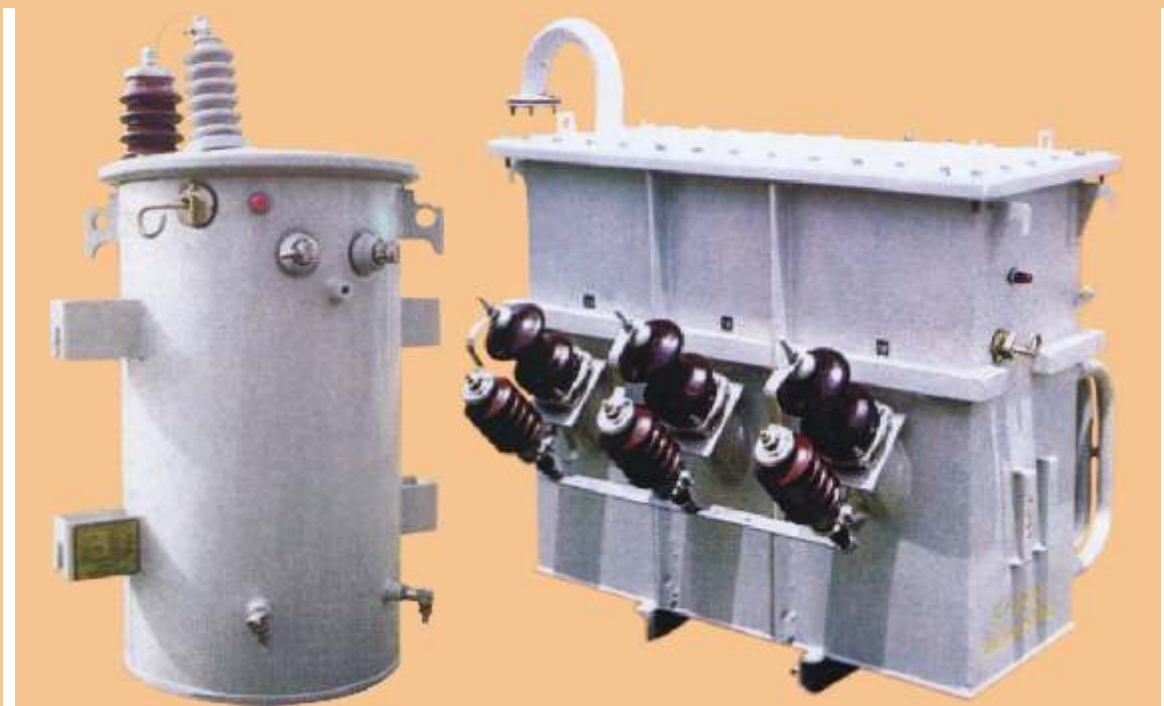




# **GUIDELINES FOR SPECIFICATIONS OF ENERGY EFFICIENT OUTDOOR TYPE THREE PHASE AND SINGLE PHASE DISTRIBUTION TRANSFORMERS**



**GOVT. OF INDIA  
MINISTRY OF POWER  
CENTRAL ELECTRICITY AUTHORITY  
NEW DELHI**

**August, 2008**



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Government of India



### **Foreword**

The objective of National Electricity Policy is “Power to all by 2012”. To achieve this, about 78500 MW of generation capacity and matching Transmission and Distribution systems are to be added during 11<sup>th</sup> Plan. This would entail addition of about 2.72 lakh MVA of Distribution Transformer capacity during the Plan. Stringent quality control has to be ensured right from selection of raw materials, manufacturing to procurement and installation of these transformers.

The Distribution utilities have generally been procuring transformers with maximum allowable losses as per IS1180. With the advent of more efficient materials and improvement in technology, it is now possible to have much more efficient and better quality transformers at reasonable prices. Standard specifications for single phase and three phase outdoor oil filled Distribution Transformers have been prepared by the Central Electricity Authority to act as Guidelines for the utilities for selection and procurement of energy efficient Transformers. The specifications have been finalized after detailed discussions with the Distribution utilities and the manufacturers of Distribution Transformers.

This has been possible through the concerted efforts of engineers in the Distribution Planning & Development Division of Central Electricity Authority. I hope the Guidelines will be of immense use for the engineers in the Power Distribution utilities.

**(Rakesh Nath)**



**Member GO&D**  
**Central Electricity Authority**  
**Ex-officio Additional Secretary**  
**Govt. of India**




## **Preface**

Reforms in the Distribution sector have got a big boost with the implementation of the Accelerated Power Development and Reform programme of Govt. of India. Distribution transformers form a very vital and substantial part in the delivery supply chain and large number of transformers are being procured by the utilities under this programme as well as with their own resources to meet the GOI mission of Power for all by 2012. Recognising the importance of standardization of specifications of the distribution transformer for procurement of quality transformers, the Central Electricity Authority has formulated technical Specifications for Three phase and single phase oil filled outdoor type Distribution transformers.

The document has been prepared after discussions and considering inputs from the various stakeholders of the Power Distribution industry viz power utilities, manufacturers and Bureau of Energy Efficiency. The document is intended to provide Guidance for preparing technical part of the tender document for procurement of Distribution Transformers.

The specifications are the result of the concerted efforts of Sh. Alok Gupta Chief Engineer DP&D and Smt. Anjuli Chandra Director (Distribution) and other officers of Distribution Planning & Development Division.

  
**(S.M. Dhiman)**

## INDEX

Sl. No.	Content	Page No.
1	SPECIFICATION FOR OUTDOORS TYPE THREE PHASE OIL IMMERSED (INCLUDING COMPLETELY SELF PROTECTED) DISTRIBUTION TRANSFORMERS 11 kV/ 433 – 250V and 33 kV /433-250V.	01
2	SPECIFICATION FOR OUTDOOR TYPE SINGLE PHASE OIL IMMERSED (INCLUDING COMPLETELY SELF PROTECTED) DISTRIBUTION TRANSFORMERS 11 kV/230 V and $11/\sqrt{3}$ kV/230 V.	55

## CONTENTS

SPECIFICATION FOR OUTDOOR TYPE THREE PHASE OIL IMMERSED (INCLUDING COMPLETELY SELF PROTECTED) DISTRIBUTION TRANSFORMERS OF 11 kV/433 – 250V and 33 kV /433-250V.

Clause No.	Contents	Page No.
1.	Scope	1
2.	Standard ratings	1
3.	Standards	1
4.	Service conditions	3
5.	Principal parameters	3
6.	Technical requirements	4
7.	Windings	5
8.	Taps	6
9.	Oil	6
10.	Insulation levels	7
11.	Losses	7
12.	Tolerances	9
13.	Percentage impedance	9
14.	Temperature rise	9
15.	Penalty for non performance	9
16.	Insulation material	9
17.	Tank	10
18.	Conservator	12
19.	Surface preparation and painting	12
20.	Bushings	15
21.	Terminal connectors	16
22.	Lightning arrestors	16
23.	Cable boxes	16
24.	Terminal markings	17
25.	Current transformers	17
26.	Fittings	18
27.	Fasteners	19
28.	Overload capacity	19
29.	Completely self protected (CSP) transformers	19
30.	Protection features	19

31.	Load management signal light	20
32.	Lightning arrestors	21
33.	Tests	21
34.	Routine tests	21
35.	Type tests to be conducted on one unit	22
36.	Acceptance tests	24
37.	Tests at site	24
38.	Inspection	24
39.	Inspection and testing of transformer oil	25
40.	Quality assurance plan	26
41.	Documentation	27
42.	Packing and forwarding	27
43.	Manadatory spares	27
44.	Guarantee	28
45.	Schedules	28
46.	Deviations	28
Annexure -I	Methodology for computing total owning cost	29
Annexure -II	Proforma for stage inspection of distribution transformers	30
Annexure -III	Proforma for pre-delivery inspection of distribution transformers	41
Annexure -IV	Source of meterial / places of manufacture, testing and inspection	47
Schedule-IA	Guaranteed and other particulars for distribution transformers	48
Schedule-IB	Additional details	52

## CONTENTS

SPECIFICATION FOR OUTDOOR TYPE SINGLE PHASE OIL IMMERSED (INCLUDING COMPLETELY SELF PROTECTED) DISTRIBUTION TRANSFORMERS 11 kV/230 V and 11/ $\sqrt{3}$  kV/230 V .

Clause No.	Contents	Page No.
1.	Scope	55
2.	Standards	55
3.	Service conditions	57
4.	Principal parameters	58
5.	Technical requirements	58
6.	Losses	60
7.	Percentage impedance	60
8.	Temperature rise	61
9.	Penalty for non performance	61
10.	Bushings	61
11.	Bushing terminals	62
12.	Tank	62
13.	Tank sealing	63
14.	Surface preparation and painting	63
15.	Rating and terminal plates	66
16.	Pressure release device	66
17.	Fittings	66
18.	Fasteners	67
19.	11 kv lightning arrestors	68
20.	Over load capacity	68
21.	Protection : (for CSP transformers)	68
22.	Routine tests	70
23.	Type tests to be conducted on one unit	70
24.	Tests at site	71
25.	Acceptance tests	71
26.	Inspection	72
27.	Quality assurance plan	74
28.	Documentation	74
29.	Packing and forwarding	75
30.	Manadatory spares	75
31.	Guarantee	75
Annexure-I	Methodology for computing total owning cost	76
Schedule IA	Guaranteed technical particulars for completely self protected distribution transformers	77
Schedule IB	Additional details	79
Schedule IIB	Source of materials/places of manufacture, testing and inspection	80

**STANDARD TECHNICAL SPECIFICATION**

**FOR**

**OUTDOOR TYPE THREE PHASE OIL IMMERSED  
(INCLUDING COMPLETELY SELF PROTECTED)  
DISTRIBUTION TRANSFORMERS**

**11 kV/433-250 V**

**AND**

**33 kV/433-250 V**

**$11/\sqrt{3}$  kV/230 V**

**TECHNICAL SPECIFICATION FOR OUTDOOR TYPE  
DISTRIBUTION TRANSFORMERS 11 kV/433 – 250V  
and 33 kV / 433-250V**

**1 SCOPE:**

- 1.1 This specification covers design, engineering, manufacture, assembly, stage testing, inspection and testing before supply and delivery at site of oil immersed, naturally cooled 3 phase 11 kV/433 - 250 V and 33 kV/433-250 V distribution transformers for outdoor use.
- 1.2 It is not the intent to specify completely herein all the details of the design and construction of equipment. However the equipment shall conform in all respects to high standards of engineering, design and workmanship and shall be capable of performing in continuous commercial operation, in a manner acceptable to the purchaser, who will interpret the meanings of drawings and specification and shall have the power to reject any work or material which, in his judgment is not in accordance therewith. The offered equipment shall be complete with all components necessary for their effective and trouble free operation. Such components shall be deemed to be within the scope of bidder's supply irrespective of whether those are specifically brought out in this specification and / or the commercial order or not.
- 1.3 The transformer and accessories shall be designed to facilitate operation, inspection, maintenance and repairs. The design shall incorporate every precaution and provision for the safety of equipment as well as staff engaged in operation and maintenance of equipment.
- 1.4 All outdoor apparatus, including bushing insulators with their mountings, shall be designed so as to avoid any accumulation of water.

**2 STANDARD RATINGS:**

- 2.1 The standard ratings shall be 10, 16, 25, 63, 100, 160, 200, 250, 315, 400, 500, 630, 1000, 1250, 1600, 2000 and 2500 kVA for 11 kV distribution transformers and 100, 160, 200, 315, 400, 500, 630, 1000, 1250, 1600, 2000, 2500 kVA for 33 kV distribution transformers.

**3 STANDARDS:**

- 3.1 The materials shall conform in all respects to the relevant Indian/International Standards, with latest amendments thereof unless otherwise specified herein. Some of them are listed below:

Indian Standard	Title	International and Internationally recognised standards
IS -2026	Specification for Power Transformers	IEC 76
IS - 1180	Outdoor distribution Transformer up to and including 100 kVA	
IS 12444	Specification for Copper wire rod	ASTM B-49
IS-335	Specification for Transformer Oil	BS 148, D-1473, D-1533-1934 IEC Pub 296
IS - 5	Specification for colors for ready mixed paints	
IS - 104	Ready mixed paint, brushing zinc chromate, priming	
IS – 2099	Specification for high voltage porcelain bushing	
IS - 649	Testing for steel sheets and strips and magnetic circuits	
IS - 4257	Dimensions for clamping arrangements for bushings	
IS - 7421	Specification for Low Voltage bushings	
IS - 3347	Specification for Outdoor Bushings	DIN 42531 to 33
IS - 5484	Specification for Al Wire rods	ASTM B - 233
IS - 9335	Specification for Insulating Kraft Paper	IEC 554
IS - 1576	Specification for Insulating Press Board	IEC 641
IS - 6600	Guide for loading of oil Immersed Transformers	IEC 76
IS - 2362	Determination of water content in oil for porcelain bushing of transformer	
IS - 6162	Paper covered aluminium conductor	
IS - 6160	Rectangular Electrical conductor for electrical machines	
IS - 5561	Electrical power connector	
IS - 6103	Testing of specific resistance of electrical insulating liquids	
IS - 6262	Method of test for power factor and dielectric constant of electrical insulating liquids	
IS - 6792	Determination of electrical strength of insulating oil	
IS - 10028	Installation and maintenance of transformers.	

3.2 Material conforming to other internationally accepted standards, which ensure equal or better quality than the standards mentioned above, would also be acceptable. In case the bidders who wish to offer material conforming to other standards, the bidder shall clearly bring out the salient points of difference between the standards adopted and the specific standards in relevant schedule. Four copies of such standards with authentic English translations shall be furnished along with the offer.

#### **4 SERVICE CONDITIONS:**

4.1 The Distribution Transformers to be supplied against this Specification shall be suitable for satisfactory continuous operation under the following climatic conditions as per IS 2026 (Part - I).

- |      |   |   |                                     |
|------|---|---|-------------------------------------|
| i)   | Location  | : | At various locations in the country |
| ii)  | Maximum ambient air temperature (°C)                    | : | 50                                  |
| iii) | Minimum ambient air temperature (°C)                    | : | -5                                  |
| iv)  | Maximum average daily ambient air temperature (°C)      | : | 40                                  |
| v)   | Maximum yearly weighted average ambient temperature(°C) | : | 32                                  |
| vi)  | Maximum altitude above mean sea level (Metres)          | : | To be specified by the user         |

#### **Note:**

1. The climatic conditions specified above are indicative and can be changed by the user as per requirements.
2. The equipment shall generally be for use in moderately hot and humid tropical climate, conducive to rust and fungus growth unless otherwise specified.

#### **5 PRINCIPAL PARAMETERS:**

5.1 The transformers shall be suitable for outdoor installation with three phase, 50 Hz, 11 kV or 33 kV system in which the neutral is effectively earthed and they should be suitable for service with fluctuations in supply voltage upto plus 12.5% to minus 12.5%.

5.2 The transformers shall conform to the following specific parameters :

Sl.No.	Item	11 kV Distribution Transformers	33 kV Distribution Transformers
1	System voltage (max.)	12 kV	36 kV
2	Rated voltage HV	11 kV	33 kV
3.	Rated voltage LV	433 - 250 V*	433 - 250 V*
4.	Frequency	50 Hz +/- 5%*	50 Hz +/- 5%
5	No. of Phases	Three	Three
6	Connection HV	Delta	Delta
7	Connection LV	Star (Neutral brought out)	Star (Neutral brought out)
8.	Vector group	Dyn-11	Dyn-11
9.	Type of cooling	ONAN	ONAN

\*The voltage level can be specified as 415-240 V/400-230 V volts as per the requirements of the purchaser.

Audible sound levels (decibels) at rated voltage and frequency for liquid immersed distribution transformers shall be as below (NEMA Standards):

kVA rating	Audible sound levels (decibels)
0-50	48
51-100	51
101-300	55
301-500	56
750	57
1000	58
1500	60
2000	61
2500	62

## 6 TECHNICAL REQUIREMENTS:

### 6.1.1 CORE MATERIAL - CRGO / AMORPHOUS METAL

#### 6.1.2 CRGO Material

6.1.2.1 The core shall be stack / wound type of high grade cold rolled grain oriented annealed steel lamination having low loss and good grain properties, coated with hot oil proof insulation, bolted together and to the frames firmly to prevent

vibration or noise. The core shall be stress relieved by annealing under inert atmosphere if required. The complete design of core must ensure permanency of the core loss with continuous working of the transformers. The value of the maximum flux density allowed in the design and grade of lamination used shall be clearly stated in the offer.

6.1.2.2 The bidder should offer the core for inspection and approval by the purchaser during manufacturing stage.

6.1.2.3 The transformers core shall be suitable for over fluxing (due to combined effect of voltage and frequency) up to 12.5% without injurious heating at full load conditions and shall not get saturated. The bidder shall furnish necessary design data in support of this situation.

6.1.2.4 No-load current shall not exceed 3% of full load current and will be measured by energising the transformer at 433 volts, 50 Hz on the secondary. Increase of voltage of 433 volts by 12.5% shall not increase the no-load current by 6% (maximum) of full load current.

### **6.1.3 AMORPHOUS METAL:**

6.1.3.1 The core shall be high quality amorphous ribbons having very low loss formed into wound cores of rectangular shape, bolted together to the frames firmly to prevent vibration or noise. The complete design of core must ensure permanency of the core loss with continuous working of the transformers. The value of the flux density allowed in the design shall be clearly stated in the offer. Curve showing the properties of the metal shall be attached with the offer.

6.1.3.2 The transformer core shall be suitable for over fluxing (due to combined effect of voltage and frequency) upto 12.5% without injurious heating at full load conditions and shall not get saturated. The bidder shall furnish necessary design data in support of this situation.

6.1.3.3 No load current shall not exceed 2% of full load current and will be measured by energising the transformer at 433 volts, 50 Hz on the secondary. For increase of voltage of 433 volts by 12.5%, the no-load current shall not increase beyond 5 % of the full load current.

## **7 WINDINGS:**

### **7.1 Material:**

7.1.1 HV and LV windings shall be wound from Super Enamel covered /Double Paper covered , aluminium /copper conductor/ foil 100 kVA and below.

7.1.2 HV and LV windings shall be wound from Super Enamel covered / Double Paper covered copper conductor/foil winding for ratings above 100 kVA.

- 7.1.3 LV winding shall be such that neutral formation will be at top.
- 7.1.4 The winding construction of single HV coil wound over LV coil is preferable.
- 7.1.5 Inter layer insulation shall be Nomex /Epoxy dotted Kraft Paper.
- 7.1.6 Proper bonding of inter layer insulation with the conductor shall be ensured. Test for bonding strength shall be conducted.
- 7.1.7 Dimensions of winding coils are very critical. Dimensional tolerances for winding coils shall be within limits as specified in Guaranteed Technical Particulars (GTP Schedule I).
- 7.1.8 Current density for HV and LV winding should not be more than 2.8 Ampere per sq mm for copper and 1.6 Ampere per sq mm for Aluminium Conductor.
- 7.1.9 The core/coil assembly shall be securely held in position to avoid any movement under short circuit conditions.
- 7.1.10 Joints in the winding shall be avoided. However, if jointing is necessary the joints shall be properly brazed and the resistance of the joints shall be less than that of parent conductor. In case of foil windings, welding of leads to foil can be done within the winding.

## **8 TAPS:**

- 8.1.1 No tapping shall be provided for transformers up to 100 kVA rating.
- 8.1.2 For ratings above 100 kVA and up to 200 kVA, tappings shall be provided, if required by the purchaser, on the higher voltage winding for variation of HV voltage within range of (+) 5.0 % to (-) 7.5% in steps of 2.5%.
- 8.1.3 For ratings higher than 200 kVA, tapping shall be provided on the higher voltage winding for variation of HV voltage within range of (+) 5.0 % to (-) 15.0 % in steps of 2.5%.
- 8.1.4 Tap changing shall be carried out by means of an externally operated self position switch and when the transformer is in de-energised condition. Switch position No.1 shall correspond to the maximum plus tapping. Each tap change shall result in variation of 2.5% in voltage. Provision shall be made for locking the tapping switch handle in position. Suitable aluminium anodised plate shall be fixed for tap changing switch to know the position number of tap.

## **9 OIL :**

- 9.1 The insulating oil shall comply with the requirements of IS 335 or BS 148.

Use of recycled oil is not acceptable. The specific resistance of the oil shall not be less than  $2.5 \times 10^{12}$  ohm-cm at 27 °C when tested as per IS 6103.

- 9.2 Oil shall be filtered and tested for break down voltage (BDV) and moisture content before filling.
- 9.3 The oil shall be filled under vacuum.
- 9.4 The design and all materials and processes used in the manufacture of the transformer, shall be such as to reduce to a minimum the risk of the development of acidity in the oil.

**10 INSULATION LEVELS:**

Sl. No.	Voltage (kV)	Impulse Voltage (kV Peak)	Power Frequency Voltage (kV)
1	0.433	-	3
2	11	95	28
3	33	170	70

**11 LOSSES:**

- 11.1 The bidder shall guarantee individually the no-load loss and load loss without any positive tolerance. The bidder shall also guarantee the total losses at 50% and 100% load condition (at rated voltage and frequency and at 75 °C).
- 11.2 The maximum allowable losses at rated voltage and rated frequency permitted at 75 °C for 11/0.433 kV transformers can be chosen by the utility from the values of 3 star, 4 star or 5 star rating for transformers up to rating of 200 kVA as indicated below:

Voltage Ratio	Rating (kVA)	3 Star		4 Star		5 Star	
		Max. Losses at 50% loading (Watts)	Max. Losses at 100% loading (Watts)	Max. Losses at 50% loading (Watts)	Max. Losses at 100% loading (Watts)	Max. Losses at 50% loading (Watts)	Max. Losses at 100% loading (Watts)
11000/433 – 250 V	16	150	480	135	440	120	400
11000/433 - 250 V	25	210	695	190	635	175	595
11000/433 - 250 V	63	380	1250	340	1140	300	1050
11000/433 - 250 V	100	520	1800	475	1650	435	1500
11000/433 - 250 V	160	770	2200	670	1950	570	1700
11000/433 - 250 V	200	890	2700	780	2300	670	2100

11.3 For transformers of other ratings the following maximum allowable losses at rated voltage and frequency and at 75 °C shall be taken:

<b>Voltage Ratio</b>	<b>Rating (kVA)</b>	<b>Max. Losses at 50% loading (Watts)</b>	<b>Max. Losses at 100% loading (Watts)</b>
11000/433 - 250 V	10	98	300
11000/433 - 250 V	250	1050	3320
11000/433 - 250 V	315	1100	3630
11000/433 - 250 V	400	1450	4630
11000/433 - 250 V	500	1600	5500
11000/433 - 250 V	630	2000	6640
11000/433 - 250 V	1000	3000	9800
11000/433 - 250 V	1250	3600	12000
11000/433 - 250 V	1600	4500	15000
11000/433 - 250 V	2000	5400	18400
11000/433 - 250 V	2500	6500	22500
33000/433 - 250 V	100	560	1820
33000/433 - 250 V	160	780	2580
33000/433 - 250 V	200	900	3000
33000/433 - 250 V	315	1300	4300
33000/433 - 250 V	400	1520	5100
33000/433 - 250 V	500	1950	6450
33000/433 - 250 V	630	2300	7600
33000/433 - 250 V	1000	3450	11350
33000/433 - 250 V	1250	4000	13250
33000/433 - 250 V	1600	4850	16000
33000/433 - 250 V	2000	5700	18500
33000/433 - 250 V	2500	7050	23000

11.4 Whenever the star ratings for the above transformers become available the values of 3 star, 4 star or 5 star could be taken by the utility. Bids with higher losses than the above specified values would be treated as non-responsive. However, the manufacturer can offer losses less than above. The utility can evaluate offers with losses lower than the maximum allowable losses on total owning cost as per formula given in Annexure-I

**12 TOLERANCES:**

12.1 No positive tolerance shall be allowed on the maximum losses displayed on the label for both 50% and 100% loading values.

**13 PERCENTAGE IMPEDANCE:**

13.1 The value of impedance of transformers at 75 °C shall be 4.5% for transformers up to and 200 kVA and for ratings above 200 kVA shall be in accordance with IS 2026.

**14 Temperature rise:** The temperature rise over ambient shall not exceed the limits given below:

14.1 Top oil temperature rise measured by thermometer : 35 °C

14.2 Winding temperature rise measured by resistance method : 40 °C

**Bids not meeting the above limits of temperature rise will be treated as non-responsive.**

14.3 The transformer shall be capable of giving continuous rated output without exceeding the specified temperature rise. Bidder shall submit the calculation sheet in this regard.

**15 PENALTY FOR NON PERFORMANCE:**

15.1 During testing at supplier's works if it is found that the actual measured losses are more than the values quoted by the bidder, the purchaser shall reject the transformer and he shall also have the right to reject the complete lot.

15.2 Purchaser shall reject the entire lot during the test at supplier's works, if the temperature rise exceeds the specified values.

15.3 Purchaser shall reject any transformer during the test at supplier's works, if the impedance values differ from the guaranteed values including tolerance.

**16 INSULATION MATERIAL:**

16.1 Electrical grade insulation epoxy dotted Kraft Paper/Nomex and pressboard of standard make or any other superior material subject to approval of the purchaser shall be used.

16.2 All spacers, axial wedges / runners used in windings shall be made of pre-compressed Pressboard-solid, conforming to type B 3.1 of IEC 641-3-2. In case of cross-over coil winding of HV all spacers shall be properly sheared

and dovetail punched to ensure proper locking. All axial wedges / runners shall be properly milled to dovetail shape so that they pass through the designed spacers freely. Insulation shearing, cutting, milling and punching operations shall be carried out in such a way, that there should not be any burr and dimensional variations.

## **17 TANK:**

- 17.1 The internal clearance of tank shall be such, that it shall facilitate easy lifting of core with coils from the tank without dismantling LV bushings.
- 17.2 All joints of tank and fittings shall be oil tight and no bulging should occur during service.
- 17.3 Inside of tank shall be painted with varnish/hot oil resistant paint.
- 17.4 The top cover of the tank shall be slightly sloping to drain rain water.
- 17.5 The tank plate and the lifting lugs shall be of such strength that the complete transformer filled with oil may be lifted by means of lifting shackle.
- 17.6 Manufacturer should carry out all welding operations as per the relevant ASME standards and submit a copy of the welding procedure and welder performance qualification certificates to the customer.

## **17.2 PLAIN TANK:**

- 17.2.1 The transformer tank shall be of robust construction rectangular/octagonal/round/elliptical in shape and shall be built up of electrically tested welded mild steel plates of thickness of 3.15 mm for the bottom and top and not less than 2.5 mm for the sides for distribution transformers upto and including 25 kVA, 5.0 mm and 3.15 mm respectively for transformers of more than 25 kVA and up to and including 100 kVA and 6 mm and 4 mm respectively above 100 kVA. Tolerances as per IS1852 shall be applicable.
- 17.2.2 In case of rectangular tanks above 100 kVA the corners shall be fully welded at the corners from inside and outside of the tank to withstand a pressure of 0.8 kg/cm<sup>2</sup> for 30 minutes. In case of transformers of 100 kVA and below, there shall be no joints at corners and there shall not be more than 2 joints in total.
- 17.2.3 Under operating conditions the pressure generated inside the tank should not exceed 0.4 kg/ sq. cm positive or negative. There must be sufficient space from the core to the top cover to take care of oil expansion. The space above oil level in the tank shall be filled with dry air or nitrogen conforming to commercial grade of IS 1747.

17.2.4 The tank shall be reinforced by welded flats on all the outside walls on the edge of the tank.

17.2.5 Permanent deflection: The permanent deflection, when the tank without oil is subjected to a vacuum of 525 mm of mercury for rectangular tank and 760 mm of mercury for round tank, shall not be more than the values as given below:

(All figures in mm)

Horizontal length of flat plate	Permanent deflection
Up to and including 750	5.0
751 to 1250	6.5
1251 to 1750	8.0
1751 to 2000	9.5
2001 to 2250	11.0
2251 to 2500	12.0
2501 to 3000	16.0
Above 3000	19.0

17.2.6 **The tank shall further be capable of withstanding a pressure of 0.8 kg/sq.cm (g) and a vacuum of 0.7 kg/sq.cm (g) without any deformation.**

17.2.7 The radiators can be tube type or fin type or pressed steel type to achieve the desired cooling to limit the specified temperature rise.

### 17.3 CORRUGATED TANK:

17.3.1 The bidder may offer corrugated tanks for transformers of all ratings.

17.2.2 The transformer tank shall be of robust construction corrugated in shape and shall be built up of tested sheets.

17.2.3 Corrugation panel shall be used for cooling. The transformer shall be capable of giving continuous rated output without exceeding the specified temperature rise. Bidder shall submit the calculation sheet in this regard.

17.2.4 Tanks with corrugations shall be tested for leakage test at a pressure of 0.25kg/sq cm measured at the top of the tank.

17.2.5 The transformers with corrugation should be provided with a pallet for transportation, the dimensions of which should be more than the length and width of the transformer tank with corrugations.

## **18 CONSERVATOR:**

- 18.1 The conservator shall be provided on transformers of rating 63 kVA and above for plain tank and 200 kVA and above for corrugated tank. For other ratings transformers manufacturer may adopt their standard practice or follow utility's requirement. For sealed type transformers conservator is not required.
- 18.2 When a conservator is provided, oil gauge and the plain or dehydrating breathing device shall be fitted to the conservator which shall also be provided with a drain plug and a filling hole [32 mm (1¼")] normal size thread with cover. In addition, the cover of the main tank shall be provided with an air release plug.
- 18.3 The dehydrating agent shall be silica gel. The moisture absorption shall be indicated by a change in the colour of the silica gel crystals which should be easily visible from a distance. Volume of breather shall be suitable for 500g of silicagel conforming to IS 3401 for transformers upto 200 kVA and 1 kg for transformers above 200 kVA .
- 18.4 The capacity of a conservator tank shall be designed keeping in view the total quantity of oil and its contraction and expansion due to temperature variations. The total volume of conservator shall be such as to contain 10% quantity of the oil. Normally 3% quantity the oil shall be contained in the conservator.
- 18.5 The cover of main tank shall be provided with an air release plug to enable air trapped within to be released, unless the conservator is so located as to eliminate the possibility of air being trapped within the main tank.
- 18.6 The inside diameter of the pipe connecting the conservator to the main tank should be within 20 to 50 mm and it should be projected into the conservator so that its end is approximately 20 mm above the bottom of the conservator so as to create a sump for collection of impurities. The minimum oil level (corresponding to -5 °C) should be above the sump level.

## **19 SURFACE PREPARATION AND PAINTING:**

### **19.1 GENERAL**

- 19.1.1 All paints, when applied in a normal full coat, shall be free from runs, sags, wrinkles, patchiness, brush marks or other defects.
- 19.1.2 All primers shall be well marked into the surface, particularly in areas where painting is evident and the first priming coat shall be applied as soon as possible after cleaning. The paint shall be applied by airless spray according to manufacturer's recommendations. However, where ever airless spray is not possible, conventional spray be used with prior approval of purchaser.

## **19.2 CLEANING AND SURFACE PREPARATION:**

- 19.2.1 After all machining, forming and welding has been completed, all steel work surfaces shall be thoroughly cleaned of rust, scale, welding slag or spatter and other contamination prior to any painting.
- 19.2.2 Steel surfaces shall be prepared by shot blast cleaning (IS9954) to grade Sq. 2.5 of ISO 8501-1 or chemical cleaning including phosphating of the appropriate quality (IS 3618).
- 19.2.3 Chipping, scraping and steel wire brushing using manual or power driven tools cannot remove firmly adherent mill-scale. These methods shall only be used where blast cleaning is impractical. Manufacturer to clearly explain such areas in his technical offer.

## **19.3 PROTECTIVE COATING:**

- 19.3.1 As soon as all items have been cleaned and within four hours of the subsequent drying, they shall be given suitable anti-corrosion protection.

## **19.4 PAINT MATERIAL:**

- 19.4.1 Following are the types of paint which may be suitably used for the items to be painted at shop and supply of matching paint to site:  
Heat resistant paint (Hot oil proof) for inside surface
- 19.4.2 For external surfaces one coat of thermo setting powder paint or one coat of epoxy primer followed by two coats of synthetic enamel/polyurethane base paint. These paints can be either air drying or stoving.
- 19.4.3 For highly polluted areas, chemical atmosphere or for places very near to the sea coast, paint as above with one coat of high build Micaceous iron oxide (MIO) as an intermediate coat may be used.

## **19.5 PAINTING PROCEDURE:**

- 19.5.1 All prepared steel surfaces should be primed before visible re-rusting occurs or within 4 hours, whichever is sooner. Chemical treated steel surfaces shall be primed as soon as the surface is dry and while the surface is still warm.
- 19.5.2 Where the quality of film is impaired by excess film thickness (wrinkling, mud cracking or general softness) the supplier shall remove the unsatisfactory paint coating and apply another coating. As a general rule, dry film thickness should not exceed the specified minimum dry film thickness by more than 25%.

## 19.6 DAMAGED PAINTWORK:

- 19.6.1 Any damage occurring to any part of a painting scheme shall be made good to the same standard of corrosion protection and appearance as that was originally applied.
- 19.6.2 Any damaged paint work shall be made good as follows:
- 19.6.2.1 The damaged area, together with an area extending 25 mm around its boundary, shall be cleaned down to bare metal.
- 19.6.2.2 A priming coat shall be immediately applied, followed by a full paint finish equal to that originally applied and extending 50 mm around the perimeter of the original damage.
- 19.6.2.3 The repainted surface shall present a smooth surface. This shall be obtained by carefully chamfering the paint edges before and after priming.

## 19.7 DRY FILM THICKNESS:

- 19.7.1 To the maximum extent practicable the coats shall be applied as a continuous film of uniform thickness and free of pores. Overspray, skips, runs, sags and drips should be avoided. The different coats may or may not be of the same colour.
- 19.7.2 Each coat of paint shall be allowed to harden before the next is applied as per manufacturer's recommendation.
- 19.7.3 Particular attention must be paid to full film thickness at the edges.
- 19.7.4 The requirements for the dry film thickness (DFT) of paint and the materials to be used shall be as given below:

Sl. No.	Paint type	Area to be painted	No. of coats	Total dry film thickness (min.) (microns)
1.	Thermo setting powder paint	inside outside	01 01	30 60
2.	<b>Liquid paint</b>			
	a) Epoxy (primer)	outside	01	30
	b) P.U. Paint (Finish coat)	outside	02	25 each
	c) Hot oil paint/ Varnish	inside	01	35/10

## 19.8 TESTS FOR PAINTED SURFACE:

19.8.1 The painted surface shall be tested for paint thickness.

19.8.2 The painted surface shall pass the cross hatch adhesion test and impact test as acceptance tests and Salt spray test and Hardness test as type test as per the relevant ASTM standards.

Note: Supplier shall guarantee the painting performance requirement for a period of not less than 5 years.

## 20 BUSHINGS:

20.1 The bushings shall conform to the relevant standards specified and shall be of outdoor type. The bushing rods and nuts shall be made of brass material 12 mm diameter for both HT and LT bushings. The bushings shall be fixed to the transformers on side with straight pockets and in the same plane or the top cover for transformers above 100 kVA. For transformers of 100 kVA and below the bushing can be mounted on pipes. The tests as per latest IS 2099 and IS 7421 shall be conducted on the transformer bushings.

20.2 For 33 kV, 52 kV class bushings shall be used for transformers of ratings 500 kVA and above. And for transformers below 500 KVA, 33 kV class bushings, for 11 kV, 17.5 kV class bushings and for 0.433 kV, 1.1 kV class bushings shall be used.

20.3 Bushing can be of porcelain/epoxy material. Polymer insulator bushings conforming with relevant IEC can also be used.

20.4 Bushings of plain shades as per IS 3347 shall be mounted on the side of the Tank and not on top cover.

20.5 Dimensions of the bushings of the voltage class shall conform to the Standards specified and dimension of clamping arrangement shall be as per IS 4257

20.6 Minimum external phase to phase and phase to earth clearances of bushing terminals shall be as follows:

Voltage	Clearence	
	Phase to phase	Phase to earth
33 kV	350 mm	320 mm
11 kV	255 mm	140 mm
LV	75 mm	40 mm

The clearances in case of cable box shall be as below:

Voltage	Clearence	
	Phase to phase	Phase to earth
33 kV	351 mm	222 mm
11 kV	127 mm	76 mm
LV	45 mm	20 mm

- 20.7 Arcing horns shall be provided on HV bushings.
- 20.8 Brazing of all inter connections, jumpers from winding to bushing shall have cross section larger than the winding conductor. All the Brazes shall be qualified as per ASME, section – IX.
- 20.9 The bushings shall be of reputed make supplied by those manufacturers who are having manufacturing and testing facilities for insulators.
- 20.10 The terminal arrangement shall not require a separate oil chamber not connected to oil in the main tank.

## **21 TERMINAL CONNECTORS:**

- 21.1 The LV and HV bushing stems shall be provided with suitable terminal connectors as per IS 5082 so as to connect the jumper without disturbing the bushing stem. Connectors shall be with eye bolts so as to receive conductor for HV. Terminal connectors shall be type tested as per IS 5561.

## **22 LIGHTNING ARRESTORS:**

- 22.1 9 kV, 5 kA metal oxide lightning arrestors of reputed make conforming to IS 3070 Part-III, one number per phase shall be provided. ( To be mounted on pole or to be fitted under the HV bushing with GI earth strip 25x4 mm connected to the body of the transformer with necessary clamping arrangement as per requirement of purchaser.) Lightning arrestors with polymer insulators in conformance with relevant IEC can also be used.

## **23 CABLE BOXES:**

- 23.1 In case HV/LV terminations are to be made through cables the transformer shall be fitted with suitable cable box on 11 kV side to terminate one 11kV/ 3 core aluminium conductor cable up to 240 sq. mm.(Size as per requirement). The bidder shall ensure the arrangement of HT Cable box so as to prevent the ingress of moisture into the box due to rain water directly falling on the box. The

cable box on HT side shall be of the split type with faces plain and machined and fitted with Neo-k-Text or similar quality gasket and complete with brass wiping gland to be mounted on separate split type gland plate with nut-bolt arrangement and MS earthing clamp. The bushings of the cable box shall be fitted with nuts and stem to take the cable cores without bending them. The stem shall be of copper with copper nuts. The cross section of the connecting rods shall be stated and shall be adequate for carrying the rated currents. On the HV side the terminal rod shall have a diameter of not less than 12 mm. The material of connecting rod shall be copper. HT Cable support clamp should be provided to avoid tension due to cable weight.

- 23.2 The transformer shall be fitted with suitable LV cable box having non-magnetic material gland plate with appropriate sized single compression brass glands on LV side to terminate 1.1 kV/single core XLPE armoured cable (Size as per requirement).

#### **24 TERMINAL MARKINGS:**

- 24.1 High voltage phase windings shall be marked both in the terminal boards inside the tank and on the outside with capital letter 1U, 1V, 1W and low voltage winding for the same phase marked by corresponding small letter 2u, 2v, 2w. The neutral point terminal shall be indicated by the letter 2n. Neutral terminal is to be brought out and connected to local grounding terminal by an earthing strip.

#### **25 CURRENT TRANSFORMERS:**

- 25.1 CT's shall be provided for transformers of rating 63 kVA and above and if required by purchaser for ratings below 63 kVA on secondary side.
- 25.2 Current transformer shall be mounted inside the tank or outside with suitable marshalling box on LV side of the transformer.
- 25.3 The current transformers shall comply with IS 2705.
- 25.4 All secondary leads of bushing mounted CT's shall be brought to a terminal box near each bushing.
- 25.5 The CT terminals shall have shorting facility.
- 25.6 CT should not get saturated upto 200% of rated current.
- 25.7 CT shall have the following parameters

Parameter	Value
Accuracy class	0.5
Burden	20 VA
Application	Metering
ISF	5

## 26 FITTINGS:

26.1 The following standard fittings shall be provided :

- i. Rating and terminal marking plates, non-detachable.
- ii. Earthing terminals with lugs - 2 Nos.
- iii. Lifting lugs for main tank and top cover
- iv. Terminal connectors on the HV/LV bushings (For bare terminations only).
- v. Thermometer pocket with cap - 1 No.
- vi. Air release device
- vii. HV bushings - 3 Nos.
- viii. LV bushings - 4 Nos.
- ix. Pulling lugs
- x. Stiffener
- xi. Radiators - No. and length may be mentioned (as per heat dissipation calculations)/ corrugations.
- xii. Arcing horns or 9 kV, 5 kA lightning arrestors on HT side - 3 No.
- xiii. Prismatic oil level gauge.
- xiv. Drain cum sampling valve.
- xv. Top filter valve
- xvi. Oil filling hole having p. 1- ¼ " thread with plug and drain plug on the conservator.
- xvii. Silicagel breather
- xviii. Base channel 75x40 mm for up to 100 kVA and 100 mmx50 mm above 100 kVA, 460 mm long with holes to make them suitable for fixing on a platform or plinth.
- xix. 4 No. rollers for transformers of 200 kVA and above.
- xx. Pressure relief device or explosion vent.

## **27 FASTENERS:**

- 27.1 All bolts, studs, screw threads, pipe threads, bolt heads and nuts shall comply with the appropriate Indian Standards for metric threads, or the technical equivalent.
- 27.2 Bolts or studs shall not be less than 6 mm in diameter except when used for small wiring terminals.
- 27.3 All nuts and pins shall be adequately locked.
- 27.4 Wherever possible bolts shall be fitted in such a manner that in the event of failure of locking resulting in the nuts working loose and falling off, the bolt will remain in position.
- 27.5 All ferrous bolts, nuts and washers placed in outdoor positions shall be treated to prevent corrosion, by hot dip galvanising, except high tensile steel bolts and spring washers which shall be electro-galvanised/plated. Appropriate precautions shall be taken to prevent electrolytic action between dissimilar metals.
- 27.6 Each bolt or stud shall project at least one thread but not more than three threads through the nut, except when otherwise approved for terminal board studs or relay stems. If bolts and nuts are placed so that they are inaccessible by means of ordinary spanners, special spanners shall be provided.
- 27.7 The length of the screwed portion of the bolts shall be such that no screw thread may form part of a shear plane between members.
- 27.8 Taper washers shall be provided where necessary.
- 27.9 Protective washers of suitable material shall be provided front and back of the securing screws.

## **28 OVERLOAD CAPACITY:**

- 28.1 The transformers shall be suitable for loading as per IS 6600.

## **29 COMPLETELY SELF PROTECTED (CSP) TRANSFORMERS:**

- 29.1 CSP transformers can be provided for ratings up to 200 kVA

## **30 PROTECTION FEATURES:**

- 30.1 **Internal HV fuse on the HV side of transformer:**

30.1.1 Expulsion/any other suitable type of fuse shall be placed in series with the primary winding. This fuse is mounted normally inside of the primary bushing for the three phases and is connected to the high voltage winding through a terminal block. This has to protect that part of the electrical distribution system which is ahead of the distribution transformers from faults which occur inside the distribution transformer i.e., either in the windings or some other part of the transformer. It shall be ensured that this fuse does not blow for faults on the secondary side (LT side) of the transformer i.e., the blowing characteristics of the fuse and LT breaker shall be so coordinated such that the fuse shall not blow for any faults on the secondary side of the transformer beyond LT breakers and those faults shall be cleared by the LT breaker only.

30.2 Internally/Externally Mounted LT Breaker on the LV Side of the Transformer:

30.2.1 **3 Pole LT circuit breaker:** All LT faults after the breaker shall be cleared by this breaker. As such it shall be designed for perfect coordination with the HT fuse link. The bidder shall furnish the time / current characteristics of LT circuit breaker and 11 kV fuses for various current multiples.

30.2.2 The two characteristics shall be drawn on the same sheet to indicate coordination between the circuit breaker and fuse. The bidder shall carry out coordination test as indicated above and this forms one of the tests for acceptance test.

30.2.3 The breaker shall be coordinated thermally with the transformer design to follow closely the variations of oil temperature due to fluctuating loads and ambient temperatures.

30.2.4 Arrangements shall be provided to enable the circuit breaker to be closed and opened manually standing on ground.

30.2.5 The cross section of the current carrying parts of the breaker shall withstand the full load current at a current density not more than 2.5 A/sq. mm (for additional mechanical strength the area should be more).

30.2.6 Rated short circuit breaking capacity of the breaker shall not be less than 2.5 kA. The circuit breaker shall conform to IS 13947.

30.2.7 In case the breaker is internal the breaker shall be located in the same oil as the core and coil assembly so that the bimetal is sensitive to the temperature of oil as well as the load.

## **31 LOAD MANAGEMENT SIGNAL LIGHT:**

31.1 A signal light shall be provided to give information about the loading condition

of the transformer. It shall forewarn any overloading problem at the installation such that replacement of the existing transformer with a higher capacity transformer can be planned. The signal light mechanism shall not reset itself when the load drops from the overloaded condition. The signal light shall remain lighted once the signal light contacts close due to overload and can be turned off by manual operation. (The signal light shall not give indication for momentary overloading).

- 31.2 Loading indication shall be available in adjustable steps of 10% starting from 70% to 110%

## **32 LIGHTNING ARRESTORS:**

- 32.1 9 kV, 5 kA metal oxide lightning arrestors Distribution class type of reputed make as per relevant standard , one number per phase shall be provided to be fitted under the HV bushing with GI earth strip 25x4 mm connected to the body of the transformer with necessary clamping arrangement

## **33 TESTS:**

- 33.1 All the equipment offered shall be fully type tested by the bidder or his collaborator as per the relevant standards including the additional type tests. The type test must have been conducted on a transformer of same design **during the last five years** at the time of bidding. The bidder shall furnish four sets of type test reports along with the offer. Offers without type test reports will be treated as non-responsive.
- 33.2 Special tests other than type and routine tests, as agreed between purchaser and bidder shall also be carried out as per the relevant standards.
- 33.3 The requirements of site tests are also given in this clause.
- 33.4 The test certificates for all routine and type tests for the transformers and also for the bushings and transformer oil shall be submitted with the bid.
- 33.5 The procedure for testing shall be in accordance with IS1180/2026 as the case may be except for temperature rise test.
- 33.6 Before despatch each of the completely assembled transformers shall be subjected to the routine tests at the manufacturer's works.

## **34 ROUTINE TESTS:**

- 34.1 Ratio, polarity, phase sequence and vector group.
- 34.2 No Load current and losses at service voltage and normal frequency.

- 34.3 Load losses at rated current and normal frequency.
- 34.4 Impedance voltage test.
- 34.5 Resistance of windings at each tap, cold (at or near the test bed temperature).
- 34.6 Insulation resistance.
- 34.7 Induced over voltage withstand test.
- 34.8 Separate source voltage withstand test.
- 34.9 Neutral current measurement-The value of zero sequence current in the neutral of the star winding shall not be more than 2% of the full load current.
- 34.10 Oil samples (one sample per lot) to comply with IS 1866.
- 34.11 Measurement of no load losses and magnetizing current at rated frequency and 90%, 100% and 110% rated voltage.
- 34.12 Pressure and vacuum test for checking the deflection.

### **35 TYPE TESTS TO BE CONDUCTED ON ONE UNIT:**

In addition to the tests mentioned in clause 33 and 34 following tests shall be conducted:

- 35.1 Temperature rise test for determining the maximum temperature rise after continuous full load run. The ambient temperature and time of test should be stated in the test certificate.
- 35.2 Impulse voltage test: with chopped wave of IS 2026 part-III. BIL for 11 kV shall be 95 kV peak instead of 75 kV
- 35.3 Short circuit withstand test: Thermal and dynamic ability.
- 35.4 Air Pressure Test: As per IS – 1180.
- 35.5 Magnetic Balance Test.
- 35.6 Un-balanced current test: The value of unbalanced current indicated by the ammeter shall not be more than 2% of the full load current.
- 35.7 Noise-level measurement.
- 35.8 Measurement of zero-phase sequence impedance.
- 35.9 Measurement of Harmonics of no-load current.
- 35.10 Transformer tank shall be subjected to specified vacuum. The tank designed

for vacuum shall be tested at an internal pressure of 0.35 kg per sq cm absolute (250 mm of Hg) for one hour. The permanent deflection of flat plates after the vacuum has been released shall not exceed the values specified below:

<b>Horizontal length of flat plate (in mm)</b>	<b>Permanent deflection (in mm)</b>
Upto and including 750	5.0
751 to 1250	6.5
1251 to 1750	8.0
1751 to 2000	9.5
2001 to 2250	11.0
2251 to 2500	12.0
2501 to 3000	16.0
Above 3000	19.0

- 35.11 Transformer tank together with its radiator and other fittings shall be subjected to pressure corresponding to twice the normal pressure or 0.35 kg / sq.cm which ever is lower, measured at the base of the tank and maintained for an hour. The permanent deflection of the flat plates after the excess pressure has been released, shall not exceed the figures for vacuum test.
- 35.12 Pressure relief device test: The pressure relief device shall be subject to increasing fluid pressure. It shall operate before reaching the test pressure as specified in the above class. The operating pressure shall be recorded. The device shall seal-off after the excess pressure has been released.
- 35.13 **Short Circuit Test and Impulse Voltage Withstand Tests:** The purchaser intends to procure transformers designed and successfully tested for short circuit and impulse test. In case the transformers proposed for supply against the order are not exactly as per the tested design, the supplier shall be required to carry out the short circuit test and impulse voltage withstand test at their own cost in the presence of the representative of the purchaser.
- 35.13.1 The supply shall be accepted only after such test is done successfully, as it confirms on successful withstand of short circuit and healthiness of the active parts thereafter on un-tanking after a short circuit test.
- 35.13.2 Apart from dynamic ability test, the transformers shall also be required to withstand thermal ability test or thermal withstand ability will have to be established by way of calculations.
- 35.13.3 It may also be noted that the purchaser reserves the right to conduct short circuit test and impulse voltage withstand test in accordance with the IS,

afresh on each ordered rating at purchaser cost, even if the transformers of the same rating and similar design are already tested. This test shall be carried out on a transformer to be selected by the purchaser either at the manufacturer's works when they are offered in a lot for supply or randomly from the supplies already made to purchaser's stores. The findings and conclusions of these tests shall be binding on the supplier.

- 35.13.4 Type test certificates for the tests carried out on prototype of same specifications shall be submitted along with the bid. The purchaser may select the transformer for type tests randomly.

### **36 ACCEPTANCE TESTS:**

- 36.1 **At least 10% transformers of the offered lot (minimum of one)** shall be subjected to the following routine/ acceptance test in presence of purchaser's representative at the place of manufacture before dispatch without any extra charges. The testing shall be carried out in accordance with IS:1180 and IS:2026.
- 36.2 Checking of weights, dimensions, fitting and accessories, tank sheet thickness, oil quality, material, finish and workmanship as per GTP and contract drawings.
- 36.3 Physical verification of core coil assembly and measurement of flux density of one unit of each rating, in every inspection with reference to short circuit test report
- 36.4 Temperature rise test on one unit of the total ordered quantity

### **37 TESTS AT SITE:**

The purchaser reserves the right to conduct all tests on transformer after arrival at site and the manufacturer shall guarantee test certificate figures under actual service conditions.

### **38 INSPECTION:**

- 38.1 In respect of raw material such as core stampings, winding conductors, insulating paper and oil, supplier shall use materials manufactured/supplied by standard manufacturers and furnish the manufacturers' test certificate as well as the proof of purchase from these manufacturers (excise gate pass) for information of the purchaser. The bidder shall furnish following documents along with their offer in respect of the raw materials:
- i. Invoice of supplier.
  - ii. Mill's certificate.
  - iii. Packing list.

- iv. Bill of landing.
- v. Bill of entry certificate by custom.

### **39 INSPECTION AND TESTING OF TRANSFORMER OIL:**

- 39.1 To ascertain the quality of the transformer oil, the original manufacturer's tests report should be submitted at the time of inspection. Arrangements should also be made for testing of transformer oil, after taking out the sample from the manufactured transformers and tested in the presence of purchaser's representative.
- 39.2 To ensure about the quality of transformers, the inspection shall be carried out by the purchaser's representative at following two stages:-
  - 39.2.1 Online anytime during receipt of raw material and manufacture/ assembly whenever the purchaser desires.
  - 39.2.2 At finished stage i.e. transformers are fully assembled and are ready for despatch.
- 39.3 The stage inspection shall be carried out in accordance with **Annexure-II**.
- 39.4 After the main raw-material i.e. core and coil material and tanks are arranged and transformers are taken for production on shop floor and a few assembly have been completed, the firm shall intimate the purchaser in this regard, so that an officer for carrying out such inspection could be deputed, as far as possible within seven days from the date of intimation. During the stage inspection a few assembled core shall be dismantled (only in case of CRGO material) to ensure that the CRGO laminations used are of good quality. Further, as and when the transformers are ready for despatch, an offer intimating about the readiness of transformers, for final inspection for carrying out tests as per relevant IS shall be sent by the firm along with Routine Test Certificates. The inspection shall normally be arranged by the purchaser at the earliest after receipt of offer for pre-delivery inspection. The proforma for pre delivery inspection of Distribution transformers is placed at **Annex- III**.
- 39.5 In case of any defect/defective workmanship observed at any stage by the purchaser's Inspecting Officer, the same shall be pointed out to the firm in writing for taking remedial measures. Further processing should only be done after clearance from the Inspecting Officer/ purchaser.
- 39.6 All tests and inspection shall be carried out at the place of manufacture unless otherwise specifically agreed upon by the manufacturer and purchaser at the time of purchase. The manufacturer shall offer the Inspector representing the Purchaser all reasonable facilities, without charges, to satisfy him that the material is being supplied in accordance with this specification. This will

include Stage Inspection during manufacturing stage as well as Active Part Inspection during Acceptance Tests.

- 39.7 The manufacturer shall provide all services to establish and maintain quality of workman ship in his works and that of his sub-contractors to ensure the mechanical /electrical performance of components, compliance with drawings, identification and acceptability of all materials, parts and equipment as per latest quality standards of ISO 9000.
- 39.8 Purchaser shall have every right to appoint a third party inspection to carryout the inspection process.
- 39.9 The purchaser has the right to have the test carried out at his own cost by an independent agency wherever there is a dispute regarding the quality supplied. Purchaser has right to test 1% of the supply selected either from the stores or field to check the quality of the product. In case of any deviation purchaser have every right to reject the entire lot or penalize the manufacturer, which may lead to blacklisting, among other things.

#### **40 QUALITY ASSURANCE PLAN:**

- 40.1 The bidder shall invariably furnish following information along with his bid, failing which his bid shall be liable for rejection. Information shall be separately given for individual type of equipment offered.
- 40.2 Statement giving list of important raw materials, names of sub-suppliers for the raw materials, list of standards according to which the raw materials are tested, list of tests normally carried out on raw materials in the presence of bidder's representative, copies of test certificates.
- 40.3 Information and copies of test certificates as above in respect of bought out accessories.
- 40.4 List of manufacturing facilities available.
- 40.5 Level of automation achieved and list of areas where manual processing exists.
- 40.6 List of areas in manufacturing process, where stage inspections are normally carried out for quality control and details of such tests and inspection.
- 40.7 List of testing equipment available with the bidder for final testing of equipment along with valid calibration reports. These shall be furnished with the bid. Manufacturer shall posses 0.1 accuracy class instruments for measurement of losses.

- 40.8 Quality Assurance Plan (QAP) with hold points for purchaser's inspection.
- 40.9 The successful bidder shall within 30 days of placement of order, submit following information to the purchaser :
  - 40.9.1 List of raw materials as well as bought out accessories and the names of sub-suppliers selected from those furnished along with offer.
  - 40.9.2 Type test certificates of the raw materials and bought out accessories.
  - 40.9.3 The successful bidder shall submit the routine test certificates of bought out accessories and central excise passes for raw material at the time of routine testing.

#### **41 DOCUMENTATION:**

- 41.1 The bidder shall furnish along with the bid the dimensional drawings of the items offered indicating all the fittings.
- 41.2 Dimensional tolerances.
- 41.3 Weight of individual components and total weight.
- 41.4 An outline drawing front (both primary and secondary sides) and end-elevation and plan of the tank and terminal gear, wherein the principal dimensions shall be given.
- 41.5 Typical general arrangement drawings of the windings with the details of the insulation at each point and core construction of transformer.
- 41.6 Typical general arrangement drawing showing both primary and secondary sides and end-elevation and plan of the transformer.

#### **42 PACKING AND FORWARDING:**

- 42.1 The packing shall be done as per the manufacturer's standard practice. However, it should be ensured that the packing is such that, the material would not get damaged during transit by Rail / Road / Sea.
- 42.2 The marking on each package shall be as per the relevant IS.

#### **43 MANADATORY SPARES:**

- 43.1 Mandatory spares shall be supplied as per the purchaser's requirement.

#### **44 GUARANTEE**

- 44.1 The manufacturers of the transformer shall provide a guarantee of 24 months from the date of receipt at the stores of the Utility or 18 months from the date of commissioning, whichever is earlier. In case the distribution transformer fails within the guarantee period the purchaser will immediately inform the supplier who shall take back the failed DT within 15 days from the date of the intimation at his own cost and replace/repair the transformer within forty five days of date of intimation with a roll over guarantee.
- 44.2 The outage period i.e. period from the date of failure till unit is repaired/ replaced shall not be counted for arriving at the guarantee period.
- 44.3 In the event of the supplier's inability to adhere to the aforesaid provisions, suitable penal action will be taken against the supplier which may inter alia include blacklisting of the firm for future business with the purchaser for a certain period.

#### **45 SCHEDULES:**

- 45.1 The bidder shall fill in the following schedule which will be part of the offer. If the schedule are not submitted duly filled in with the offer, the offer shall be liable for rejection.

Schedule-A : Guaranteed Technical Particulars

Schedule-B : Schedule of Deviations

#### **46 DEVIATIONS :**

- 46.1 The bidders are not allowed to deviate from the principal requirements of the Specifications. However, the bidder is required to submit with his bid in the relevant schedule a detailed list of all deviations without any ambiguity. In the absence of a deviation list in the deviation schedules, it is understood that such bid conforms to the bid specifications and no post-bid negotiations shall take place in this regard.
- 46.2 The discrepancies, if any, between the specification and the catalogues and / or literatures submitted as part of the offer by the bidders, shall not be considered and representations in this regard shall not be entertained.
- 46.3 If it is observed that there are deviations in the offer in guaranteed technical particulars other than those specified in the deviation schedules then such deviations shall be treated as deviations.
- 46.4 All the schedules shall be prepared by vendor and are to be enclosed with the bid.

## METHODOLOGY FOR COMPUTING TOTAL OWNING COST

<b>TOC = IC + (A x Wi) + (B x Wc)</b>	
Where,	
TOC	= Total Owning Cost
IC	= Initial cost (including taxes) of transformer as quoted by the manufacturer
A factor	= Cost of no load losses in Rs/watt
B factor	= Cost of load losses in Rs /watt
Wi	= No load losses quoted by the manufacturer in watt
Wc	= Load losses quoted by the manufacturer in watt

The “A” and “B” factors capture the net present value of energy losses based on hours of operation, cost of energy (electrical tariff), equipment life (years of expected service) and cost of money (rate of return).

i) Capitalised cost of no load losses/watt = A factor

$$A \text{ factor} = H \times \frac{E_c}{1000} \times \frac{(1+r)^n - 1}{r(1+r)^n}$$

ii) Capitalised cost of load losses/watt = B factor = A factor x LLF

iii) Capitalised cost of transformer = IC + (A x Wi) + (B x Wc)

where

i) H = No. of service hours per year of the distribution transformer = 8400 hr.

ii) r = Rate of interest = prime lending rate (in per unit)

iii)  $E_c$  = Average Energy cost (Rs/kWH) at 11 kV for the utility. For 33 kV Distribution Transformers average cost of energy at 33 kV level may be taken

iv) n = Life of the transformer in years = 25 years

v) LLF = Loss Load factor =  $0.3 LF + 0.7 LF^2$ , where LF is the load factor

LF for rural areas = 0.5

LF for urban areas = 0.7

**PROFORMA FOR STAGE INSPECTION OF DISTRIBUTION TRANSFORMERS**

**(A) GENERAL INFORMATION:**

1. Name of firm : M/s.
2. Order No. and Date :
3. Rating-wise quantity offered :
4. Details of offer
  - a) Rating
  - b) Quantity
  - c) Serial Numbers
5. Details of last stage inspected lot:
  - a) Total quantity inspected
  - b) Serial Numbers
  - c) Date of stage inspection
  - d) Quantity offered for final inspection of (a) above with date

**(B) Availability of material for offered quantity :**

Details to be filled in

**(C) Position of manufacturing stage of the offered quantity :**

- a) Complete tanked assembly
- b) Core and coil assembly ready
- c) Core assembled
- d) Coils ready for assembly
  - (i) HV Coils
  - (ii) LV Coils

- Note:**
- (i) A quantity of more than 100 Nos. shall not be entertained for stage inspection.
  - (ii) The stage inspection shall be carried out in case :-
    - (a) At least 25% quantity offered has been tanked and
    - (b) core coil assembly of further at least 30% of the quantity offered has been completed.
  - (iii) Quantity offered for stage inspection should be offered for final Inspection within 15 days from the date of issuance of clearance for stage inspection, otherwise stage inspection already cleared shall be liable for cancellation.

Sl. No	Particulars	As offered	As observed	Deviation and Remarks
(D)	<b>Inspection of Core :</b>			
	(I) <b>Core Material</b>			
	(1) Manufacturer's Characteristic Certificate in respect of grade of lamination used. (Please furnish test certificate)			
	(2) Remarks regarding Rusting and smoothness of core.			
	(3) Whether laminations used for top and bottom yoke are in one piece.			
	(II) <b>Core Construction :</b>			
	(1) No. of Steps			
	(2) Dimension of Steps			
	Step No. 1 2 3 4 5 6 7 8 9 10 11 12			
	<b>As offered:</b>			
	W mm			
	T mm			
	<b>As found:</b>			
	W mm			
	T mm			
	(3) Core Dia (mm)			
	(4) Total cross Section area of core			
	(5) Effective cross Sectional area of core			
	(6) Clamping arrangement			
	(i) Channel Size			
	(ii) Bolt size and No.			
	(iii) Tie Rods size and No.			
	(iv) <b>Painting</b>			
	(a) Channels			
	(b) Tie Rods			
	(c) Bolts			
	(7) Whether top yoke is cut for LV connection.			
	(8) If yes, at 7 above, whether Reinforcement is done.			
	(9) Size of Support Channels provided for Core base and bottom yoke (Single piece of channels are only acceptable)			

Sl. No	Particulars	As offered	As observed	Deviation and Remarks
	(10) Thickness of insulation provided between core base and support channel.			
	(11) core length (leg center to leg center)			
	(12) Window height			
	(13) Core height			
	(14) Core weight only (without channels etc.)			
<b>(E)</b>	<b>INSPECTION OF WINDING</b>			
	<b>(I) Winding material</b>			
	(1) Material used for			
	(a) HV winding			
	(b) LV winding			
	(2) Grade of material for			
	(a) HV winding			
	(b) LV winding			
	3) Test certificate of manufacturer (enclose copy) for winding material of:			
	(a) HV			
	(b) LV			
	<b>(II) CONSTRUCTIONAL DETAILS</b>			
	(1) Size of Cross Sectional area of conductor for :			
	(a) HV winding			
	(b) LV winding			
	(2) Type of insulation for conductor of :			
	a) HV winding			
	(b) LV winding			
	(3) Diameter of wire used for delta formation (mm)			
	(4) Diameter of coils in:			
	a) LV winding			
	i) Internal dia (mm)			
	ii) Outer dia (mm)			
	b) HV winding			

Sl. No	Particulars	As offered	As observed	Deviation and Remarks
	i) Internal dia (mm)			
	ii) Outer dia (mm)			
	(5) Current Density of winding material used for :			
	(a) HV			
	(b) LV			
	(6) Whether neutral formation on top.			
	(7) HV Coils/ Phase			
	a) Number			
	b) Turns / coil			
	c) Total turns			
	(8) LV Coils/ Phase			
	a) Number			
	b) Turns / coil			
	c) Total turns			
	(9) Method of HV Coil Joints			
	(10) Total weight of coils of			
	a) LV winding (kg)			
	b) HV winding (kg)			
	<b>(F) INSULATION MATERIALS :</b>			
	(I) <b>MATERIAL :</b>			
	1) Craft paper			
	a) Make			
	b) Thickness (mm)			
	c) Test Certificate of manufacturer (enclose copy).			
	2) Press Board			
	a) Make			
	b) Thickness (mm)			
	c) Test Certificate of manufacturer (enclose copy).			
	3) Material used for top and bottom yoke and insulation			
	(II) <b>Type and thickness of material used : (mm)</b>			
	a) Between core and LV			
	b) Spacers			
	c) Inter layer			
	d) Between HV and LV winding			

Sl. No	Particulars	As offered	As observed	Deviation and Remarks
	e) Between phases			
	f) End insulation			
<b>(G)</b>	<b>CLEARANCES : (mm)</b>			
	<b>(I) Related to core and windings</b>			
	1) LV to Core (Radial)			
	2) Between HV and LV (Radial)			
	3) (i) Phase to phase between HV Conductor			
	(ii) Whether two Nos. Press Board each of minimum 1 mm thick provided to cover the tie rods.			
	4) Thickness of locking spacers between LV coils (mm)			
	5) Axial wedges between HV and LV coils / phase (Nos.)			
	6) No. of radial spacers per phase between HV coils			
	7) Size of duct between LV and HV winding (mm)			
	<b>(II) Between core - coil assembly and tank : (mm)</b>			
	1) Between winding and body:			
	a) Tank lengthwise			
	b) Tank Breadth wise			
	2) Clearance between top cover and top yoke upto 100 kVA and between top cover and top most live part of tap changing switch for 200 kVA and above.			
<b>(H)</b>	<b>TANK :</b>			
	<b>(I) Constructional details :</b>			
	1) Rectangular shape			
	2) Thickness of side wall (mm)			
	3) Thickness of top and bottom plate (mm)			
	4) Provision of slopping top cover towards HV bushing.			

Sl. No	Particulars	As offered	As observed	Deviation and Remarks
	5) Tank internal dimensions (mm)			
	a) Length			
	b) Breadth			
	c) Height			
	(i) On LV side			
	(ii) On LV side			
	(II) <b>General details :</b>			
	1) Inside painted by varnish/ oil corrosion resistant paint (please specify which type of coating done).			
	2) Gasket between top cover and tank			
	i) Material			
	ii) Thickness (mm)			
	iii) Jointing over laps (mm)			
	3). Reinforcement of welded angle (specify size and No. of angle provided ) on side walls of tank.			
	4) Provision of lifting lugs:			
	a) Numbers			
	b) Whether lugs of 8 mm thick MS Plate provided			
	c) Whether reinforced by welded plates edge wise below the lug upto re-enforcing angle of the tank done.			
	5) Pulling lug of MS Plate			
	a) Nos.			
	b) Thickness (mm)			
	c) Whether provided on breadth side or length side			
	6) Provision of air release plug			
	7) Provision of galvanized GI Nuts Bolts with 1 No. Plain and 1 No. spring washer.			
	8) Deformation of length wise side wall of tank when subject to:			
	a) Vacuum of (-) 0.7 kg/sq cm for 30 minutes.			

Sl. No	Particulars	As offered	As observed	Deviation and Remarks
	b) Pressure of 0.8 kg/sq cm for 30 minutes.			
<b>(I)</b>	<b>RAIDATORS :</b>			
	1. Fin Radiators of 1.25 mm thick sheet			
	a) Dimension of each fin (LxBxT)			
	b) Fins per radiator			
	c) Total No. of radiators			
	2. Verification of manufacturer's test certificate regarding Heat dissipation (excluding Top and Bottom) in w/sq m			
	3. Verification of position of radiator with respect to bushing.			
<b>(J)</b>	<b>CONSERVATOR :</b>			
	1. Dimensions ( L x D) (in mm)			
	2. Volume (m <sup>3</sup> )			
	3. Inside dia of Conservator tank pipe (mm)			
	4. Whether conservator outlet pipe is projected approx. 20 mm inside the conservator tank.			
	5. Whether arrangement made so that oil does not fall on the active parts.			
	6. Whether die cast metal oil level gauge indicator having three positions at ( - 5° C, 30° C and 98°C) is provided .			
	7. Whether drain plug and filling hole with cover is provided.			
	8. Inner side of the conservator Tank painted with-			
<b>(K)</b>	<b>BREATHER :</b>			
	1. Whether Die cast Aluminium body breather for silica gel provided.			
	2. Make			
	3. Capacity			

Sl. No	Particulars	As offered	As observed	Deviation and Remarks
<b>(L)</b>	<b>TERMINALS :</b>			
	1. Material whether of Brass Rods/ Tinned Copper.			
	a) HV			
	b) LV			
	2. Size (dia in mm)			
	a) HV			
	b) LV			
	3. Method of Star connection formed on LV side of 6mm thick (Should use Al./Cu. Flat bolted/ brazed with crimped lugs on winding alternatively for 63 and 100 kVA ratings brazing is done covered with tubular sleeve duly crimped). - Please state dimensions of Al/ Cu flat or tubular sleeve used. (mm)			
	4. Method of Connection of LV winding to LV Bushing (end of winding should be crimped with lugs (Al/Cu) and bolted with bushing stud).			
	5. Method of Connection of HV winding to HV bushing (Copper joint should be done by using silver brazing alloy and for Aluminium, brazing rod or with tubular connector crimped at three spots).			
	6. Whether SRB Ptube/insulated paper used for formation of Delta on HV.			
	7. Whether Empire sleeves used on the portion of HV winding joining to HV bushing.			
	8. Whether neutral formation is covered with cotton tape			
<b>(M)</b>	<b>BUSHINGS :</b>			
	1. Whether HV bushings mounted on side walls.			

Sl. No	Particulars	As offered	As observed	Deviation and Remarks
	2. Whether sheet metal pocket used for mounting bushing (pipe are not acceptable)			
	a) HV			
	b) LV			
	3. Whether arrangement for studs for fitting of HV Bushing are in diamond shape (so that Arcing Horns are placed vertically).			
	4. Position of mounting of LV bushings.			
	5. Bushing Clearance: (mm)			
	a) LV to Earth			
	b) HV to Earth			
	c) Between LV Bushings			
	d) Between HV Bushings			
<b>(N)</b>	<b>TANK BASE CHANNEL / ROLLERS :</b>			
	1. Size of channel (mm)			
	2. Whether channels welded across the length of the tank			
	3. Size and type of roller (mm)			
<b>(O)</b>	<b>OIL :</b>			
	1. Name of supplier			
	2. Break down voltage of oil: (kV)			
	i) Filled in tanked transformer			
	ii) In storage tank (to be tested by Inspecting Officer).			
	3. Supplier's test certificate (enclose copy)			
<b>(P)</b>	<b>ENGRAVING :</b>			
	1. Engraving of Sl. No. and name of firm.			
	i) On bottom of clamping channel of core-coil assembly.			
	ii) On side wall and top cover of tank along with date of despatch.			

Sl. No	Particulars	As offered	As observed	Deviation and Remarks
<b>(Q)</b>	i) MS plate of size 125x125 mm welded on width side of stiffner			
	ii) Following details engraved (as per approved GTP):			
	(a) Serial Number			
	(b) Name of firm			
	(c) Order No. and Date			
	(d) Rating			
	(e) Name of Inspecting Officer			
	(f) Designation			
	(g) Date of dispatch			
<b>(R)</b>	<b>NAME PLATE DETAILS :</b>			
	Whether Name Plate is as per approved drawing			
<b>(S)</b>	<b>Colour of Transformer</b>			
	1. Tankbody with dark Green colour			
	2. Conservator with white colour			
<b>(T)</b>	<b>CHECKING OF TESTING FACILITIES:</b>			
	(Calibration certificate also to be checked for its validity)			
	<b>TESTS :</b>			
	1. No Load Current			
	2. No Load Loss			
	3. % Impedance			
	4. Load Losses			
	5. Insulation Resistance Test			
	6. Vector Group Test (phase relationship)			
	7. Ratio and Polarity test relationship			
	8. Transformer Oil Test (Break Down Voltage)			
	9. Magnetic Balance			
	10. Measurement of winding resistance (HV and LV both)			
	11. Induced over voltage withstand test (Double voltage and Double frequency)			

Sl. No	Particulars	As offered	As observed	Deviation and Remarks
	12. Separate source power frequency withstand test at 28 kV for HV and 3 kV for LV (one minute).			
	13. Air pressure/ Oil leakage Test			
	14. Vacuum test			
	15. Unbalanced current test			
	16. Temperature rise (Heat Run) test.			
<b>(U)</b>	We have specifically checked the following and found the same as per G.T.P./deviations observed as mentioned against each:			
	i) Rustlessness of CRGO laminations used			
	ii) Core steps			
	iii) Core area			
	iv) Core weight			
	v) Winding cross sectional area			
	a) LV			
	b) HV			
	vi) Weight of windings			
	vii) Clearance between winding and wall of tank (mm)			
	a) Length-wise			
	b) Breadth-wise			
	viii) Clearance between top of yoke/ top most live part of tap changer to tank cover.			
	ix) Details of Neutral formation			
	x) Connections to bushings:			
	a) LV			
	b) HV			
	xi) Slope of tank top			
	xii) Position of mounting of bushings			

COMPANY'S INSPECTING OFFICER

FIRM'S REPRESENTATIVE

DATE OF INSPECTION:

## Annexure-III

### PROFORMA FOR PRE-DELIVERY INSPECTION OF DISTRIBUTION TRANSFORMERS

1.	Name of the firm	:	
2.	Details of offer made	:	
	(i) Order No. and Date	:	
	(ii) Rating	:	
	(iii) Quantity	:	
	(iv) Sl. No. of transformers	:	
3.	Date of stage inspection of the lot	:	
4.	Reference of stage inspection clearance	:	
5.	Quantity offered and inspected against the order prior to this lot		

#### (A) ACCEPTANCE TESTS TO BE CARRIED OUT

Sl. No.	PARTICULARS	OBSERVATIONS
1.	(a) Ratio Test	AB/an
		BC/bn
		CA/Cn
	(b) Polarity Test	
2.	No load loss measurement	
		W1
		W2
		W3
	TOTAL	
	Multiplying Factor	
	CT	
	Watt meter	
	Total x MF	
	NET LOSS	
3.	Load loss measurement	
		W1
		W2
		W3
	<b>Total</b>	
	<b>Multiplying Factors:-</b>	

Sl. No.	PARTICULARS	OBSERVATIONS
	<b>CT</b>	
	<b>Watt meter</b>	
	<b>PT</b>	
	Total x MF	
	Loss at ambient temperature (watt)	
	Loss at 75°C (with calculation sheet) (watt)	
4.	Winding Resistance :	
	<b>H.V. (In Ohms)</b>	
	(a) At ambient temperature of _____ °C.	A-B
		B-C
		C-A
	(b) Resistance at 75 °C.	A-B
		B-C
		C-A
	<b>L.V. (In Ohm)</b>	
	(a) At ambient temperature of _____ °C.	a-b
		b-c
		c-a
	(b) Per Phase resistance at 75 °C.	a-n
		b-n
		c-n
5.	Insulation Resistance (M ohm) :	HV-LV
		HV-E
		LV-E
6.	Separate Source Voltage withstand test voltage:	
	<b>HV</b>	28 kV for 60 secs.
	<b>LV</b>	3 kV for 60 secs.
7.	Induced over-voltage withstand test at double voltage and double frequency	100 Hz, 866 volts for 60 seconds.
8.	No load current at	
	90% volts	
	110% volts	
9.	Unbalance current	
10.	Vector group test	Diagram and readings be shown in separate sheets

Sl. No.	PARTICULARS	OBSERVATIONS	
11.	Percentage Impedance at 75° C (Please furnish calculation sheet)		
12.	Transformer oil test (Break down voltage)		
13.	Oil leakage test		
14.	Heat run test	To be carried out once against the order	
15.	Bushing clearance (mm)	<b>HV</b>	<b>LV</b>
	(a) Phase to Phase		
	(b) Phase to Earth		
16.	Comments on compliance by the firm on the modifications done as per stage inspection clearance letter issued		
17.	Whether fittings of the order have been verified.		
18.	Whether aluminium die cast silicagel breather with tin container is fitted on the transformers offered.		
19.	Whether engraving of Sl.No. and Name of firm on core clamping channel, side wall and top cover of tank has been verified.		
20.	Whether MS Plate of size 125 x 125 mm welded on with side of stiffner.		
21.	Whether engraving of name of firm, Sl. No. and Rating of transformer, Order No. and date and Date of Despatch on MS Plate.		
22.	Copy of calibration certificates of metering equipments be enclosed.		

**(B) POINTS TO BE SEEN / DIMENSIONS TO BE NOTED AT THE TIME OF DISMANTLING OF TRANSFORMERS :**

Sl. No.	PARTICULARS	OBSERVATIONS
1.	Details of the transformer dismantled for physical verification	
	(a) Rating (kVA)	
	(b) Sl. No.	
2.	Whether GI Nut Bolts with one spring one plain washer provided for tightening the tank cover.	

SI. No.	PARTICULARS	OBSERVATIONS
3	Details of gasket used between top cover and tank Material :	
	(i) Thickness (mm)	
	(ii) Type of joints	
4	Whether core is earthed properly with copper strip (one end should be tightened in between the core laminations and other end bolted on core clamping channel).	
5	Connections from winding to bushings (describe the manner in which it has been done )	
	(a) HV	
	(b) LV	
	(c) Formation of Star connection on LV side.	
6	Winding wire dia and cross sectional area :	
	(a) <b>HV</b>	
	(i) Dia (mm)	
	(ii) Area (sq mm)	
	(b) <b>LV</b>	
	(i) L x W x Nos. of layer	
	(ii) Area (sq mm)	
7.	Thickness of press board (s) provided between HV coils to cover the tie rods	
8.	Whether painted with oil and corrosion resistant paint / varnish	
	(a) Inside of the tank	
	(b) Inside of the conservator tank	
	(c) Core clamping and core base channels	
	(d) Tie rods	
	(e) Core bolts	
9.	Whether tie rods and core bolts insulated, if yes, material of insulation.	
10.	Whether flap on inner side of top cover provided to prevent direct falling of oil on core- coil assembly.	
11.	Method of joints	
	(a) Between HV Coils	
	(b) Between tap coils	
	(c) For tap changer	

Sl. No.	PARTICULARS	OBSERVATIONS
12.	Whether engraving of Sl. No. and name of firm done on bottom channel of core coil assembly.	
13.	Diameter of copper wire, used for formation of delta (should not be less than 1.5 times the dia of conductor). (mm)	
14.	Whether empire sleeves provided upto the end portion of HV winding joining to bushing	
15.	<b>HV Coils :</b>	
	(a) Inner dia (mm)	
	(b) Outer dia (mm)	
16.	<b>LV Coils :</b>	
	(a) Inner dia (mm)	
	(b) Outer dia (mm)	
17.	Core dia	
18.	Core height including base channel and insulation in between (mm)	
19.	Leg Center of core	
20.	Clearances between	
	(a) Core and LV (mm)	
	(b) HV and LV (mm)	
	(c) Phase to phase of HV coils (mm)	
	(d) Core coil assembly and tank body (mm)	
	(i) Length-wise	
	(ii) Width-wise	
	(e) Top of yoke and top cover (mm)	
	(f) Top most live part of tap changer and top cover.	
21.	Weight of core only (kg)	
22.	Weight of windings (kg)	
	(a) LV	
	(b) HV	
23.	Whether core laminations are in one piece, used for	
	(a) Bottom yoke	
	(b) Top yoke	
24.	Specific remarks regarding smoothness and rusting of core used.	

<b>S. No.</b>	<b>PARTICULARS</b>	<b>OBSERVATIONS</b>
25	Volume of oil filled (to be done once against the order)	
	(a) In conservator tank	
	(b) In tank of the transformer	
26	Weight of transformer (inclusive of all fittings, accessories, oil etc. complete)	
27	Inner dimensions of the tank	
	(a) Length	
	(b) Width	
	(c) Height	
	(i) LV side	
	(ii) HV side	
28	Remarks, if any :	

**Note :** Please ensure that complete details have been filled in the proforma and no column has been left blank.

**SIGNATURE OF INSPECTING OFFICER**  
(with name and designation)

**SIGNATURE OF FIRM'S REPRESENTATIVE**  
(with name and designation)

DATE OF INSPECTION : \_\_\_\_\_

## Annexure-IV

### SOURCE OF MATERIALS/PLACES OF MANUFACTURE, TESTING AND INSPECTION

Sl. No.	Item	Source of Material	Place of Manufacture	Place of testing and inspection
1.	Laminations			
2.	Copper Conductor			
3.	Insulated winding wires			
4.	Oil			
5.	Press boards			
6.	Kraft paper			
7.	MS Plates/Angles/Channels			
8.	Gaskets			
9.	Bushing HV/LV			
10.	Paints			

**SCHEDULE IA**  
**GUARANTEED AND OTHER PARTICULARS FOR DISTRIBUTION**  
**TRANSFORMERS**  
**(To be furnished by the Manufacturer)**

- | <b>Sl.No.</b> | <b>Description</b>   |
|---------------|--|
| 1.            | Make   |
| 2.            | Name of Manufacturer   |
| 3.            | Place of Manufacture   |
| 4.            | Voltage Ratio  |
| 5.            | Rating in kVA  |
| 6.            | Core Material used and Grade:<br>a) Flux density<br>b) Over fluxing without saturation<br>(Curve to be furnished by the<br>Manufacturer in support of his claim) |
| 7.            | Maximum temperature rise of :<br>a) windings by resistance method<br>b) Oil by thermometer   |
| 8.            | Magnetising (no-load) current at:<br>a) 90% Voltage<br>b) 100% Voltage<br>c) 110% Voltage  |
| 9.            | Core loss in watts :<br>a) Normal voltage<br>b) Maximum voltage  |
| 10.           | Resistance of windings at 20 °C<br>(with 5% tolerance) :<br>a. HV Winding (ohms)<br>b. LV Winding (ohms)   |
| 11.           | Full load losses (watts) at 75 °C  |
| 12.           | Total Losses at 100% load at 75 °C   |
| 13.           | Total Losses at 50% load at 75 °C  |
| 14.           | Current density used for : (Amper/sq mm)<br>a) HV Winding  |

- b) LV Winding
- 15. Clearances : (mm)
  - a) Core and LV
  - b) LV and HV
  - c) HV Phase to Phase
  - d) End insulation clearance to earth
  - e) Any point of winding to tank
- 16. Efficiency at 75 °C :
  - a) Unity P.F. and
  - b) 0.8 P.F.
    - 1) 125% load
    - 2) 100% load
    - 3) 75% load
    - 4) 50% load
    - 5) 25% load
- 17. Regulation at :
  - a) Unity P.F.
  - b) 0.8 P.F. at 75 °C
- 18. % Impedance at 75 °C
- 19. Flash Test :
  - (i) HV 28 kV / 50 HZ for 1 minute
  - (ii) LV 3 kV/50 Hz for 1 minute
- 20. Over potential Test (Double Voltage and Double frequency for 1 minute)
- 21. Impulse test
- 22. Mass of : (kg)
  - a) Core lamination (minimum)
  - b) Windings (minimum)
  - c) Tank and fittings
  - d) Oil
  - e) Oil quantity (minimum) (litre)
  - f) Total weight
- 23. Oil Data :

1. Quantity for first filling (minimum) (litre)
  2. Grade of oil used
  3. Maker's name
  4. BDV at the time of filling (kV)
24. Transformer:
- 1) Overall length x breadth x height (mm x mm x mm)
  - 2) Tank length x breadth x height
  - 3) Thickness of plates for
    - a) Side plate (min)
    - b) Top and bottom plate (min)
  - 4) Conservator Dimensions
25. Radiation:
- 1) Heat dissipation by tank walls excluding top and bottom
  - 2) Heat dissipation by cooling tube
  - 3) Diameter and thickness of cooling tube
  - 4) Whether calculation sheet for selecting cooling area to ensure that the transformer is capable of giving continuous rated output without exceeding temperature rise is enclosed.
26. Inter layer insulation provided in design for :
- 1) Top and bottom layer
  - 2) In between all layer
  - 3) Details of end insulation
  - 4) Whether wedges are provided at 50% turns of the HV coil
27. Insulation materials provided
- a) For Conductors
    - (1) HV
    - (2) LV
  - b) For Core
28. 25. Material and Size of the wire used
- 1) **HV**    **Dia**    **(mm)**    **(SWG)**
  - 2) **LV**    a) Strip size

b) No. of Conductors in parallel

c) Total area of cross section (sq mm)

29. Whether the name plate gives all particulars as required in Tender

30. Particulars of bushings HV/LV

- 1) Maker's name
- 2) Type IS-3347/IS-2099/IS7421
- 3) Rating as per IS
- 4) Dry power frequency voltage withstand test
- 5) Wet power frequency voltage withstand test

**Note:**

The following shall be specifically confirmed:

- 1) Whether the offer conforms to the limits of impedance mentioned in the specification
- 2) Whether the offer conforms to the limits of temperature rise mentioned in the specification.
- 3) Whether the losses of the transformers offered are within the limits specified.
- 4) Whether the transformer offered is already type tested for the design and test reports enclosed.

**SCHEDULE IB  
ADDITIONAL DETAILS**

<b>Sl.No.</b>	<b>Description</b>	
1.	Core Grade	
2.	Core diameter	mm
3.	Gross core area	sq cm
4.	Net core area	sq cm
5.	Flux density	Tesla
6.	Mass of core	kg
7.	Loss per kg of core at the specified flux density	watt
8.	Core window height	mm
9.	Center to center distance of the core	mm
10.	No. of LV Turns	
11.	No. of H V turns	
12.	Size of LV conductor bare/covered	mm
13.	Size of HV conductor bare/covered	mm
14.	No. of parallels	
15.	Current density of LV winding	A/sq mm.
16.	Current density of HV winding	A/sq mm
17.	Wt. of the LV winding for Transformer	kg
18.	Wt. of the HV winding for Transformer	kg
19.	No. of LV Coils/phase	
20.	No. of HV coils / phase	
21.	Height of LV Windings	mm
22.	Height of HV winding	mm
23.	ID/OD of HV winding	mm
24.	ID/OD of LV winding	mm
25.	Size of the duct in LV winding	mm
26.	Size of the duct in HV winding	mm
27.	Size of the duct between HV and LV	mm
28.	HV winding to LV winding clearance	mm
29.	HV winding to tank clearance	mm
30.	Calculated impedance	%
31.	HV to earth creepage distance	mm
32.	LV to earth creepage distance	mm

**STANDARD TECHNICAL SPECIFICATION**

**FOR**

**OUTDOOR TYPE SINGLE PHASE OIL IMMERSED**  
**(INCLUDING COMPLETELY SELF PROTECTED)**  
**DISTRIBUTION TRANSFORMERS**

**11 kV/230 V**

**and**

**11 kV/ $\sqrt{3}$ /230 V**



**TECHNICAL SPECIFICATION FOR OUTDOOR TYPE  
SINGLE PHASE OIL IMMERSSED (INCLUDING COMPLETELY SELF  
PROTECTED) DISTRIBUTION TRANSFORMERS**

**1 SCOPE:**

- 1.1 This specification covers design, engineering, manufacture, assembly, stage testing, inspection and testing before supply and delivery at site of oil immersed naturally cooled 11 kV/230 V,  $11/\sqrt{3}$  kV/230 V single phase including 'Completely Self Protected (CSP)' distribution transformers for outdoor use.
- 1.2 It is not the intent to specify completely herein all the details of the design and construction of equipment. However, the equipment shall conform in all respects to high standards of engineering, design and workmanship and shall be capable of performing in continuous commercial operation in a manner acceptable to the purchaser, who will interpret the meanings of drawings and specification and shall have the power to reject any work or material which, in his judgment is not in accordance therewith. The offered equipment shall be complete with all components necessary for their effective and trouble free operation. Such components shall be deemed to be within the scope of bidder's supply irrespective of whether those are specifically brought out in this specification and/or the commercial order or not.
- 1.3 The transformer and accessories shall be designed to facilitate operation, inspection, maintenance and repairs. The design shall incorporate every precaution and provision for the safety of equipment as well as staff engaged in the operation and maintenance of equipment.
- 1.4 All outdoor apparatus, including bushing insulators with their mountings, shall be designed so as to avoid any accumulation of water.

**1.5 STANDARD RATINGS**

- 1.5.1 Standard ratings of single phase transformers shall be 6.3, 7.5, 10, 16 and 25 kVA.

**2 STANDARDS:**

- 2.1 The materials shall conform in all respects to the relevant Indian Standard, with latest amendments thereof unless otherwise specified herein; some of them are listed below.

Indian Standards	Title	International and Internationally recognised standards
IS 2026 (Part-I to IV)	Specification for Power Transformers	IEC-76
IS1180 (Part 1 and 2)	Outdoor Three Phase Distribution Transformers	
IS 335	Specification for Transformer Oil	BS 148/ASTM D1275, D1533, IEC Pub 296
IS 3070	Specification for Lightning Arresters	IEC 99-1
IS 6600	Guide for loading of oil immersed transformers	IEC 76
IS 2099	High Voltage Porcelain Bushings	IEC 137
IS 9335	Specification for Insulating Kraft Paper	IEC 554
IS 1576	Specification for Insulating Press Board	IEC 641
IS 5	Specification for colors for ready mixed paints	
IS 13947 (Part 2)	Specification for LT Circuit Breaker	IEC 947-2
IS 12444	Specification for Copper wire rod	ASTM B-49
IS 104	Ready mixed paint, brushing zinc chromate, priming	
IS 649	Testing for steel sheets and strips and magnetic circuits	
IS 4257	Dimensions for clamping arrangements for bushings	
IS 7421	Specification for Low Voltage bushings	
IS 5484	Specification for Al Wire rods	ASTM B - 233
IS 2362	Determination of water content in oil for porcelain bushing of transformer	
IS 6162	Paper covered aluminum conductor	
IS 6160	Rectangular Electrical conductor for electrical machines	

IS 5561	Electrical power connector	
IS 6103	Testing of specific resistance of electrical insulating liquids	
IS 6262	Method of test for power factor and dielectric constant of electrical insulating liquids	
IS 6792	Determination of electrical strength of insulating oil	
IS 10028	Installation and maintenance of transformers.	

2.2 Material conforming to other internationally accepted standards, which ensure equal or better quality than the standards mentioned above would also be acceptable. In case the bidder who wishes to offer material conforming to the other standards, salient points of difference between the standards adopted and the specific standards shall be clearly brought out in relevant schedule. Four copies of such standards with authentic English translations shall be furnished along with the offer.

### 3 SERVICE CONDITIONS:

3.1 The distribution transformers to be supplied against this specification shall be suitable for satisfactory continuous operation under the following climatic conditions as per IS 2026 (Part-I).

- i) Location : At various locations in the country
- ii) Max ambient air temperature (°C) : 50
- iii) Minimum ambient air temperature (°C) : -5
- iv) Maximum Average daily ambient air temperature (°C) : 40
- v) Maximum Yearly weighted average ambient temperature (°C) : 32
- vi) Maximum altitude above mean sea level (metres) : To be specified by user

Note:

1. The climatic conditions specified above are indicative and can be changed by the user as per requirements
2. The equipment shall generally be for use in moderately hot and humid tropical climate, conducive to rust and fungus growth unless otherwise specified

#### 4 PRINCIPAL PARAMETERS:

- 4.1 The Transformer shall be suitable for outdoor installation with single phase, 50 Hz, 11 kV systems in which the neutral is effectively earthed and they should be suitable for service under fluctuations in supply voltage up to plus 12.5% to minus 12.5%.
- 4.2 The transformer shall conform to the following specific parameters. Rated HV side value (11 kV or  $11/\sqrt{3}$  kV) shall be specified in the detailed bill of quantity by purchaser.

SI.No.	ITEM	SPECIFICATION
1.	System voltage (max)	7/ 12 kV
2.	Rated voltage HV Rated voltage LV	$11/\sqrt{3}$ or 11 kV 230 V*
3.	Frequency	50 Hz +/- 5%
4.	No. of Phases	Single
5.	Type of cooling	ONAN

\*The voltage level can be specified as 240/250 volts as per the requirements of the purchaser.

#### 4.3 INSULATION LEVELS

Voltage volts	Impulse Voltage (kV Peak)	Power Frequency (kV)
433	-	3
11000	95	28

#### 5 TECHNICAL REQUIREMENTS:

##### 5.1 CORE MATERIAL:

- 5.1.1 Transformer core shall be wound core type construction using new and high quality cold rolled grain oriented (CRGO) steel with heat resistant insulating coating or amorphous metal.
- 5.1.2 The bidder should offer the core for inspection and approval by the purchaser during manufacturing stage.

- 5.1.3 The transformer shall be suitable for over fluxing (due to combined effect of voltage and frequency) upto 12.5% without injurious heating. The operating flux density shall be such that there is a clear safe margin over the over fluxing limit of 12.5%.

## **5.2 WINDINGS:**

- 5.2.1 HV and LV windings shall be wound from copper conductors covered with double paper/enamel. The inter layer insulation shall be of nomex/epoxy resin dotted kraft paper.
- 5.2.2 Proper bonding of inter layer insulation with the conductor shall be ensured. Test for bonding strength to be conducted.
- 5.2.3 The core coil assembly shall be dried in an oven. The type of winding shall be indicated in the tender. Whether LV windings are of conventional type or foil wound shall be indicated.
- 5.2.4 Dimensions of winding coils are very critical. Dimensional tolerances for winding coils shall be within limits as specified in guaranteed technical particulars (GTP).
- 5.2.5 The core coil assembly shall be securely held in position to avoid any movement under short circuit conditions.
- 5.2.6 Joints in the winding shall be avoided. However, if jointing is necessary the joints shall be properly brazed and the resistance of the joints shall be less than that of parent conductor. In case of foil windings, welding of leads to foil can be done within the winding.

## **5.3 WINDING CONNECTION AND TERMINAL ARRANGEMENTS:**

- 5.3.1 For 11 kV transformers both ends of primary winding shall be brought out through HV bushings. For  $11/\sqrt{3}$  kV transformers, neutral end of the primary HV winding shall be brought out for connecting to 'Neutral' supply wire through 1.1 kV bushings. There shall be provision for connecting 'Neutral' terminal, to local 'Earth' by way of a tinned Copper strip of adequate size and dimension. The secondary winding shall be connected to two LV bushings.

## **5.4 OIL:**

- 5.4.1 The insulating oil shall comply with the requirements of IS 335 or BS 148. Use of recycled oil is not acceptable. The specific resistance of the oil shall not be less than  $2.5 \times 10^{12}$  ohm-cm at 27 °C when tested as per IS 6103.
- 5.4.2 Oil shall be filtered and tested for break down voltage (BDV) and moisture content before filling

5.4.3 The design and all materials and processes used in the manufacture of the transformer, shall be such as to reduce to a minimum the risk of the development of acidity in the oil.

## 6 LOSSES:

6.1 The bidder should guarantee individual no-load loss and load loss without any positive tolerance. The bidder should also guarantee the total losses at 50% and 100% load condition (at rated voltage and frequency and at 75 °C without any positive tolerance).

<b>Voltage Ratio</b>	<b>Rating (kVA)</b>	<b>Total losses at 50% loading in watts (max) at 75 °C</b>	<b>Total losses at 100 % loading in Watts (max) at 75 °C</b>
11/ 3 kV / 230 V	6.3	51	130
11/ 3 kV / 230 V	7.5	57	155
11/ 3 kV / 230 V	10	65	200
11/ 3 kV / 230 V	16	100	250
11/ 3 kV / 230 V	25	110	350
11 kV / 230 V	6.3	51	130
11 kV / 230 V	7.5	57	155
11 kV/230 V	10	65	200
11 kV/230 V	16	100	250
11 kV/230 V	25	110	350

6.2 Whenever the star ratings as promoted by Bureau of Energy Efficiency (BEE) for the above transformers become available the values of 3 star, 4 star or 5 star can be taken by the utility.

6.3 The above losses are maximum allowable and there would not be any positive tolerance. Bids with higher losses than the above specified values would be treated as non-responsive. However, the manufacturer can offer losses less than above stated values. The utility can evaluate offers with losses lower than the maximum allowable losses on total owning cost basis in accordance with methodology given in Annex-I.

## 7 PERCENTAGE IMPEDANCE:

7.1 The recommended percentage impedance at rated frequency and at 75°C shall be less than 4% with tolerance as per IS-2026.

## **8 TEMPERATURE RISE:**

8.1 The temperature rise over ambient shall not exceed the limits given below :

8.2 Top oil temperature rise measured by thermometer : 35°C

8.3 Winding temperature rise measured by resistance method : 40°C

8.4 **Bids not conforming to the above limits of temperature rise will be treated as non-responsive.**

## **9 PENALTY FOR NON PERFORMANCE**

9.1 During testing at supplier's works if it is found that the actual measured losses are more than the values quoted by the bidder, the purchaser shall reject the transformer and he shall also have the right to reject the complete lot.

9.2 Purchaser shall reject the entire lot during the test at supplier's works, if the temperature rise exceeds the specified values.

9.3 Purchaser shall reject any transformer during the test at supplier's works, if the impedance values differ from the guaranteed values including tolerance and if they do not meet the requirements of clause 7.1

## **10 BUSHINGS:**

10.1 The bushings shall be either porcelain or epoxy type and shall conform to the relevant standards specified. Polymer insulator bushings conforming with relevant IEC can also be used.

10.2 For HV, 12 kV class bushings shall be used and for LV, 1.1 kV class bushings shall be used.

10.3 The terminal arrangement shall not require a separate oil chamber not connected to oil in the main tank.

10.4 The HV bushings shall be fixed to the top cover of the transformer and the LV bushings shall be fixed to transformer on sides and in the same plane.

10.5 The bushing rods and nuts shall be of brass/stainless steel.

10.6 The HV bushings shall not have arcing horns.

10.7 Bushings shall be marked with manufacturer's name, month and year of manufacture.

## **11 BUSHING TERMINALS:**

11.1 HV terminal shall be designed to directly receive ACSR conductor upto 7/2.59 mm (without requiring the use of lug) and the LV terminals shall be suitable for directly receiving LT cables (aluminum) ranging from 10 Sq mm to 25 Sq mm both in vertical and horizontal position and the arrangements should be such as to avoid bimetallic corrosion. Terminal connectors must be type tested as per IS 5561.

## **12 TANK :**

12.1 The oil volume inside the tank shall be such that even under the extreme operating conditions, the pressure generated inside the tank does not exceed 0.4 kg/sq. cm positive or negative. There must be sufficient space from the core to the top cover to take care of oil expansion.

12.2 The tank cover shall have plasticised surface at the top to guard against bird faults. Alternately, suitable insulating shrouds shall be provided on the bushing terminals.

12.3 The Transformer tank shall be of robust construction round/rectangular in shape and shall be built up of tested CRCA/Mild Steel Sheet.

12.4 The tank shall be capable of withstanding a pressure of 1 kg/cm<sup>2</sup> (g) and a vacuum of 760 mm of Hg for 30 minutes without any permanent deflection ( Air pressure test shall be conducted as per IS -1180 )

12.5 The L - seam joint, C - seam joint and all fittings and accessories shall be oil tight and no deflection / bulging should occur during service.

12.6 Manufacturer should carry out the all the welding operations as per the relevant ASME standards and submit a copy of the welding procedure and welder performance qualification certificates to the Purchaser.

12.7 The circular bottom plate edges of the tank should be folded upward, for at least 25 mm, to have sufficient overlap with vertical sidewall of the transformer.

12.8 The Transformer tank and the top cover shall be designed in such a manner as to leave no external pockets in which water can lodge.

12.9 Tank shall have permanent lugs for lifting the transformer bodily and there shall be facilities for lifting the core coil assembly separately.

12.10 The transformer shall be provided with two mounting lugs suitable for fixing the transformer to a single pole by means of 2 bolts of 20 mm diameter as per ANSI C 57.12.20-1988.

- 12.11 Both mounting lugs are made with steel of minimum 5 mm thickness.
- 12.12 Jump proof lips shall be provided for upper mounting lug.
- 12.13 Mounting lug faces shall be in one plane.
- 12.14 Minimum Oil level mark shall be embossed inside the tank (at 25<sup>o</sup> C).
- 12.15 The top cover shall be fixed to the tank through clamping only.
- 12.16 HV bushing pocket shall be embossed to top side of the top cover so as to eliminate ingress of moisture and water.
- 12.17 The edges of the top cover shall be formed, so as to cover the top end of the tank and gasket.
- 12.18 Nitrile/ polyurethane /neoprene rubber gaskets' conforming to latest IS 4253 part-II shall be provided between tank and top cover.
- 12.19 The gaskets shall be continuous i.e. without any joint.

### **13 TANK SEALING:**

- 13.1 The space on the top of the oil shall be filled with dry air or nitrogen. The nitrogen plus oil volume inside the tank shall be such that even under extreme operating conditions, the pressure generated inside the tank does not exceed 0.4 kg/sq. cm positive or negative. The nitrogen shall conform to commercial grade of the relevant standards.

### **14 SURFACE PREPARATION AND PAINTING:**

#### **14.1 GENERAL**

- 14.1.1 All paints, when applied in a normal full coat, shall be free from runs, sags, wrinkles, patchiness, brush marks or other defects.
- 14.1.2 All primers shall be well marked into the surface, particularly in areas where painting is evident, and the first priming coat shall be applied as soon as possible after cleaning. The paint shall be applied by airless spray according to manufacturer's recommendations. However, where ever airless spray is not possible, conventional spray shall be used with prior approval of Purchaser.

#### **14.2 CLEANING AND SURFACE PREPARATION:**

- 14.2.1 After all machining, forming and welding has been completed, all steel work surfaces shall be thoroughly cleaned of rust, scale, welding slag or spatter and other contamination prior to any painting.

- 14.2.2 Steel surfaces shall be prepared by Shot blast cleaning (IS 9954) to grade Sa. 2.5 of ISO 8501-1 or chemical cleaning including phosphating (IS 3618).
- 14.2.3 The pressure and volume of the compressed air supply for blast cleaning shall meet the work requirements and shall be sufficiently free from all water contamination to ensure that the cleaning process is not impaired.
- 14.2.4 Chipping, scraping and steel wire brushing using manual or power driven tools cannot remove firmly adherent mill-scale and shall only be used where shot blast cleaning is impractical. Manufacturer shall indicate such location, for purchaser's information, in his offer.

#### **14.3 PROTECTIVE COATING:**

As soon as all items have been cleaned and within four hours of the subsequent drying, they shall be given suitable anti-corrosion protection.

#### **14.4 PAINT MATERIAL:**

Following are the types of paint that may be suitably used for the items to be painted at shop and supply of matching paint to site:

- 14.4.1 Heat resistant paint (Hot oil proof) for inside surface / varnish.
- 14.4.2 For external surfaces one coat of Thermo Setting paint or 1 coat of epoxy primer followed by 2 coats of polyurethane base paint. These paints can be either air-drying or stoving.
- 14.4.3 In case of highly polluted area, chemical atmosphere or at a place very near the sea coast, paint as above with one intermediate coat of high build MIO (Micaceous iron oxide) as an intermediate coat may be used to give a total dry film thickness of 150 to 180 microns.

#### **14.5 PAINTING PROCEDURE:**

- 14.5.1 All prepared steel surfaces should be primed before visible re-rusting occurs or within 4 hours, whichever is sooner. Chemical treated steel surfaces shall be primed as soon as the surface is dry and while the surface is still warm.
- 14.5.2 Where the quality of film is impaired by excess film thickness (wrinkling, mud cracking or general softness) the supplier shall remove the unsatisfactory paint coating and apply another. In all instances where two or more coats of the same paint are specified, such coatings may or may not be of contrasting colours.

##### **14.5.2.1 DAMAGED PAINTWORK:**

- 14.5.3 Any damage occurring to any part of a painting scheme shall be made good

to the same standard of corrosion protection and appearance as that was originally employed.

14.5.4 Any damaged paint work shall be made good as follows:

14.5.4.1 The damaged area, together with an area extending 25 mm around its boundary, shall be cleaned down to bare metal.

14.5.4.2 A priming coat shall be immediately applied, followed by a full paint finish equal to that originally applied and extending 50 mm around the perimeter of the original damage.

14.5.4.3 The repainted surface shall present a smooth surface. This shall be obtained by carefully chamfering the paint edges before and after priming.

**14.7 DRY FILM THICKNESS:**

14.7.1 To the maximum extent practicable the coats shall be applied as a continuous film of uniform thickness and free of pores. Over spray, skips, runs, sags and drips should be avoided. The different coats may or may not be of the same colour.

14.7.2 Each coat of paint shall be allowed to harden before the next is applied as per manufacturer’s recommendation.

14.7.3 Particular attention must be paid to full film thickness at edges.

14.7.4 The requirements for the dry film thickness (DFT) of paint and the materials to be used shall be as given below :

Sl. No.	Paint Type	Area to be painted	No. of coats	Total dry film thickness (minimum )
1.	Thermo setting paint	inside	01	30 microns
		outside	01	60 microns
2.	<b>Liquid paint</b>			
	a) Epoxy (primer)	outside	01	30 microns
	b) Polyurethane base (Finish coat)	outside	02	25 microns each
	c) Hot oil paint / Varnish	inside	01	35 / 10 microns

**14.8 TESTS:**

14.8.1 The painted surface shall be tested for paint thickness.

- 14.8.2 The painted surface shall pass the cross hatch adhesion test and impact test as routine test, Salt spray and Hardness test as type test as per the relevant ASTM standards.

Note: Supplier shall guarantee the painting performance requirement for a period of not less than 5 years.

## **15 RATING AND TERMINAL PLATES:**

- 15.1 There shall be a rating plate on the transformer containing the information given in the relevant Indian Standard. The HV winding terminals shall be marked 1U and 1N for  $11/\sqrt{3}$  kV HV winding. In case of 11 kV HV winding the terminal shall be marked as 1U – 1V or as per purchaser's requirement. The corresponding secondary terminal shall be marked as 2u and 2n.

## **16 PRESSURE RELEASE DEVICE:**

- 16.1 The transformer shall be equipped with a self sealing pressure release device designed to operate at a minimum pressure of 8 PSI (0.564 kg/ cm<sup>2</sup>). The pressure release device shall be provided in the low voltage terminating portion of the tank above top oil level. Alternatively a self ventilating type top cover can be provided.

## **17 FITTINGS:**

- 17.1 The following standard fittings shall be provided :
- 17.1.1 Two earthing terminals.
  - 17.1.2 Two lifting lugs.
  - 17.1.3 HT side neutral earthing strip.
  - 17.1.4 Rating and terminal marking plates.( Non detachable type)
  - 17.1.5 Metal oxide lightning arrester 9 kV, 5kA.
  - 17.1.6 Pressure relief device or self ventilating cover
  - 17.1.7 Circuit Breaker operating mechanism.
  - 17.1.8 Oil immersed LT circuit breaker (If internal), along with operating rod.
  - 17.1.9 HV fuse links.
  - 17.1.10 Signal light.

- 17.1.11 HV bushings.
- 17.1.12 LV bushings.
- 17.1.13 HV and LV terminal connectors.
- 17.1.14 Top cover fixing clamps.
- 17.1.15 Mounting lugs - 2 Nos.
- 17.1.16 Bird guard.
- 17.1.17 LV earthing arrangement.
- 17.1.18 Any other fitting necessary for satisfactory performance of the product.

**18 FASTENERS:**

- 18.1 All bolts, studs, screw threads, pipe threads, bolt heads and nuts shall comply with the appropriate Indian Standards for metric threads, or the technical equivalent.
- 18.2 Bolts or studs shall not be less than 6 mm in diameter except when used for small wiring terminals.
- 18.3 All nuts and pins shall be adequately locked.
- 18.4 Wherever possible bolts shall be fitted in such a manner that in the event of failure of locking resulting in the nuts working loose and falling off, the bolt will remain in position.
- 18.5 All ferrous bolts, nuts and washers placed in outdoor positions shall be treated to prevent corrosion, by hot dip galvanising, except high tensile steel bolts and spring washers which shall be electro-galvanised/ plated. Appropriate precautions shall be taken to prevent electrolytic action between dissimilar metals.
- 18.6 Each bolt or stud shall project at least one thread but not more than three threads through the nut, except when otherwise approved for terminal board studs or relay stems. If bolts and nuts are placed so that they are inaccessible by means of ordinary spanners, special spanners shall be provided.
- 18.7 The length of the screwed portion of the bolts shall be such that no screw thread may form part of a shear plane between members.
- 18.8 Taper washers shall be provided where necessary. Protective washers of suitable material shall be provided front and back of the securing screws.

**19 11 kV LIGHTNING ARRESTORS:**

High surge capacity 9 kV, 5 kA Distribution class type lightning arrester conforming to IS 3070 Part III shall be mounted on the transformer clamped securely to the tank, to protect the transformer and associated line equipment from the occasional high voltage surges resulting from lightning or switching operations. The earthing terminal of the lightning arrestors shall be connected solidly to the transformer tank earthing terminal. Lightning arrestors with polymer insulators in conformance with relevant IEC can also be used.

**20 OVER LOAD CAPACITY:**

20.1 The transformer shall be suitable for loading as per latest IS 6600.

**21 PROTECTION: (for CSP transformers )**

The transformer shall have the following CSP features as its integral part:

**21.1 INTERNAL HV FUSE ON THE HT SIDE OF TRANSFORMER:**

**21.1.1** Expulsion/any other suitable fuse conforming to IS 9385 is to be placed in series with the primary winding. This fuse is to be connected to the high voltage winding through a terminal block. It shall be ensured that this fuse does not blow for faults on the secondary side (LT side) of the transformer i.e., the blowing characteristic of the fuse and LT breaker shall be so coordinated that the fuse shall not blow for any faults on the secondary side of the transformer beyond LT Breaker and those faults shall be cleared by the LT breaker only.

**21.1.2 INTERNALLY/EXTERNALLY MOUNTED, 'LT' BREAKER ON THE 'LV' SIDE OF THE TRANSFORMER:**

**21.1.3** All LT faults after the breaker shall be cleared by this breaker. As such it shall be designed for perfect coordination with the HT fuse for various current multiples. The two characteristics shall be drawn on the same sheet to indicate coordination between the circuit breaker and fuse. The bidder shall carry out coordination test as indicated above, and this forms one of the tests for acceptance.

**21.1.4** The breaker shall be coordinated thermally with the transformer design to follow closely the variations of oil temperature, due to fluctuating loads and ambient temperatures.

**21.1.5** In case of internal breaker, this is to be accomplished by connecting the breaker in series between the secondary winding and the secondary bushings. The breaker shall be located in the same oil as the core and coil assembly so that

the bimetal are sensitive to the temperature of oil as well as the load current.

- 21.1.6 Arrangements shall be provided to enable the circuit breaker to be closed and opened manually standing on ground.
- 21.1.7 The cross section of the current carrying parts of the breaker shall withstand the full load current at a current density not more than 2.5 A/sq.mm (for additional mechanical strength the area should be more).
- 21.1.8 The circuit breaker shall have short circuit rating of 2.5 kA and shall conform to IS 13947.
- 21.1.9 In case the breaker is internal the breaker shall be located in the same oil as the core and coil assembly so that the bimetal is sensitive to the temperature of oil as well as the load.

## **21.2 LOAD MANAGEMENT SIGNAL LIGHT:**

- 21.2.1 A signal light shall be provided to give information about the loading condition of the transformer. It shall forewarn any overloading problem at the installation such that a change out of the existing transformer with a higher capacity transformer can be planned. The signal light mechanism shall not reset itself when the load drops from the overloaded condition. The signal light shall remain lighted once the signal light contacts close due to overload and can be turned off by manual operation. (The signal light shall not give indication for momentary overloading).
- 21.2.2 Loading indication shall be available in adjustable steps of 10% starting from 70% to 110% loading.

## **21.3 TESTS:**

- 21.3.1 All the equipment offered shall be fully type tested by the bidder as per the relevant standards including the additional type tests mentioned at clause 23. The type test must have been conducted on a transformer of same design **during the last five years** at the time of bidding. The bidder shall furnish four sets of type test reports along with the offer. Offers without type test reports will be treated as non-responsive.
- 21.4 Special tests other than type and routine tests, as agreed between purchaser and bidder shall also be carried out as per the relevant standards.
- 21.5 The test certificates for all routine and type tests for the transformers and also for the bushings and transformer oil shall be submitted with the bid.

21.7 The procedure for testing shall be in accordance with IS 1180/2026 as the case may be except for temperature rise.

21.8 Before despatch each of the completely assembled transformer shall be subjected to the routine tests at the manufacturers works.

## **22 ROUTINE TESTS:**

22.1 Ratio, polarity tests.

22.2 No load current and losses at service voltage and normal frequency.

22.3 Load losses at rated current and normal frequency.

22.4 Impedance Voltage test.

22.5 Resistance of windings cold (at or near the test bed temperature).

22.6 Insulation resistance.

22.7 Induced over voltage withstand test.

22.8 Separate source voltage withstand test.

22.9 Breaker coordination test.

22.10 Oil sample test (one sample per lot) to comply with IS 1866.

22.11 Air pressure test on empty tank as per IS 1180

## **23 TYPE TESTS TO BE CONDUCTED ON ONE UNIT:**

In addition to the tests mentioned above following tests shall be conducted :

23.1 Temperature rise test for determining the maximum temperature rise after continuous full load run. The ambient temperature and time of test should be stated in the test certificate.

23.2 Impulse voltage withstand test: As per IS 2026 part-III. Basic insulation level (BIL) for 11 kV shall be 95 kV peak instead of 75 kV.

23.3 Air pressure test: As per IS 1180 part-II.

23.4 Short circuit withstand test: Thermal and dynamic ability.

23.5 Oil samples (Post short circuit and temperature rise test)

- 23.6 Noise level measurement.
- 23.7 Permissible flux density and over fluxing withstand test.
- 23.8 Type test certificates for the tests carried out on prototype of same specifications shall be submitted along with the bid.
- 23.9 The purchaser may select the transformer for type tests randomly.
- 23.10 Short Circuit Test and Impulse Voltage Withstand Test:** The purchaser intends to procure transformers designed and successfully tested for short circuit and impulse test. In case the transformers proposed for supply against the order are not exactly as per the tested design, the supplier shall be required to carry out the short circuit test and impulse voltage withstand test at their own cost in the presence of the representative of the purchaser.
- 23.11 The supply shall be accepted only after such test is done successfully, as it confirms on successful withstand of short circuit and healthiness of the active parts thereafter on un-tanking after a short circuit test.
- 23.12 Apart from dynamic ability test, the transformers shall also be required to withstand thermal ability test or thermal withstand ability will have to be established by way of calculations.
- 23.13 It may also be noted that the purchaser reserved the right to conduct short circuit test and impulse voltage test in accordance with the IS, afresh on each ordered rating at purchaser's cost, even if the transformers of the same rating and similar design are already tested. This test shall be carried out on a transformer to be selected by the purchaser either at their works when they are offered in a lot for supply or randomly from the supplies already made to purchaser's Stores. The findings and conclusions of these tests shall be binding on the supplier.
- 24 TESTS AT SITE:**
- 24.1 The purchaser reserves the right to conduct all tests on transformer after arrival at site and the manufacturer shall guarantee test certificate figures under actual service conditions.
- 25 ACCEPTANCE TESTS:**
- 25.1** The transformers shall be subjected to the following routine/ acceptance test in the presence of purchaser's representative at the place of manufacture before despatch without any extra charges. The testing shall be carried out in accordance with IS 1180 and IS 2026.

- 25.2 Checking of mass, dimensions, fitting and accessories, tank sheet thickness, oil quality, material, finish and workmanship as per GTP/QA plan and contract drawings.
- 25.3 Physical verification of core coil assembly and measurement of flux density of one unit of each rating, in every inspection with reference to short circuit test report.
- 25.4 All tests as specified in clause 22.

## **26 INSPECTION:**

26.1 In respect of raw material such as core stampings, winding conductors, insulating paper and oil, supplier shall use materials manufactured/supplied by standard manufacturers and furnish the manufacturers' test certificate as well as the proof of purchase from the manufacturers (excise gate pass) for information of the purchaser. The bidder shall furnish following documents along with their offer in respect to the raw materials :

26.1.1 Invoice of supplier.

26.1.2 Mill's certificate.

26.1.3 Packing List.

26.1.4 Bill of landing.

26.1.5 Bill of entry certificate by custom.

26.2 To ensure about the quality of transformers, the inspection shall be carried out by the purchaser's representative at following stages:

26.2.1 Online anytime during receipt of raw material and manufacture/ assembly whenever the purchaser desires.

26.2.2 When the raw material is received, and the assembly is in process in the shop floor.

26.2.3 At finished stage i.e. transformers are fully assembled and are ready for despatch.

26.3 After the main raw-materials i.e. core and coil materials and tanks are arranged and transformers are taken for production on shop floor and a few assembly have been completed, the firm shall intimate the purchaser in this regard, so that an officer for carrying out such inspection could be deputed, as far as possible within seven days from the date of intimation. During the stage inspection a few assembled core shall be dismantled (only in case of CRGO

material) to ensure that the CRGO laminations used are of good quality. Further, as and when the transformers are ready for despatch, an offer intimating about the readiness of transformers, for final inspection for carrying out tests as per relevant IS and as in clauses above, shall be sent by the firm along with routine test certificates. The inspection shall normally be arranged by the purchaser at the earliest after receipt of offer for pre-delivery inspection.

- 26.4 In case of any defect/defective workmanship observed at any stage by the purchaser's inspecting officer; the same shall be pointed out to the firm in writing for taking remedial measures. Further processing should only be done after clearance from the Inspecting officer/purchaser.
- 26.5 All tests and inspection shall be carried out at the place of manufacture unless otherwise specifically agreed upon by the manufacturer and purchaser at the time of purchase. The manufacturer shall offer the inspector representing the purchaser all reasonable facilities, without charges, to satisfy him that the material is being supplied in accordance with this specification. This will include stage inspection during manufacturing stage as well as active part inspection during acceptance tests.
- 26.6 The manufacturer shall provide all services to establish and maintain quality of workmanship in his works and that of his sub-contractors to ensure the mechanical/electrical performance of components, compliance with drawings, identification and acceptability of all materials, parts and equipment as per latest quality standards of ISO 9000.
- 26.7 Along with the bid the manufacturer shall prepare Quality Assurance Plan (QAP) identifying the various stages of manufacture, quality checks performed at each stage and the customer hold points. The document shall also furnish details of method of checking, inspection and acceptance standards/values and get the approval of purchaser or his representative before proceeding with manufacturing. However, purchaser or his representative shall have the right to review the inspection reports, quality checks and results of manufacturer's in house inspection department which are not customer hold points and the manufacturer shall comply with the remarks made by purchaser or his representative on such reviews with regards to further testing, rectification or rejection etc. Manufacturer should submit the list of equipment for testing along with latest calibration certificates to the purchaser.
- 26.8 Purchaser shall have every right to appoint a third party inspection to carry out the inspection process. The purchaser has the right to have the test carried out at his own cost by an independent agency wherever there is a dispute regarding the quality of supply. Purchaser has right to test 1% of the supply selected either from the stores or field to check the quality of the product. In

case of any deviation purchaser has every right to reject the entire lot or penalise the manufacturer, which may lead to blacklisting among other things.

## **27 QUALITY ASSURANCE PLAN:**

27.1 The bidder shall invariably furnish following information along with his bid, failing which his bid shall be liable for rejection. Information shall be separately given for individual type of material offered.

27.2 Statement giving list of important raw materials, names of sub-suppliers for the raw materials, list of standards according to which the raw materials are tested, list of test normally carried out on raw materials in presence of bidder's representative and copies of test certificates.

27.3 Information and copies of test certificates as above in respect of bought out accessories.

27.4 List of manufacturing facilities available.

27.5 Level of automation achieved and list of areas where manual processing exists.

27.6 List of areas in manufacturing process, where stage inspections are normally carried out for quality control and details of such tests and inspections.

27.7 List of testing equipment available with the bidder for final testing of equipment along with valid calibration reports shall be furnished with the bid. Manufacturer shall possess 0.1 accuracy class instruments for measurement of losses.

27.8 Quality assurance plan with hold points for purchaser's inspection.

27.9 The successful bidder shall within 30 days of placement of order, submit following information to the purchaser.

27.9.1 List of raw materials as well as bought out accessories and the names of sub-suppliers selected from those furnished along with offer.

27.9.2 Type test certificates of the raw materials and bought out accessories.

27.10 The successful bidder shall submit the routine test certificates of bought out accessories and central excise passes for raw material at the time of routine testing.

## **28 DOCUMENTATION:**

28.1 Completely dimensioned drawings indicating general arrangement and details of fittings, clearances and winding details shall accompany the tender.

28.2 Drawings of internal constructional details and fixing details of coils should also be indicated. Tank dimensions, position of fittings, clearances between leads within the transformer, core grade of laminations, distance of core centers, area of conductor bare and with insulation. No. of coils, No. of turns per coil material of bushing metal parts etc., shall also be furnished with tender.

**29 PACKING and FORWARDING:**

29.1 The packing shall be done as per the manufacturer's standard practice. However, he should ensure the packing is such that, the material should not get damaged during transit by rail/road.

29.2 The marking on each package shall be as per the relevant IS.

**30 MANADATORY SPARES:**

30.1 Mandatory spares shall be supplied as per the purchaser's requirement.

**31 GUARANTEE:**

31.1 The manufacturers of the transformer shall provide a guarantee of 36 months from the date of receipt at the stores of the Utility or 24 months from the date of commissioning, whichever is earlier. In case the DT fails within the guarantee period the purchaser will immediately inform the supplier who shall take back the failed DT within 15 days from the date of the intimation at his own cost and replace/repair the transformer within forty five days of date of intimation with a roll over guarantee.

31.2 The outage period i.e. period from the date of failure till unit is repaired/replaced shall not be counted for arriving at the guarantee period.

31.3 In the event of the supplier's inability to adhere to the aforesaid provisions, suitable penal action will be taken against the supplier, which may inter alia include blacklisting of the firm for future business with the purchaser for a certain period.

## Methodology for computing total owning cost

<b>TOC = IC + (A x Wi) + (B x Wc)</b>		
Where,		
TOC	=	Total Owing Cost
IC	=	Initial cost including taxes of transformer as quoted by the manufacturer
A factor	=	Cost of no load losses in Rs/watt
B factor	=	Cost of load losses in Rs/watt
Wi	=	No load losses quoted by the manufacturer in watt
Wc	=	Load losses quoted by the manufacturer in watt

The “A” and “B” factors capture the net present value of energy losses based on hours of operations, cost of energy (electrical tariff), equipment life (years of expected service) and cost of money (rate of return).

Capitalised cost of no load losses/w = A factor

$$A \text{ Factor} = H \times \frac{E_c}{1000} \times \frac{(1+r)^n - 1}{r(1+r)^n}$$

Capitalised cost of load losses/w = B factor = A factor x LLF

Capitalised cost of transformer = IC + (A x Wi) + (B x Wc)

where

- i) H = No. of service hours per year of the distribution transformer = 8400 hours.
- ii) r = Rate of interest = prime lending rate
- iii)  $E_c$  = Average energy cost (Rs/kWH) at 11 kV/33 kV kV for the utility.
- iv) n = Life of the transformer in years = 25 years
- v) LLF = Loss Load factor =  $0.3 \text{ LF} + 0.7 \text{ LF}^2$ , where LF is the load factor  
 LF for rural areas = 0.5  
 LF for urban areas = 0.7

## Schedule IA

### GUARANTEED TECHNICAL PARTICULARS FOR COMPLETELY SELF PROTECTED DISTRIBUTION TRANSFORMERS

Sl.No.	Description	6.3kVA	7.5kVA	10kVA	16kVA	25kVA
1.	Name of the manufacturer and place of manufacture					
2.	Continuous maximum rating as per this specification.					
3.	Normal ratio of transformer					
4.	Method of connection HV/LV					
5.	Maximum current density in Windings :					
	1. HV (A/sq mm)					
	2. LV (A/sq mm)					
6.	Maximum hot spot temperature °C. (Ambient air temperature on which above is based) °C.					
7.	Maximum temperature : °C					
	(a) Maximum observable oil temperature (ambient air temperature on which above is based)					
	b) Maximum winding temperature at an ambient temperature of					
8.	No-load losses at rated voltage (watt)					
9.	Full load losses at 75 °C (watt)					
10.	Total losses at 100% load (watt)					
11.	Total losses at 50% load (watt)					
12.	Efficiency at normal voltage :					
	(i) Unity Power Factor					
	(a) At 50% load					
	(b) At 75% load					
	(c) At full load					
	(ii) 0.8 Power Factor					
	(a) At 50% load					
	(b) At 75% load					
	(c) At full load					
13.	Regulation as percentage of normal voltage :					

- (a) At unity power factor
  - (b) At 0.8 power factor lagging
14. Percentage impedance voltage at normal ratio between HV and LV windings
  15. Type of transformers, CRGO/ amorphous type
  16. Type of Insulation used in
    - HV Windings
    - LV Windings
  17. Type of insulation used in
    - Core bolts
    - Core bolt washers
    - End plates
    - Core lamination
  18. Impulse withstand test voltage level (kV)
    - HV Windings
    - LV Windings
  19. Characteristics of transformer oil
  20. Total content of oil in litres
  21. Whether transformer will be transported with oil?
  22. Type of transformer tank
  23. Approximate overall dimensions
    - a) Height                    m m
    - b) Length                    m m
    - c) Width                    m m
 Tank dimensions
    - a) Diameter                m m
    - b) Height                    m m
  24. Mass of insulated conductor
    - HV (minimum) kg
    - LV (minimum) kg
  25. Mass of core (minimum) kg (CRGO or amorphous metal)
  26. Mass of complete transformer arranged for transport (kg)

## ADDITIONAL DETAILS

Sl. No.	Description	
1.	Core grade	
2.	Core dimensions	mm
3.	Gross core area	cm <sup>2</sup>
4.	Net Core area	cm <sup>2</sup>
5.	Flux density	Tesla
6.	Mass of Core	kg
7.	Loss per kg of core at the specified flux density	watt
8.	Core window height	mm
9.	Center to center distance of the core	mm
10.	No. of LV Turns	
11.	No. of HV turns	
12.	Size of LV Conductor bare/ covered (dia)	mm
13.	Size of HV conductor bare/covered (dia)	mm
14.	No. of parallels	
15.	Current density of LV winding	A/sq mm
16.	Current density of HV winding	A/sq mm
17.	Mass of the LV winding for Transformer	kg
18.	Mass of the HV winding for Transformer	kg
19.	No. of of LV Coils/phase	
20.	No. of HV coils . phase	
21.	Height of LV Windings	mm
22.	Height of HV winding	mm
23.	ID/OD of LV winding HV	mm
24.	ID/OD of LV winding	mm
25.	Size of the duct in LV winding	mm
26.	Size of the duct in HV winding	mm
27.	Size of the duct between HV and LV	mm
28.	HV winding to LV clearance	mm
29.	HV winding to tank clearance	mm
30.	Calculated impedance	%
31.	HV to earth creepage distance	mm
32.	LV to earth creepage distance	mm

## Schedule II

### SOURCE OF MATERIALS/PLACES OF MANUFACTURE, TESTING AND INSPECTION

Sl. No.	Item	Source of Material	Place of Manufacture	Place of testing and inspection
1.	Laminations			
2.	Aluminium/Copper			
3.	Insulated winding wires			
4.	Oil			
5.	Press boards			
6.	Kraft paper			
7.	MS plates/Angles/Channels			
8.	Gaskets			
9.	Bushing HV/LV			
10.	Paints			
11.	Lightning Arrestors			
12	Current Transformer			

**Price : Rs. 340.00**