. OIP condenser bushing of appropriate without arcing horns. Bushings shall be provided with TEST TAP rated for 2kV.

15.3 Neutral Termination

The neutral point shall be brought out through an Oil/Air solid porcelain bushing of suitable rating.

15.4 Tertiary Winding Terminations

The three ends of the internally formed delta of the tertiary winding shall be brought out through solid porcelain bushings having voltage class as mentioned in the STP. These bushings shall be suitably positioned that proper protection/ grounding can be done as required.

15.5. Terminal Connections

15.5.1 General

i) The bushing shall be equipped with suitable terminals for connector as specified herein.

ii) Each terminal (including the neutral) shall be distinctly marked on both the primary and secondary side in accordance with the diagram of connection supplied with the transformers.

iii) Vertical / horizontal / universal type bi-metallic, rigid connector for bushing stud shall be provided.

iv) Clamp and connector shall be made from Cold forged Aluminium Alloy Plate i.e Extruded Aluminium Clamp and Connector shall be processed through Cold forging for 220KV, 132KV, 52KV & 36KV Bushings.

v) The Nuts & Bolts associated with equipment of connector pieces shall be MS Hot dip galvanized. Quality of Nuts & bolts shall conform to relevant IS of latest edition.

vi) Minimum thickness at any point of current carrying part of any clamp & connector shall not be less than 12mm.

vii) From outermost hole edge to nearest edge of any clamp & connector the distance shall not be less than 10mm.

15.5.2 HV Terminal

The HV Terminal connectors (TC) shall be suitable to connect between transformer HV bushing and double ACSR MOOSE conductor. Proper bimetallic (ALCO) shall be provided. Shall have proper bolts to get proper connection and shall be easily removable on requirement. The contact area between bushing & TC and TC & conductor shall be suitable for carrying 120% of the rated current continuously and fault currents as per standards.

15.5.3 IV Terminal

The HV Terminal connectors (TC) shall be ssuitable to connect between transformer IV bushing and double ACSR KUNDAH conductor. Proper bimetallic (ALCO) shall be provided. Shall have proper bolts to get proper connection and shall be easily removable on requirement. The contact area between bushing & TC and TC & conductor shall be suitable for carrying 120% of the rated current continuously and fault currents as per standards.

15.5.4 Neutral Terminal

The Neutral Terminal Connector shall be suitable to connect between transformer Neutral bushing and ACSR KUNDAH / earthing GI strip. Proper bimetallic (ALCO) shall be

provided. Shall have proper bolts to get proper connection and shall be easily removable on requirement. The contact area between bushing & TC and TC & conductor shall be suitable for carrying the fault current as per standards.

15.5.5 Tertiary Terminal

The tertiary Terminal connectors shall be suitable to connect between transformer tertiary bushings- and ACSR KUNDAH conductor / earthing GI. The contact area between bushing & TC and TC & conductor shall be suitable for carrying the fault current as per standards.

16 Cooling Equipment and its Control

16.1. Cooling Equipment for Radiator Bank

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

16.1.2. In case of separately mounted radiator bank arrangement, the main tank shall have provision such that cooler banks can be placed on either side of the main tank without the need of any extra member/pipe maintaining the electrical clearances.

16.1.3. The radiator shall be of sheet steel in accordance with IS 513 and minimum thickness 1 mm. Each radiator bank shall be provided with the following accessories:

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

16.1.4. Each radiator bank shall be detachable and shall be provided with flanged inlet and outlet branches. Expansion joint shall be provided on top and bottom cooler pipe connection.

16.1.5. Required number of standby fans of approximately 20% capacity shall also be provided with each radiator bank.

16.1.6. Cooling fans shall not be directly mounted on radiator bank which may cause undue vibration. These shall be located so as to prevent ingress of rain water. Each fan shall be suitably protected by galvanized wire guard. The exhaust air flow from cooling fan shall not be directed towards the main tank in any case.

16.1.7. Two (2), 100% centrifugal or axial in line oil pumps, if applicable, (out of which one pump shall be standby) shall be provided with each radiator bank. Measures shall be taken to prevent mal-operation of Buchholz relay when all oil pumps are simultaneously put into service. The pump shall be so designed that upon failure of power supply to the pump motor, the pump impeller will not limit the natural circulation of oil.

16.1.8. An oil flow indicator shall be provided for each pump, for the confirmation of the oil pump operating in a normal state. An indication in the flow indicator and potential free contacts for remote alarm shall be provided.

16.1.9. Valves shall be provided across the pump and oil flow indicator to avoid oil drain and long outage during maintenance / replacement of pump and oil flow indicator.

16.1.10. Cooling fans and oil pump motors shall be suitable for operation from 415 volts, three phase 50 Hz power supply and shall conform to IS: 325. Each cooling fan and oil pump motors shall be provided with starter thermal overload and short circuit protection. The motor winding insulation shall be conventional class 'B' type. Motors shall have hose proof enclosure equivalent to IP: 55 as per IS: 4691.

16.1.11. The cooler pipes, support structure including radiators and its accessories shall be hot dip galvanized or corrosion resistant paint should be applied to external surface of it.

16.1.12. Air release device and oil plug shall be provided on oil pipe connections. Drain valves shall be provided in order that each section of pipe work can be drained independently.

16.2. **Cooling Equipment Control for Radiator banks**

16.2.1. Manual and Automatic operation control of fans/pumps shall be provided (with temperature change) from contacts of winding temperature indicator. The manufacturer shall recommend the setting of WTI for automatic changeover of cooler control over entire cooling option. The setting shall be such that hunting i.e. frequent start-up operations for small temperature differential do not occur.

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

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

16.2.4. Following lamp indications shall be provided in cooler control cabinet:

a) Cooler Supply failure (main)
b) Cooler supply changeover
c) Cooler Supply failure (standby)
d) Control Supply failure
e) Cooling fan failure for each bank
f) Cooling pump failure for each pump g)
Common thermal overload trip

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

16.2.5. The cooler control cabinet / Marshalling box shall have all necessary devices meant for cooler control and local temperature indicators. All the contacts of various protective devices mounted on the transformer and all the secondary terminals of the bushing CTs shall also be wired upto the terminal board in the cooler control cabinet/ Marshalling

box. All CT secondary terminals in the cooler control cabinet shall have provision for shorting to avoid CT open circuit while it is not in use.

16.2.6. All necessary terminations for remote connection to Purchaser's panel shall be wired up to the Marshalling box.

16.2.7. The manufacturer shall derive AC power for Cooler Control Circuitry from the AC feeder.

16.3. **Auxiliary Power Supply for OLTC, Cooler Control and Power Circuit**

16.3.1. 415 volt, three phase 50Hz four (4) wire AC supply shall be provided by the Purchaser at cooler control cabinet.

16.3.2. For each circuit, suitably rated power contactors, MCBs/MCCBs as required for entire auxiliary power supply distribution scheme including distribution to DM boxes, Fibre optic sensor Box etc. (as applicable), shall be provided by supplier in cooler control cabinet.

16.3.3. Auxiliary power supply distribution scheme shall be submitted for approval. Supply and laying of Power, Control and special cables from marshalling box to all accessories is in the scope of the supplier.

17. **Valves**

17.1. All valves upto and including 100 mm shall be of gun metal or of cast steel/cast iron. Larger valves except radiator shut off valves may be of gun metal or may have cast iron bodies with gun metal fittings. They shall be of full way type with internal screw and shall open when turned counter clock wise when facing the hand wheel. All hardware used shall be hot dip galvanized / stainless steel.

17.2. Suitable means shall be provided for locking the valves in the open and close positions which can be operated with special tools only. Provision is not required for locking individual radiator valves.

17.3. Each valve shall be provided with the indicator to show clearly the position

(open/close) of the valve.

17.4. All valves flanges shall have machined faces.

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

17.6. The oil sampling point for main tank shall have two identical valves put in series. Oil sampling valve shall have provision to fix rubber hose of 10 mm size to facilitate oil sampling.

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

18. Cabling

All interconnecting control and power cables between various parts of Transformers like turret CT, MBs, Fans, pumps, Buchholz, PRD etc. shall be routed through covered cable tray or GI conduit and shall be properly dressed. All cables shall be armoured type. Un-armoured cables (if provided) in any circuitry, shall be through GI conduit and no part shall be exposed. Cable terminations shall be through stud type TB and ring type lugs. Typical Technical specification for cables is attached at **Annexure-G.** Supplier shall provide type tested cables from approved sources. No type testing for cables is envisaged. Both ends of all the wires (control & power) shall be provided with proper ferrule numbers for tracing and maintenance. Further, any special cables (if required) shall also be considered included in the scope. All cable accessories such as glands, lugs, cable tags/ numbers etc as required shall be considered included in the scope of supply.

19. Tap Changing Equipment

Each transformer shall be provided with On Load Tap changing equipment as specified elsewhere. The OLTC offered shall be suitable for bi directional power flow and shall comprise tap selectors and high speed transition diverter switch.

19.1. **ON Load Tap Changing (OLTC) Equipment**

19.1.1. **Main OLTC Gear Mechanism**

19.1.1.1. Each transformer shall be provided with an on load tap changing Mechanism. ***The tap changer shall be suitable for bidirectional power flow. The OLTC shall be comprising tap selectors and diverter switch of high speed transition.*** This shall be designed suitable for remote operation from the remote tap changer control (RTCC) panel in the control room in addition to being capable of local manual as well as local electric al operation.

The tapings shall be controlled by a high speed resistor transition type gear in which tap change is carried out virtually under 'no volt' 'no ampere' condition and the selector switches do not make and break any current, main current is never interrupted and a resistor is provided to limit the arching at diverter contacts to a minimum. Shall be suitable for outdoor mounting and continuously rated for operating at all position including positions in the middle of tap change. In particulars, the tap change gear shall be suitable for delivering the full output plus permissible overload and operating the lowest voltage tap on the HV side.

The value of the transition resistor shall be indicated on the rating plate of the OLTC with continuous current rating with reference to design ambient temperature specified.

Each transformer shall be provided with On Load Tap changer units for controlling the voltage.

191.1.2. OLTC shall be motor operated suitable for local as well as remote operation. The diverter switch or arcing switch shall be designed so as to ensure that its operation once commenced shall be completed independently of the control relays or switches, failure of auxiliary supplies etc. To meet any contingency which may result in incomplete operation of the diverter switch, adequate means shall be provided to safeguard the transformer and its ancillary equipment. The current diverting contacts shall be housed in a separate oil chamber not communicating with the oil in main tank of the transformer. The contacts shall be accessible for inspection without lowering oil level in the main tank and the contacts shall be replaceable.

191.1.3. Necessary safeguards shall be provided to avoid harmful arcing at the current diverting contacts in the event of operation of the OLTC gear under overload conditions of the transformer.

191.1.4. The OLTC oil chamber shall have oil filling and drain valve, oil sampling valve, relief vent and level glass. Oil sampling valve of minimum size, accessible from ground, shall be provided to take sample of oil from the OLTC chamber. It shall also be fitted with an oil surge relay which shall be connected between OLTC oil chamber and OLTC conservator tank.

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

19.2. **Local OLTC Control Cabinet (Drive Mechanism Box)**

Each transformer unit of OLTC gear shall have following features:

19.2.1 OLTC shall be suitable for manually handle operated and electrically motor operated. For local manual operation from Local OLTC Control cabinet (Drive Mechanism Box), an external handle shall be provided.

19.2.2. OLTC's Local control cabinet shall be mounted on the tank in accessible position. The cranking device/ handle for manual operation for OLTC gear shall be removable and suitable for operation by a man standing at ground level. The mechanism shall be complete with the following:

Mechanical tap position indicator which shall be clearly visible from near the transformer. A mechanical operation counter of at least five digits shall be fitted to indicate the number of operations completed and shall have no provision for resetting. Mechanical stops to prevent over-cranking of the mechanism beyond the extreme tap positions.

The manual control considered as back up to the motor operated on load tap changer control shall be interlocked with the motor to block motor start-up during manual operation.

The manual operating mechanism shall be labeled to show the direction of operation for raising the voltage and vice-versa.

An electrical interlock to cut-off a counter impulse for reverse step change being initiated during a progressing tap change and until the mechanism comes to rest and resets circuits for a fresh position.

19.2.3. For electrical operation from local as well as remote, motor operated mechanism shall be provided. It shall not be possible to operate the electric drive when the manual operating gear is inserted. It shall not be possible for any two controls to be in operation at the same time. Thermal device or other means shall be provided to protect the motor and control circuit.

19.2.4. The Local OLTC Drive Mechanism Box shall house all necessary devices meant for OLTC control and indication. It shall be complete with the followings:

i. A circuit breaker/contactor with thermal overload devices for controlling the AC Auxiliary supply to the OLTC motor
ii. Emergency Push Button to stop OLTC operation
iii. Cubicle light with door switch
iv. provided with anti-condensation metal clad heaters to prevent condensation of moisture
v. Padlocking arrangement for hinged door of cabinet
vi. All contactors relay coils and other parts shall be protected against corrosion, deterioration due to condensation, fungi etc.
vii. The cabinet shall be tested at least IP 55 protection class.

19.2.5. All relays and operating devices shall operate correctly at any voltage within the limits specified in this specification In case auxiliary power supply requirement for OLTC DM Box is different than station auxiliary AC supply, then all necessary converters shall be provided by the Supplier.

19.2.6. Operating mechanism for on load tap changer shall be designed to go through one step of tap change per command only, until the control switch is returned to the off position between successive operations / repeat commands.

19.2.7. Limit switches shall be provided to prevent overrunning of the mechanism and shall be directly connected in the control circuit of the operating motor provided that a mechanical de-clutching mechanism is incorporated. In addition, a mechanical stop

shall be provided to prevent over-running of the mechanism under any condition. An interlock to cut-out electrical control when it tends to operate the gear beyond either of the extreme tap positions.

19.2.8. OLTC local control cabinet shall be provided with tap position indication for the transformer. Drive Mechanism shall be equipped with a fixed resistor network capable of providing discrete voltage steps or provide 4-20mA transducer outputs for tap position indication in MB/ Cooler Control Cabinet and input to RTCC/SCADA system.

19.2.9. 'Local-remote' selector switch shall be provided in the local OLTC control cabinet. In Local mode, all electrical commands from remote (RTCC, SCADA etc.) shall be cut-off/blocked. Electrical operations to change tap positions shall be possible by using raise/lower push buttons under local mode from DM Box. In remote mode electrical commands from RTCC/SCADA etc. shall be executed. The remote-local selector switch shall be having at-least two spare contacts per position.

19.2.10. Following minimum contacts shall be available in DM Box, which shall be wired to Digital RTCC panel:

a. INCOMPLETE STEP which shall not operate for momentary loss of auxiliary power.
b. OLTC motor overload protection
c. Supply to DM Motor fail
d. OLTC IN PROGRESS
e. Local / Remote Selector switch position
f. OLTC upper/lower limits reached.
g. Facility to trip the OLTC DM motor from remote during any emergency

19.2.11. All relays, switches, fuses etc. shall be mounted in the OLTC local control cabinet and shall be clearly marked / labelled for the purpose of identification.

19.2.12. A permanently legible lubrication chart if required shall be fitted within the OLTC local control cabinet.

19.3. **RTCC Panel**

The supplier shall supply one indoor cubicle for each transformer (RTCC panel) for installation in the purchaser's control room for the remote operation of the tap change from control room and from remote (viz. Load dispatch centre through SCADA).

The RTCC panel shall be made of CRCA sheet steel of thickness minimum 2.5 mm for load as well as non load bearing member.

The RTCC panel shall be provided with suitable size Min. 3 mm thick detachable gland plate.

The following control switches/ push buttons shall be provided in the RTCC panel.

Push button for 'RAISE"
Push button for "LOWER"
"EMERGENCY STOP" button to stop TC operation.
"Control Supply ON/OFF" switch.
"OFF/MASTER/FOLLOWER/INDEPENDENT" Mode Selector Switch.

The RTCC panel shall be provided with an annunciation window having minimum the following indications.

The RTCC panel shall be provided with an annunciation Relay system having TEST, ACCEPT & RESET facilities. The relay shall be suitable for TRIP and NON-TRIP alarms. In the event of any contact initiates, the corresponding window shall glow and an audible alarm shall be operated. The TRIP window shall have Black text in Red background and Non-Trip alarm window shall have black text in white background.
There shall be minimum two nos. each of TRIP & NON TRIP windows as SPARES.

The relay shall be suitable for the following TRIP and NON-TRIP alarms.

WTI alarm and trip
OTI alarm and trip
Bucholz relay alarm and trip for main tank
OSR trip.
MOG low level alarm for main tank and OLTC
PRV main tank trip

PRV OLTC Trip
Sudden pressure relay trip
Main fan in GR-1 fail
Main fan in GR-2 fail
Drive Motor Auto trip
Out of step alarm

Following bunched LED indications shall be provided on the RTCC panel.

Supply ON- Green
Tap Change in Progress- Amber
OLTC control supply On- Green
DC Supply ON- Green
TC Upper limit reached- Yellow
TC Lower limit reached- Red
TC in LOCAL mode- Red
TC in REMOTE mode- Blue
4- to 20 mA signals for WTI, OTI repeater and tap positions for SCADA use..

Further the the RTCC panel shall be provided with
1)Remote Oil & winding temperature indicators
2)Remote tap position indicators etc.

Following signals / controls shall be available for connecting to remote from RTCC through SCADA

1) TAP positions
2) Winding and Oil temperatures
3) Tap changer LOW and RAISE controls.
4) And all protection alarm and trip signals from transformer to RTCC panel for extending to elsewhere (Load dispatch Centre) through SCADA.

4 to 20mA signal for SCADA for tap positions for connecting from RTCC

The welding of the panel shall be continuous on joints. Welding at regular intervals on joints and filling of gaps with use of Mseal is not accepted.

All cables shall be bottom entry and access from rear side. The auxiliary supply to the panel is 240 V AC, single phase, 50 Hz / 110 V DC. Following shall be provided in the RTCC panel.

1) Cubicle lamp with door switch and separate fuse / MCB
2) Approved space heaters controlled by thermostat and separate fuse / MCB
3) Incoming fuse switch / MCB for the incoming supply
4) A table showing voltages on each tap position engraved in stainless steel plate shall be fixed on the front of the panel by rivet.
5) Stainless steel door handle with lock & additional facility for padlock
6) Earthing strip inside the panel for connecting to the substation grounding.
7) Single phase power plug industrial type 15/5 Amp. With MCB.
8) All hinged parts (doors etc) shall be properly grounded.

The RTCC Panel shall be provided with Raise/Lower push buttons, Master / Follower/ Independent/ Off mode selection features and emergency stop Push Button for control of OLTC.

19.4. **Master / Follower/ Independent / Off mode**

Master Position: If the selector switch is in master position, it shall be possible to control the OLTC units of other parallel operating transformers in the follower mode by operation from the master unit.

Follower Position: If the selector switch is in Follower position control of OLTC shall be possible only from panel where master mode is selected.

Independent Position: In independent position of selector switch, control of OLTC shall be possible only from the panel where independent mode is selected. Suitable interlock arrangement shall be provided to avoid unwanted / inconsistent operation of OLTC of the transformer

. **Raise/Lower control:** The remote OLTC scheme offered shall have provision to raise or lower taps for the Transformers.

The relays shall ensure positive completion of lowering/raising of the OLTC tap, once the command is issued from the relay. "Step-by-Step" operation shall be ensured so that only one tap change from each tap changing pulse shall be effected. If the command remains in the "operate" position, lock-out of the mechanism is to be ensured.

20. Constructional features of Cooler Control Cabinet/ Individual Marshalling Box/ and RTCC Panel

20.1. Each transformer unit shall be provided with local OLTC Drive Mechanism Box, cooler control cabinet /individual marshalling box and RTCC panel.

20.2. The cooler control cabinet, Marshalling Box, RTCC panel etc. shall be made of CRCA sheet of minimum thickness of 2.5mm and shall be painted suitably as per **Annexure-D.**

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

20.4. All doors, removable covers and plates shall be gasketed all around with suitably profiled. All gasketed surfaces shall be smooth straight and reinforced if necessary to minimize distortion to make a tight seal. For Control cubicle / Marshalling Boxes etc. which are outdoor type, all the sealing gaskets shall be of EPDM rubber or any better approved quality, whereas for all indoor control cabinets / RTCC panel, the sealing gaskets shall be of neoprene rubber or any better approved quality. The gaskets shall be tested in accordance with approved quality plan, IS: 1149 and IS: 3400.

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

20.6. The size of all cabinets shall be suitable for fixing all required accessories. All accessories shall be easily accessible inspection and maintenance. All cabinets except RTCC shall be tank mounted. The RTCC panel shall be suitable for mounting indoor.

21. Fittings & accessories

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

a. Conservator for main tank with air cell, oil filling hole and cap, isolating valves, drain valve, magnetic oil level gauge with low & high level alarm contacts, prismatic oil level gauges and dehydrating breather

b. Conservator for OLTC with drain valve, oil surge Relay, filling hole with cap, prismatic oil level gauge and dehydrating breather

c. Pressure relief devices

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

e. Air release plug

f. Inspection openings and covers

g. Bushing with metal parts and gaskets to suit the termination arrangement

h. Winding & Oil temperature indicators for local and remote mounting

i. Cover lifting eyes, transformer lifting lugs, jacking pads, towing holes and core and winding lifting lugs

j. Protected type mercury or alcohol in glass thermometer or magnetic or micro-switch type dial type temperature indicator.

k. Bottom and top filter valves with threaded male adaptors, bottom sampling valve and drain valve

l. Rating and diagram plates (in English) on transformers and auxiliary apparatus

n. On load tap changing gear, OLTC DM Box, Cooler control cabinet, Fibre optic sensor box and RTCC Panel (indoor type) as applicable

o. Cooling equipment

p. Bushing current transformers for winding temperature imaging.

q. Oil flow indicator

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

s. Terminal marking plates

t. Valves schedule plate

u. Ladder to climb up to the Transformer tank cover with suitable locking arrangement to prevent climbing during charged condition

v. Suitable Platform for buchholz relay shall be provided, in case these are not accessible from transformer top.

w. Haulage lugs

x. Flow sensitive conservator isolation valve.

y. Flanged bi-directional wheels

22. Bushing Current Transformer

Bushing CTs shall be used for HV, IV winding temperature imaging on required phases. Test windings shall be provided for bushing CTs for testing purposes.

22.1. Current transformers shall comply with IS 2705/IEC-60044-1.

22.2. It shall be possible to remove the turret mounted current transformers from the Transformer tank without removing the tank cover. Necessary precautions shall be taken to minimize eddy currents and local heat generated in the turret.

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

23. General warranty

The bidder shall among other things guarantee the following:

i) Quality and strength of materials used.

ii) The tenderer shall give guarantee for satisfactory working of the complete transformer for **114 months** from the date of commissioning of equipment or **120 months** from the date of receipt of transformer at site, whichever is earlier..

Guarantee period will be reckoned from the date of receipt of 100 % accessories and not from the date of receipt of main tank only.

Defects any noticed during this period due to faulty design/ workmanship, inferior raw materials or non adherence to the relevant standards shall be made good by way of replacement on all free of cost to KSEB Ltd

24. Hand Tools

One set of hand tools of reputed make packed in a carry bag/box broadly comprising of double ended spanners (open jaws, cranked ring, tubular with Tommy bar each of sizes 9mm to 24mm, one set each), adjustable wrenches (8 &12 inch one set), gasket punches (of different sizes used - one set), pliers (flat nose, round nose & side cutting one of each type), hammer with handle (one), files with handle (two), knife with handle (one), adjustable hacksaw (one), and cold chisel (one), Hole punching tools for punching holes on gaskets (of all required sizes for the offered transformer) etc. shall be supplied per lot.

25. Centre of Gravity

The centre of gravity of the assembled transformer shall be low and as near the vertical centre line as possible.

The transformer shall be stable with or without oil. If the centre of gravity is eccentric relative to track either with or without oil, its location shall be shown on the outline drawing.

26. Inspection and Testing

The manufacturer should have a well established Quality Assurance System in place and the QAP should be submitted for review and approval of KSEB Limited within 30 days from the date of purchase order. The manufacturer shall carry out a comprehensive inspection and testing program during manufacture of the equipment. The inspection envisaged by the Purchaser is given below. This is however not intended to form a comprehensive program as it is Supplier's responsibility to draw up and carry out such a program in the form of detailed quality plan duly approved by Purchaser for necessary implementation.

26.1. Inspection

26.1.1. Tank and Conservator

a)Check for flatness

b) Welder's qualification and welding procedure

c) Inspection of major weld preparation

d) Crack detection of major strength weld seams by dye penetration test

e) Measurement of film thickness of:

i Oil insoluble varnish

ii Zinc chromate paint

iii Finished coat

f) Check correct dimensions between wheels, demonstrate turning of wheels through 90 degree and further dimensional check.

g) Check for physical properties of materials for lifting lugs, jacking pads, etc. All load bearing welds including lifting lug welds shall be subjected to Non Destructive Testing.

h)Leakage test of the conservator
i) Certification of all test results
j)Test for proper and effective shielding of tank

26.1.2. **Core**

a. Sample testing of core materials for checking specific loss, bend properties, magnetization characteristics and thickness
b. Check on the quality of varnish if used on the stampings:
   i) Measurement of thickness and hardness of varnish on stampings
   ii) Solvent resistance test to check that varnish does not react in hot oil
   iii) Check overall quality of varnish by sampling to ensure uniform shining colour, no bare spots, no over burnt varnish layer and no bubbles on varnished surface
c. Check on the amount of burrs
d. Bow check on stampings
e. Check for the overlapping of stampings. Corners of the sheet are to be part.
f. Visual and dimensional check during assembly stage
g. Check for inter-laminar insulation between core sectors before and after pressing
h. Visual and dimensional checks for straightness and roundness of core, thickness of limbs and suitability of clamps
i. High voltage test (2 kV for one minute) between core and Yoke clamps, Yoke clamps to tank and Core to Tank
j. Certification of all test results

26.1.3. **Insulation Material**

a. Sample check for physical properties of materials
b. Check for dielectric strength
c. Visual and dimensional checks
d. Check for the reaction of hot oil on insulating materials
e. Dimension stability test at high temperature for insulating material
f. Tracking resistance test on insulating material
g. Certification of all test results

26.1.4. **Winding**

a. Sample check on winding conductor for mechanical properties and electrical conductivity
b. Visual and dimensional checks on conductor for scratches, dent marks etc.
c. Sample check on insulating paper for pH value, bursting strength and electric strength
d. Check for the reaction of hot oil on insulating paper
e. Check for the bonding of the insulating paper with conductor
f. Check and ensure that physical condition of all materials taken for windings is satisfactory and free of dust
g. Check for absence of short circuit between parallel strands
h. Check for brazed joints wherever applicable
i. Measurement of voltage ratio to be carried out when core/yoke is completely restacked and all connections are ready
j. Conductor enamel test for checking of cracks, leakage and pin holes
k. Conductor flexibility test
l. Heat shrink test for enameled wire m.
Certification of all test results

26.1.5. **Checks Before Drying Process**

a. Check condition of insulation on the conductor and between the windings.
b. Check insulation distance between high voltage connections, cables and earth and other live parts
c. Check insulating distances between low voltage connections and earth and other parts
d. Insulation of core shall be tested at 2 kV/minute between c o r e and Yoke clamps, Yoke clamps to tank and Core to Tank
e. Check for proper cleanliness and absence of dust etc.
f. Certification of all test results

26.1.6. **Checks During Drying Process**

a. Measurement and recording of temperature, vacuum and drying time during drying process
b. Check for completeness of drying by periodic monitoring of dryness
c. Certification of all test results

26.1.7. **Assembled Transformer**

a. Check completed transformer against approved outline drawings, provision for all fittings, finish level etc.
b. Jacking test of Transformer in oil-filled condition (excluding separately mounted cooler bank)
c. Dye penetration test shall be carried out after the jacking test

26.1.8. **Bought Out Items**

The makes of all major bought out items shall be subject to Purchaser's approval for 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/ Individual Marshalling box and common marshalling box as applicable
h) Cooling equipment
i) Oil pumps
j) Fans/Air Blowers
k) Tap change gear
l) Pressure relief device.

The above list is not exhaustive and the Supplier shall also include other bought-out items in his program .

26.2. **Factory Tests**

The manufacturer shall be fully equipped to perform all the required tests as specified. Bidder shall confirm the capabilities of the proposed manufacturing plant in this regard when submitting the bid. Any limitations shall be clearly stated in.

The supplier shall bear all additional costs related to tests which are not possible to carry out at his own works.

The supplier shall submit an Inspection and test plan (ITP) for approval. A typical test plan is indicated in "**Annexure-E".**

All tests shall be done in line with IS 2026/IEC-60076 and the test procedures as mentioned in "**Annexure-E".** Complete test report shall be submitted to purchaser after proper scrutiny and signing on each page by the testing engineer of the supplier.

26.3 Type Tests on fittings:

The following fittings shall conform to type tests as per relevant IS/IEC and the type test reports shall be furnished by the supplier along with the drawings of equipment/ fittings.

1) OLTC
2) Buchholz relay
3) Cooler Control cabinet, O L T C D M box
4) Pressure Relief device Test

The pressure Relief Device of each size shall be subjected to increase in oil/ air pressure. It shall operate before reaching the test pressure specified in transformer tank pressure test above. 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 of IS 13947/Equivalent IEC standard.

5) Magnetic Oil Level gauge & Terminal Box.

6) Air Cell (Flexible air separator) - Oil side coating, Air side under Coating, Air side outer coating and coated fabric as per IS: 3400/ BS: 903/ IS: 7019

7)OTI & WTI

8) Oil pump
9)Cooling fan and motor assembly
10)Bushings

26.4. Pre-Shipment Checks at Manufacturer's Works

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

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

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

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

27 Packing

The packing may be in accordance with the supplier's standard practice but full particulars of packing shall be submitted for the approval of the purchaser. Special arrangement should be made to facilitate handling and to protect and projecting connections from damage in transit. Vibration monitoring device shall be fitted on the transformer to monitor the vibration during transit. The transformer shall be shipped in Nitrogen filled condition. All parts shall be adequately marked to facilitate field erection. Boxes and crates shall be marked with the contact number and shall have a packing list enclosed showing the parts contained therein, weight and special lifting and storing instruction if any.

As the equipment is liable to be stored in the open, packing shall be suitable for outdoor storage under humid atmospheric conditions.

28. Receipt and Storage Checks

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

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

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

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

29 Supervision of Erection & Commissioning

Supervision of erection of the transformers and commissioning of the transformers are in the scope of the supplier as already stated in clause 1.1.

Annexure – A

Standard Technical Particulars / Parameters.
(220/110/11kV, 160MVA 3-Phase Auto Transformer)

Cl. No.	Description	Unit	TECHNICAL PARAMETERS
1	Rated Capacity		
1.1	HV	MVA	160
1.2	IV	MVA	160
1.3	LV (Tertiary: For Stabilizing)	MVA	53.33
2	Voltage ratio	kV	220/110/11
3	Single / Three Phase Design		Three
4	Applicable Standard		IS 2026/IEC 60076
5	Frequency	Hz	50
6	Cooling & Percentage Rating at different cooling		ONAN/ONAF/(ODAF) : 60% / 80%/100%
7.1	Type of Transformer		Outdoor Type Interconnection Power Transformer
7.2	Type of Transformer		Constant Ohmic impedance type (Refer Note1)
8	Polarity		Subtractive
9	Voltage variation on supply side		+ / - 10%
10	Frequency variation on supply side		+ / - 5%
11	Transient condition		- 20% or + 10% combined variation of voltage and frequency
12	Radio interference Voltage		Maximum 250 µV.
13	HV-IV Impedance at 75 Deg C at Principal Tap	%	% impedance at principal tap at rated voltage, frequency at 160 MVA Base shall be **10.32%, with a tolerance of +10%.** (Match with existing transformer with % impedance for parallel operation with existing single phase units as below: Tap-1 – 10.268 Tap-5 – 10.322
14	Type of insulating media		Immersed in mineral Oil
15	Losses		
15.1	No load losses in kW		Maximum no load loss at rated condition allowed without any positive tolerance shall be 30 kW

15.2	Load loss at principal tap		Maximum load loss at rated condition @ 75°C and principal tap allowed without any positive	
15.3	Auxilliary losses		Maximum guaranteed auxiliary losses at rated voltage and frequency of aux. supply shall be **6**	
16	Loss Capitalization formula		As per CBIP manual section-AA (Publication No.317, 2013)	
16.1	Capitalized value of No load loss per kW (in Indian Rupees)		Rs. **4,72,003**/-per kW	
16.2	Capitalized value of load loss per kW (in Indian Rupees)		Rs. **2,51,106**/-per kW	
16.3	Capitalized value of auxiliary load loss per kW (in Indian Rupees)		Rs. **1,88,801**/-per kW	
17	Service		OUTDOOR	
18	Duty		CONTINUOUS	
19	Overload Capacity		IS 6600/IEC 60076-7, IEC 354	
20	Temperature rise over 50°C Ambient Temp			
20.1	Top oil measured by thermometer	Deg. C	45	
20.2	Average winding temperature measured by Thermometer	Deg. C	50	
23	Design Clearances in mm.		Phase to Earth	Phase to Phase
	Highest System voltage of 245kV	mm.	1800	2000
	Highest System voltage of 145kV	mm.	1050	1220
	Highest System voltage of 33kV	mm.	320	350
	Highest System voltage of 11kV	mm.	140	280
24	Windings			
24.1	System Fault level			
	HV	kA	50	
	IV	kA	31.5	
	LV	kA	25	
24.2	Lightning Impulse withstand Voltage			
	HV	kVp	1050	
	IV	kVp	650	
	LV	kVp	170	
	Neutral	kVp	95	
24.3	One Minute Power Frequency withstand Voltage			

	HV	kVrms	460
	IV	kVrms	275
	LV	kVrms	70
	Neutral	kVrms	38
25	Neutral Grounding		Solidly grounded
26	Insulation		
	HV		GRADED
	IV		GRADED
	LV		UNIFORM
27	Tertiary Connection		DELTA
28	Tan delta of winding	%	< 0.5%
29	Vector Group (3 –ph) (unless specified differently elsewhere)		YNa0d11
30	Tap Changer		OLTC. Shall be suitable for bi-directional power flow.
30.1	Tap Range & No. of steps		+2.5% to -12.5% of HV variation in the step of 1.25%,
30.2	Location of Tap changer		On the HV winding.
30.3	Design		Constant flux voltage variation type as per IS 2026
30.4	Tap control		Full capacity - on load tap changer suitable for group / independent, remote /local electrical and local manual operation and bi-
31	Bushings		
31.1	Rated voltage		
	HV	kV	245
	IV	kV	145
	LV	kV	36
	Neutral	kV	36
31.2	Rated current (Min.)		
	HV	A	800
	IV	A	1250
	LV	A	3150
	Neutral	A	2000
31.3	Lightning Impulse withstand Voltage		
	HV	kVp	1050
	IV	kVp	650
	LV	kVp	170
	Neutral	kVp	95

31.4	One Minute Power Frequency withstand Voltage		
	HV	kVrms	460
	IV	kVrms	275
	LV	kVrms	95
	Neutral	kVrms	38
31.5	Minimum total creepage distances		
	HV	mm	6125
	IV	mm	3625
	LV	mm	900
	Neutral	mm	900
31.6	Tan delta of bushing		
	HV	%	<0.5%
	IV	%	<0.5%
	LV	%	N.A
	Neutral	%	N.A
31.7	Max Partial discharge level at Um		
	HV	pC	10
	IV	pC	10
	Max Partial discharge level at 1.5Um/√3	pC	100
32	Max Noise level at rated voltage and at principal tap on full load and all cooling active	dB	Shall not exceed limits as per NEMA TR1 with all accessories running, measured as per standard
33	Auxiliary supply to OLTC, oil pumps and cooler fans		3 Phase, 415V ± 10%
34	Auxiliary DC supply for alarm and tripping (volt)		110V DC
35	Width of rail gauge		1676 mm

Notes:

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

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

2. Tan delta of Winding & Bushing shall be measured at ambient temperature.

Annexure-B

Specification for Transformer Insulating Oil.
(IS 335)

TRANSFORMER OIL:

Sl. No.	Characteristics.	Requirement	Methods of Test.
1.	*Appearance*	The oil shall be clear and transparent and free from suspended matter or sediment.	A representative sample of oil shall be examined in a 100 mm thick layer at ambient temperature.
2.	Density at 20°C Max.	0.89 g/cm3	IS.1448,ISO 3675/12185
3.	Kinematic Viscosity at 27°C Max.	27 CST	IS.1448
4.	Interfacial tension at 27°C Min.	0.04 N/m	IS.6104,ISO 6295
5.	Flash point (Penskey Marten – closed cup)	140oC(Min.)	IS.1448,ISO2719
6.	Pour point	-6 (Max.)	IS.1448,IEC 60296, ISO 3016
7.	Neutralization value (total acidity) Max.	0.03 mg KOH/g	IS.335 Appx.A. IEC62021-1
8.	Corrosive sulphur (in term of classification of copper strip)	Non-corrosive	IS.335 Appx.B. DIN51353, BS2000 PART373
9.	Electric strength (break down voltage) Min.		
	a) New untreated oil	30KV(rms) (if the above value is not attained, the oil shall be treated.	IS.6792 IEC 60814
	b)After treatment	60KV(rms)	IS.6792. IEC 60814
10.	Dielectric dissipation factor (tan delta) at 90oC Max.	0.002	IS.6262 IEC60247/61620
11	Specific resistance (resistivity)		
	a)at 90°C Min.	$35x10^{12}$ ohm-cm	IS.6103
	b)at 27°C Min.	$1500x10^{12}$ ohm-cm	
12	Oxidation stability		IEC 61125 part C

	a) Neutralization value after oxidation (Max.)	0.40 mg/KOH/g	
	b) Total sludge after Oxidation Max.	0.10 percent by weight.	
13.	Presence of oxidation inhibitor.	The oil shall not contain anti-oxidant inhibitors.	IS.335 Appendix .D
14	Water contents Max.	50 ppm	IS.2362.IEC 60814
15	Ageing characteristics After 96 hrs. with catalyst (copper)		
	a) Resistivity		As per ASTM –D 1934.
	i) 27oC	$2.5x10^{12}$ ohm cm.	
	ii) 90oC	$0.2x10^{12}$ ohm cm.	
	b) Tan delta at 90oC	0.2 (Max.)	
	c) Total acidity	0.05 mg/KOH/gm (Max.)	
	d) Total Sludge content % by mass	0.05% (Max.)	

Annexure- C

Design Details

Sr. No.	Description
1.	Core and Magnetic Design
2.	Over-fluxing characteristics up to 1.7Um
3.	Inrush-current characteristics while charging from HV & IV respectively.
4.	Winding and tapping design
5.	Short-circuit withstand capability including thermal stress for min. 2 Sec.
6.	Thermal design including review of localized potentially hot area.
7.	Cooling design
8.	Overload capability
9.	Eddy current losses
10.	Seismic design, as applicable
11.	Insulation co-ordination
12.	Tank and accessories
13.	Bushings
14.	Tap changers
15.	Protective devices
16.	Fans, pumps and radiators
17.	Sensors and protective devices– its location, fitment, securing and level of redundancy
18.	Oil and oil preservation system
19.	Corrosion protection
20.	Electrical and physical Interfaces with substation
21.	Earthing (Internal & External)
22.	Processing and assembly
23.	Testing capabilities & Detailed test procedure.
24.	Inspection and test plan
25.	Transport and storage
26.	Sensitivity of design to specified parameters
27.	Acoustic Noise
28.	Spares, inter-changeability and standardization
29.	Maintainability
30.	PRD and SPR (number & locations)

31.	Conservator capacity calculation
32.	Winding Clamping arrangement details with provisions for taking it “in or out of tank”
33.	Conductor insulation paper details
34.	Location of Optical temperature sensors
35.	The design of all current connections
36.	Location & size of the Valves

Annexure – D

Painting Procedure

Painting	Surface preparation	Primer coat	Intermediate undercoat	Finish coat	Total dry film thick-ness (DFT)	Colour shade
Main tank, pipes, conservator tank, oil storage tank& DM Box etc. (external	Shot Blast cleaning Sa 2 ½*	Epoxy base Zinc primer (30-40 m)	Epoxy high build Micaceous iron oxide (HB MIO) (75 m)	Aliphatic polyurethan e (PU) (Minimum 50 m)	Minimum 155 m	Shade no.631 of IS 5 or equivalent
Main tank, pipes (above 80 NB), conservator tank, oil storage tank & DM Box etc. (Internal	Shot Blast cleaning Sa 2 ½*	Hot oil proof, low viscosity varnish or Hot oil resistant, non- corrosive Paint	--	--	Minimum 30 m	Shade no.631 of IS 5 or equivalent
Radiator (external surfaces)	Chemical / Shot Blast cleaning Sa 2	Epoxy base Zinc primer (30-	Epoxy base Zinc primer (30-40 m)	PU paint (Minimum 50 m)	Minimum 100 m	Shade no.631 of IS 5 or equivalent

	supplier may also offer Radiators with hot dip galvanized in place of painting with minimum thickness of 40 m (min)					
Radiator and pipes up to 80 NB (Internal surfaces)	Chemical cleaning, if required	Hot oil proof, low viscosity varnish or Hot oil resistant, non- corrosive	--	--	--	--
Digital RTCC Panel	Seven tank process as per IS:3618 & IS:6005	Zinc chromate primer (two coats)	--	EPOXY paint with PU top coat or POWDER	Minimum 80 m / for powder coated minimum	Shade no.631 of IS 5 or equivalent

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

Annexure -E

Test Plan

No.	Test	
1.	Measurement of winding resistance	Routine
2.	Voltage ratio measurement	Routine
3.	Polarity test	Routine
4.	No-load loss and excitation current measurement	Routine
5.	Magnetic balance test (for three phase Transformer only)	Routine
6.	Impedance and load loss measurement	Routine
7.	Measurement of insulation resistance & Polarization Index	Routine
8.	Measurement of insulation power factor and capacitance between	Routine
9.	Chopped wave lightning impulse test for the line terminals	Routine
10.	Full wave lightning impulse test for the line terminals (LI)	Routine
11.	Measurement of transferred surge on LV (Tertiary) as applicable	Type
12.	Induced voltage withstand test (IVW) with PD	Routine
13.	Applied voltage test (AV)	Routine
14.	On-load tap changer test(Ten complete cycle before LV test)	Routine
15.	Gas-in-oil analysis	Routine
16.	Core assembly dielectric and earthing continuity test	Routine
17.	Oil leakage test on transformer tank	Routine

18.	Appearance, construction and dimension check	Routine
19.	Measurement of no load current & Short circuit Impedance with	Routine
20.	High voltage with stand test on auxiliary equipment and wiring after	Routine
21.	Tank vacuum test	Routine
22.	Tank pressure test	Routine
23.	Lightning impulse test for the neutral terminals (LIN)	Type
24.	Temperature rise test	Type
25.	Measurement of Zero seq. reactance (for three phase Transformer only)	Type
26.	Measurement of harmonic level in no load current	Type
27.	Measurement of acoustic noise level	Type
28.	Measurement of power taken by fans and oil pumps (Not applicable for ONAN)	Type
29.	Dynamic Short circuit withstand test	Type
30.	DGA tests before and after conducting the Temperature Rise	Type
31.	Pressure Relief Device Test	Type

Annexure - G

1.1 KV GRADE POWER & CONTROL CABLES

1 Approval shall be obtained for all Power & Control cables used for cabling purposes.

2 Separate cables shall be used for AC & DC.

3 At least one (1) core shall be kept as spare in each copper control cable of 4C, 5C or 7C size whereas minimum no. of spare cores shall be two (2) for control cables of 10 core or higher size.

4 Copper wires used for manufacturing the cables shall be true circular in shape before stranding and shall be uniformly good quality, free from defects.

5 The fillers and inner sheath shall be of non-hygroscopic, fire retardant material, shall be softer than insulation and outer sheath shall be suitable for the operating temperature of the cable.

6 Progressive sequential marking of the length of cable in metre at every one metre shall be provided on the outer sheath of all cables.

7 Strip wire armouring method (a) mentioned in Table 5, Page-6 of IS: 1554 (Part 1) – 1988 shall not be accepted for any of the cables. For control cables only round wire armouring shall be used.

8 The cables shall have outer sheath of a material with an oxygen index of not less than 29 and a temperature index of not less than 250°C.

9 All the cables shall conform to fire resistance test as per IS: 1554 (Part - I).

10 The normal current rating of all PVC insulated cables shall be as per IS: 3961.

11 Repaired cables shall not be accepted.

12 Allowable tolerance on the overall diameter of the cables shall be plus or minus 2 mm.

13 **PVC Power Cables**

13.1 The PVC (70°C) insulated 1100V grade power cables shall be of FR type, C1 category, conforming to IS: 1554 (Part-I) and its amendments read along with this specification and shall be suitable for a steady conductor temperature of 70°C. The conductor shall be stranded copper. The Insulation shall be extruded PVC to type-A of IS: 5831. A distinct inner sheath shall be provided in all multi core cables. For multi core armoured cables, the inner sheath shall be of extruded PVC. The outer sheath shall be extruded PVC to Type ST-1 of IS: 5831 for all cables.

14 **PVC Control Cables**

14.1 The 1100V grade control cables shall be of FR type C1 category conforming to IS: 1554 (Part-1) and its amendments, read along with this specification. The conductor shall be stranded copper. The insulation shall be extruded PVC to type A of IS: 5831. A distinct inner sheath shall be provided in all cables whether armoured or not. The over sheath shall be extruded PVC to type ST-1 of IS: 5831 and shall be grey in colour except where specifically advised by the Employer to be black.

14.2 Cores shall be identified as per IS: 1554 (Part-1) for the cables up to five (5) cores and for cables with more than five (5) cores the identification of cores shall be done by printing legible Hindu Arabic Numerals on all cores as per clause 10.3 of IS : 1554 (Part - 1).

STANDARD TECHNICAL DATA SHEET - 1.1kV kV GRADE PVC CONTROL CABLES

SN	Description	Parameters							
1a	Cable Sizes	2 c x 2.5	3c x 2.5	5c x 2.5	7 c x 2.5	10 c x 2.5	14 c x 2.5	19 c x 2.5	27 c x 2.5
1b	Manufacturer's type designation	YWY	YWY	YWY	YWY	YWY	YWY	YWY	YWY
2	Applicable standard	IS: 1554/PT-I/1988 & its referred standards							
3	Rated Voltage(volts)	1100 V grade							
4	Type & Category	FR & C1							
5	Suitable for earthed or unearthed system	for both							
6	Continuous current rating when laid in air in a ambient temp. of 50oC and for maximum conductor temp. of 70°C of PVC Cables [For	22	19	19	14	12	10.5	9.7	8
7	Rating factors applicable to the current ratings for various conditions of installation:	As per IS-3961-Pt-II-67							
8	Short circuit Capacity								

a)	Short Circuit Amp. (rms)KA for 1 sec duration	0.285	0.285	0.285	0.285	0.285	0.285	0.285	0.285
b)	Conductor temp. allowed for the short circuit duty	160 C							
9	Conductor								
a)	Material	Plain annealed High Conductivity stranded Copper (as per IS:8130/84)							
b)	Grade	Electrolytic							
c)	Cross Section area (Sq.mm.)	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5
d)	Number of wires(No.)	as per Table 2 of IS 8130							
e)	Form of Conductor	Non-compacted Stranded circular shaped conductor							
f)	Direction of lay of stranded layers	Outermost layer shall be R.H lay							
10	Conductor resistance (DC) at 20 oC per km-maximum	7.41	7.41	7.41	7.41	7.41	7.41	7.41	7.41
11	Insulation								
a)	Composition of insulation	Extruded PVC type A as per IS-5831-84							
b)	Nominal thickness of insulation(mm)	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9
c)	Minimum thickness of insulation	0.71	0.71	0.71	0.71	0.71	0.71	0.71	0.71
12	Inner Sheath								
a)	Material	Extruded PVC type ST I as per IS-5831-84							
b)	Calculated diameter over the laid up cores,(mm)	7.2	7.8	9.7	10.8	14.4	15.9	18	22.1
c)	Thickness of Sheath (minimum)mm	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3
13	Armour	as per IS 3975/99							
a)	Type and material of armour	Gal. Steel Wire							
b)	Direction of armouring	left hand							

c)	Calculated diameter of cable over inner sheath (under armour) mm	7.8	8.4	10.3	11.4	15	6.5	18.6	22.7
d)	Nominal diameter of round armour wire/strip	1.4	1.4	1.4	1.4	1.6	1.6	1.6	1.6
e)	Number of armour wires/strips	Armouring shall be as close as practicable							
f)	Short circuit capacity of the armour along for 1 sec for info only	0.05 x AVt (K Amp)(where A = total area of armour in mm2 & t = time in seconds)							
g)	DC resistance at 20 oC (Ω/Km) & Resistivity	As per IS 1554 Part (1), wherever applicable and IS 3975-1999							
14	Outer Sheath								
a)	Material (PVC Type)	ST-1& FR							
b)	Calculated diameter under the sheath	10.6	11.2	13.1	14.2	18.2	19.7	21.8	25.9
c)	Min.thickness of sheath(mm)	1.24	1.24	1.24	1.24	1.4	1.4	1.4	1.56
d)	Guaranteed value of minimum oxygen index of outer sheath at 27°C	Min 29.0	Min 29.0	Min 29.0	Min 29.0	Min 29.0	Min 29.0	Min 29.0	Min 29.0
e)	Guaranteed value of minimum temperature index at 21 oxygen	Min 250	Min 250	Min 250	Min 250	Min 250	Min 250	Min 250	Min 250
f)	colour of sheath	Grey	Grey	Grey	Grey	Grey	Grey	Grey	Grey
15a)	Overall diameter of	$							
b)	Tolerance on overall diameter (mm)	+2/-2 mm							
16	Cable Drums	shall conform to IS 10418 and technical specification							
a)	Max./ Standard length per drum for each size of cable (single length) with ±5% Tolerance (mtrs)	1000/500							

b)	Non standard drum lengths	Maximum one(1) non standard lengths of each cable size may be supplied in drums only over & above the standard lengths as specified above.(if required for completion of project)							
17	Whether progressive sequential marking on outer sheath provided								
18	Identification of cores	Yes							
a)	colour of cores	R & Bk	R, Y & Bl	Red R,Y,Bl	Grey	Grey	Grey	Grey	Grey
b)	Numbering	N.A	N.A	N.A	Numerals in black ink				
19	Whether Cables offered are ISI marked	YES							
20	Whether Cables offered are suitable for laying as per IS 1255	YES							

$'- As per manufacturer design data

Sd/-
Chief Engineer(SCM)

BIDDING SCHEDULE
(To be filled in and signed by the Bidder)
SCHEDULE 'A'
SCHEDULE OF GUARANTEED TECHNICAL PARTICULARS FOR 220/110/11kV, 160MVA THREE PHASE AUTO TRANSFORMERS

No.	Particulars	Offered

A	**General Data of Bidder**	
1	Name of Manufacturer	
2	Country of Origin	
3	Business Type of Company (eg. Manufacturer/ Supplier / Transporter etc.)	
B	**General Data of the Transformer**	
1	Conforming Applicable Standards (including Bushing & other)	
2	Conceptual Design of Transformer (e.g. Outdoor oil immersed core type /Indoor dry core type/etc)	
3	Type of Operation of the Transformer (e.g. Interconnection / Distribution/ Generator step-up) * Interconnection means used in Transmission Grid SS	
4	Rated Frequency (in Hz)	
5	Rated Frequency (in Hz)	
6	Rated MVA Capacity Of the Transformer iv) HV v) IV vi) LV (Tertiary)	
7	Rated No-load Voltage of the Transformer 4. HV 5. IV	

	6. LV (Tertiary)	
8	No Load Current in percent of Full Load current at rated KV & rated frequency at Normal Tap	
9	Vector Group	
10	Type of Cooling	
11	Method of Neutral Grounding	
12	Rated No load Voltages of windings in kV d) HV Winding e) IV Winding f) LV – Tertiary winding	
13	Normal ratio of transformation	
14	Rated Current in Ampere. d) HV Winding e) IV Winding f) LV- Tertiary winding	
15	Overload capacity	
16	Width of Track gauge (in mm)	
C	**Thermal Data**	
1	Temperature rise of top oil (in ° C) above ambient temperature of 50 °C measured by thermometer with ONAN/ONAF/ODAF cooling	
2	Temperature rise of winding measured by resistance : With ONAN/ONAF/ODAF cooling, in ° C	

3	Limit of hot spot temperature in ° C for which the transformer is designed	
4	Temperature gradient between Oil & Winding.	
5	Limit for hot spot temperature for which transformer is designed.	
D	**Impedance Data**	
1	Percentage Impedance at rated current and frequency at 75 ° C(with tolerance) 4) At maximum tap 5) At Normal tap 6) At Lowest tap	
2	Reactance of windings in ohm at 75 ° C d) At maximum tap e) At Normal tap f) At Lowest tap	
3	Resistance of windings in ohm at 75 ° C d) At maximum tap e) At Normal tap f) At Lowest tap	
4	Zero Sequence Impedance at 75 ° C at 100% rating a. At maximum tap b. At Normal tap c. At Lowest tap	
E	**Guaranteed Loss**	
1	Guaranteed no load loss (KW) on principal tap at rated voltage and Frequency & tolerance, if any	
2	No load loss at rated voltage and frequency at highest tap (max.)	

3	Guaranteed load loss at rated current at rated voltage, rated frequency and 75° C average winding temperature, kW (excluding aux. losses). At principal tap a.For ONAN cooling b.For ONAF cooling c.For ODAF cooling At maximum tap a.For ONAN cooling b.For ONAF cooling c.For ODAF cooling At minimum tap a.For ONAN cooling b.For ONAF cooling c.For ODAF cooling	
4	Guaranteed copper loss (KW) on principal tap at rated voltage and Frequency & tolerance, if any	
5	Maximum Auxiliary Loss (KW)	
6	Total losses at normal ratio, rated output, rated voltage, rated frequency and maximum attainable temperature at site including auxiliary losses.	
7	Time for which the transformer can be run at full load without exceeding the max. permissible temperature at reference temperature when power supply to fans is cut off (in minutes)	
8	Exciting current and power factor	
F	**Efficiency & Regulation**	

1	Efficiency (in percent) at unity power factor at 75°C	
	At 110% Load	
	At 100% Load	
	At 75% Load	
	At 50% Load	
	At 25% Load	
2	Efficiency (in percent) at 0.85 power factor (Lag) at 75°C	
	At 110% Load	
	At 100% Load	
	At 75% Load	
	At 50% Load	
	At 25% Load	
3	Maximum Efficiency %	
4	% Load and power factor at which Max efficiency occurs	
5	Regulation at Unity Power factor	

6	Regulation at 0.8 lagging Power factor	
G	**Radiators**	
1	Overall dimensions l x b x h ,mm	
2	Total weight with oil, Kg	
3	Total weight without oil	
4	Vacuum withstand capacity, *tor*	
5	Capacity of cooling units	
6	Mounting of radiators	
7	Number of radiators	
8	Type & size of individual radiator valve	
9	Total radiating surface, sq.mm	
10	Thickness of radiator tubes, mm	
11	Oil drain plug and air release plug provided on each radiator Yes/No	
12	Schematic flow diagram of the cooling system furnished (Yes/No)	
H	**Cooling System**	
	Cooling Fans	
1	Make and type	
1.1	No. of fans in each group excluding standby fans	

1.2	No. of connected units	
1.3	No. of standby units	
1.4	Rated power input, watts	
1.5	Capacity (cum/minute)	
1.6	Rated voltage,	
1.7	Locked rotor current,	
1.8	Efficiency of motor at full load, %	
1.9	Temp.rise of motor at full load, °C	
1.10	Temperature range over which the control is adjustable, °C	
1.11	Whether fans suitable for continuous operation	
1.12	Period of continuous working at full load without fan for ONAN/ONAF	
1.13	Continuous MVA rating without fan for ONAN/ONAF	
2	**Cooling Oil pumps**	
2.1	Make and type	
2.2	No. of oil pumps on each group excluding standby pump	
2.3	No. of connected units in each group.	
2.4	No. of standby units for each group.	

2.5	No. Of radiator/ cooling groups	
2.6	Rated power input of each pump, watts	
2.7	Capacity (cum/minute)	
2.8	Rated voltage,	
2.9	Locked rotor current,	
2.10	Efficiency of motor at full load, %	
2.11	Temp.rise of motor at full load, °C	
2.12	Temperature range over which the control is adjustable, °C	
2.13	Whether oil pumps suitable for continuous operation	
2.14	Estimated time constant in hours for 1. Natural cooling (ONAN) 2. Forced air cooling (ONAF) 3. Forced oil cooling (ODAF)	
2.15	Period of continuous working at full load without fan or oil pump.	
3	**Cooling Calculations shall be submitted**	
I	**Core**	
1	Type of core construction	
2	Type of core joints	
3	Net core area in sq. metre	
4	Core material & grade of sheet HIB or better	

5	Thickness of lamination mm	
6	Insulation of core lamination, mm	
7	Specific loss of core material (Watts/Kg)	
8	Whether core construction is without core bolts	
9	Insulation of core bolt washers	
10	Insulation between core laminations	
11	Core bolt insulation power frequency withstand test voltage for 1 mt.	
12	Are the core bolts grounded, if so how?	
13	Details of oil duct	
14	Whether in the plane and at right angle to the plane of winding	
15	Across the plane of laminations	
16	Design flux density of the core at rated voltage & frequency at principal tap, Tesla	
16.1	1. Core	
16.2	2. Yoke	
17	Maximum flux density allowed in the core at extreme over excitation / over fluxing , Tesla	
17.1	Power factor of Magnetizing current at normal ratio and frequency	

17.2	85 % of rated voltage	
17.3	100 % of rated voltage	
17.4	105 % of rated voltage	
17.5	110 % of rated voltage	
18	Power factor of Mag. Current at normal voltage ratio and frequency	
19	Over Excitation withstand time (secs) at 110% / 125% /140%	
20	Materials of core clamping plate	
21	Thickness of core clamping plate	
22	Insulation of core clamping plate	
23	Describe Location/ method of core grounding	
24	Details of oil ducts in core	
25	Equivalent cross section area of core, mm2	
26	Guaranteed No load current at 90% /100% / 110% rated voltage & frequency(Amp)	
26.1	HV	
26.2	IV	
26.3	LV	

27	Noise level (in db) when energized at normal voltage and normal frequency at no load.	
J	**Winding**	
1	No. of winding	
2	Type of Winding (eg. Helical / Disc/ layer /pancake) HV IV LV	
3	Arrangement of main winding & Geometrical sequence	
4	Winding material HV IV LV	
5	Maximum current density allowed, Amp per mm2 HV IV LV	
6	Whether windings are Interleaved (HV/IV/LV)	
7	Whether HV windings are Preshrunk (HV/IV/LV)	
8	Whether electro-static shields are provided to obtain uniform voltage distribution in the windings	
9	Gauge/area of cross section of conductor, mm2 HV IV LV	

10	Maximum current density achieved in winding Amps/ mm2 4) HV 5) IV 6) LV	
11	Insulating material used for: HV turn IV turn Tap winding to earth LV turn LV to core Between HV & IV Between IV & LV Between HV & LV (as applicable)	
12	Insulation material thickness in mm used for: HV turn IV turn Tap winding to earth LV turn LV to core Between HV & IV Between IV & LV Between HV & LV (as applicable)	
13	Type of coil axial support 4) HV winding 5) IV winding 6) LV winding	
14	Type of coil radial support d) HV winding e) IV winding f) LV winding	

15	Weight of support insulators including insulation cylinders	
16	Maximum allowable torque on coil clamping bolts	
17	Inter-turn insulation	
18	Extent of extreme end turns reinforcement	
19	Extent of end turns reinforcement	
20	Extent of turns adjacent to tappings	
21	Test voltage for 10 Seconds 50 cycles inter turn insulation test for Cl.J16, kV rms	
22	Test voltage for 10 Seconds 50 cycles inter turn insulation test for Cl. J 17, (28.17.2), kV rms	
23	Test voltage for 10 Seconds 50 cycles inter turn insulation test for Cl.J 18, kV rms	
24	Test voltage for 10 Seconds 50 cycles inter turn insulation test on main body of the winding, kV rms	
K	**Tertiary Winding**	
1	Whether delta is formed internally	
2	Whether all three bushings are taken outside (YES/ NO)	
3	Design value of surges transferred on tertiary terminals	
3.1	For 1050 kVp, 1.2/ 50 µs surge striking on HV terminal and with a)Both tertiary terminals open	

	b)One terminal earthed.	
3.2	For 650 kVp, 1.2/ 50 µs surge striking on IV terminal and with c) Both tertiary terminals open d) One terminal earthed.	
L	**Minimum design clearance , mm**	
1	HV to earth in air	
2	HV to earth in oil	
3	IV to earth in air	
4	IV to earth in oil	
5	LV to earth in air	
6	LV to earth in oil	
7	Between HV & IV in Air	
8	Between HV & IV in Oil	
9	Between IV & LV in Air	
10	Between IV & LV in Oil	
11	Between HV & LV in Air	
12	Between HV & LV in Oil	
13	Top winding & Yoke	

14	Bottom winding & Yoke	
M	**Insulating Oil**	
1	Governing standard	
2	Type of oil	
3	Spec. resistance (ohmscm) at 27°C /90° C	
4	Tan delta	
5	Water content , ppm	
6	Dielectric strength (BDV), kV	
7	Characteristics of oil after ageing test	
8	Sludge content	
9	Neutralisation number	
10	Quantity of oil Ltrs	
11	In the transformer tank	
12	In each radiator	
13	Total quantity	
14	10% excess oil furnished?	
N	**Conservator**	
1	Details of oil preservation equipment offered	
2	Oil preservation system provided (Yes/No)	

3	Total volume of conservator (Ltr)	
4	Volume between highest and lowest visible oil levels (Ltr)	
5	Details of Air cell 5) Make 6) Type 7) Material 8) Capacity	
O	**Bushing Particulars**	
1	Manufacturer v) HV vi) IV vii) LV (Tertiary) viii) Neutral	
2	Type of bushings 5) HV 6) IV 7) LV (Tertiary) 8) Neutral	
3	Reference Standard 5 HV 6 IV 7 LV (Tertiary) 8 Neutral	
4	Rated Voltage in kV	HV IV LV Neutral
5	Rated Current in Amp.	
6	Lightning impulse voltage(1.20/50µSec.) in kVp	

7	Switching impulse voltage in kV	
8	Power Frequency Withstand Voltage (Dry)	
9	Power Frequency Withstand Voltage (Wet)	
9.1	Wet Flash over voltage, kV	
9.2	Dry Flash over voltage, kV	
10	Partial discharge level	
11	Creepage distance in mm	
12	Creepage distance (protected)	
13	Whether test tap is provided? If so, power frequency withstand test voltage of test tap,	
14	Quantity of oil used in bushing & specification of oil used.	
15	Weight of assembled bushing, Kg	
16	Minimum clearance height for removal of bushings, mm	
17	Recommended gap setting for Arcing horn	
18	Cantilever strength	
19	Terminal connections	
P	**Details of bushing CT**	

1	Purpose	
2	Installed on which bushing HV/IV	
3	No. of bushing CTs installed	
4	Type	
5	Make	
6	Reference standard	
7	No. of cores	
8	Whether TEST winding provided or not	
9	CT ratio	
10	Burden, VA	
11	Class of accuracy	
Q	**On Load Tap Changer**	
1	Make	
2	Type	
3	Total Tap Range (+) percent to (-) percent of Voltage	
4	Percent of Voltage per tap step	
5	No. of steps	
6	Time (in second) for total tap change	

7	Diverter selector switch transient time, cycles	
8	Power flow-uni directional/ bidirectional/restricted bi directional	
9	Rated voltage to earth, kV	
10	Rated currents, Amp	
11	Control – Manual / Local electrical / Remote electrical	
12	Is suitable for Parallel operation	
13	Protective devices	
14	Auxiliary supply details	
15	Value of maximum short circuit current, kA	
16	Maximum impulse withstand test voltage with 1.2/50µS, full wave between switch assembly and ground, kV peak	
17	Maximum Power frequency test voltage between switch assembly and earth, kV rms	
18	Maximum impulse withstand test voltage with 1.2/50µs, across the tapping range, kV peak	
19	Approx. overall dimensions of the tap changer (in case of separate tank type), mm	
20	Approx. overall weight, (in case of separate tank type), Kg	
21	Approx. mass of oil (in case of separate tank type), Kg	
22	Particulars of the OLTC control panel for installation in the control room (RTCC panel)	

23	Driving Mechanism box	
24	Make and Type	
25	Details of apparatus proposed	
R	**Details of protective devices**	
1	Pressure release device	
1.1	Make & Type	
1.2	Minimum pressure the device is set to rupture.	
1.3	Rain hood provided or not	
2	Explosion vent	
2.1	Type & make	
2.2	Minimum pressure the device is set to rupture.	
3	Bucholz relay of main tank	
3.1	Type & make	
3.2	No. of contacts	
4	Oil Surge relay	
4.1	Type & make	
4.2	No. of contacts	
5	OTI	
5.1	Make & Type	
5.2	No. of contacts	

5.3	Setting range	
6	WTI	
6.1	Make & Type	
6.2	No. of contacts	
6.3	Setting range	
7	Oil Level guage	
7.1	Type & make	
7.2	No. of contacts	
S	**Lifting Jacks**	
1	No. of jacks in one set	
2	Type and make	
3	Capacity (tonnes)	
4	Pitch, mm	
5	Lift, mm	
6	Height in closed position, mm	
7	Mean dia. of thread, mm	
T	**Alarm and trip contact ratings of protective devices**	
1	Rated / making / breaking currents , Amp & voltage for	
1.1	PRV for main tank and OLTC tank	
1.2	Bucholz relay	

1.3	OTI	
1.4	WTI	
1.5	Magnetic oil level gauge	
U	**Fittings accessories for each transformer are furnished as per different clauses in the specification (separate sheet giving details, make and bill of materials to be attached)**	
V	**Painting: as per annexure –D for the transformer, radiator, marshalling box, etc (Yes/No)**	
W	**Details of Tank**	
1	Material	
2	Approximate thickness of sheet	
3	Sides, mm	
4	Bottom, mm	
5	Cover (Top), mm	
6	Radiators, mm	
7	Pressure mm of Hg	
8	Vacuum recommended for Hot oil Circulation	
9	Vacuum to be maintained during oil filling in transformer tank	
10	Vacuum to which the tank can be subjected without distortion as per specification	
11	Confirmation of tank designed and tested for vacuum pressure (Ref: CBIP manual) (Yes/No)	

12	Is the tank lid slopped?	
13	Inspection cover provided(Yes/No)	
14	Location of inspection cover (Yes/No)	
15	Min. dimensions of inspection cover (provide list of all inspection cover with dimension), mm x mm	
16	No. of bi-directional wheels provided	
17	Track gauge required for the wheels in transverse axis	
18	Track gauge required for the wheels in longitudinal axis	
19	Type of pressure relief device/ explosion vent and the pressure at which it operates	
20	Minimum clearance height for lifting core and winding from tank, mm	
21	Minimum clearance height for lifting tank cover, mm	
22	**Over all transformer dimensions**	
22.1	Length , mm	
22.2	Breadth , mm	
22.3	Height , mm	
23	Transformer tank dimensions	
23.1	Length , mm	
23.2	Breadth , mm	
23.3	Height , mm	
24	Marshalling box dimensions	

24.1	Length , mm	
24.2	Breadth , mm	
24.3	Height , mm	
25	Weight data	
25.1	Core, Kg	
25.2	Frame parts, Kg	
25.3	Core and frame, Kg	
25.4	Weight of core clamp kg	
25.5	Weight of winding kg HV IV LV	
25.6	Total winding Kg	
25.7	Core and frame winding, Kg	
25.8	Tank, Kg	
25.9	Tank lid, Kg	
25.10	Empty conservator tank, Kg	
25.11	Each radiator empty , Kg	
25.12	Total weight of all radiator empty , Kg	
25.13	Weight of oil in tank , Kg	
25.14	Weight of oil in each conservator, Kg	

25.15	Weight of oil in each radiators, Kg	
25.16	Total weight of oil in radiator, Kg	
25.17	OLTC gear including oil , Kg	
25.18	Total transport weight of the transformer , Kg	
25.19	Total transport weight of the transformer with OLTC and all accessories, Kg	
26	Volume data	
26.1	Volume of oil in main tank, litres	
26.2	Volume of oil between highest and lowest levels of main conservator, litres	
26.3	Volume of oil between highest and lowest levels of OLTC conservator, litres	
26.4	Volume of oil in each radiator, litres	
26.5	Total volume of oil in radiators, litres	
26.6	Volume of oil in OLTC, litres	
26.7	Transformer total oil volume , litres	
27	Shipping data	
27.1	Weight of heaviest package, kG	
27.2	Dimensions of the largest package (L xB x H) mm	
X	**Tests**	
1	All in process tests confirmed as per Cl.25.1 & Annexure-F (Yes /No)	
2	All types tests confirmed as per Cl. 25.2 and Annexures E,F (Yes / No)	
3	All routine tests confirmed as per 25.2	

	and Annexures E,F (Yes / No)	
3	All special tests confirmed as per Annexure E and Cl. 25.2 (Yes / No)	
Y	**Others**	
1	Transformer will be transported with oil/gas/dry air	
2	Quality Assurance Plan:	
3	An outline of quality assurance plan used by the bidder To be submitted attached	
4	General warranty for the transformer	
5	Test procedure	
Z	**Important design parameters**	
1	Maximum no load loss at rated condition allowed without any positive tolerance (kW).	
2	Maximum load loss at rated condition @ 75°C and principal tap allowed without any positive tolerance (kW).	
3	Grade of core sheet, Hi-B or better	
4	Type of winding for HV	
5	Design value of flux density	
6	Design value of current density	
7	Weight of HV winding	
8	Weight of LV winding	
9	Weight of support insulators including insulation cylinders	
10	Weight of core(kg)	

11	Weight of core clamp	
12	Per turn voltage	
13	Conductor cross sectionHV LV	
14	Winding stack height(mm)	
15	Confirm that the weight of copper in winding and CRGO in core during detailed design and manufacturing and supply of the transformer is not less than the values mentioned above.	
16	Transformer tank dimensions(mm)(lxbxh)	
17	Weight of tank (kg)	
18	Total volume of oil in tank (Litres)	
19	Weight of core, winding and frame(kg)	
20	Overall dimensions of the transformer(mm)(lxbxh)	

SCHEDULE 'B'

SCHEDULE OF GUARANTEED TECHNICAL PARTICULARS

ON LOAD TAPCHANGING GEAR (To be filled by the Bidder)

Sl. No	ITEM	Offered
1	Make	
2	Type designation	
3	Suitable for auto/manual Operation (Yes / No)	
4	Rated voltage (KV)	
5	Rated current (Amps)	
6	Step voltage (Volts)	
7	Number of steps	
8	Rated voltage of drive motor (V)	
9	List of routine tests to be carried out	
10	Location of the taps with respect to the terminals of the tapped winding	
11	Drawing or pamphlet-number of the technical and descriptive particulars of the OLTC, enclosed with the Bid.	
12	Is suitable for bi directional power flow? Yes/ No	
13	Drawing number of the complete control schematic drawing enclosed with the Bid, along with a write-up of the scheme provided.YES / NO	

14	Separate conservator and oil surge relay provided (YES / NO)	
15	Local outdoor cabinet general arrangement drawing number (enclosed with the Bid).	
16	Remote indoor control cabinet arrangement drawing number (enclosed with the Bid.)	
17	Quantity of oil in the OLTC chamber (Ltrs)	
18	Capacity of OLTC conservator tank in Cu.mtr.	

SCHEDULE 'C' (To be filled in and signed by the Bidder)
SCHEDULE OF GUARANTEED TECHNICAL PARTICULARS
CONTROL CABINETS

No.	Item	MK Box	Cooler Control	RTCC
1	Manufacturer's name and Country			
2	Indoor/ outdoor application			
3	Design ambient air temperature (C ^{0})			
4	Thickness of sheet steel for outdoor & indoor panels (mm)			
5	)egree of protection provided (as per IS:13947 or equivalent)			
6	Bill of material for various equipment giving make, type, ratings etc. enclosed(YES/NO)			
7	Colour of finish paint			
	3) Outside			
	4) Inside			
8	Temperature rise at rated current over specified ambient temp of 50°C			
9	Temperature rise at rated current over specified ambient temp of 50° C			
10	Continuous current rating (Amp)			
11	Three second current rating (KA) (short time)			
12	Control wiring			

	2) Material of conductor for various circuits			
	ii)Size of conductor For various circuits mm2			
	iii)Conductor – Solid / Stranded			
13	Terminal Blocks			
	i) Make			
	ii) Current rating			
14	Power terminals (Amp)			
15	Other terminals (Amp)			
16	All tests as specified in Section-D (ii) DATA SHEET A1 Specification for the control panel will be carried out Yes / No.			
17	Space heater rating (Watts)			