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# SUPPLY CHAIN MANAGEMENT THIRUVANANTHAPURAM

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## SPECIFICATION

66.67 MVA, 220/110kV SINGLE PHASE AUTO TRANSFORMERS

APPLICABLE TO KSEBL	Rev#0	DOC. NO.: <b>SCM-SPEC/XT/ 66.67MVA Transformer</b>
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Technical Specification and Evaluation Committee for Transmission Material



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**(i) Document Approval & Control Status**

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Date	06/08/2021	09/08/2021	09/08/2021
Signature	<b>Sd/-</b>	<b>Sd/-</b>	<b>Sd/-</b>

**(ii) Amendments and History**

<b>Sec. #</b>	<b>Rev. #</b>	<b>Date</b>	<b>History of Change</b>



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**1. PURPOSE:**

Purpose of this document is to document updates & history, upkeep and publish the specifications related to **66.67 MVA, 220/110kV Single Phase Auto Transformers** 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 **66.67 MVA, 220/110kV Single Phase Auto Transformers** 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.**



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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 66.67 MVA, 220/110kV SINGLE PHASE AUTO TRANSFORMERS

##### 1) SCOPE:

- 1.1 This specification covers the design, fabrication, manufacture, shop testing, supply, delivery, supervision of erection, testing and commissioning of 66.67MVA, 220/110KV, single-phase auto transformers for 220kV substation Kattakkada. The physical dimensions should be such that these transformers can be easily erected at the existing sub station. The impedance of the transformers should match with the existing transformers at 220kV substation, Kattakkada so that parallel operation is possible with existing transformer. The bidder shall furnish complete details of the equipment with all necessary drawings. The impedance of existing transformers are 9.94%, 9.97% and 9.93% and hence the offered transformer impedance shall be 10% with tolerance of maximum -10%.

##### 2) STANDARDS:

- 2.1. The transformers shall conform in all respects to IS:2026 – Specification for Power Transformers /B.S.171/ or IEC recommendations No.76 (except where specified otherwise) and other relevant standards with latest amendments for transformers & accessories. Equipment meeting any other authoritative standard which ensures an equal or better quality than the standard mentioned above will also be acceptable. The transformers shall also fully conform to the specifications of the C.B.I. & P Manual on transformers and Indian Electricity Rules.

IS:5	Colours for ready mix paints
IS:325	3 phase induction motors
IS:335	New Insulating oil for transformers
IS:1271	Thermal evaluation and classification of electrical insulation
IS 2026 (part I to V)	Power transformer
IS 2071	Method of High Voltage Testing
IS:2099	Bushing for Alternating voltage above 1000V
IS 2147	Degree of Protection
IS:2705	Current Transformers
IS:3347	Dimensions for porcelain Transformer bushing
IS:3637	Gas operated relays
IS:3639	Fitting & Accessories for power transformers



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IS 5561	Electric Power connectors
IS 6600/BS:CP"10:0	Guide for loading of oil immersed Transformers
IS:10028	Code of practice for selection, installation & maintenance of transformers Part I, II and III
	CBIP manual on transformers

If the standard is not quoted for any item, it shall be presumed that the latest version of Indian Standard shall be applicable for that item.

The equipment complying other internationally accepted standards, may also be considered if they ensure performance superior to the Indian Standards.

#### 3) CLIMATIC CONDITIONS:

Maximum temperature of air in shade	: 40 <sup>0</sup> C
Minimum temperature of air in shade	: 15 <sup>0</sup> C
Maximum humidity	: 100%
Average number of thunderstorm days per annum	: 50 days
Average number of dust storm days per annum	: 5 days
Average number of rainy days per annum	: 90 days
Average annual rainfall	: 3000 mm
Number of months during which tropical monsoon	
Conditions prevail	: 5 months
Altitude above M.S.L	: 0-1000 m

#### 4) TYPE & RATING:

The transformers shall be of core type construction, 1 phase; oil immersed, and shall be suitable for outdoor service as step down transformers. The rating and electrical characteristics of the transformers shall be as follows: -

220/110 kV single phase auto transformers of rating 66.67 MVA to form three phase banks of 200 MVA	
No. of units required	3 Nos
Max. Continuous capacity	66.67 MVA
Frequency	50 Hz
No. of phases	Single phase





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Rated voltage on series winding	220 kV / Ö 3
Rated voltage on common winding	110 kV / Ö 3
Rated voltage on tertiary	11kV (Tertiary to be brought out on two bushings and delta closed externally) This is only a stabilizing winding
Type of cooling	ONAN/ONAF
Overload capacity	As per IS:6600
<b>WINDING CONNECTIONS</b>	
High voltage	Single phase transformers to be connected in star
Low voltage	
Tertiary	Delta
Polarity	Subtractive
Vector Group	<b>YNa0d11</b>
On Load Tap changers	On load units with steps of +2.5% to -10% to be provided on the series section of the winding in steps of 1.25%

**Note:** - The transformers shall be complete in all respects as per KSEBL requirements with all the necessary fittings and accessories.

#### 5) **INSULATION:**

5.1. The dielectric strength of the winding insulation and of the bushing shall conform to the value given in I.S.S. 2026 B.S. 171 or IEC publication No.76.

5.2. Insulation requirement of the windings and their terminals will be as follows: -

Rated Voltage (kV)	110	220
BIL (kV)	550	1050

The H.V. windings of the transformers connected in star shall have graded insulation.

5.3. The insulation class of the neutral end of the windings be graded to 95kV (Impulse) and 38 kV (Power frequency with stand).

5.4. The minimum clearance in air between live conductive parts and live conductive parts to earthed structure shall be as follows as per CBIP manual. The transformer when assembled shall maintain the required statutory clearance.



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Highest voltage of equipment KV (RMS)	Clearance	
	Phase to phase (mm)	Phase to Earth (mm)
123	1220	1050
245	2350	2080

5.5. Insulation resistance shall be specified in the nameplate.

**6) TEMPERATURE RISE:**

6.1 Each transformer shall be capable of operating continuously at their normal rating without exceeding temperature limits as specified below:

	<u>Type of cooling</u>	<u>Temperature rise</u>
1. Winding	ONAN/ONAF	55 <sup>0</sup> C
2. Oil	-do-	50 <sup>0</sup> C

6.2. Maximum yearly weighted average temperature (Air) 32<sup>0</sup>C

**7) FREQUENCY:**

The transformers shall be suitable for continuous operation with a frequency variation of  $\pm 2.5\%$  from normal of 50 Hz. without exceeding the specified temperature rise.

**8) PARALLEL OPERATION:**

Transformers with similar ratio shall operate satisfactorily in parallel with each other if connected between high voltage and low voltage bus bars.

**9) IMPEDANCE:**

Suppliers shall indicate the guaranteed impedance and tolerances and also upper and lower limit of impedances, which can be offered without an increase in the quoted price. Impedances shall include positive and zero sequence and shall be expressed in terms of the branches of the star connected equivalent diagrams, all on the same kVA basis and the range shall be given for each branch of the equivalent circuit in turn

Percentage impedance between HV and LV windings will be as given below:

220/110kV single-phase transformer 66.67 MVA Base -10 %



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Maximum permissible tolerance on percentage impedance voltage at principal tapping shall be +/- 10%.

#### 10) Transformer Losses and Bid acceptance

- (a) The price bids will be evaluated against no load, load losses and auxiliary losses with capitalization of losses as per the following formula adopted by the KSEBL for working out comparable costs with difference in prices and losses:

$$\text{Capitalized cost of transformer} = I_C + AW_L + BW_N + CW_O$$

Where,  $I_C$  = Cost of Transformer (All inclusive unit rate offered);

$W_L$  = Load losses in KW at rated tap and rated voltage ;

$W_N$  = No load loss in KW at rated tap and rated voltage .

$W_O$  = Auxiliary loss in KW, A, B and C are load, no load and auxiliary capitalization figures

A =Rs 251,106 per KW B = Rs. 472,003/- per kW and C =RS 1,88801 per KW

Following shall be the guaranteed maximum losses without any positive tolerance:

- 1) No Load Loss on principal tap at Rated Voltage and frequency, in KW : 26
  - 2) Load Losses in kw(Copper + stray loss)at rated current on principal tap at 75°C:  
177
  - 3) Auxiliary/Cooler Loss in KW :3
- (b) The Transformers are to be designed with maximum permissible losses as indicated above.
- (c) Bids with losses beyond the maximum limits mentioned above shall be treated as non-responsive and rejected.
- (d) 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.
- (e) Once a bidder becomes successful on the basis of loss capitalization with certain declared loss value, they have to strictly achieve the same or lower loss value during the course of testing of transformers, offered for supply. No tolerance as per IS/IEC will be applicable. If the figures of losses measured during tests or in service are found to be higher than the figures guaranteed, at the option of the KSEBL, the transformer will be rejected or accepted with the reduction in price with 1.5 times of the above figures. However If the losses exceed 10% of the guaranteed value, the transformer will be rejected and the supplier has to replace it with a transformer with acceptable loss value. In this process, the delay so occurred will be on the vendor's account. If the vendor fails



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to achieve the acceptable loss during second time, the contract will be terminated at the vendor's risk and cost. The measurement of losses shall be carried out with 3 (Three) Watt meter method only and CT,s, PT,s and meters used for these measurements shall be of class of accuracy of 0.2S/0.2.

#### 11) COOLING

- 11.1. ONAN/ONAF cooling shall be adopted for 66.67 MVA transformers. Cooling fans shall be located such that they are readily accessible for inspection and repair. Fans shall be interchangeable.
- 11.2. Coolers shall be designed to withstand the vacuum pressure conditions specified for the tank. Pressure test shall be conducted for each coolers.
- 11.3. Coolers shall be so designed as to be accessible for cleaning and painting to prevent accumulation of water on the outer surface, to completely drain oil into the tank and to ensure against formation of gas pockets when the tank is being filled. Coolers shall be provided on the HV and LV side.
- 11.4. All coolers shall be attached to and mounted on the transformer tank. The arrangements of coolers shall be such that accessories may be mounted as specified herein. An equalizer pipe shall be provided between coolers, bushing chamber and conservator tank.
- 11.5. Cooler units shall be connected to the tank by machined steel flanges welded to the cooler units and to the tank and provided with gaskets. At each cooler unit connection, there shall be provided on the tank an indicating shut off valve, which can be fastened in either open or closed position. A separate oil tight blank flange shall be provided for each tap connection for use when the cooler unit is detached. Each cooler unit shall have a lifting eye, an oil drain at the bottom, and vent at the top.
- 11.6. Fans or blowers for air forced cooling shall be mounted so as to ensure that no damage to the coolers can arise from vibration of fans. Galvanized wire mesh screens shall be fitted to prevent accidental contact with the blades, the mesh being not greater than 25mm. The fan housing shall be waterproof.
- 11.7. The Transformer shall be capable of giving a continuous output of at least 66 2/3% with all the artificial cooling out of service and without exceeding the temperature rise stipulated in clause 6.1 above. The transformers have two sets of radiators.

#### 12) COOLER CONTROL:

- 12.1. Cooler units shall be suitable for operation with 415 Volt, 3 phase, 50Hz power supply.
- 12.2. Control equipment for Fan motors shall be mounted in a marshalling cabinet adjacent to the transformer and shall include the necessary contactors with automatic control and annunciator equipment and provision for manual control.



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- 12.3. A single metal enclosed main isolating switch with HRC fuses shall be provided for the cooling plant contactor group.
- 12.4. The switching in or out of the cooling equipment shall be controlled by winding temperature and there shall be provisions for automatic switching in or out at predetermined temperature levels which should be capable of adjustment and setting at will. The bidder shall specify the loading of the transformers in case of failure of one or more set of fans.
- 12.5. One number stand by fan, fan failure indication and allied control circuits shall be provided.

#### 13) CORE:

- 13.1. The core shall be built up with high grade cold rolled grain oriented non ageing, low loss and high permeability silicon steel laminations specially suitable or transformer cores.
- 13.2. After being sheared the lamination shall be treated to remove all burns and shall be re-annealed to remove all residual stresses. At least one side of each lamination shall be provided with suitable insulation, which shall be inert to be action of hot transformer oil. Paper and varnish insulation will not be accepted. The nature of insulation should be specified in the tender.
- 13.3. The core shall be rigidly clamped butt-jointed or inter leaved and bolted to ensure adequate mechanical strength and to prevent vibration during operation. The bolts used in the assembly of the core shall be suitably insulated and clamping structure shall be so constructed that eddy currents will be minimum.
- 13.4. The core shall be provided with lugs suitable for lifting the complete core and coil assembly of the transformer.
- 13.5. The core and coil shall be so fixed in the tank that shifting will not occur when the transformer is moved or during a short circuit.
- 13.6. Indigenous make CRGO steel is desirable for cores. However if core materials if imported, the bidder should produce shipping details, test certificate etc of the material.
- 13.7. The successful bidder shall furnish Bill of materials of the core.

#### 14) WINDING:

- 14.1. The conductors shall be of electrolytic grade copper and the windings made in dust proof atmosphere. The windings shall be so designed that all coil assemblies of identical voltage ratings shall be interchangeable, and field repairs to the windings can be made readily, without special equipment. The coil shall be supported between adjacent sections by insulating spacers, and the barriers, bracings and other insulation used in the assembly of the windings shall be arranged to ensure a free circulation of the oil and to reduce hot spots in the windings.
- 14.2. The insulation of the coils shall be high-grade craft / Manila paper and shall be treated with suitable insulating varnish or equivalent compound to develop the full electrical strength of the

windings. All materials used, in the insulation and assembly of the windings shall be insoluble, non-catalytic and chemically inactive in the hot transformer oil and shall not soften or otherwise be adversely affected under the operating conditions.

- 14.3. All threaded connections shall be provided with locking facilities. All leads from the winding to the terminal board and brushings shall be rigidly supported to prevent injury from vibration. Guide tubes shall be used where practicable.
- 14.4. The windings shall be clamped securely in place so that they will not be displaced or deformed during short circuits. The assembled core and windings shall be vacuum – dried and suitably impregnated before removal from the treating tank. The copper conductors used in the coil structure shall be best suited to the requirements, and all permanent current carrying joints in the windings and the leads shall be welded or braced.
- 14.5. If additional protection of the tertiary winding is required for the satisfactory performance of the transformers, the detailed scheme should be specified in the tender and the equipments required for this protection shall be supplied by the bidder.
- 14.6. The conductors shall be transposed at sufficient intervals in order to minimize eddy currents and equalize the distribution of current & temperature along with windings.
- 14.7 All materials required for tertiary formation including supports, insulated bus conductors and essential addl. protection shall be within the purview of the Supply contractor."

**15) INSULATING OIL:**

Oil for first filling together with 10% extra shall be supplied with each transformer. The oil shall comply in all respects with the provisions of IS.335, B.S.148 or IEC Publication No:296. Particular attention shall be paid to deliver the oil free from moisture having uniform quality throughout in non-returnable steel drums. No inhibitors shall be used in the oi

The quantity of oil for first filling of each transformer shall be stated in the tender.

The oil shall have the following main characteristics or equivalent (the requirement indicated is determined in accordance with the test methods adopted by IS.335).

**TRANSFORMER OIL**

Sl. No.	Characteristics.	Requirement	Methods of Test.
1.	<i>Appearance</i>	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/cm <sup>3</sup>	IS.1448

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3.	Kinematic Viscosity at 27°C Max.	27 CST	IS.1448
4.	Interfacial tension at 27°C Min.	0.04 N/m	IS.6104
5.	Flash point (Penskey Marten – closed cup)	140°C(Min.)	IS.1448
6.	Pour point	-6 (Max.)	IS.1448
7.	Neutralization value (total acidity) Max.	0.03 mg KOH/g	IS.335 Appx.A.
8.	Corrosive sulphur (in term of classification of copper strip)	Non-corrosive	IS.335 Appx.B.
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
	b)After treatment	60KV(rms)	IS.6792.
10.	Dielectric dissipation factor (tan delta) at 90°C Max.	0.002	IS.6262
11.	Specific resistance (resistivity)		
	a)at 90°C Min.	35x10 <sup>12</sup> ohm-Cm	IS.6103
	b)at 27°C Min.	1500x10 <sup>12</sup> ohm-Cm	
12.	Oxidation stability		
	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.

15.	Ageing characteristics After 96 hrs. with catalyst (copper)		
	a) Resistivity		As per ASTM –D 1934.
	i) 27 <sup>o</sup> C	2.5x10 <sup>12</sup> ohm cm.	
	ii) 90 <sup>o</sup> C	0.2x10 <sup>12</sup> ohm cm.	
	b) Tan delta at 90 <sup>o</sup> C	0.2 (Max.)	
	c) Total acidity	0.05 mg/KOH/gm (Max.)	
	d) Total Sludge content % by mass	0.05% (Max.)	

**16) TANK:**

- 16.1. The transformer tank and cover shall be fabricated from good commercial grade low carbon steel suitable for welding and of adequate thickness. The tank and the cover shall be of welded construction. All seams shall be welded. The tank shall have sufficient strength to withstand without permanent distortion (i)filling by vacuum and (ii)c continuous internal gas pressure of 0.35 atmosphere with oil at operating level. The tank cover shall be bolted to the tank and the transformer design shall be such that the tank will not be split between the lower and upper cooler connection for un tanking. Suitable slope shall be provided for the top cover so that the rainwater shall be properly drained off.
- 16.2. An inspection opening with a welded flange and a bolted cover shall be provided on the tank cover which shall be of a sufficient size to afford easy access to the lower ends of the bushings, terminals, earth connections etc.
- 16.3. All bolted connections to the tank shall be fitted with suitable oil-tight gaskets, which shall give satisfactory service under the operating conditions. Special attention shall be given to the methods of making the hot oil tight joints between the tank and the cover as also between the cover and the bushings and all other outlets to ensure that the joints can be remade satisfactorily and with ease, with the help of semi/skilled labor. Where compressible gaskets are used, steps shall be provided to prevent over compression.
- 16.4. Suitable guides shall be provided for positioning the various parts during assembly or dismantling. Adequate space shall be provided between the cores and windings and the bottom of the tank for collection of any sediment.
- 16.5. Lifting eyes or lugs shall be provided on all parts of the transformer requiring independent handling during assembly or dismantling. In addition, the transformer tank shall be provided with lifting, lugs and bosses properly secured to the sides of the tank for lifting the transformer either by crane or by jacks.



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- 16.6. The design of the tank, the lifting lugs and bosses shall be such that the complete transformer assembly filled with oil can be lifted with the use of these lugs without any damage or distortions.
- 16.7. The tank shall be provided with 2 suitable copper alloy lugs for the purpose of grounding.
- 16.8. Each tank shall be equipped with the following valves with standard screw connection for external piping.
- i) One 100mm drain valve located on the low voltage side of the transformer and placed to completely drain the tank. This valve shall be equipped with a small sampling cock.
  - ii) One 50mm filter-cum-sampling valve located at the top of the tank on the High-Voltage side. The opening of this valve shall be baffled to prevent aeration of the oil.
  - iii) One 50 mm filter valve, located on the low voltage side of the transformer at the bottom of the tank. These filter valves shall be provided diagonally opposite direction.
  - iv) One relief valve to operate at a pressure below the test pressure of the tank.
  - v) One flanged type 12.5 mm air release valve.

**17) UNDERCARRIAGE:**

The transformer tank shall be supported on a structural steel base equipped with forged steel or cast steel single, flanged wheel suitable for moving the transformer completely filled with oil. Jacking steps shall be provided. It shall be possible to change the direction of the wheels through 90o when the transformer is lifted on jacks to permit movement of the transformer both in longitudinal and transverse direction. Track gauge in both longitudinal and transverse direction shall be 1435 mm. Pulling eyes shall be provided to facilitate moving the transformers and they shall be suitable braced in a vertical direction so that bending does not occur when the pull has a vertical component. Suitable jacks for lifting the transformer for changing the plane of rotation of the wheels, shall be provided by the supplier.

**18) TAP CHANGING MECHANISM:**

- 18.1. Each transformer shall be provided with an on load tap changing mechanism. This shall be designed suitable for remote control operation from switchboards in the control room in addition to being capable of local manual as well as local electrical operation. Number of taps shall be 11.
- 18.2. Operation of the local or remote control switch shall cause one tap movement only until the control switch is returned to the off position for the next operation.
- 18.3. The local control switches shall be mounted in the outdoor cubicle or in the driving gear housing.
- 18.4. The equipment shall be so arranged so as to ensure that when a tap change operation has been commenced it shall be completed independently to the operation of the control relays and

switches. If a failure of the auxiliary supply during a tap change or any other contingency would result in that movement not being completed, adequate means shall be provided to safe guard the transformer and its auxiliary equipment from damage.

- 18.5. Limit switches may be connected in the control circuit of the operating motor provided that a mechanical declutching mechanism is incorporated.
- 18.6. Thermal devices or other means shall be provided to protect the motor and control circuits. All relays, MCBs, switches, fuses etc. shall be mounted in the marshalling box or driving gear housing and shall be clearly marked to indicate their purpose.
- 18.7. The control circuit shall operate at 110V single-phase supply from a transformer having a ratio of 250/55-0-55V with the centre point earthed through a removable link mounted in the marshalling box. The manufacturer shall supply this auxiliary transformer.
- 18.8. The whole of the apparatus shall be of robust design and capable of giving satisfactory service without undue maintenance under the condition to be met in service, including frequent operation.
- 18.9. A five-digit counter shall be fitted to the tap changing mechanism to indicate the number of operations completed by the equipment.
- 18.10. A permanently legible lubrication chart shall be fitted within the driving mechanism chamber.
- 18.11. The on-load tap changer shall include the following.
  - a) An oil immersed tap selector and arcing switch or arc suppressing tap selector, provided with resistor for reduction of make and break arcing voltages, overloads, and short circuits.
  - b) Motor driven mechanism.
  - c) Control and protection devices.
  - d) Local tap-changer position indicator.
  - e) Manual operating device.
- 18.12. The on load tap changer shall be designed so that the contacts do not interrupt arc within the main tank of the transformer. The tap selector and arcing switch on arc suppressing tap selector switch shall be located in one or more oil filled compartments. The compartment shall be provided with a means of releasing the gas produced by the arcing. It shall be designed so as to prevent the oil in the tap-selector compartment from mixing with the oil in the transformer tank.
- 18.13. The oil in those compartments of the main tap changing apparatus which do not contain contacts used for making or breaking current shall be maintained under conservator head by means of a 50mm diameter pipe connection from the highest point of the chamber to the conservator. This connection shall be controlled by a suitable valve and shall be arranged so that any gas leaving the chamber will pass into the gas and oil actuated relay. A separate



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Buchholz relay shall be provided for the on load tap changer. One double float gas detector relay (buchholz relay) conforming to ISS-3637 with alarm and tripping contacts to detect accumulation of gas and sudden changes of oil pressure, complete with shut off valves (on both sides) and flange couplings to permit easy removal without lowering oil level in the main tank, a bleed valve for gas venting and a test valve. The chamber shall have oil filling and drain plug, relief vent and level gauge.

- 18.14. The tap changer shall be capable of permitting parallel operation with other transformers of the same types.
- 18.15. The transformer shall give full load output on all taps. The manual operating device shall be so located on the transformer that a man standing at the level of the transformer tracks can operate it. It shall be strong and robust in construction.
- 18.16. The control scheme for the tap changers shall be provided for independent control of the tap changers when the transformers are in independent service. In addition, provision shall be made to enable parallel control also at times so that the tap changer will be operated simultaneously when one unit is in parallel with another so that under normal conditions the tap changer will not become out of step and this will eliminate circulating current. Additional features like master follower and visual indication during the operation of motor shall also be incorporated.
- 18.17. Necessary interlock blocking independent control when the units are in parallel shall be provided.
- 18.18. Under abnormal conditions such as may occur if the contractor controlling one tap changer sticks, the arrangement must be such as to switch off supply to the motor so that and out of step condition is limited to one tap difference between the units. Details of out of step protection provided for the taps should be furnished in the tender.
- 18.19. The contactors and associated gear for the tap changer driving motors shall be housed in a local kiosk mounted adjacent to or on the transformer. The motors shall be suitable for operation with 415V, 3-phase 50-cycle external power supply.
- 18.20. The supplier shall furnish, in addition to the equipment above, one indoor cubicle for each transformer, for installation in the purchaser's control room, which shall contain.

Indication of the transformer ratio in use on each transformer in KV and the number designating the tap in use by means of digital type indicators or tap position indicator with tap number shall be provided and the corresponding voltage ratio could be read from rating and connecting diagram plate.

Independent Master follower selector switch, Facia/digital type taps position indicator, other required devices, indicating lamps, etc. An indication lamp showing tap change in



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progress. Necessary audible and visual alarm. Annunciation relays suitable for the following trip and non-trip alarm with 3 spare windows suitable for 110V DC.

1. Oil Temperature alarm.
2. Winding temperature alarm
3. Winding temperature trip.
4. Buchholz alarm
5. Buchholz trip
6. Tap changer Buch-holz alarm
7. Tap changer out of step alarm
8. Low oil level alarm.
9. Cooling fans working.

Each relay for tripping function shall have two normally open, and two normally closed contacts for connection to tripping relays.

- 18.21. Complete particulars of the tap-changing gear including the capacity of the motor shall be stated in the tender. Detailed drawings shall be furnished.

#### **19) OIL PRESERVING EQUIPMENT:**

- 19.1. Gaskets of nitrile rubber or equivalent shall be used to ensure perfect oil tightness. All gaskets shall be closed design (without open ends) and shall be of one piece only. Gaskets of neoprene and / or any kind of impregnated /bonded core or cork only which can easily be damaged by over-pressing are not acceptable.
- 19.2 Oil preserving equipment shall be conservator expansion tank type with breather. The breather shall be metallic/stainless steel body with site glass fitted with good quality regenerated type silica gel.
- 19.3. The conservator of expansion tank shall have two filter valves, one at the bottom at the end, the other at the top, opposite end, in addition to the valve specified in the accessories for the main tank. The conservator or expansion tank shall also have a shut off valve and a sump with a small drain valve and sampling cock, the latter so arranged as not to interfere with oil lines. The oil level gauge shall be mounted on the conservator or expansion tank.

#### **20) BUSHINGS:**

The characteristics of bushings shall be as per IS 2099/73 with revision, if any:

- 20.1. The bushings shall have high factors of safety against leakage to ground and shall be so located as to provide adequate electrical clearances between bushings and between the bushings and grounded parts. The grounded parts of the bushing shall be at a minimum height of 2.6 Mts. above ground. Bushings of identical voltage rating shall be interchangeable. All bushings shall be equipped with suitable terminals of approved type and size and all external current carrying



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contact surfaces shall be silver plated, adequately. The insulation class of the high voltage neutral bushing shall be properly co-ordinate with the insulation class of the neutral of the high voltage winding.

- 20.2. All main winding and neutral leads shall be brought out through outdoor type bushings which shall be so located that the full flash-over strength will be utilized and the adequate phase clearance shall be realized.
- 20.3. Each bushing shall be co-ordinates with the transformer insulation, so that all flashovers will occur outside the tank.
- 20.4. All porcelain used in bushings shall be of the wet process, homogeneous & free from cavities or other flaws. The glazing shall be uniform in colour and free from blisters, burns and other defects.
- 20.5. The bushings for the 220KV and 110KV shall be of oil filled condenser type. In the case of oil filled type bushings the oil used will be the same as that used in the transformer. Porcelain bushings or condenser bushings may be used for voltage ratings up to 36KV.
- 20.6. All bushings shall have puncture strength greater than the dry flashover value.
- 20.7. Main terminals shall be solder less terminals, and shall be of the type and size specified in the schedule of requirements, or drawings.
- 20.8. The spacing between the bushings must be adequate to prevent flashover between phases under all conditions of operation.
- 20.9. The bidder is requested to give the guaranteed withstood voltage for the above.
- 20.10. Bushing CTs required for temperature indicators may be provided in the bushings of transformers.
- 20.11. Tan-Delta measurement tap shall be provided for each bushing. Tan-Delta shall be specified in the nameplate (both transformer and bushing).
- 20.12. Terminal connectors for Double Moose shall be provided (with a spacing of 250mm) on 220kV side and connectors for Double Kundah shall be provided (with a spacing of 250mm) on 110 kV side.

#### 21) 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.

#### 22) ACCESSORIES:

- 22.1. Each transformer shall be provided with the following accessories also:

- i) Dial type thermometer for oil:- A dial type weather proof indicating thermometer of robust pattern mounted on the side of the transformer at a convenient height to read the temperature in the hottest part of the oil and fitted with alarm and trip contacts.
- ii) One winding hot spot temperature detector in one winding of each as described below:  
It shall be indicating type and of weatherproof design responsive to the combination of hot oil temperature and winding calibrated to follow the hottest spot temperature of the transformer winding. The winding temperature detector shall operate a remote alarm and trip in the event the hottest spot temperature approaches dangerous values.
- iii) One magnetic-type oil-level gauge with low-level alarm contacts and a dial showing minimum, maximum and normal oil levels. The gauge shall be readable from the transformer base level. A low gas pressure electric alarm device shall also be provided if the transformer is equipped within inert gas pressure equipment.
- iv) One oil filtering valve (inlet) 50mm size- (vide clause 16.8 iii above)
- v) One oil drain valve – 100mm size (16.8. i)
- vi) One filter valve located at the top of the tank on the H.V.Side –50mm size (16.8.ii).
- vii) Pressure relief device:  
A safety valve of the Chimney type with an equalizer pipe inter-connecting the top of the conservator and uppermost part of the safety valve should be provided to prevent rise of oil in the safety valve pipe. A stopcock should also be provided in the interconnecting pipe. An air release cock shall also be fitted in a convenient position. Means shall be provided to prevent ingress of rainwater.  
The safety valve shall preferably take off from the side of the transformer tank cover. This is with a view to prevent the gases forming in the tank from rising into the safety valve pipe and thereby by-passing the Buchholz relay (defeating its purpose) and for avoiding the necessity for providing a bottom diaphragm for the safety valve pipe which would be necessary in case it takes off from the tank cover.  
Auto resealing type pressure relief device, which can give a trip signal while operation for quick release of excess pressure developed in the transformer in an emergency is also to acceptable.
- viii) One double float gas detector relay (Buch-holz relay) conforming to ISS-3637 with alarm and tripping contacts to detect accumulation of gas and sudden changes of oil pressure, complete with shut off valves (on both sides) and flange couplings to permit easy removal without lowering oil level in the main tank, a bleed valve for gas venting and a test valve.
- ix) Radiators complete

- x) a) An oil conservator or  
b) Oil preserving equipment complete in all respects as described in Cl 18.
- xi) Eye bolts and lugs on all parts for ease of handling.
- xii) Two grounding terminals.
- xiii) Diagram and rating plates.
- xiv) One set of equipment for control, protection, indication and annunciation for each transformer comprising motor contactors, detecting elements for devices, indicating apparatus, instruments, relays, annunciators, etc. The necessary contactors, switches and lamps shall be provided.
- xv) Suitable weatherproof cubicles for housing the following equipments (One for each transformer)
  - a) Temperature indicators with glass windows of adequate size for taking readiness (This may be mounted separately at the discretion of the manufacturer)
  - b) Control and protection equipments for the local electrical control of tap changer, if the same cannot be accommodate in motor driving gear housing
  - c) Terminal blocks for C.T. secondaries and other cable.
- xvi) One indoor cubicle, for on load tap changer, alarm and indicating devices.
- xvi) Set of devices for lifting the various parts of the transformer as also the complete transformer (one set common for two transformers).
- xvii) Provision shall be made for installing resistance temperature detectors for temperature recording instruments arranged separately for the following:
  - a) Hot oil
  - b) Winding hot spot.
- xix) One set of equipment for control, protection, indication and annunciation for each transformer comprising detecting elements or devices, indicating apparatus, instruments, relays, annunciators etc. The remote control and indication will be provided on the control panels in the control room.

22.2. (a) The equipment and accessories furnished with the transformer shall be suitably mounted on the transformer for ease of operation, inspection and maintenance and the mounting details shall be subject to the approval of the purchaser. All valves shall be provided with blind companion flanges.

(b) The switching in and switching out of the cooling equipment shall be controlled by winding temperature and there shall be provision for automatic switching in or out at pre-determined temperature levels which should be capable of adjustment and setting at will. The winding temperature indicators shall therefore be provided with contacts for switching and switching out of the cooling system at pre-determined temperatures.



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Indication, alarm and relay equipment shall have contacts suitable for operation with 110Volts D.C supply. Any other accessories or appliances recommended by the manufacturer for the satisfactory operation of the transformers together with their prices shall be given in the tender.

**23) PAINTING:**

Before shipment, all steelwork not under oil, shall be painted with a primary coat of anticorrosive paint of durable nature and suitable for two coats of **Light Admiralty Grey No.697** (as per IS.5/1949 with latest amendment) paint as per the manufactures standard practice to be applied at factory. The bidder shall supply a small quantity of paint required for touch up at site. The interior surfaces shall be painted according to the best standard practice.

**24) PACKING:**

The packing may be in accordance with the supplier's standard practice but he should give full particulars of packing 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 maximum weight of a single package should not be more than 40 tons and maximum size of package should not be more than 4m x 4m x 2.4m (hx1xb). The transformer shall be shipped filled with oil/with inert gas (which ever way desired by the purchaser depending on the size etc.)All parts shall be adequately marked to facilitate field erection. Boxes and crates shall be marked with the contract number and shall have a packing list enclosed showing the parts contained therein.

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

**25) INSPECTION & TESTING:-**

All testing equipments and instruments shall be got calibrated from national accredited labs (NABL) and shall have valid calibration certificates at the time of testing. The CT/PT units used shall be with accuracy class 0.2s/0.2. The transformer shall be completely assembled and tested at the factory. If the purchaser selects to have a representative, he shall witness all tests. Tests shall be performed in compliance with B.S.171. I.E.C. Publication No.76, IS.2026: 1962 or any other authoritative standard

26.1	<b>Inspection and Testing during manufacture</b>	Client shall be intimated minimum 20 days in advance for the stage inspection during manufacturing and all test results shall be got approved before proceeding to next stage of production.
26.1.1	Tank and conservator	1) Check correct dimension between wheels





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		<p>demonstrate turning of wheels through 90 deg and further dimensional check.</p> <p>2) Check for physical properties of material for lifting lugs, jacking pads etc. all load bearing welds, including lifting lug welds shall be subjected to required load tests</p> <p>3) Leakage test of the conservator &amp; radiators as per CBIP</p> <p>4) Certification of all test results</p> <p>5) Vacuum and pressure test on tank as type test as per CBIP</p>
26.1.2	Core	<p>1) Vendor to submit the documentary evidence for procurement of CRGO laminations and prove that they have procured / used new core material. During in process inspection of lamination the vendor &amp; Customer shall randomly select / seal lamination for testing at ERDA / CPRI (Accredited NABL labs) for Specific core loss, accelerated ageing test , surface insulation resistivity, AC permeability and magnetization, Stacking factor, ductility etc. This testing shall be in the scope of vendor.</p> <p>2) Check on the quality of varnish if used on the stampings.</p> <ul style="list-style-type: none"> <li>a. Measurement of thickness and hardness of varnish on stampings</li> <li>b. Solvent resistance test to check that varnish does not react in hot oil</li> <li>c. Check overall quality of varnish by sampling to ensure uniform hipping color, no bare spot. No over burnt varnish layer and no bubbles on varnished surface</li> </ul> <p>3) Check on the amount of burrs</p> <p>4) Bow check on stamping</p>

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		<ul style="list-style-type: none"> <li>5) Check for the overlapping of stampings. Corners of the sheet are to be apart.</li> <li>6) Visual and dimensional check during assembly stage.</li> <li>7) Check on complete core for measurements of iron- loss and check for any hot spot by exciting the core so as to include the designed value of flux density in the core</li> <li>8) Check for inter laminar insulation between core sectors before and after pressing</li> <li>9) Visual and dimensional check for straightness and roundness of core, thickness of limbs and suitability of clamps</li> <li>10) High voltage test (2KV dc for one minute) between core and clamps</li> <li>11) Certification of all test results</li> </ul>
26.1.3	Insulating material	<ul style="list-style-type: none"> <li>1) Sample check for physical properties of material</li> <li>2) Check for dielectric strength, DP</li> <li>3) Visual and dimensional checks</li> <li>4) Check for the reaction of hot oil on insulating materials</li> <li>5) Certification of all test results</li> </ul>
26.1.4	Windings	<ul style="list-style-type: none"> <li>1) Sample check on winding conductor for mechanical properties and electrical conductivity</li> <li>2) Visual and dimensional check on conductor for scratches, dept. mark etc.</li> <li>3) Sample check on insulating paper for bursting strength, electric strength</li> <li>4) Check for the reaction of hot oil on insulating paper</li> <li>5) Check for the binding of the insulating paper on conductor</li> </ul>



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		<ul style="list-style-type: none"> <li>6) Check and ensure that physical condition of all materials taken for winding is satisfactory and free of dust</li> <li>7) Check for absence of short circuit between parallel strands</li> <li>8) Check for Brazed joints wherever applicable</li> <li>9) Measurement of voltage ratio to be carried out when core / yoke is completely restocked and all connections are ready</li> <li>10) Certification of all test results.</li> </ul>
26.1.4.1	Checks before drying process	<ul style="list-style-type: none"> <li>1. Check conditions of insulation on the conductor and between the windings</li> <li>2) Check insulation distance between high voltage connection cables and earthed and other live parts</li> <li>3) Check insulation distance between low voltage connection cables and earthed and other parts</li> <li>4) Insulation test of core earthing</li> <li>5) Check for proper cleanliness</li> <li>6) Check tightness of coils i.e. no free movements</li> <li>7) Certification of all test results</li> </ul>
26.1.4.2	Checks during drying process	<ul style="list-style-type: none"> <li>1) Measurement and recording of temperature and drying time during vacuum treatment.</li> <li>2) Check for completeness of drying</li> <li>3) Certification of all test result.</li> </ul>
26.1.5	Oil	As per IS 335
26.1.6	Test on fittings and accessories	As per manufacturer's standard
26.2	Special test	<b>In case the product offered is never tested for dynamic short circuit the same to be conducted by bidder at his own cost at Govt. recognized independent test laboratory / internationally accredited test lab.</b>

26.3 Following type tests shall be done on one unit of offered item:

- 1) Impulse withstand test on HV and MV limbs of the transformers for chopped wave as per standard and Measurement of transferred surge on LV (Tertiary) due to HV lightning impulse and IV lightning impulse (as applicable).
- 2) Temperature rise test as per IS
- 3) Dissolved gas analysis before and after Temperature Rise test.
- 4) Pressure relief device test.
- 5) Pressure and Vacuum test on tank\* (\* Stage Inspection)
- 6) measurement of acoustic noise level(CI.16.12 IS 2026 part-1)
- 7) measurement of harmonic level on no load current
- 8) High voltage withstand test shall be performed on the auxiliary equipment and wiring after complete assembly.

The following tests shall be made on the transformer unless otherwise stated in the schedule of requirements.

- a) *All tanks, single welds, cooling coils, radiators, valves and other parts necessary for complete transformer shall be tested for leaks and strength, by applying to the complete tank filled with oil and air pressure not less than 0.35 atmosphere for a period of 12 hours as per. If leaks occur, the tests shall be conducted again after all leaks have been stopped.*
- b) Measurement of winding resistance and insulation resistance.
- c) Turns ratio for all sets of windings on each tap
- d) Polarity and phase relations.
- e) Exciting current at 100 and 110 percent of rated voltage.
- f) Excitation losses at 90,100 and 110 percent rated voltage measured by the average voltage voltmeter method. The excitation losses given in the test report shall be measured after the impulse tests are completed.
- g) Measurement of insulation resistance between each winding and winding to earth with PI.
- h) Regulation at rated load and unity, 0.9, 0.8 lagging power factor.
- i) Load losses measured at rated frequency, by applying primary voltage sufficient to produce rated current in the windings with the secondary windings short-circuited and impedance.
- j) Separate source voltage withstand test.
- k) Induced over voltage withstand test with P.D. indication.

- l) Tests on load tap changers.
- m) Positive phase sequence impedance.
- n) Measurement of auxiliary losses for the cooling equipment.
- o) Measurement Tan delta and capacitance for winding and bushing.
- p) Routine test shall be conducted including 24 hours pressure test to check for leakage in the presence of Board's representative if so desired by the Board.
- q) Efficiency at UPF and 0.8 pf at 50%, 75% and 100% load to be calculated.
- r) Test on RTCC, Cooler Control Cubicle and Marshalling Box.
- s) Magnetic balance test.
- t) Measurement of BDV.

**26.4 TESTS AT SITE:**

After erection at site the transformers shall be subject to the following tests:

- i) Insulation resistance test.
- ii) Ratio and polarity test.
- iii) Dielectric test on oil.
- iv) Low voltage excitation at 440V in LV side.
- v) Vector group test.
- vi) Core balance test.
- vii) Tan delta measurement
- viii) Open circuit and short circuit test.
- ix) Tap changer continuity test.

**26) FURTHER TESTS:**

The purchaser reserves the right of having other reasonable tests carried out at his own expense either before shipment, or at site to ensure that the transformer complies with the requirements of this specification.

**27) TEST REPORTS:**

*After all tests have been completed, seven certified copies of each test report should be furnished. Each report shall supply the following information.*

- i) Complete identification data including serial number of the transformer
- ii) Method of application, where applied, duration, and interpretation of results in each tests.
- iii) Temperature data corrected to 75°C including ambient temperature.
- iv) The permissible limits of test results as per relevant ISS and guaranteed values shall be indicated in the test reports.

**28) TOOLS:**

The following tools of reputed firms having high quality shall be supplied along with each transformer.

- 1) DE Spanner set from 32 mm to 6 mm size
  - 2) 20 cm heavy duty cutting pliers
  - 3) Nose pliers
  - 4) Circlip pliers
  - 5) Hydraulic jacks suitable for this transformer
  - 6) Screw drivers – 4 nos (1 large, 2 medium, 1 small)
  - 7) Star screw driver
  - 8) Monkey pliers
  - 9) Adjustable spanners
  - 10) Tomy bar – 2 nos and any special tool required
- All the tools except jack must be supplied in a toolbox.

**29) DRAWING AND DATA TO BE FURNISHED BY THE SUPPLIER:**

Within two weeks after the award of the contract the manufacturer shall supply four copies of drawings, which will describe the equipment in detail for approval, and shall subsequently provide seven complete sets of final drawings for approval.

The following drawings of technical literature for each item are to be supplied as part of this contract.(Soft copy and Hard copy)

- a) Out line dimensional drawings of transformer and accessories.
- b) Assembly drawings and weights of main component parts
- c) Shipping drawings showing dimensions and weights of each package.
- d) Drawings giving details of foundation and structure.
- e) Tap changing gear arrangement showing constructional details and general arrangement.
- f) Schematic control and wiring diagram for all auxiliary equipments and cooler control system.
- g) Schematic diagram showing the flow of oil in the cooling system as well as each limb and winding. Longitudinal and cross sectional views showing the duct sizes, cooling pipes etc. for the transformer drawn to scale shall be furnished.
- h) Large scale drawings of high and low tension windings of the transformers showing the nature and arrangement of insulation and terminal connections.
- i) Bushing drawing and specification.



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- j) Details of nameplate, terminal marking and connection diagram.
- k) All Test reports
- l) Six copies of instruction books/operation and maintenance manuals and spare part bulletins per transformer.
- m) Description, literature and data on transformer construction, winding, bushing, heat exchanger, tap changing gear etc. (2 sets per transformer)

The bidder shall also quote for any item other than that specified above as spares recommended for five years normal operation.

The bidders are required to furnish information regarding the experience on the following points.

- 1) Name of Manufacturer.
- 2) Status of the Firm as manufacturer of the transformer quoted.
- 3) Description of the transformers similar to that quoted supplied and installed during the last 5 years with the name of the party to whom supply was made.
- 4) Details as where the transformers were installed, their performance etc.
- 5) Testing facilities at manufacturer's works.
- 6) If the manufacturer has collaboration with another firm details regarding the same.

**Service of engineers for supervision of erection and commissioning of the transformer at site to be provided free of cost if required.**

**30) DEVIATION:-**

Deviation from this specification, if any, shall be clearly bought out in the offer. Unless owner explicitly accepts such deviations, it shall be constructed that the offer fully complies with the specification.

**31) REJECTION:-**

The Purchaser may reject transformer, if any of the following conditions during or service arises:

- i) If the losses found exceeds the specified value .
- ii) Impedance value exceeds the guaranteed value by + 10% or more.
- iii) Oil or winding temperature rise exceeds the specified value by 5 deg. C.
- iv) Transformer fails on impulse test.
- v) Transformer fails on power frequency voltage withstand test.



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- vi) The difference is impedance values of any two phase during single phase short circuit impedance test exceeds 2% of the average value guaranteed by the manufacturer / contractor.
- vii) Transformer is proved to have been manufactured not in accordance with agreed specification.

Sd/-  
Chief Engineer(SCM)





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**TECHNICAL SPECIFICATION**

**66.67 MVA, 220/110kV SINGLE PHASE AUTO TRANSFORMERS**

Doc. #: **SCM-SPEC/XT/66.67MVA Trs.**

Rev.#: 0

Effective Date 29/07/2021

**GUARANTEED TECHNICAL PARTICULARS OF 66.67 MVA, 220/110 kV SINGLE PHASE AUTO TRANSFORMERS**

Sl.No.		
1.	Name of Manufacturer	
2.	Normal continuous rating	
3	Normal ratio of transformation	
4.	Phase connections	
	a) H.V. Winding	
	b) L.V. Winding	
	c) Vector group reference No. & symbol	
5.	Maximum temperature rise	
	i) Of oil by thermometer	
	ii)Of winding by resistance	
	iii)By hot spot temperature indicator	
6.	Limit for hot spot temperature for which the transformer is designed	
7.	Temperature gradient between winding and oil	
8.	Voltage to earth for which the star point will be insulated	
	a) kV (Impulse)	
	b) kV (Power Frequency)	
9.	Type of cooling	
10	Maximum flux density in iron at normal voltage frequency and ratio	
	a) Core : CGS Lines/Sq.mm	
	b) Yoke	



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11.	Maximum current density in winding at C.M.R.	
	a) H.V. Winding: Amps/Sq.mm	
	b) L.V. Winding: Amps/Sq.mm	
	C) Tertiary Winding: Amps/Sq.mm	
12.	Magnetizing current (H.V) at normal voltage and ratio . . . Amps.	
13.	Power factor of magnetizing current at normal voltage and frequency	
14.	i) Guaranteed no load loss at normal ratio, rated frequency and 75 <sup>0</sup> C average winding temperature kW.	
	ii) Tolerance if any applicable to 14 (i) . . . . .kW	
	iii) Guaranteed load losses (kW)	
	iv) Tolerance if any applicable to 14 (iii) .....kW	
15.	I) Guaranteed total losses at normal ratio, rated output, rated voltage, rated frequency and 75 <sup>0</sup> C average winding temperature including auxiliary losses at rated output kW	
	ii) Auxiliary losses at rated output included in 15(I) above kW	
	iii) Tolerance if any applicable to 15(I)	
16.	Total losses at normal ratio, rated output, rated voltage, rated frequency and maximum attainable temperature at site including auxiliary losses . . . kW	
17.	Auxiliary losses if any at rated load. kW	
18.	Efficiencies at normal ratio, rated voltage rated frequency and 75 <sup>0</sup> C average winding temperature for the outputs of	
	a) Full load %	
	b) <sup>3</sup> / <sub>4</sub> full load %	
	c) <sup>1</sup> / <sub>2</sub> full load %	
	d) <sup>1</sup> / <sub>4</sub> full load %	

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19(i)	Resistance per phase of	
	a) H.V. Winding: Ohms	
	b) L.V. Winding :Ohms	
(ii)	Reactance per phase of	
	a) H.V. Winding: Ohms	
	b) L.V. Winding :Ohms	
20.	Resistance voltage drop at 75 <sup>0</sup> C average winding temperature expressed as percentage rated voltage (%)	
21.	Reactance voltage drop expressed as percentage of rated voltage (%)	
22.	Impedance voltage at normal current and voltage at 75 <sup>0</sup> C average winding temperature expressed as percentage rated voltage (%)	
	a) between H.V. and L.V.Winding (%)	
	b) between H.V. and tertiary (%)	
	c) between L.V. and tertiary (%)	
23.	Regulation at full load at 75 °C	
	a) Unity Power factor	
	b) 0.8 power factor (lagging)	
24.	Type of transformer (core or shell)	
25.	Width of track gauge (mm)	
26.	Core	
	a) Material of core lamination	
	b) Thickness of core plates	
	c) Whether core plates are grain oriented cold rolled	
	d) Insulation of core lamination	
	e) Insulation of core – bolts/core bolt washers	
	g) Insulation of core and plates	

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	h) Details of oil ducts	
	Whether in the plane and at right angle to the plane of winding	
	Across the plane of laminations	
27.	Windings:	
a)	Type of winding	
	i) H.V. Winding	
	ii) L.V. Winding	
	iii) Tertiary Winding	
b)	Insulation of H.V.Winding	
c)	Insulation of L.V.Winding	
d)	Insulation of tertiary winding	
e)	Insulation between H.V and L.V. winding	
f)	Power frequency high voltage tests	
	i) Test voltage for 1 minute withstand test on high voltage windings (induced) kV (RMS)	
	ii) Test for 1 minute withstand test on neutral and of high voltage windings kV (RMs)	
	iii) Test for 1 minute withstand test on line end of low voltage windings kV (RMS)	
	Iv) Impulse test on high-voltage winding 1.2/50 full wave withstand kV (Crest)	
	v) Impulse test on low – voltage winding 1.2/50 full wave withstand kV (Crest)	
	vi) Wave form for impulse test	
g)	Inter-turn insulation	
	i) Extent of extreme and turns reinforcement	
	ii) Extent of end turns reinforcement	
	iii) Extent of turns adjacent to tappings	

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	iv) Test voltage for 10 seconds 50 cycles inter turn insulation test on(i) kV (RMS)	
	v) Test voltage for 10 seconds, 50 cycles inter turn insulation test on (ii) kV (RMS)	
	vi) Test voltage for 10 seconds, 50 cycles inter turn insulation test on (iii) kV(RMS)	
	vii) Test voltage for 10 seconds 50 cycles inter turn insulation test on main body of the winding kV (RMS)	
h)	Type of axial coil supports	
	a) High voltage winding	
	b) Low voltage winding	
i)	Type of radial coil supports	
	a) High voltage winding	
	b) Low voltage winding	
j)	Whether H.V.Windings are interleaved	
k)	Details of special arrangements (if any) made to improve stress conditions.	
l)	Size of cooling ducts	
m)	Drawing to scale indicating flow of oil in the radial and axial ducts of each limb and windings	
28.	Maximum out of balance force in winding on short circuit at the terminals . . . .Kg	
29.	KVA capacity of the tertiary winding	
30.	Thickness of transformer tank plate	
	a) Sides mm	
	b) Bottom mm	
	c) Top mm	
31.	Type and details of winding hot spot temperature detector	
32.	Power requirement of heater in conservator	



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33.	Buch-holz relay description, data range of settings, schematic diagram etc	
34.	Bushings	
	i) Type	
	ii) Dry flash over voltage	
	iii) Wet flash over voltage	
	iv) Dry 60 s with stand Test voltage kV rms	
	v) Wet 30-s with stand Test voltage kV rms	
	vi) Under oil flash over or Puncture withstand	
	vii) Test voltage (Power frequency ) KV rms	
	viii) Full wave impulse withstand test voltage with 1.2/50 microsecond wave	
	Positive (kV p)	
	Negative (kV p)	
	ix) Creepage distance in air mm	
	x) Recommended Gap setting	
	xi) Weight of Assembled bushing	
35.	Free space removal or bushings	
36.	Total volume of conservator . . . Litres	
37.	Volume of conservator between the highest and lowest levels	
38.	Bushing potential device	
	a) Name of manufacturer	
	b) Description data and literature	
	c) Rated capacity	
	d) Rated secondary voltage	
39.	Make, type and details of	
	a) Winding temperature indicator	



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	b) Oil temperature indicator	
	c) Oil level indicator	
40.	Cooling System	
a)	Type and make of fan motors for forced air cooling equipments	
b)	Rating and speed of motors	
c)	Efficiency of motors at full load	
d)	Temperature rise of Motors at full load	
e)	Number of fan motors	
f)	Number of stand by fans	
41.	Period of continuous working at full load without fans for ONAN/ONAF type	
42.	Continuous MVA rating without fans for ONAN/ONAF	
43.	Calculated time constants (hrs.)	
	1) Natural cooling	
	2) Forced Air Cooling	
44.	Details of On Load Tap changing gear	
	1) Make	
	2) Type	
	3) Rating	
	Rated voltage	
	Rated current	
	Step voltage	
	Number of steps	
	4) Control	
	5) Auxiliary Supply Details	
	6) Position of taps	



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	7) Parallel Operation	
	8) Protective Devices	
	9) Approximate overall weight	
	10) Approximate overall dimensions	
	11) Approximate overall quantity of oil in litres	
45.	Weight of copper required to complete the transformer Kg	
46.	Weight of steel required to complete the transformer Kg	
47.	Weight of fittings and parts detached for transport Kg	
48.	Weight of core and windings Kg	
49.	Weight of complete transformer with all fittings & Oil kg	
50.	Weight of complete transformer arranged for transport or the heaviest package if broken down Kg	
51.	Weight of oil in the transformer Kg	
52.	Dimensions of the transformers in metres	
	a) Maximum height to top of bushings	
	b) Over all length	
	c) Overall breadth	
53.	Description of any other accessories or Appliances recommended by the tenderer	

**Name and Address of Bidder**