SUPPLY CHAIN MANAGEMENT

THIRUVANANTHAPURAM

SPECIFICATION

10 MVA, 66/11 kV 3 PHASE TRANSFORMERS

APPLICABLE TO KSEBL	**Rev#0**	DOC. NO.: **SCM-SPEC/XT/ 10MVA Power Transformer**
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Technical Specification and Evaluation Committee for Transmission Material

KSEB കേരളത്തിന്റെ ഊർജ്ജം	**SUPPLY CHAIN MANAGEMENT** **Thiruvananthapuram**			
	TECHNICAL SPECIFICATION **10 MVA, 66/11 kV 3 PHASE TRANSFORMERS**			
	Doc. #: **SCM-SPEC/XT/10MVA Trs.**	Rev.#: 0		Effective Date 29/07/2021

(i) Document Approval & Control Status

	Compiled by	Verified by	Approved by
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Position	Assistant Engineer (Supply Chain Management)	Executive Engineer (Supply Chain Management)	Chief Engineer (Supply Chain Management)
Date	06/08/2021	09/08/2021	09/08/2021
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 **10 MVA, 66/11 kV 3 Phase 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 **10 MVA, 66/11 kV 3 Phase 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.**

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 10 MVA, 66/11 kV 3 PHASE TRANSFORMERS

1. **Scope:**

1.1. This specification covers the design, manufacture, shop testing, supply, delivery, supervision of erection, testing and commissioning of 10 MVA, 66/11 KV 3 phase transformers for various substations. Complete details of the equipment with all necessary drawings shall be furnished by the bidder.

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.

3. **Climatic Conditions**:

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

4. **Type & Rating**:

The transformers shall be of core type construction, 3 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:-

10 MVA, 66/11 kV

No. of units required	5 Nos
Max. Continuous capacity	10 MVA
Frequency	50 Hz

No. of phases	Three phases shall be indicated as RYBN for primary, r,y,b,n as secondary
Rated voltage	66/11 kV
Type of cooling	ONAN
Overload capacity	As per IS:6600
WINDING CONNECTIONS: 10 MVA	
High voltage	Three phase star connected
Low voltage	Three phase star connected
Tertiary	Not provided
Polarity	Subtractive
Vector Group	YNyno
On Load Tap changers	Tap range of +2.5% to –10% to be provided on the HV winding in steps of 1.25% for rated voltage on the LV side.

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

5. <u>Insulation</u>:

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)	66	11
BIL (KV)	325	75

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.

Highest voltage of equipment KV (RMS)	Clearance	
	Phase to phase (mm)	Phase to Earth (mm)
72.5	700	630

12	280	140

5.5. Insulation resistance shall be specified in the nameplate.(Greater than 1GΩ at 5kV.) Tan delta of the transformer should be less than 0.5% at 20° C at 10kV.

6. **Temperature Rise**:

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

Type of cooling		Temperature rise
1. Winding	ONAN/ONAF	55° C
2. Oil	-do-	50°C

6.2 Maximum yearly weighted average temperature (Air) 32^0C.

7. **Frequency**: - The transformers shall be suitable for continuous operation with a frequency variation of ± 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**:- Percentage impedance between H.V. and LV windings will be as given below:
66/11 kV Three Phase Transformer 10 MVA base - 10 %
Maximum tolerance permissible on percentage impedance voltage at principal tapping shall be +/- 10%

10. Losses:

10.1 Maximum no load loss at rated condition allowed without any positive tolerance shall be 8.4 kW

10.2 Maximum load loss at rated condition @ 75°C and principal tap allowed without any positive tolerance shall be 57 kW

10.3 No load loss capitalization figure is Rs.4,72,003 per kW

10.4 Load loss capitalization figure is Rs.2,51,106 per kW

10.5 The transformers will be evaluated against no load and load losses guaranteed by the supplier with capitalization of losses as per CBIP guidelines for loss capitalization. The corresponding capitalization figures for no load and load losses shall be as per Cl.10.3& 10.4 above respectively. In the event of measured loss figures during testing exceeding the guaranteed loss figures of the supplier penalty shall be levied at a rate of 1.25 times the figures mentioned above for no load & load losses . However losses exceeding 5% of guaranteed value will be rejected.

11. **Cooling**:-

11.1. ONAN cooling shall be adopted for 10 MVA Transformers.

11.2. Coolers shall be designed to withstand the Vaccum 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 drawn 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.** The minimum clearance between transformer main tank outer surface and radiator fins shall be 25 cm

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.

12. <u>Core:</u>

12.1. 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 for transformer cores.(Hi-B core)

12.2. 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.

12.3. 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.

12.4. The core shall be provided with lugs suitable for lifting the complete core and coil assembly of the transformer.

12.5. 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.

12.6. For core materials, the bidder should produce following information :
(1)Supplier of CRGO.
(2)Test Certificate.
(3)Specific loss(w/kg) at 1.6 Tesla flux density.

12.7. The successful bidder shall furnish Bill of materials of the core.

13. Winding:

13.1. 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.

13.2. 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.

13.3. All threaded connections shall be provided with locking facilities. All leads from the winding to the terminal board and bushings shall be rigidly supported to prevent injury from vibration. Guide tubes shall be used where practicable.

13.4. 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.

13.5. The conductors shall be transposed at sufficient intervals in order to minimize eddy currents and equalise the distribution of current & temperature along with windings.

14. 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 oil.

The quantity of oil for first filling of each transformer shall be stated in the tender. The cost of oil shall be given as a separate item.

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).

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 $20^{O}C$ Max.	0.89 g/cm^3	IS.1448
3)	Kinematic Viscosity at $27^{O}C$ Max.	27 CST	IS.1448
4)	Interfacial tension at $27^{O}C$ Min.	0.04 N/m	IS.6104
5)	Flash point (Penskey Marten – closed cup)	$140^{O}C$(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^{O}C Max.	0.002	IS.6262
11)	Specific resistance (resistivity)		
	a)at 90^{O}C Min.	$35x10^{12}$ ohm-Cm	IS.6103
	b)at 27^{O}C Min.	$1500x10^{12}$ 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-ocident 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 –D1934.
	i) 27^{O}C	$2.5x10^{12}$ ohm cm.	

ii) 90^{O}C	0.2x10^{12} ohm cm.
b) Tan delta at 90^{O}C	0.2 (Max.)
c) Total acidity	0.05 mg/KOH/gm(Max.)
d) Total Sludge content % by mass	0.05% (Max.)

15. Tank:

15.1. 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 untanking. Suitable slope shall be provided for the top cover so that the rainwater shall be properly drained off.

15.2. 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.

15.3. 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 tights 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 case, with the help of semi/skilled labor. Where compressible gaskets are used, steps shall be provided to prevent over compression.

15.4. 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.

15.5. 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.

15.6. 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.

15.7. The tank shall be provided with 2 suitable copper alloy lugs for the purpose of grounding.

15.8. 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.

ii) One 50mm filter 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. S**ampling valve(15mm) shall be attached to both bottom and top filter valves.

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.

16. **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.

17. **Tap Changing Mechanism:**

17.1. 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.

17.2. 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.

17.3. The local control switches shall be mounted in the outdoor cubicle or in the riving gear housing.

17.4. 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.

17.5. Limit switches may be connected in the control circuit of the operating motor provided that a mechanical declutching mechanism is incorporated.

17.6. Thermal devices or other means shall be provided to protect the motor and ontrol circuits. All relays, switches, fuses etc. shall be mounted in the marshalling box or driving gear housing and shall be clearly marked to indicate their purpose.

17.7. 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.

17.8. 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.

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

17.10. A permanently legible lubrication chart shall be fitted within the driving mechanism chamber.

17.11. 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.

17.12. 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.

17.13. 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. A separate oil surge relay shall be provided for the on load tap changer as per relevant specifications.

17.14. The tap changer shall be capable of permitting parallel operation with other transformers of the same types.

17.15. 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.

17.16. 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.

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

17.18. 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.

17.19. 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.

17.20. 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 tap position in use by means of digital type indicators or tap position indicator with tap number shall be provided. The tap position indicator shall also provide output for SCADA application(4-20mA)

Independent Master Follower selector switch, Facia/digital type taps position indicator, other required devices, indicating lamps, etc. An indication lamp showing tap change in 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 oil surge relay trip
7) Tap changer out of step alarm
8) Low oil level alarm.

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

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

18. Oil Preserving Equipment:

18.1. Gasket:- The gasket material used shall be Neoprine based rubberized cork type RC 70-C as per IS 4253 (part II) 1980 Charactistices shall be;

1)	Specific Gravity	-	0.7 to 0.8
2)	Hardness IHRD	-	70 $\pm$ 5
3)	Compressibility at 28kg/cm^2 , %	-	30 $\pm$ 5 (for 6.4 t) 33 $\pm$ 5 (for 9.6 t)
4)	Compressibility at 60kg/cm^2 , %	-	40 $\pm$ 5 (for 6.4 t)

			45 ± 5 (for 9.6 t)
5)	Recovery at 28kg/cm^2 % min	-	80
6)	Recovery at 60kg/cm^2 % min	-	70
7)	Tensile strength kg/cm^2 min	-	18
8)	Compression set % max.	-	80 (temp 110^{O}C to 120^{O}C)
9)	Flexibility	-	Shall pass
10)	Chemical test on water extract		

(a) pH – 5 to 8
(b) Chloride content as chloride ion – 0.2% (max.)
(c) Sulphate content as sulphate ion – 0.2% (max.)

18.1. 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 regenerative type silica gel(cobalt free type).

18.2. 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.

19. **Bushings:-** The characteristics of bushings shall be as per IS 2099/73 with revision, if any:

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

19.2. 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 utilised and the adequate phase clearance shall be realised.

19.3. Each bushing shall be co-ordinated with the transformer insulation, so that all flashovers will occur outside the tank.

19.4. 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.

19.5. The bushings for the 110KV and 66KV shall be of oil filled condenser type. Porcelain bushings or condenser bushings may be used for voltage ratings up to 36KV.

19.6. All bushings shall have puncture strength greater than the dry flashover value.

19.7. Main terminals shall be solder less terminals, and shall be of the type and size specified in the schedule of requirements, or drawings.

19.8. The spacing between the bushings must be adequate to prevent flashover between phases under all conditions of operation.

19.9. The tenderer is requested to give the guaranteed withstand voltages for the above and also a calibration curve with different settings of the co-ordination gap, to the purchaser to decide the actual gap setting. Bidders' recommendations are also invited in this respect.

19.10. Bushing CT's required for temperature indicators may also be provided in the bushings of transformers.

19.11. Tan-Delta measurement tap shall be provided for each bushing. Tan-Delta shall be specified in the nameplate.

19.12. Terminal connector for **Single Kundah** shall be provided on 66 kV side and connectors for **Single Kundah** shall be provided on 11 kV side.

19.13. Position of neutral bushing shall be near to R- phase.

20. **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.

21. **Accessories:-**

21.1. 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 15.8 iii above).

v) One oil drain valve – 100mm size (15.8. i).

vi) One filter valve located at the top of the tank on the H.V.Side –50mm size (15.8.ii) and sampling valves in cl.15.8.3.

vii) Spring loaded with detachable diaphragm type pressure relief valve with two trip contacts for the main tank with limit switch design IP 65 with additional rain hood.

viii) Spring loaded with detachable diaphragm type pressure relief valve with two trip contacts for OLTC with limit switch design IP65 with additional rain hood.

OR

Suitable diaphragm, which may crack and release the excess pressure generated internally during an abnormal condition.

ix) 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.

x) Radiators complete

xi) a) An oil conservator or

b) Oil preserving equipment complete in all respects as described in Cl. 18.

xii) Eye bolts and lugs on all parts for ease of handling.

xiii) Two grounding terminals.

xiv) Diagram and rating plates.

xv) One set of equipment for control, protection, indication and annunciation for each transformer comprising motor contractors, detecting elements for devices, indicating apparatus, instruments, relays, annunciators, etc. The necessary contactors, switches and lamps shall be provided.

xvi) Suitable weatherproof cubicles for housing the following equipments (One for each transformer)

a) Temperature indicators with glass windows of adequate size for taking readings (This may be mounted separately at the discretion of the manufacturer)

b) Terminal blocks for CT secondaries and all other alarm and trip.

c) Terminal blocks for C.T. secondaries and other cable.

xvii) One indoor cubicle, for on load tap changer, alarm and indicating devices.

xviii) Set of devices for lifting the various parts of the transformer as also the complete transformer (one set common for two transformers).

xix) 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.

xx) One RTCC panel(indoor) as per Clause 17.20.

21.2. 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.

21.3. Indication, alarm and relay equipment shall have contacts suitable for operation with 110Volts D.C supply.

22. 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 Admirality Grey No.697(as per IS 5/1949 with latest amendment) 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.

23. **Packing:-** The packing may be in accordance with the supplier's standard practice out 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 devise(returnable)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.

Quality Assurance Plan(QAP) should be submitted with the bid.

The transformer shall be offered for stage inspection as follows:

23.1	Tank and conservator	1) Check correct dimension between wheels demonstrate turning of wheels through 90 deg and further dimensional check. 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 3) Leakage test of the conservator & radiators as per CBIP 4) Certification of all test results 5) Oil leakage test on all tanks at normal head of oil plus 35 kN / sqm at the base of the tank for 24 hrs 6) Vacuum and pressure test on tank as type test as per CBIP
23.2	Core	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 & 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. 2) Check on the quality of varnish if used on the stampings. a) Measurement of thickness and hardness of varnish on stampings b) Solvent resistance test to check that varnish does not react in hot oil

		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 3) Check on the amount of burrs 4) Bow check on stamping 5) Check for the overlapping of stampings. Corners of the sheet are to be apart. 6) Visual and dimensional check during assembly stage. 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 8) Check for inter laminar insulation between core sectors before and after pressing 9) Visual and dimensional check for straightness and roundnes of core, thickness of limbs and suitability of clamps 10) High voltage test (2KV for one minute) between core and clamps 11) Certification of all test results
23.3	Insulating material	1) Sample check for physical properties of material 2) Check for dielectric strength, DP 3) Visual and dimensional checks 4) Check for the reaction of hot oil on insulating materials 5) Certification of all test results
23.4	Windings	1) Sample check on winding conductor for mechanical properties and electrical conductivity 2) Visual and dimensional check on conductor for scratches, dept. mark etc. 3) Sample check on insulating paper for bursting strength, electric strength 4) Check for the reaction of hot oil on insulating paper 5) Check for the binding of the insulating paper on conductor 6) Check and ensure that physical condition of all materials taken for winding is satisfactory and free of dust 7) Check for absence of short circuit between parallel strands 8) Check for Brazed joints wherever applicable 9) Measurement of voltage ratio to be carried out when core / yoke is completely restocked and all connections are ready 10) Certification of all test results.

23.4.1	Checks before drying process	1) Check conditions of insulation on the conductor and between the windings 2) Check insulation distance between high voltage connection cables and earthed and other live parts 3) Check insulation distance between low voltage connection cables and earthed and other parts 4) Insulation test of core earthing 5) Check for proper cleanliness 6) Check tightness of coils i.e. no free movements 7) Certification of all test results
23.4.2	Checks during drying process	1) Measurement and recording of temperature and drying time during vacuum treatment. 2) Check for completeness of drying 3) Certification of all test result.
23.5	Oil	As per IS 335
23.6	Test on fittings and accessories	As per manufacturer's standard

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.

24. **<u>Special test</u>:- 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.**

25. **Factory Assembly And Tests:**

25.1. The transformer shall be completely assembled and tested a the factory. If the purchaser selects to have a representative, all tests shall be witnessed by him. Tests shall be performed in compliance with B.S.171. I.E.C. Publication No.76, IS.2026:1962.

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

25.3 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 24 hours. 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 voltage voltmeter method. The excitation losses given in the test report shall be measured after the impulse tests are completed.

g) Impedance between each pair of windings.

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.

j) Dielectric test on each transformer as per ISS.

k) Tests on load tap changers.

l) Zero and positive phase sequence impedance.

m) Temperature tests on one transformer for each rating at an equivalent to rated load. The current required for the auxiliaries shall be stated in the test report.

n) Impulse tests shall be made on one unit of each rating. Method of tests shall be subject to the approval.

o) Tan delta measurement.

p) Routine test shall be conducted including 24 hours pressure test to check for leakage in the presence of Board's representative.

26. **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) Vector group test.
v) Core balance test.
vi) Tan delta measurement
vii) Open circuit and short circuit test.
viii) Tap changer continuity test.

27. **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.

28. Test Reports:- After all tests have been completed, two certified copies of each test report shall 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 $75^{O}C$ including ambient temperature.
iv) The permissible limits of test results as per relevant ISS and guaranteed values shall be indicated in the test reports.

29. **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.

30. **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.

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.
j) Details of name plate, terminal marking and connection diagram.
k) 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 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.

31. DEVIATIONS IF ANY FROM THESE SPECIFICATIONS SHOULD BE CLEARLY LISTED AND BROUGHT OUT SEPARATELY AS PER ANNEXURES–III(B)& III(C).

Clause wise compliance statement shall be attached along with the bid. It should be recorded as ”complied with” on the right side of each clause in the bid document.
The schedule of prices should be indicated in Part III.

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

Sd/-

Chief Engineer(SCM)

ANNUEXURE – II

GUARANTEED TECHNICAL PARTICULARS OF 10 MVA, 66/11 kV THREE PHASE

POWER TRANSFORMERSTO BE FURNISHED BY THE BIDDER

Special note:

The values of following parameters are to be essentially specified by the bidder:

1) 1.Max. value of current density at any tap
2) 2.Max value of flux density
3) 3.Minimum cross sectional area of CRGO
4) 4.Minimum weight of covered conductor of (i) HV winding(ii)LV winding(iii)tap winding
5) 5.Minimum quantity of transformer oil in main tank

No approximation is allowed. The bidder should give the undertaking that the transformer being manufactured will have no values inferior to the value given here. During stage inspection, if the values of these parameters are found to be not in compliance with the declared values, the product will be rejected.

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

ii)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

11 Maximum current density in winding at C.M.R.

a) H.V. Winding: Amps/Sq.mm

b) L.V. 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 Guaranteed no load loss at normal ratio, rated frequency and 75^0C 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 75^0C 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 ^{0} C average winding temperature for the outputs of

a) Full load %

b) $^{3}/_{4}$ full load %

c) $^{1}/_{2}$ full load %

d) $^{1}/_{4}$ full load %

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^{0}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^{0}C average winding temperature expressed as percentage

rated voltage (%) between H.V. and L.V.Winding (%)

23) Regulation at full load at 75^0C

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

h) Details of oil ducts

i) Whether in the plane and at right angle to the plane of winding

27) Windings:

a) Type of winding

i) H.V. Winding

ii) L.V. Winding

b) Insulation of H.V.Winding

c) Insulation of L.V.Winding

d) Insulation between H.V and L.V. winding

e) Power frequency high voltage tests

i) Test voltage for 1 minute withstand test on high voltage windings (induced) kV (RMS)

ii) Test voltage for 1 minute withstand test on neutral and of high voltage windings kV (RMs)

iii) Test voltage for 1 minute withstand test on neutral and 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

f) Inter-turn insulation

i) Extent of extreme and turns reinforcement

ii) Extent of end turns reinforcement

iii) Extent of turns adjacent to tappings

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)

g) Type of axial coil supports

a) High voltage winding

b) Low voltage winding

h) Type of radial coil supports

a) High voltage winding

b) Low voltage winding

i) Whether H.V.Winding are interleaved

j) Details of special arrangements (if any) made to improve stress conditions.

k) Size of cooling ducts

l) 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) Thickness of transformer tank plate

a) Sides mm

b) Bottom mm

c) Top mm

30) Type and details of winding hot spot temperature detector

31) Power requirement of heater in conservator

32) Main and OLTC Buch-holz relay description, data range of settings, schematic diagram etc

33) Bushings HV LV Neutral

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

a) Positive (kV p)

b) Negative (kV p)

ix) Creepage distance in air mm

x) Recommended Gap setting

xi) Weight of Assembled bushing

xii) Quantity of oil

34) Free space removal or bushings

35) Total volume of conservator . . . Litres

36) Volume of conservator between the highest and lowest levels

37) Bushing potential device

a) Name of manufacturer

b) Description data and literature

c) Rated capacity

d) Rated secondary voltage

38) Make, type and details of

a) Winding temperature indicator

b) Oil temperature indicator

c) Oil level indicator

39) Calculated time constants (hrs.)

Natural cooling

40) Details of On Load Tap changing gear

a) Make

b) Type

c) Rating

1) Rated voltage

2) Rated current

3) Step voltage

4) Number of steps

d) Control

e) Auxiliary Supply Details

f) Position of taps

g) Parallel Operation

h) Protective Devices

i) Approximate overall weight

j) Approximate overall dimensions

k) Approximate overall quantity of oil in litres

41) Weight of copper required to complete the transformer Kg

42) Weight of steel required to complete the transformer Kg

43) Weight of fittings and parts detached for transport Kg

44) Weight of core and windings Kg

45) Weight of complete transformer with all fittings & Oil kg

46) Weight of complete transformer arranged for transport or the heaviest package if broken down Kg

47) Weight of oil in the transformer Kg

48) Dimensions of the transformers in metres

a) Maximum height to top of bushings

b) Over all length

c) Overall breadth

49) Description of any other accessories or Appliances recommended by the tenderer

) No load loss at rated voltage and frequency at principal tap (max.), kW

Tolerance if any on the above

Load loss at rated output, rated frequency and 75 deg C winding temperature at Principal tap (kW)

Tolerance if any on the above

50 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)
21	Max. value of current density at any tap
22	Max value of flux density
23	Minimum cross sectional area of CRGO
24	Minimum weight of covered conductor of (i) HV winding (ii)LV winding

(iii)tap winding

25 Minimum quantity of transformer oil in main tank

Bidder's Name	
Name	
Designation	
Date	