



Draft specification on 5 kVA to 25 kVA single phase distribution transformers is being displayed on the website for comments. Kindly send your comments through e-mail at dineshkumar@recl.nic.in. Please contact Mr. Dinesh Kumar for any clarification on tel. 011-41757035. Kindly submit comments by 31/3/07.



Rural Electrification Corporation Limited
(A Government of India Enterprises)



STANDARD
TECHNICAL SPECIFICATION
(REC SPECIFICATION 78/2006)
(DRAFT)
FOR

**SINGLE PHASE $11/\sqrt{3}$ kV/230V or 11kV/230V OIL
IMMERSED CSP DISTRIBUTION TRANSFORMERS
OF CAPACITIES UP TO & INCLUDING 25 kVA**

New Delhi-110003

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Energising Lives-Making A Difference



FOREWORD

REC presently has specification Nos. 14/1976, 49/1989, 50/1997 & 75/2005 for single phase distribution transformers of various types. Recently, in December 05, specification for 5 kVA single-phase completely self-protected distribution transformers has been released. The specifications had been finalized by a Committee with members from CEA, CPRI, REC, NTPC, Power Grid, NHPC, DVC, UPPCL, MSEB, APTRANSCO, BSEB & WBSEB. The Committee had deliberated and agreed for procurement of only completely self-protected transformers in order to reduce the failure-rate and procurement of transformers based on the concept of total owning cost of the transformer, allowing supply of CRGO or amorphous core transformers.

In order to standardize the product and for the benefit of the utilities as well as the manufacturers, it was considered prudent to rationalize the specifications for all single phase distribution transformers on the lines of specifications issued for 5 kVA distribution transformers. A Committee headed by GM (T&D) of REC was set-up to look into the matter and finalize the specifications for single-phase distribution transformers. The Committee has deliberated on various aspects and finalized the specifications. The Committee decided to withdraw the earlier REC technical specifications Nos. 14/1976, 50/1997 & 75/2005 for single phase distribution transformers and to have only one REC specification for single phase transformers up to 25 kVA as enclosed herewith. Salient aspects considered while formulating the specifications are as below:-

- 1) The design of the transformer has been left open to the manufacturers, to the extent possible, so that the concept of new technologies and innovations and any new materials available in future may be utilized without requiring change in the specifications.
- 2) Use of phase-to-phase or phase to neutral primary for distribution transformers needs to be specified by the utility.
- 3) In line with changes adopted by BIS due to changes in IEC standards for LT voltage as 230 volts, distribution transformers have been considered to be rated for 230 volts secondary, as LT line length shall be very short and voltage regulation on LT shall be minimal up-to 25 kVA distribution transformers.
- 4) Completely self-protected distribution transformers have been specified allowing use of internally mounted circuit breaker or MCCB on the LT side, LA & internal fuse on HT side.
- 5) Option to the manufacturer has been allowed for supply of CRGO or amorphous core transformers with capitalization of losses during bid-evaluation in line with decision of 14th standardization conference in 1997. Rate of electricity charges at 11 kV bus need to be specified by the utilities for the purpose of capitalization of losses. Utilities will be benefited by introducing the concept of capitalization of losses and total owning cost of the transformer. This shall also result into procurement of energy efficient transformers and shall be open to any new technology, which can provide lower losses and hence more benefit to the utility.



- 6) Only wound core construction in line with decision in 14th standardization conference in 1997 with copper windings has been allowed.
- 7) Permissible temperature rise for oil and winding have been considered to be 35°C and 40 °C respectively.
- 8) BIL for 11 kV has been considered as 95 kV peak with chopped wave and short circuit test with thermal and dynamic ability have been included as type test.
- 9) Acceptance test on oil sample taken from assembled transformers has been introduced.
- 10) Detailed specification on painting has been introduced which shall ensure life of painting to be of the order of 10 years.
- 11) Maximum permissible losses have been based on input from the industry as to what are the achievable losses, considering best practices in manufacturing, as there does not exist BIS standard for 1 ϕ distribution transformers.
- 12) The basis of deciding A&B factors for loss capitalization is enclosed at Annexure 'A'.
- 13) 5 years guarantee from the date of receipt in stores of the utility has been considered and the bidder has been asked to ensure repair facilities regional basis.

It is hoped that all utilities shall follow the enclosed specifications for all future procurements of 1 ϕ phase distribution transformer up to 25 kVA. Any feedback from the utilities, for any improvement in the specifications in the next revision, shall be highly appreciated.



REC Specification No. 78/2006

TECHNICAL SPECIFICATION FOR OUTDOOR TYPE SINGLE PHASE OIL IMMERSED 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/ $\sqrt{3}$ kV/240V or 11 kV/240V Single phase 5, 10, 16 & 25 kVA 'Completely Self Protected' Distribution Transformers.

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. The purchaser 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 or not.

1.3. The supplier of the transformer shall acquaint & satisfy itself with the practice of erection & commissioning followed by the power utility.

2. STANDARD RATINGS

2.1. Standard Ratings of single phase Transformers shall be 5, 10, 16 & 25 kVA, 11/ $\sqrt{3}$ kV/230 V or 11 kV/230V.

2.2. In case 11/ $\sqrt{3}$ kV primary is adopted, 3 Ph.,4 Wire system at 11kV (with separate neutral wire running continuously from 33/11 kV sub-station) shall be adopted and proper earthing of neutral wire separately at both ends shall be ensured.

3. STANDARDS

3.1. The materials shall conform in all respects to the relevant Indian Standard Specifications with latest amendments thereof; some of them are listed below.



Indian Standard	Title
IS-2026 (Part-I to IV)	Specification for Power Transformer
IS-1180 (Part 1& 2)	Outdoor Three Phase Distribution Transformer
IS-3347	Dimensions of Porcelain Transformer Bushings in lightly polluted atmosphere
IS-7421	Specification for Low Voltage Bushings upto 1000 V
IS - 12444	Specification for electrolytic copper wire rods
IS-13730	Enameled winding wires
IS-7404	Paper covered copper conductors
IS-3024	Grain oriented electrical steel sheets
IS-649	Methods of testing steel sheets for magnetic circuits
IS-335	New insulating Oil
IS-1866	Code of practice for Electrical maintenance & supervision of mineral oil in electrical equipment
IS-3070 (Pt-III)	Specification for Metal Oxide Lightning Arresters
IS-6600	Guide for loading of oil immersed transformers
IS-2099	Porcelain Bushings above 1000 V
IS 9335	Cellulosic papers for electrical purposes
IS 1576	Specification for Solid Insulating Press Board
IS 5/1961	Specification for colors for ready mixed paints
IS-13947 (Part 2)	Specification for LT Circuit Breaker
IS-9954	Pictorial surface preparation standard for painting of steel
IS-6162(Pt I/II)	Paper Covered Al. Conductor
IS 10028	Selection, Installation & Maintenance of Transformers
IS 13759	PU primer
IS13798	PU base knifing filler
IS 13799	PU base surfacer
IS 3618	Phosphate treatment of iron & steel
IS 1477	Code of practice for painting of ferrous metal
IS 9385/IEC 60282	HV Fuses
IS 11149	Specification for rubber gaskets
IS 4257	Dimension for clamping arrangement of bushing

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) latest revision.

a. Location

:At various locations in the country



- b. Max ambient air temperature (deg.C) : 50
- c. Min. ambient air temperature (deg.C) : -5
- d. Max. Average daily ambient air temperature (deg.C) : 40
- e. Max. Yearly weighted average ambient temperature (deg.C) : 32
- f. Max. altitude above mean sea level (Meters) : 1000

The equipment shall be for use in moderately hot and humid tropical climate, conducive to rust and fungus growth.

5. PRINCIPAL PARAMETERS

System parameters

- a) System voltage (max) 12 kV
- b) Rated voltage HV $11/\sqrt{3}$ / 11 kV
- c) Rated voltage LV 230 V (253 V Max)
- d) Frequency 50 c/s +/- 5%
- e) No. of Phases Single
- f) Over fluxing limit 12.5 %
(Due to combined effect of Voltage and Frequency)
- g) Permissible temperature rise over ambient
 - i) Of top oil measured 35 deg.C
(by thermometer)
 - ii) Of winding measured 40 deg.C
(by resistance)
- h) Minimum clearances in air As per IS - 1180 latest

5.1.1. The transformer shall conform to the following specific parameters.

Note : Rated HV side value ($11/\sqrt{3}$ or 11 kV) shall be specified in the detailed bill of quantity by Purchaser.

Table 1

Sl.No	ITEM	SPECIFICATION			
		5kVA	10 kVA	16 kVA	25 kVA
1.	Continuous rated capacity	5kVA	10 kVA	16 kVA	25 kVA
2.	Line current HV (11/ $\sqrt{3}$ kV / 11 kV)	0.79/0.45	1.57 /0.909	2.36 / 1.36	3.96 / 2.27
3.	Line current LV	21.74 A	43.48 A	69.57 A	108.70A
4.	Type of cooling	ONAN	ONAN	ONAN	ONAN
5.	Tap changing arrangement	Not applicable	Not applicable	Not applicable	Not applicable
	Impedance				



Sl.No	ITEM	SPECIFICATION			
6.	No Load Loss (W)	2.5 %	4 %	4 %	4%
7	CRGO	25	30	45	55
	Amorphous	8	12	17	25
	Full Load Loss (W)	135	180	230	310
8.	At 75 deg C				
	Rating of LTCB (A)	25	50	75	125
9.					
10.	BIL for 11 kV	← 95 kV chopped impulse →			

7. TEMPERATURE RISE

7.1. The temperature rise over ambient shall not exceed the limits described above.

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

8. OVER LOAD CAPACITY

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

9. TOLERANCES

9.1. Unless otherwise specified herein, the test value of the transformers supplied should be within the tolerance permitted in the relevant standards.

10. TECHNICAL REQUIREMENTS

10.1. Winding connection & terminal arrangements

10.2. For 11/ $\sqrt{3}$ kV Transformers, Neutral end of the primary HV winding shall be brought out for connection to 'Neutral' supply wire through 1.1 kV bushings. 'Neutral' terminal shall be connected to transformer tank by way of a tinned Copper strip of adequate size and dimension. The secondary winding shall be connected to two LV bushings.

11. Bushings

11.1. The porcelain bushings shall conform to IS 2099, IS 3347 & IS 7421. Polymer insulator bushings shall also be acceptable as per relevant IEC.

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

11.3. 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. The bushing rods and nuts shall be of brass.

11.4. The HV bushings shall not have arcing horns.

11.5. The bushings shall be embossed with the manufacturer's name and the month and year of manufacturing.

12. CORE, WINDINGS, OIL AND INSULATION MATERIAL



12.1. CORE MATERIAL

12.1.1. Transformer core shall have wound core construction using new and high quality CRGO steel with heat resistant insulating coating or Amorphous Metal. The laminations shall be free from burrs & edge bends. Air gap in the core assembly shall be avoided. The core shall be properly stress relieved by annealing in inert atmosphere as per core material manufacturer's recommendations. **Amorphous metal shall be annealed under magnetic field.** 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%.

12.1.2. Following documents as applicable shall be submitted during inspection as a proof towards use of prime core material

- a. Invoice of the supplier
- b. Mills Test Certificate
- c. Packing List
- d. Bill of Lading
- e. Bill of entry certificate to customs

12.2. WINDING

12.2.1. HV and LV windings shall be wound from copper conductors. The HV winding shall be covered with Super enamel & LV winding with DPC / Super Enamel. The inter layer insulation shall consist of epoxy resin coated paper or epoxy resin dotted paper. Compression bonding of the windings shall be ensured by deploying suitable press in the winding process or by curing of epoxy paper insulation in a suitable press. 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. The core/coil assembly shall be securely held in position to avoid any movement under short circuit conditions. Winding shall be made in dust free environment.

12.2.2 Joints in the winding shall be avoided. However if joining is necessary, the joints shall be properly brazed & the resistance of joints shall be less than the parent conductor.

12.3. Oil

12.3.1. The insulating oil shall be new and shall comply with the requirements of IS 335 & REC Spec. 39-1993 (latest version). Use of recycled oil is not acceptable.

12.3.2. Oil shall be filtered & tested for BDV & moisture content before filling. Oil filling shall be carried under vacuum of 5 tor min.

12.3.3. Testing of oil after filling



Testing of oil sample for BDV & moisture content from assembled transformers shall be carried out as acceptance test in line with REC spec. 39 & IS 1866.

13. TERMINAL CONNECTORS

13.1. HV terminal shall be designed to directly receive ACSR conductor (without requiring the use of lug) and the LV terminals, if required, shall be suitable for directly receiving LT cables (aluminum) 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. Detailed arrangement of connectors shall be in line with Annex-I for Brass/Copper Alloy Stem. Terminals shall be made bird proof by providing suitable cover. Other designs of terminal connectors shall also be acceptable subject to their meeting all functional requirements.

14. PROTECTION

The transformer shall have the following CSP features :

14.1. Internal HV fuse on the HT side of transformer

14.1.1. Suitable replaceable fuse shall be placed inside the transformer, in series with the primary winding. The fuse on primary side of the distribution transformer shall take care of any fault occurring inside the transformer itself. The characteristic of the fuse and LT breaker shall be well coordinated so 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 LT breaker only. The fuse shall confirm to IS 9385 and shall be tested for short circuit current.

14.2. LT Circuit breaker:

14.2.1. This breaker shall clear all LT faults after the 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 HV fuse. The bidder shall carry out coordination test as indicated above, and this forms one of the tests for acceptance. The LT breaker shall also be coordinated with overload characteristics of the transformer. The reference temperature for calibration shall be 40 deg C.

14.2.2. Arrangement shall be made so that the circuit breaker can be closed and opened manually standing on ground.

14.2.3. 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). Rated short circuit breaking capacity of the breaker shall not be less than 2.5 kA. The circuit breaker shall confirm to IS-13947 with power factor 0.4 lagging. Time current characteristics & other requirements shall be in line with IS 13947 & REC spec. no. 18/1993 (latest version).



Time current characteristics of LT CB shall be as below :

Sl.No.	Test current	Initial test conditions	Time limits of tripping/ no tripping	Remarks
1.	1.05 I _n	Cold	t \geq 2.5h	No tripping
2.	1.20 I _n	Immediately after Sl.no.1	10 min \leq t \leq 2h	Tripping
3.	1.30 I _n	Cold	t \leq 30 min	Tripping
4.	1.40 I _n	Cold	t \leq 10 min	Tripping
5.	2.50 I _n	Cold	t \leq 1 min	Tripping
6.	4.00 I _n	Cold	t \geq 5 S	Tripping
7.	6.00 I _n	Cold	t \leq 5 S	Tripping
8.	12.00 I _n	Cold	t \geq 40mS	Tripping

Where I_n is full load LV current of the transformer

14.2.4. Successful bidder shall submit the coordination of time-current characteristics of LT & HT side plotted on the same sheet of paper for approval of the owner.

14.2.5. Bidder shall offer either internally mounted oil immersed circuit breaker or MCCB as specified below. (Utilities may specify any one option).

a. Internally mounted, Oil immersed 'LT' Breaker :

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.

b. MCCB

Double pole MCCB (confirming to IS 13947) from reputed manufacturers of appropriate rating with inverse time characteristics for overload & instantaneous magnetic trip (trip time less than 10 mS at 0.4 lagging p.f.) for short circuits shall be provided after the LT bushing in the distribution box. All plastic material shall comply to glow wire test as per relevant IS. Type test report from NABL accredited laboratory shall be submitted.

A distribution box (made of MS or SMC or FRP) shall be provided as an integral part of the transformer to be mounted on the tank before installation on the pole. LT bushing shall be inside the distribution box and a facility for sufficient number of outgoing feeders through cable glands shall be provided. Distribution box shall also have provision for installation of energy meter.

Distribution box shall be designed for out-door duty with minimum IP - 53 protection. It shall have pad-locking arrangement.



14.3. Signal light for tripping of LT breaker.

14.3.1 The distribution box shall be equipped with an LED to indicate tripping of LTCB. On resetting of LTCB the LED shall be automatically switched off.

14.4. 11 kV LIGHTENING ARRESTERS

14.4.1. High surge capacity 9 kV, 5 kA metal oxide lightning arrester conforming to IS-3070 (Pt-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 arresters shall be connected solidly to the earthing terminal on the tank body. Lightning arrestors with polymer insulators in line with relevant IEC shall also be acceptable.

15. PRESSURE RELEASE DEVICE

15.1. 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/cm²). The PRD shall be provided in the low-voltage terminating portion of the tank above top oil level. Inlet port shall be ¹/₄ inch or longer NPT. Resealing pressure shall be 0.3 kg/cm².

16. FITTINGS

The following standard fittings shall be provided.

- a) Two earthing terminals.
- b) Two lifting lugs.
- c) HT side neutral earthing strip
- d) Rating and terminal marking plates.
- e) Metal oxide lightning arrester 9kV, 5kA.
- f) Pressure relief device
- g) MCCB or Oil immersed LT circuit breaker along with operating rod (make, type and technical details to be provided along with the bid.)
- h) HV fuse links.
- i) Signal light.
- j) HV bushings.
- k) LV bushings.
- l) HV & LV terminal connectors.
- m) Top cover fixing clamps.
- n) Mounting lugs - 2 Nos.
- o) Bird guard.
- p) LV earthing arrangement
- q) Any other fitting necessary for satisfactory performance.
- r) Oil level indicator
- s) 5 year guarantee plate

17. LOSSES

17.1. The maximum losses at rated voltage and rated frequency permitted at 75 deg. C. shall be as per table-1 at clause 5.1.



17.2. The losses are maximum allowable and there would not be any positive tolerance. Transformers with higher losses than the above-specified losses would be rejected.

17.3. Transformers with losses less than those specified above will be capitalized during bid evaluation as per loss capitalization formula as below.

$$\text{TOC (after loss capitalization)} = \text{Quoted Price} + \text{NLL} \times \text{A} + \text{LL} \times \text{B}$$

Loss Capitalization factors:

A. Iron Losses (per watt) = Rs. 89.67 x Ec

B. Copper Losses (per watt) = Rs. 26.90 x Ec

Ec is cost of energy at 11 kV bus (to be specified by the utility)

18. PROCEDURE FOR BID EVALUATION:

18.1. The following format shall be filled by the bidder along with bid for evaluating Total Ownership Cost (TOC).

SNO	Price Component	
1	Unit ex-works price (Rupees)	
2	Freight & Insurance (Rupees)	
3	Excise duty (Rupees) 2) Educational cess on Excise duty (Rupees)	
4	Sales Tax (Rupees)	
5	Total Cost per Unit without Capitalization (1+2+3+4) (Rupees)	
6	NLL (Watts)	
7	Cost of NLL/Watt (Rupees) (A)	
8	Cost of Total NLL (6 x 7) (Rupees)	
9	LL (Watts)	
10	Cost of LL/Watt (Rupees) (B)	
11	Cost of total LL (9 x 10) (Rupees)	
12	TOC price per Unit with Capitalization (5+8+11) (Rupees)	

19. PENALTY FOR NON-PERFORMANCE

19.1. Loss values beyond guaranteed values, but less than Max. losses specified at cl.17.1 - During testing, if it is found that the actual measured losses are more than the values quoted by the bidder, penalty shall be recovered from the bidder at double the loss capitalization rate arrived at clause 17.4. For fraction of a Watt, proportionate penalty will be recovered.



19.2. Transformers with temperature rise and impedance beyond guaranteed values:

19.2.1. Purchaser reserves the right to reject any transformer during the test at supplier's works, if the temperature rise exceeds the guaranteed values.

19.2.2. Purchaser reserves the right to reject any transformer during the test at supplier's works, if the impedance values differ from the guaranteed values including tolerance.

19.2.3. Purchaser also reserves the right to retain the rejected transformer and take it into service until the Bidder replaces it with a new transformer at no extra cost. The delivery as per contract will be counted when the manufacturer provides the new transformer as per specification.

19.2.4. Transformers having losses above the values specified in the clause 17.1 shall be rejected.

20. RATING AND TERMINAL PLATES

20.1. There shall be a rating plate on the transformer containing the information given in IS-1180. The HV winding terminals shall be marked 1P and 1N for 11 $\sqrt{3}$ kV, HV winding or as per purchaser's requirement. The corresponding secondary terminal shall be marked as 2s and 2n. Rating & terminal (LV) plates shall be weather resistant with engraved letters. Terminal plate shall also include type of core used.

21. FASTENERS

21.1. All bolts, studs, screw threads, pipe threads, nuts & washers shall comply with the appropriate Indian Standards for metric threads, or the technical equivalent. Bolts or studs shall not be less than 6 mm in diameter except when used for small wiring terminals. All nuts and pins shall be adequately locked.

21.2. Wherever possible, bolts shall be fitted in such a manner that in the event of failure of locking, resulting in the nuts becoming loose and falling off, the bolt will remain in position.

21.3. All ferrous bolts, nuts and washers 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.

21.4. Each bolt or stud shall project at least 2-3 threads but not more than three threads through the nut, except when otherwise approved for terminal board studs or relay stems. If bolts/nuts are placed so that they are inaccessible by means of ordinary spanners, special spanners shall be provided.



- 21.5. 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.
- 21.6. Taper washers shall be provided where necessary. Protective washers of suitable material shall be provided in front and back of the securing screws.

22. TANK

- 22.1. 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. The space above oil level in the tank shall be filled with dry air or nitrogen conforming to commercial grade of IS 1747.
- 22.2. 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.
- 22.3. The Transformer tank shall be of robust construction, and shall be built up of tested CRCA / MS Sheet.
- 22.4. The tank shall be capable of withstanding a pressure of 1 kg/cm² (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)
- 22.5. The L - seam joint, C - seam joint and all fittings and accessories shall be oil tight and no deflection / bulging should occur during service.
- 22.6. Manufacturer should carry out all welding operations as per the relevant ASME standards and submit a copy of the welding procedure qualifications and welder performance qualification certificates to the Purchaser.
- 22.7. No patch welding shall be allowed.
- 22.8. Tank shall have permanent lugs for lifting the Transformer bodily and there shall be facilities for lifting the core coil assembly separately.
- 22.9. 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.
- 22.10. Minimum Oil level mark shall be embossed inside the tank (at 25⁰ C).
- 22.11. The top cover shall be fixed to the tank through clamping or bolting.
- 22.12. HV bushing pocket shall be embossed to topside of the top cover so as to eliminate ingress of moisture.



22.13. The edges of the top cover shall be formed, so as to cover the top end of the tank and gasket.

22.14. Sealing gaskets – Continuous (without joint) oil resistant high quality Nitrile / neoprene / Polyurethane rubber gaskets conforming to Type-III as per latest IS-11149 shall be provided between tank & top cover and for fixing the bushings.

22.15. Tank Sealing

The transformer shall be of sealed tank construction with welded or bolted cover which seals the interior of the tank from atmosphere & in which gas volume plus oil volume remains constant. 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 Standard.

23. SURFACE PREPARATION & PAINTING

23.1. General

23.1.1. All paints shall be applied in accordance with the paint manufacturer's recommendations. Particular attention shall be paid to the following:

- a. Proper storage to avoid exposure as well as extremes of temperature.
- b. Surface preparation prior to painting.
- c. Mixing and thinning.
- d. Application of paints and the recommended limit on time intervals between coats.
- e. Shelf life for storage.

23.1.2. All paints, when applied in a normal full coat, shall be free from runs, sags, wrinkles, patchiness, brush marks or other defects.

23.1.3. 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 but not later than 6 hrs. to avoid rust formation. The paint shall preferably be applied by airless spray according to manufacturer's recommendations. However, wherever airless spray is not possible, conventional spray shall be used with prior approval of Purchaser.

23.1.4. The manufacturer shall, prior to painting protect nameplates, lettering gauges, sight glasses, light fittings and similar such items.

23.2. Paint Material

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



- 23.2.1. Heat & oil resistant paint (Hot oil proof) / varnish/thermosetting paint for inside surface.
- 23.2.2. For external surfaces one coat of Thermo Setting paint or 2 coats of epoxy primer followed by 2 coats of PU paint. These paints can be either air-dried or stoved.
- 23.2.3. The color of the finishing coats shall be dark admiral gray conforming to shade No. 632 of IS-5.

23.3. Cleaning and Surface Preparation

- 23.3.1. 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.
- 23.3.2. Steel surfaces shall be prepared by Shot blast cleaning to Grade Sa 2 ½ of IS 9954 or chemical cleaning by Seven Tank process including Phosphating (IS 3618).
- 23.3.3. The pressure and volume of the compressed air supply for blast cleaning shall meet the work requirements and shall be sufficiently free from water contamination to ensure that the cleaning process is not impaired.
- 23.3.4. 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.

23.4. Painting Procedure

- 23.4.1. All painting shall be carried out in conformity with both Specification and with the paint manufacturer's recommendation. All paints in any one particular system, whether shop or site applied, shall originate from one paint manufacturer.
- 23.4.2. Particular attention shall be paid to the manufacturer's instructions on storage, mixing, thinning and pot life. The paint shall only be applied under the manufacturer's recommended condition. Minimum and maximum time intervals between coats shall be closely followed.
- 23.4.3. All prepared steel surfaces should be primed before visible re-rusting occurs or within 4 hours, whichever is sooner. Chemically treated steel surfaces shall be primed as soon as the surface is dry and while the surface is still warm. All threaded areas shall be masked before painting.



23.4.4. 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. Where two or more coats of paint are specified, such coatings may or may not be of contrasting colours.

23.4.5. Paint applied to items that are not being painted shall be removed at Supplier's expense, leaving the surface clean, unstained and undamaged.

23.5. Damaged Paintwork

23.5.1. 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 originally employed.

23.5.2. Any damaged paintwork shall be made good as follows:

- a. The damaged area, together with an area extending 25 mm around its boundary, shall be cleaned down to bare metal.
- b. 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.
- c. The repainted surface shall present a smooth surface. This shall be obtained by carefully chamfering the paint edges before and after priming.

23.6. Dry Film Thickness

23.6.1. 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.

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

23.6.3. The requirements for 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.)
1.	Liquid paint a) Epoxy primer	Outside	02	30 microns each
	b) P.U.Paint (Finish coat)	Outside	02	25 microns each
	c) Hot oil paint/ Varnish	Inside	01	35/10 microns



Sl.No.	Paint Type	Area to be painted	No. of coats	Total Dry film thickness (min.)
2.	Electrostatic dry powder PU Paint (Powder Coating)	Inside	01	20 microns
		Outside	01	40 microns

23.7. Tests

23.7.1. The painted surface shall be tested for paint thickness by elcometer in line with ASTM D 1186. Impact test at 100kg/sq.cm. shall be carried out as per ASTM 2794.

23.7.2. The painted surface shall pass the Cross Hatch Adhesion test in line with ASTM D 3359. Salt spray test and hardness test on sample shall be carried out as type test as per relevant ASTM B117-21 or ASTM D 3363.

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

24. ROUTINE, ACCEPTANCE & TYPE TESTS

24.1. 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 mentioned at clause 24.5.

24.2. The type test must have been conducted on a transformer of same design. The Bidder shall furnish four sets of type test reports not older than 5 years from NABL accredited laboratory along with the offer. Offers without type test reports are liable to be treated as non-responsive.

24.3. Special tests other than type and routine tests, as agreed between purchaser and bidder shall also be carried out as per the relevant standards.

24.4. ROUTINE TESTS

- a. Ratio and polarity tests.
- b. No load current and losses at service voltage and normal frequency.
- c. Load losses at rated current and normal frequency.
- d. Impedance Voltage test.
- e. Resistance of windings cold (at or near the test bed temp.)
- f. Insulation resistance.
- g. Induced over voltage withstand test.



- h. Separate source voltage withstand test.
- i. LT Circuit Breaker coordination test.
- j. Oil samples test (one sample / lot) to comply with IS 1866.
- k. Air Pressure test on empty tank as per IS 1180
- l. Efficiency & regulation tests as per cl. 19 of IS 1180.
- m. Air pressure test on assembled transformer at 0.35 kg/cm² for 10 min.

24.5. TYPE TESTS TO BE CONDUCTED ON ONE UNIT

24.5.1. In addition to the tests mentioned in cl. 24.4 following tests shall also be conducted.

- a. 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.
- b. Impulse voltage test: As per clause no. 13 (with chopped wave) of IS-2026 part-III as per latest version. BIL for 11 kV shall be 95 kV peak.
- c. Short Circuit Withstand Test : Thermal and dynamic ability including test as per cl. 16.11.4.5 of IS 2026.
- d. Oil samples (Post short circuit & temperature rise test)
- e. Noise level measurement (for reference only).
- f. Permissible flux density and over fluxing withstand test.
- g. Vacuum test as per IS 1180 Pt-II.

24.5.2. Bidder shall offer type tested product in line with the specifications. However, the purchaser may get the type tests repeated in it's presence at an independent NABL accredited laboratory on a transformer selected randomly from the lot offered. The cost of type tests shall be borne by the purchaser, in case type tests are repeated, in line with rates quoted by the bidder and taken into consideration for bid evaluation.

24.6. TESTS AT SITE

24.6.1. 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.

24.7. ACCEPTANCE TESTS

24.7.1. The transformers shall be subjected to the following routine/ acceptance test, in line with Manufacturing Quality Plan (MQP) approved by the owner, in presence of owner'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.

- a. Checking of weights, dimensions, fitting and accessories, tank sheet thickness, oil quality.
- b. Material, finish and workmanship as per GTP / QA Plan and Contract drawings.



- c. 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.
- d. All tests as specified in clause 24.4.
- e. Air Pressure test on assembled transformer as per IS 1180 as acceptance test on 10% samples/lot at a pressure of 0.35 kg/sq.cm. for 10 minutes.
- f. Testing of oil sample for BDV & moisture content - 5% samples from assembled transformers per lot offered for inspection shall be carried out as acceptance test in line with REC spec. 39 & IS 1866.

25. INSPECTION

- 25.1.** All tests and inspection shall be made at the place of manufacturer unless other wise specifically agreed upon between the manufacturer and the purchaser at the time of purchase. The manufacturer shall make available to the inspector, representing the owner, all reasonable facilities, without any additional charge to satisfy him that the material offered is in accordance with specification.
- 25.2.** 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.
- 25.3.** However, owner 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 regard to further testing, rectification or rejection etc. Manufacturer should submit the list of equipment for testing along with latest calibration certificates to the purchaser.
- 25.4.** Purchaser shall have every right to appoint a third party inspection to carryout the inspection process. The purchaser has the right to have the test carried out at his own cost by an independent agency. Purchaser shall have the 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 shall have every right to reject the entire lot or penalize the manufacturer, which may lead to blacklisting.

26. QUALITY ASSURANCE PLAN

- 26.1.** The Bidder shall furnish following information along with bid :
 - 26.1.1. Statement giving list of important raw materials, names of sub-suppliers for raw materials, list of standards according to which the raw materials are tested. List of tests normally carried out on raw materials in presence of Bidder's representative.



- 26.1.2. List of manufacturing facilities available.
 - 26.1.3. Level of automation achieved and lists of areas where manual processing exists.
 - 26.1.4. List of areas in manufacturing process, where stage inspections are normally carried out for quality control and details of such tests and inspections.
 - 26.1.5. List of testing equipment available with the bidder for final testing of equipment along with valid calibration reports shall be furnished with the bid.
- 26.2.** The successful Bidder shall, within 30 days of placement of order, submit following information to the purchaser.
- a. List of raw materials as well as bought out accessories and the names of sub-suppliers selected from those furnished along with offer.
 - b. Type test certificates of the raw materials and bought out accessories.
 - c. The manufacturer shall submit Manufacturing Quality Plan (MQP) for approval & the same shall be followed during manufacture and testing. The owner shall mark CHP (Customer hold point) on the MQP, beyond which point, manufacturing shall be taken up only after inspection by the owner's representative.
- 26.4.** The successful bidder shall submit the routine test certificates of bought out accessories and central excise passes for raw material at the time of inspection.

27. DOCUMENTATION/DRAWING

- 27.1.** Completely dimensioned drawings indicating general arrangement and details of fittings, clearances and winding details shall accompany the bid.
- 27.2.** Drawings of internal constructional details, fixing details of core and coils should also be indicated. Tank dimensions, position of fittings, clearances between leads within the transformer, grade of core 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.

28. PACKING & FORWARDING

- 28.1.** 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.
- 28.2.** The marking on each package shall be as per relevant IS.

29. MANDATORY SPARES

- 29.1.** Mandatory spares shall be supplied as per the owner's requirement.

30. GUARANTEED TECHNICAL PARTICULARS

- 30.1.** Guaranteed technical particulars shall be submitted by the bidders along with the bid as per proforma enclosed at Annexure-II & III, without which the bid shall be liable to be rejected.



31. QUALIFYING REQUIREMENTS

31.1. The manufacturer of the transformer shall have the following facilities in it's works:-

- a. Coil-making facility.
- b. Facility for core-coil assembly.
- c. Coil-drying facility.
- d. Oil-filtration.
- e. Oil-filling under vacuum.
- f. Air-pressure test.
- g. Facility for routine and acceptance tests with Digital Power Analyser of accuracy class 0.2 % or better.

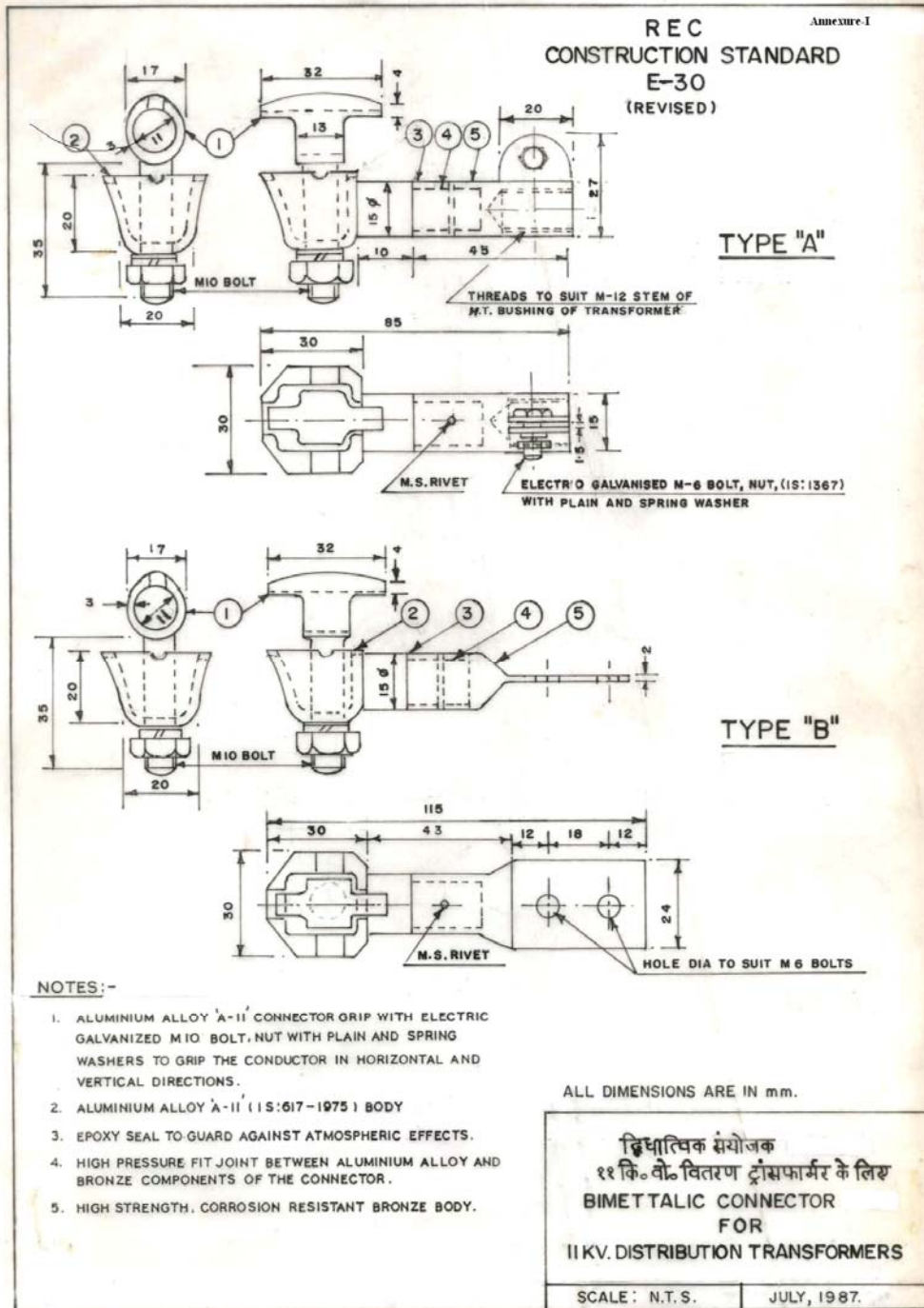
31.2. The bidder shall declare in his bid that the above minimum facilities are available at the manufacturer's works without which the bid shall be liable to be rejected. The manufacturer shall be allowed to out-source core-making, tank fabrication, painting or galvanizing.

32. GUARANTEE

32.1. The manufacturer of the transformer shall provide a guarantee of 5 years from the date of receipt at the stores of the utility. The supplier of the transformer shall make arrangement for spare transformers & service center on regional basis to take care of the transformers (replace/repair the transformer) within a reasonable time (of the order of one month), free of cost, in case the transformer fails during the guarantee period of 5years. The bidder shall also ensure that reasonable, good quality repair facilities are available in the regions of the equipment being supplied.



Annexure - I





Note to Annexure-I

General Requirements for bimetallic bushing terminals :-

All components of the bimetallic bushing terminals shall be made of aluminum alloy 'A-11' of designation 2280 (IS: 617) & bronze of tensile strength not less than 300 N/sq.mm. The terminal body shall be of a single casting. The plain washers, spring washers, nuts & bolts shall be electro-galvanized; zinc shall conform to grade Zn 98 of IS: 209. Nuts shall be made of material conforming to property class 4.8 of IS: 1367 for mechanical properties.

The bushing terminals shall be suitable for holding aluminum conductors, both in vertical or horizontal directions.

The terminals shall be free from flaws, irregularities and sharp radii of curvature.

Epoxy seal shall be provided to seal the bimetallic joint to guard against atmospheric effects.

Test Requirements:-

	HT	LT
1) Rated normal current rating	50 A	200 A
2) Short time current rating	3000 A for 1 sec.	3000 A for 1 sec.
3) Tensile strength	110 kg.	110 kg.
4) Temperature rise test - Steady state temperature rise of terminals shall not exceed 45 deg C, above the reference ambient temperature of 40 deg C, when carrying rated current.		

Type Tests

- a) Tensile Test
- b) Resistance Test
- c) Temperature rise
- d) Short time current test

Acceptance Tests

- a) Tensile Test
- b) Resistance Test
- c) Temperature rise
- d) Dimensional check

Routine Tests

- a) Visual
- b) Dimensional

Notes:-

- a) Permissible tolerances for forged or cast metal parts shall be as per 'Coarse Class: specified in IS: 2102.
- b) All the above tests shall be carried out in accordance with IS: 5561 or its latest version.
- c) Supplier of transformer/terminals shall provide the necessary testing facilities at this works for the acceptance tests.

ANNEXURE - II

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



Sl.No.	Description		
1.	Name and place of the manufacturer	:	
2.	Continuous max. rating.	:	
3.	Nominal ratio of transformer	:	
4.	Method of Connection HV / LV	:	
5.	Max. Current density in Windings. a) HV wdg. A/sq.cm b) LV wdg. A/sq.cm	: : :	
6.	a) Max. Hot Spot Temp. (Deg. C). b) Ambient air temp. on which above is based (Deg.C).	: :	
7.	a) Max. Oil temp. (Deg.C). b) Ambient air temp. on which above is based (Deg.C). c) Max. Winding Temperature (Deg. C). d) Ambient air temp. on which above is based (Deg.C).	: : : :	
8.	No load losses at Rated voltage (watts)	:	
9.	Full Load losses at 75 deg C (watts)	:	
10.	Total losses at 100% Load (watts)	:	
11.	Total Losses at 50% load (watts)	:	
12.	Efficiency at normal voltage a) Unity Power Factor At 50% Load At 75% Load At full Load b) 0.8 Power Factor At 50% Load At 75% Load At full Load	: : : : : : : :	
13.	Regulation at full load as percentage of normal voltage. a) At unity power factor % b) At 0.8 Power factor lagging %	: : :	
14.	% Impedance voltage at normal ratio between HV & LV windings	:	
15.	Type of transformer core – CRGO/Amorphous	:	



Sl.No.	Description		
16.	Type of Insulation used in a) HV Windings b) LV Windings	:	
17.	Type of insulation used in a) Core bolts b) Core bolt washers c) End plates d) Core lamination	:	
18.	Impulse test voltage level a. HV Windings b. LV Windings	:	
19.	Characteristics of transformer oil	:	
20.	Total content of oil in liters	:	
21.	Whether transformer will be transported with oil?	:	
22.	Type of transformer tank	:	
23.	Approx. overall dimensions a) Height mm b) Breadth mm c) Width mm Tank dimensions a) Diameter mm b) Height mm	:	
24.	Excitation current (No load) Amp	:	
25.	Full Load Current Amp	:	
26.	Overload capacity		
27.	Weight of insulated conductor HV (min.) kg. LV (min.) kg.	:	
28.	Weight of core (min.) kg (CRGO or Amorphous metal)	:	
29.	Weight of complete transformer for transport kg.	:	

ANNEXURE-III

ADDITIONAL DETAILS

Sl.No.	Description	Unit
1.	Core Grade	
2.	Core dimensions	mm



Sl.No.	Description	Unit
3.	Gross Core area	cm
4.	Net Core area	cm
5.	Flux density	Tesla
6.	Wt. of Core	kg.
7.	Loss per kg. of Core at the specified Flux density	
8.	Core window height	Watts
9.	Center to center distance of the core	mm
10.	No. of L.V. Turns	mm
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	Amps/sq.mm.
16.	Current density of HV winding	Amps/sq.mm
17.	Wt. of LV winding for Transformer	kg.
18.	Wt. of HV winding for Transformer	kg.
19.	No. of LV Coils/phase	
20.	No. of HV coils/ phase	
21.	Height of LV Winding	mm
22.	Height of HV winding	mm
23.	ID/OD of LV winding	mm
24.	ID/OD of HV 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 & 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

Annexure - A

Loss Capitalisation Formula

The following illustrates the method for calculating the loading factors for evaluation of loss capitalization to be specified by the purchaser. The values indicated are typical values and the utility may adopt values different from those indicated in case the rates of interest, cost of energy and the number of hours of operation are different from those indicated in the example below. A life expectancy of less than 25 years is not recommended.



LOADING FACTOR FOR NO LOAD LOSS

$$A = H \times E_c \times \left[\frac{(1+r)^n - 1}{r(1+r)^n} \right]$$

Rate of Interest in per unit r	Expected life n	Number of hours of operation in a year H	Cost of energy to the utility at 11kV level Ec	1 + r	(1+r) ⁿ	(1+r) ⁿ - 1	$\left[\frac{(1+r)^n - 1}{r(1+r)^n} \right]$	A=loading factor per kW of iron loss
0.08	25	8400	Ec	1.08	6.848475	5.84848	10.67477619	Rs. 89668xEc
LOADING FACTOR FOR COPPER LOSS								
					LLF = 0.2*LF + 0.8 *LF*LF			
					= 0.3			
B = A x LLF = Rs. 89668x Ec x 0.3 = Rs.26900 x Ec								

Where

- A = Loading factor in Rs. per kW of no load loss.
- B = Loading factor in Rs. Per kW for load loss.
- H = No. of hours, the transformer will remain charged in a year i.e. no. of hours of operation (taken as 8400 hrs.).
- Ec = Cost of energy to the utility at 11 kV level.
- r = Rate of interest per unit (Taken as 8%)
- n = Expected life of the transformer (Taken as 25 years)
- LLF = Loss load factor (where LLF=0.2 x Load factor + 0.8 x L.F.²)
- LF = Load factor (taken as 0.5)
- Ec = Cost of energy (in Rupees per unit at 11kV feeder level).

Note: In case of non-availability of Ec (Energy cost per unit) at 11kV feeder level, utility should consider the Bulk Rate Tariff plus 5% as the cost of energy at 11kV feeder level. Load factor considered for B factor is 0.5, higher load factor may be considered for urban areas.