|  |  |  |
| --- | --- | --- |
|  | भारतीय मानक ब्यूरो  ***(उपभोक्ता मामले , खाद्य एवं सार्वजनिक वितरण मंत्रालय ,भारत सरकार )***  **BUREAU OF INDIAN STANDARDS**  *(Ministry of Consumer Affairs, Food & Public Distribution, Govt. of India)* | **मानक भवन**, 9 **बहादुरशाह ज़फर मार्ग, नई दिल्ली** - 110002  Manak Bhavan, 9 Bahadur Shah Zafar Marg, New Delhi-110002  **दूरभाष** Phone : 2323 0131 / 2323 3375 / 2323 1192  **वेबसाइट**  Website : www.bis.org.in |

|  |
| --- |
| ***DRAFTS IN WIDE CIRCULATION*** |

**Document Despatch Advice**

|  |  |
| --- | --- |
| **REFERENCE** | **Date** |
| **ETD 16/ T**- 2 | 02 Nov **201**8 |

**TECHNICAL COMMITTEE ETD 16**

**-------------------------------------------------------------------------------------------------------------------**

ADDRESSED TO:

1. All Members of Transformers Sectional Committee, ETD 16;

2. All Members of Electrotechnical Division Council; and

3. All other Interested.

Dear Sir(s),

Please find enclosed a copy each of the following draft Indian Standards:

|  |  |
| --- | --- |
| **DOC NO.** | **TITLE** |
| ETD 16(6*824*) | **OUTDOOR/INDOOR TYPE LIQUID IMMERSED DISTRIBUTION TRANSFORMERS**  **UPTO AND INCLUDING 2 500 kVA, 33kV — SPECIFICATION** Part 2 Natural/Synthetic Ester Liquid Immersed |

Kindly examine the draft standards and forward your views stating any difficulties which you are likely to experience in your business or profession, if these are finally adopted as Indian Standards.

Comments, if any, may please be made in the format given overleaf and mailed to the undersigned.

Last date for comments: **02 Jan 2018.**

In case no comments are received or comments received are of editorial nature, you will kindly permit us to presume your approval for the above document as finalized. However, in case of comments of technical in nature are received then it may be finalized either in consultation with the Chairman, Sectional Committee or referred to the Sectional Committee for further necessary action, if so desired by the Chairman, Sectional Committee.

Thanking you,

Yours faithfully

(Rajeev Sharma)

Sc ‘F’ & Head (Electrotechnical)

Email: [eetd@bis.org.in](mailto:eetd@bis.org.in)

Encl: As above

|  |  |  |
| --- | --- | --- |
|  | भारतीय मानक ब्यूरो  ***(उपभोक्ता मामले , खाद्य एवं सार्वजनिक वितरण मंत्रालय ,भारत सरकार )***  **BUREAU OF INDIAN STANDARDS**  *(Ministry of Consumer Affairs, Food & Public Distribution, Govt. of India)* | **मानक भवन**, 9 **बहादुरशाह ज़फर मार्ग, नई दिल्ली** - 110002  Manak Bhavan, 9 Bahadur Shah Zafar Marg, New Delhi-110002  **दूरभाष** Phone : 2323 0131 / 2323 3375 / 2323 1192  **वेबसाइट**  Website : www.bis.org.in |

|  |
| --- |
| व्‍यापक परिचालन में मसौदे |

प्रलेख प्रेषण संज्ञापन

|  |  |
| --- | --- |
| **संदर्भ  ईटीडी** | **दिनांक** |
| **ईटीडी16/ टी-2** | **02/11/2018** |

तकनीकी समिति : ईटी **16**

-----------------**----------------------------------------------------------------------------------------------------------------------------**

प्रेषती :

1. **ईटी** 16 **के सभी सदस्‍य**

**2**. **विद्युत तकनीकी विभाग परिषद के सभी सदस्‍य तथा**

**3**. **रूचि रखने वाले अन्‍य सभी निकाय**

**महोदय,**

**कृप्‍या निम्‍नलि‍खित मसौदे की एक प्रति संलग्‍न है :**

|  |  |
| --- | --- |
| **प्रलेख** | **शीर्षक** |
| **ईटीडी16(6824)** | **बाहय/आंतरिक-रंग तरल इम्मेर्सेड वितरण ट्रांसफार्मर**  **तक 2 500 kVA , 33 kV - विशिष्टि**  भाग 2 प्राकृतिक/संश्लेषित एस्टर तरल निमिज्जित |

**कृप्‍या इन मसोदों का अवलोकन करें और अपनी सम्‍मतियॉं यह बताते हुए भेजें कि अंतत: यदि यह मानक के रूप मे प्रकाशित हो जाए तो इस पर अमल करने में आपके व्‍यवसाय अथवा कारोबार में क्‍या कठिनाइयॉं आ सकती हैं ।**

**सम्‍मतियॉं भेजने की अंतिम तारीख 02/01/2019**

**सम्‍मतियॉं यदि कोई हो तो कृप्‍या अगले पृष्‍ठ पर दिए पत्र में अधोहस्‍ताक्षरी को उपरिलिखित पते पर भेज दें ।**

**यदि कोई सम्‍मति प्राप्‍त नहीं होती अथवा सम्‍मति में केवल भाषा संबंधी त्रुटि हुई तो उपरोक्‍त प्रलेख को यथावत अतिंम रूप दिया जाएगा । यदि कोई सम्‍मति तकनीकी प्रकृति की हुई तो विषय समिति के अध्‍यक्ष के परामर्श से अथवा उनकी इच्‍छा पर आगे की कार्यवाही के लिए विषय समिति को भेजे जाने के बाद प्रलेख को अतिंम रूप दे दिया जाएगा**

**धन्‍यवाद,**

**भवदीय,**

(राजीव शर्मा)

**प्रमुख (विद्युत तकनीकी)**

**संलग्‍न : उपरिलिखित**

|  |  |
| --- | --- |
| **Date** | **Document No.** |
| 02 Nov 2018 | Doc: ETD 16(6824) |

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| **Sl. No.** | **Name of the Organization** | **Clause/**  **Sub-clause** | **Paragraph/**  **Figure/Table** | **Type of Comment (General/**  **Technical/**  **Editorial** | **Comments** | **Proposed Change** |
|  |  |  |  |  |  |  |
|  |  |  |  |  |  |  |
|  |  |  |  |  |  |  |
|  |  |  |  |  |  |  |
|  |  |  |  |  |  |  |
|  |  |  |  |  |  |  |
|  |  |  |  |  |  |  |
|  |  |  |  |  |  |  |
|  |  |  |  |  |  |  |

**IS 1180 (Part 2) : 2018**

**Doc: ETD 16 (6824)**

भारतीय मानक

**बाहय/आंतरिक-रंग तरल इम्मेर्सेड वितरण ट्रांसफार्मर**

**तक 2 500 kVA , 33 kV - विशिष्टि**

भाग 2 प्राकृतिक/संश्लेषित एस्टर तरल निमिज्जित

**Indian Standard**

**OUTDOOR/INDOOR TYPE LIQUID IMMERSED DISTRIBUTION TRANSFORMERS**

**UPTO AND INCLUDING 2 500 kVA, 33kV — SPECIFICATION**

Part 2 Natural/Synthetic Ester Liquid Immersed

ICS 29.180

© BIS 2018

**B U R E A U O F I N D I A N S T A N D A R D S**

MANAK BHAVAN, 9 BAHADUR SHAH ZAFAR MARG

NEW DELHI 110002

*November* 2018 **Price Group**

Transformers Sectional Committee, ETD 16

FOREWORD

This Indian Standard was adopted by the Bureau of Indian Standards, after the draft finalised by the Transformers Sectional Committee, had been approved by the Electrotechnical Division Council.

IS 1180 (Part 1) : 2014 addresses specification of mineral oil immersed outdoor/indoor type distribution transformers up to 2 500 kVA 33 kV. A note under **cl 9.1** of this standard allowed use of other insulating liquids namely natural ester, synthetic organic ester subject to agreement between the user and the supplier.

However, it was also mentioned in the foreword of IS 1180 (Part 1) : 2014 that when sufficient experience of  ester liquids is available, separate standard on distribution transformers filled with Natural/Synthetic Organic esters shall be brought out. In the intervening period, several distribution transformers have been filled/ retrofilled with esters and a few power transformers have also been developed using esters. A need is now felt to have a separate, dedicated standard on energy efficient distribution transformers using ester liquids and hence this standard is formulated.

As mineral oil is semi-biodegradable, toxic in nature and is more prone to fire hazards having a low fire point of the order of 150 °C, use of ester liquids - natural vegetable based esters as well as synthetic organic esters with fire point above 300 °C in lieu of mineral oil in several countries has increased due to fire safety and environmental considerations.

All other specifications and parameters of these distribution transformers filled with ester liquids are same as mineral oil filled transformers as per IS 1180 (Part 1) : 2014 except type of cooling and temperature rises.

Total losses according to five energy efficiency levels; level 1; level 2, level 3, level 4 and level 5 as applicable for mineral oil immersed distribution transformers as per IS 1180 (Part 1) : 2014 are also maintained for ester filled distribution transformers.

Being ‘K’ class liquid having fire point above 300 °C, the best advantage of the liquid is to work on higher temperature rises with compatible high temperature insulation material.

This standard explores such possibility based on IS 2026 (Part 14) ‘Liquid-immersed power transformers using high temperature insulation materials’.

Of the several possibilities of using high temperature insulation system, the standard recommends, to start with, a semi hybrid insulation system where thermally upgraded paper (TUP) is used only for the conductor insulation to allow higher than conventional average winding rises. Based on the availability 130 /140 temperature class of material can also be used.

In due course of time when sufficient experience builds using ester liquids, higher temperature rises may be recommended using high temperature insulation systems.

Temperature rises as recommended for conventional insulation and mineral oil have also been kept as an alternative and may be used for retro filling option.

Pad mounted distribution transformers are popular abroad. They are self-protected and obviate the need of ring main unit as used in prefabricated compact substations up to 33 kV.

Such Pad mounted Distribution transformers are also suggested for use in the country up to 33 kV filled with ester liquids. When sufficient experience builds, a separate standard in IS 1180 series can be developed to address Pad mounted transformers in detail.

There is no IEC standard on the subject of ester filled Distribution transformers. However, considerable assistance has been taken while preparing this standard; from IS 16659 “Unused natural esters for transformers and similar electrical equipment, IS 16081 *—* “Specification for unused synthetic organic esters for electrical purposes” and IS 2026 (Part 14) *—* “Liquid immersed Power transformer using high-temperature insulation materials”.

IS 1180 (Part 1): 2014 is a necessary adjunct to this standard.

For the purpose of deciding whether a particular requirement of this standard is complied with, the final value, observed or calculated, expressing the result of a test, shall be rounded off in accordance with IS 2 : 1960 ‘Rules for rounding off numerical values (*revised*)’. The number of significant places retained in the rounded off value should be the same as that of the specified value in this standard.

**IS 1180 (Part 2): 2018**

***Indian Standard***

**OUTDOOR/INDOOR TYPE LIQUID IMMERSED DISTRIBUTION TRANSFORMERS UPTO AND INCLUDING 2500 kVA, 33 kV – SPECIFICATION**

**PART 2 NATURAL/SYNTHETIC ESTER LIQUID IMMERSED**

1. **SCOPE**

This standard specifies the requirements and tests including standard loss levels of natural/synthetic ester liquid immersed, natural air-cooled, outdoor/indoor type, double-wound distribution transformers for use in power distribution systems with nominal system voltages up to and including 33 kV and of following types and ratings:

1. Three phase ratings up to and including 200 kVA both non-sealed and sealed type;
2. Three phase ratings higher than 200 kVA, up to and including 2 500 kVA both non-sealed type and sealed type;
3. Single phase ratings up to and including 100 kVA sealed type.

**NOTES**:

**1** The following types of transformers are not covered under the scope of this standard:

1. Inverter duty transformers;
2. Traction transformers;
3. Instrument transformers;
4. Transformers for static converters;
5. Starting transformers;
6. Testing transformers;
7. Welding transformers;
8. Earthing transformers;
9. Mining transformers;
10. Transformers for solar, wind power application;
11. Transformers for railways (locomotive and other applications);
12. Furnace transformers;
13. Rectifier transformers; and
14. Dual ratio in primary / secondary windings transformers.

**2** For Indoor type Distribution Transformers, relevant provisions of Central Electricity Authority (CEA) regulations, if any, shall be applicable.

**2 REFERENCES**

The standards listed in Annex A contain provisions which, through reference in this text, constitute provisions of this standard. All standards are subject to revision, and parties to agreements based on this standard are encouraged to investigate the possibility of applying the most recent editions of the standards listed in Annex A.

Annex B gives list of IEC, IEEE Standards, Cigre brochures etc on ester fluids.

**3 TERMINOLOGY**

For the purpose of this standard, the following terms and definitions shall apply in addition to those given in IS 1885 (Part 38).

**3.1 Distribution Transformer**

A distribution transformer is a transformer that provides the final voltage transformation by stepping voltages down within a distribution circuit or from a distribution circuit to an end user or application.

NOTE — The distribution circuit voltages are 3.3 kV, 6.6 kV, 11 kV, 22 kV and 33 kV in the country. The power supply for the end users is 415 V, 3 Phase (240 V, 1 Phase), 50 Hz. Transformers with primary voltages of 3.3, 6.6, 11, 22 or 33 kV and secondary voltage of 433 V, 3 Phase (and 250 V single Phase) are called Distribution Transformers. The maximum rating of these transformers for the purpose of this standard is considered up to 2 500 kVA, 3 Phase.

**3.2 Non-Sealed Type Transformer**

A transformer which has a breather for breathing out and breathing in and/or a conservator with expansion and contraction of oil with temperature. The transformer tank body and cover are bolted/clamped/welded type. The tank can also be of corrugated construction.

**3.3 Sealed Type Transformer**

A transformer which is non-breathing that is so sealed that normally there is no significant interchange between its contents and the external atmosphere. No conservator is provided. Such a transformer may or may not have a cushion of inert gas (for example Nitrogen, IS 1747).

Sealed transformers fall in to two categories:

1. Transformers in which the total volume of liquid together with inert gas/ N2 or any combination thereof, remains constant over the temperature range.
2. Transformers in which the total volume of liquid, inert gas/ N2 or any combination thereof, varies over the temperature range and this variation is accommodated by a sealed flexible container (corrugated tank) or a flexible membrane.

Sealed type transformers usually have a bolted/ clamped/ welded cover construction.

**3.4 “K” Class Insulating Liquids**

According to IS 13503, liquids with fire point above 300 °C are classified as K class liquids. Synthetic Organic Ester, Natural Ester and Silicon liquids come under this category. Percentage of biodegradability of silicone liquid is low (around 5 percent). For the purpose of this standard, only Synthetic esters and Natural esters which are 80 to 100 percent biodegradable are considered.

**3.4.1** *Natural Esters*

Vegetable oils obtained from seed (such as soya, rapeseed and sunflower) and liquids from other suitable biological materials and comprised of triglycerides are called Natural esters. Suitable chemical substances called “additives” are deliberately added to natural ester insulating liquids in order to improve certain characteristics, for example pour point, viscosity, foaming and oxidation stability. Natural esters are suitable for sealed transformers and transformers equipped with airbags or suitable liquid preservation system which prevents direct contact of oxygen with the liquid in the conservator. Natural esters are not recommended for free breathing type transformers since oxygen from air accelerates oxidation of natural esters and which increases the viscosity of the liquid.

**3.4.2** *Synthetic Organic Esters*

By definition an ester is a reaction product from the combination of an acid and an alcohol. Synthetic organic esters are manufactured from carefully selected raw materials to give a product that is tailored to specific application of transformers blended with additives to improve certain characteristics, for example pour point, viscosity, foaming excellent oxidation stability making it suitable for the breathing system where the liquid has free access to oxygen from air. Synthetic organic esters are suitable for non-sealed and sealed transformers without any preservation system.

**3.5 Pad Mounted Transformer**

An outdoor transformer utilized as part of underground distribution system with enclosed compartment(s) for high voltage and low voltage cables entering from below and mounted on a foundation pad.

The pad mounted transformer generally covers two bushing and terminal arrangements for radial feed systems. It consists of a tank with high voltage and low voltage cable terminating compartments separated by a barrier of metal or other rigid material. These compartments are located side by side on one side of the transformer tank. The transformer shall be of sealed construction.

**4 SERVICE CONDITIONS**

The provisions of IS 2026 (Part 1) shall apply.

NOTE — In case of indoor transformers and transformers installed in an enclosure, suitable ventilation, if required, shall be provided to maintain service conditions as per IS 2026 (Part 1).

**5 GENERAL**

Technical parameters including standard loss levels of three categories of distribution transformers are given in **6**, **7** and **8.**

Other requirements as described in **9** to **22** are applicable for all types and ratings of distribution transformers.

**6 TECHNICAL PARAMETERS OF THREE PHASE DISTRIBUTION TRANSFORMERS UP TO AND INCLUDING 200 kVA (NON-SEALED AND SEALED TYPE)**

**6.1 Ratings**

The standard ratings shall be as per Table 1.

**Table 1 Standard Ratings**

*(Clause* 6.1)

**\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_**

|  |  |  |
| --- | --- | --- |
| **Sl No.** | **Nominal System Voltage** | **Standard Ratings (kVA)** |
| (1) | (2) | (3) |
| i) | Up to and including 11 kV | \*6.3, \*10, 16, \*20, 25, \*40, 63, 100, 160 and 200 |
| ii) | Above 11 kV up to and including 22 kV | 63, 100, 160 and 200 |
| iii) | Above 22 kV up to and including 33 kV | 100, 160 and 200 |

NOTE — \* ratings are non-preferred.

**6.2 Rated Frequency**

The rated frequency shall be 50 Hz.

**6.3 Nominal System Voltage**

Nominal system voltage shall be chosen from the following:

High Voltage (HV) *—* 3.3, 6.6, 11, 22 and 33 kV

Low Voltage (LV) *—* 415 V

**6.4 Basic Insulation Level (BIL)**

Minimum basic insulation level shall be as given in Table 2.

**Table 2 Minimum Basic Insulation Level**

*(Clause* 6.4)

|  |  |  |
| --- | --- | --- |
| **Sl No.** | **Nominal System Voltage**  (kV) | **Minimum BIL**  (kVP) |
| (1) | (2) | (3) |
| i) | 3.3 | 40 |
| ii) | 6.6 | 60 |
| iii) | 11 | 75 |
| iv) | 22 | 125 |
| v) | 33 | 170 |

NOTE — Insulation coordination of all relevant fittings and accessories corresponding to higher BIL values shall be ensured.

**6.5 No-Load Voltage Ratios**

The no-load voltage ratios shall be as follows:

3 300/433-250, 6 600/433-250, 11 000/433-250, 22 000/433-250 and 33 000/433-250 V

NOTE― Secondary voltage may be selected as 415-240 V, subject to agreement between the user and the supplier.

**6.6 Winding Connections and Phase Displacement**

The primary winding shall be connected in delta and the secondary winding in star [vector symbol, Dyn 11 (*see* IS 2026 Part 1)], so as to produce, a positive phase displacement of 30o from the primary to the secondary vectors of the same phase. The neutral of the secondary winding shall be brought out to a separate insulated terminal.

**6.7 Tapping Range and Tapping Methods**

**6.7.1** No taps are normally required to be provided upto 100 kVA rating, unless specifically specified by the user.

**6.7.2** The standard tapping range, when taps are provided above 100 kVA rating shall be as follows:

Winding tapped *—* HV

Number of tap positions *—* 4

Voltage variation *—* +2.5percent to -5 percent of HV in steps of 2.5 percent

**6.7.3** Off circuit tap-changing arrangement shall be either by means of links or by means of an externally-operated switch with mechanical locking device and a position indicator. Arrangement for pad-locking shall be provided.

**6.7.4** Provision of any other tapping range and tapping step is subject to agreement between the user and the supplier.

**6.8 Losses and Impedance Values**

**6.8.1** *Losses — Multiple Rating with Regard to Energy Efficiency*

**6.8.1.1** For transformers of HV voltage up to 11 kV, the total losses (no-load + load losses at 75℃) at 50 percent of rated load and total losses at 100 percent of rated load shall not exceed the maximum total loss values given in Table 3.

**Table 3 Maximum total losses up to 11kV class Transformers**

*(Clause* 6.8.1.1, 6.8.1.2 *and* 6.8.1.3)

|  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Sl. No.** | **Rating**  **(kVA)** | **Impedance**  **(percent)** | **Maximum Total Loss (W)** | | | | | | | | | |
| Energy Efficiency  Level 2 | | Energy Efficiency  Level 3 | | Energy Efficiency  Level 4 | | Energy Efficiency  Level 5 | | Energy Efficiency  Level 6 | |
| (1) | (2) | (3) | 50 % Load  (4) | 100 % Load  (5) | 50 % Load  (6) | 100 % Load  (7) | 50 % Load  (8) | 100 % Load  (9) | 50 % Load  (10) | 100 % Load  (11) | 50 % Load  (12) | 100 % Load  (13) |
| i) | 6.3 | 4.0 | 53 | 173 | 47 | 158 | 43 | 135 | 41 | 123 | 38 | 113 |
| ii) | 10 | 4.5 | 84 | 240 | 75 | 215 | 68 | 208 | 63 | 191 | 58 | 173 |
| iii) | 16 | 4.5 | 135 | 440 | 120 | 400 | 108 | 364 | 97 | 331 | 87 | 301 |
| iv) | 20 | 4.5 | 159 | 527 | 144 | 487 | 130 | 443 | 117 | 403 | 105 | 366 |
| v) | 25 | 4.5 | 190 | 635 | 175 | 595 | 158 | 541 | 142 | 493 | 128 | 448 |
| vi) | 40 | 4.5 | 249 | 834 | 224 | 775 | 202 | 705 | 182 | 642 | 164 | 583 |
| vii) | 63 | 4.5 | 340 | 1 140 | 300 | 1 050 | 270 | 956 | 243 | 870 | 219 | 791 |
| viii) | 100 | 4.5 | 475 | 1 650 | 435 | 1 500 | 392 | 1 365 | 352 | 1 242 | 317 | 1 130 |
| ix) | 160 | 4.5 | 670 | 1 950 | 570 | 1 700 | 513 | 1 547 | 462 | 1 408 | 416 | 1 281 |
| x) | 200 | 4.5 | 780 | 2 300 | 670 | 2 100 | 603 | 1 911 | 543 | 1 739 | 488 | 1 582 |

NOTE — Level 1 has not been used so as to align the maximum total losses criterion with IS 1180 (Part1) : 2014.

**6.8.1.2** For transformers having voltage class above 11kV and up to and including 22 kV, the permissible total loss values shall not exceed by 5 percent of the maximum total loss values mentioned in Table 3.

**6.8.1.3** For transformers having voltage class above 22 kV and up to and including 33 kV, the permissible total loss values shall not exceed by 7 ½ percent of the maximum total loss values mentioned in Table 3.

**6.8.2** *Impedance*

The recommended impedance at 75ºC for different ratings is as per Table 3.

**6.9 Permissible Flux Density and Over Fluxing**

**6.9.1** The maximum flux density in any part of the core and yoke at rated voltage and frequency shall be such that the flux density with + 12.5 percent combined voltage and frequency variation from rated voltage and frequency shall not exceed 1.9 Tesla.

NOTE — The design calculations in support of flux density shall be furnished by manufacturer.

**6.9.2** No load current up to 200 kVA shall not exceed 3 percent of full load current and will be measured by energizing the transformer at rated voltage and frequency. Increase of 12.5 percent of rated voltage shall not increase the no load current by 6 percent maximum of full load current.

**6.10 Limits of Temperature-rise**

**6.10.1** The type of cooling shall be type KNAN as per IS 2026 (Part 2).

**6.10.2** The permissible temperature-rise shall not exceed the limits of 40oC (when measured by resistance method) for transformer winding and 35oC (measured by thermometer) for top liquid when tested in accordance with IS 2026 (Part 2) when conventional insulation system is used (as for retro filling).The marginal increase in temperature rises by use of Ester liquids is ignored (since this is compensated by slow ageing).

**6.10.3** The permissible temperature rise shall not exceed the limits of 55oC (when measured by resistance method) for transformer winding and 50oC (measured by thermometer) for top liquid when tested in accordance with IS 2026 (Part 2) when semi hybrid high temperature insulation is used in accordance with IS 2026 (Part 14).

NOTE― Semi hybrid insulation system consists of mainly high temperature solid insulation materials thermally upgraded paper (TUP) used for windings alone.

During temperature-rise test, total losses at 75 oC shall be fed.

**7 TECHNICAL PARAMETERS OF THREE PHASE DISTRIBUTION TRANSFORMERS HIGHER THAN 200 kVA UP TO AND INCLUDING 2 500 kVA (NON- SEALED AND SEALED TYPE)**

**7.1 Ratings**

The standard ratings shall be as per Table 4.

**Table 4 Standard ratings**

(*Clause* 7.1)

|  |  |  |
| --- | --- | --- |
| **Sl No.** | **Nominal System Voltage** | **Standard Ratings(kVA)** |
| (1) | (2) | (3) |
| I) | Up to and including 11 kV | 250, 315, 400, 500, 630, 800,1 000, 1 250, 1 600, 2 000 and 2 500 |
| Ii) | Above 11 kV up to and including 22 kV | 250, 315, 400, 500, 630, 800,1 000, 1 250, 1 600, 2 000 and 2 500 |
| Iii) | Above 22 kV up to and including 33 kV | 250, 315, 400, 500, 630, 800,1 000, 1 250, 1 600, 2 000 and 2 500 |

**\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_**

**7.2 Rated Frequency**

The rated frequency shall be 50 Hz.

**7.3 Nominal System Voltage**

Nominal system voltage shall be chosen from the following:

HV — 3.3, 6.6, 11, 22 and 33 kV

LV *—* 415V

**7.4 Basic Insulation Level (BIL)**

The minimum basic insulation level (BIL) shall be as given in Table 5.

**Table 5 Minimum Basic Insulation Level**

(*Clause* **7.4**)

|  |  |  |
| --- | --- | --- |
| **Sl No.** | **Nominal System Voltage (kV)** | **Minimum Basic Insulation Level (kVP)** |
| (1) | (2) | (3) |
| i) | 3.3 | 40 |
| ii) | 6.6 | 60 |
| iii) | 11 | 75 |
| iv) | 22 | 125 |
| v) | 33 | 170 |

NOTE — Insulation coordination of all relevant fittings and accessories corresponding to higher BIL values shall be ensured.

**7.5 No-Load Voltage Ratios**

The no-load voltage ratios shall be as follows:

3 300/433-250, 6 600/433-250, 11 000/433-250, 22 000/433-250 and 33 000/433-250 V

NOTE — Secondary voltage may be selected as 415-240 V, subject to agreement between user and supplier.

**7.6 Winding Connections and Phase Displacement**

The primary winding shall be connected in delta and the secondary winding in star [vector symbol, Dyn 11 (*see* IS 2026 Part 1)], so as to produce, a positive phase displacement of 30o from the primary to the secondary vectors of the same phase. The neutral of the secondary winding shall be brought out to a separate insulated terminal.

Alternatively [Dyn1 (*see* IS 2026 Part 1)] can also be specified. If system and application requirements demand different vector groups, the same can also be adopted.

**7.7 Tapping Ranges and Tapping Methods**

**7.7.1** The standard tapping ranges, when taps are provided, shall be as follows:

|  |  |
| --- | --- |
|  |  |
| Winding tapped *—* | HV |
| Number of tap *—*positions | 7 |
| Voltage variations *—* | + 5 percent to -10 percent in steps of 2.5 percent for variation of HV |

**7.7.2** Off circuit tap-changing arrangement shall be either by means of links or by means of an externally-operated switch with mechanical locking device and a position indicator. Arrangement for pad-locking shall be provided.

**7.7.3** For ratings 500 kVA and above, on load tap changers may be provided for variation of HV voltage from + 5 percent to – 15 percent in steps of 2.5 percent.

**7.7.4** Provision of any other tapping range and tapping step is subject to agreement between user and the supplier.

**7.8 Losses and Impedance Values**

**7.8.1** *Losses — Multiple rating with regard to Energy Efficiency*

**7.8.1.1** For transformers of HV voltage up to 11 kV, the total losses (no-load + load losses at 75ºC) at 50 percent of rated load and total losses at 100 percent of rated load shall not exceed the maximum total loss values given in the following Table 6.

**Table 6 Maximum total losses up to 11 kV Class Transformer**

(*Clauses* 7.8.1.1, 7.8.1.2, 7.8.1.3 ***and*** 7.8.2)

|  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Sl. No.** | **Rating (KVA)** | **Impedance (%)** | **Maximum Total loss (W)** | | | | | | | | | |
| **Energy Efficiency Level 2** | | **Energy Efficiency Level 3** | | **Energy Efficiency Level 4** | | **Energy**  **Efficiency Level 5** | | **Energy Efficiency Level 6** | |
| **50% Load** | **100% Load** | **50% Load** | **100% Load** | **50% Load** | **100% Load** | **50% Load** | **100% Load** | **50% Load** | **100% Load** |
| i) | 250 | 4.50 | 980 | 2 930 | 920 | 2 700 | 864 | 2 488 | 811 | 2 293 | 761 | 2 113 |
| ii) | 315 | 4.50 | 1 025 | 3 100 | 955 | 2 750 | 890 | 2 440 | 829 | 2 164 | 772 | 1 920 |
| iii) | 400 | 4.50 | 1 225 | 3 450 | 1 150 | 3 330 | 1 080 | 3 214 | 1 013 | 3 102 | 951 | 2 994 |
| iv) | 500 | 4.50 | 1 510 | 4 300 | 1 430 | 4 100 | 1 354 | 3 909 | 1 282 | 3 727 | 1 215 | 3 554 |
| v) | 630 | 4.50 | 1 860 | 5 300 | 1 745 | 4 850 | 1 637 | 4 438 | 1 536 | 4 061 | 1 441 | 3 717 |
| vi) | 800 | 5.0 | 2 287 | 6 403 | 2 147 | 5 838 | 2 015 | 5 323 | 1 892 | 4 853 | 1 776 | 4 425 |
| vii) | 1 000 | 5.00 | 2 790 | 7 700 | 2 620 | 7 000 | 2 460 | 6 364 | 2 310 | 5 785 | 2 170 | 5 259 |
| viii) | 1 250 | 5.00 | 3 300 | 9 200 | 3 220 | 8 400 | 3 142 | 7 670 | 3 066 | 7 003 | 2 991 | 6 394 |
| ix) | 1 600 | 6.25 | 4 200 | 11 800 | 3 970 | 11 300 | 3 753 | 10 821 | 3 547 | 10 363 | 3 353 | 9 924 |
| x) | 2 000 | 6.25 | 5 050 | 15 000 | 4 790 | 14 100 | 4 543 | 13 254 | 4 309 | 12 459 | 4 088 | 11 711 |
| xi) | 2 500 | 6.25 | 6 150 | 18 500 | 5 900 | 17 500 | 5 660 | 16 554 | 5 430 | 15 659 | 5 209 | 14 813 |

NOTE — Level 1 has not been used so as to align the maximum total losses criterion with IS 1180 (Part1) : 2014.

**7.8.1.2** For transformers having voltage class above 11 kV and up to and including 22,kV, the permissible total loss values shall not exceed by 5 percent of the maximum total loss values mentioned in Table 6.

**7.8.1.3** For transformers having voltage class above 22 kV and up to and including 33 kV, the permissible total loss values shall not exceed by 7 ½ percent of the maximum total loss values mentioned in Table 6.

**7.8.2** *Impedance*

The recommended percent impedance at 75oC for different ratings shall be as per Table 6.

**7.9 Permissible Flux Density and Overfluxing**

**7.9.1** The maximum flux density in any part of the core and yoke at rated voltage and frequency shall be such that the flux density with + 12.5 percent combined voltage and frequency variation from rated voltage and frequency does not exceed 1.9 Tesla.

**NOTE —** The design calculations in support of flux density shall be furnished by the manufacturer.

**7.9.2** No load current shall not exceed 2 percent of the full load current and shall be measured by energizing the transformer at rated voltage and frequency. Increase of 12.5 percent of rated voltage shall not increase the no load current by 5 percent of full load current.

**7.10 Limits of Temperature Rise**

**7.10.1** The type of cooling shall be KNAN as per IS 2026 (Part 2).

**7.10.2** The permissible temperature-rise shall not exceed the limits of 45°C (when measured by resistance method) for transformer winding and 40°C (measured by thermometer) for top liquid when tested in accordance with IS 2026 (Part 2) when conventional insulation system is used (as for retro filling). The marginal increase in temperature rises by use of Ester liquids is ignored (since this is compensated by slow ageing).

**7.10.3** The permissible temperature rise shall not exceed the limits of 60oC (when measured by resistance method) for transformer winding and 55oC (measured by thermometer) for top liquid when tested in accordance with IS 2026 (Part 2) when semi hybrid high temperature insulation (thermally upgraded paper TUP) is used in windings in accordance with IS 2026 (Part 14).

During heat run test losses computed at 75oC shall be fed.

**8 TECHNICAL PARAMETERS OF SINGLE PHASE DISTRIBUTION TRANSFORMERS UP TO AND INCLUDING 100 kVA (SEALED TYPE)**

**8.1 Ratings**

The standard ratings shall be as per Table 7

**Table 7 Standard Ratings**

(*Clause***8.1**)

|  |  |  |
| --- | --- | --- |
| **Sl No.**  (1) | **Nominal System Voltage**  (2) | **Standard Ratings** (kVA)  (3) |
|  | Up to and including 11 kV | 5, 10, 16, 25, \*50, \*75 and \*100 |
|  | Above 11 kV up to and  including 22 kV | 10, 16, 25, \*50, \*75 and \*100 |
|  | Above 22 kV up to and  including 33 kV | 16, 25, \*50, \*75 and \*100 |
| NOTE **—** \*Ratings are non-preferred. | | |

**8.2 Rated Frequency**

The rated frequency shall be 50 Hz.

**8.3 Nominal System Voltage**

Nominal system voltage shall be chosen from the following:

HV — 3.3, 6.6, 11, 22 and 33 kV

LV — 415V (240 V, 1 phase)

**8.4 Basic Insulation Level (BIL)**

Minimum Basic Insulation level shall be as given in Table 8.

**Table 8 : Minimum Basic Insulation Level**

*(Clause* **8.4**)

|  |  |  |
| --- | --- | --- |
| **Sl No.**  (1) | **Nominal System Voltage**  (kV)  (2) | **Minimum BIL**  (kVp)  (3) |
|  | 3.3 | 40 |
|  | 6.6 | 60 |
|  | 11 | 75 |
|  | 22 | 125 |
|  | 33 | 170 |
|  |  |  |
| NOTE— Insulation coordination of all relevant fittings and accessories corresponding to higher BIL values shall be ensured. | | |

**8.5 No Load Voltage Ratio**

The no-load voltage ratios shall be as follows:

3 300/√3 / 250 V , 3 300 / 250 V

6 600/√3 / 250 V , 6 600 / 250 V

11 000/√3 / 250 V , 11 000 / 250 V

22 000/√3 / 250 V , 22 000 / 250 V

33 000/√3 / 250 V , 33 000 / 250 V

NOTE — Secondary voltage may be selected as 415-240 V, subject to agreement between the user and the supplier

**8.6 Number of Phases and Polarity**

Number of phases shall be one (Single Phase).

Polarity: Additive or Subtractive

**8.7 Tap Changing Arrangement**

Taps are not required.

**8.8 Losses and Impedance values**

**8.8.1** *Losses — Multiple Rating with Regard to Energy Efficiency*

**8.8.1.1** For transformer of HV voltage up to 11 kV, the total losses (no load + load losses at 75 ̊C) at the 50 percent of rated load and total losses at 100 percent of rated load shall not exceed the maximum total loss values given in Table 9.

**Table 9 Maximum Total Losses of Single Phase Transformers Up to 11 kV**

(*Clause* 8.8.1.1, 8.8.1.2, 8.8.1.3 and8.8.2)

|  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Sl. No.**  **(1)** | **Rating (KVA)**  **(2)** | **Impedance (%)**  **(3)** | **Maximum Total Loss (W)** | | | | | | | | | |
| Energy Efficiency Level 2 | | Energy Efficiency Level 3 | | Energy Efficiency Level 4 | | Energy Efficiency Level 5 | | Energy Efficiency Level 6 | |
| 50% Load  (4) | 100% Load  (5) | 50% Load  (6) | 100% Load  (7) | 50% Load  (8) | 100%  Load  (9) | 50% Load  (10) | 100%  Load  (11) | 50% Load  (12) | 100%  Load  (13) |
| i) | 5 | 2.5 | 35 | 95 | 30 | 75 | 27 | 68 | 24 | 62 | 21 | 57 |
| ii) | 10 | 4.00 | 60 | 170 | 55 | 150 | 50 | 135 | 45 | 122 | 40 | 112 |
| iii) | 16 | 4.00 | 82 | 224 | 63 | 190 | 58 | 175 | 54 | 164 | 50 | 145 |
| iv) | 25 | 4.00 | 110 | 300 | 95 | 260 | 88 | 240 | 80 | 225 | 74 | 210 |
| v) | 50 | 4.0 | 210 | 590 | 190 | 520 | 177 | 480 | 160 | 451 | 148 | 420 |
| vi) | 75 | 4.0 | 310 | 880 | 285 | 780 | 265 | 720 | 242 | 670 | 223 | 625 |
| vii) | 100 | 4.0 | 410 | 1 140 | 375 | 1 030 | 350 | 964 | 320 | 900 | 299 | 842 |

NOTE — Level 1 has not been used so as to align the maximum total losses criterion with IS 1180 (Part1) : 2014.

**8.8.1.2** For transformers having voltage class above 11 kV and up to and including 22 kV, the permissible total loss values shall not exceed by 7 ½ percent of the maximum total loss values mentioned in Table 9.

**8.8.1.3** For transformers having voltage class above 22 kV and up to and including 33 kV, the permissible total loss values shall not exceed by 10 percent of the maximum total loss values mentioned in Table 9.

**8.8.2** *Impedance*

The recommended percent impedance at 75°C for different ratings shall be as per Table 9.

**8.9 Permissible Flux Density and Overfluxing**

**8.9.1** The maximum flux density in any part of the core and yoke at rated voltage and frequency shall be such that the flux density with + 12.5 percent combined voltage and frequency variation from rated voltage and frequency does not exceed 1.9 Tesla.

NOTE — The design calculations in support of flux density shall be furnished by the manufacturer.

**8.9.2** No load current shall not exceed 3 percent of full load current and will be measured by energizing the transformer at rated voltage and frequency. Increase of 12.5 percent of rated voltage shall not increase the no-load current by 6 percent maximum of full load current.

**8.10 Limits of Temperature Rise**

**8.10.1** The type of cooling shall be KNAN as per IS 2026 (Part 2).

**8.10.2** The permissible temperature-rise shall not exceed the limits of 40 ̊C (when measured by resistance method) for transformer winding and 35 ̊C (measured by thermometer) for top liquid when tested in accordance with IS 2026 (Part 2). The marginal increase in temperature rises by use of Ester liquids is ignored (since this is compensated by slow ageing).

**8.10.3** The permissible temperature-rise shall not exceed the limit of 55oC (when measured by resistance method) for transformer winding and 50oC (measured by thermometer) for liquid when tested in accordance with IS 2026 (Part 2) when semi hybrid high temperature insulation, thermally upgraded paper (TUP) is used for windings alone in accordance with IS 2026 ( Part 14 ).

During heat run test load losses at 75oC shall be fed.

**9 STANDARD MATERIALS**

**9.1** Major material used in the transformer shall conform to the following Indian Standards:

1. Cold Rolled Grain Oriented electrical steel – IS 3024
2. Amorphous core material – (IS 16585)
3. Copper/Aluminum conductor – IS 191, IS 1897, IS 7404, IS 12444, IS 13730/IS 6162 series as given in Annex A.
4. Kraft paper –IS 9335 series as given in Annex A.
5. Press Board – IS 1576
6. Synthetic organic Ester – IS 16081
7. Natural Ester – (IS 16659)

**10 TERMINAL ARRANGEMENT**

**10.1 For Three Phase Transformers:**

**10.1.1** The transformers shall be fitted on high voltage and low voltage sides with outdoor type bushings of appropriate voltage and current ratings. The high voltage bushings (3 Nos.) shall conform to IS 2099. The low voltage bushings (4 Nos.) shall conform to IS 7421. Alternatively, the low voltage side may be made suitable for adoption of PVC / XLPE cables of suitable size.

**10.1.2** If required by the user, a suitable cable-end box may be provided on the high voltage and or low voltage side. Alternatively bus duct arrangement may be provided on low voltage side by agreement between the user and the supplier.

NOTE— Porcelain / Epoxy / Silicon Rubber Bushing may also be used in the cable box subject to agreement between the user and the supplier.

**10.1.3** In case of sealed type transformer, the terminal arrangements shall be such that it shall be possible to replace the bushings (external) without opening the cover and also without affecting the sealing of the transformer. The arrangement shall meet the following requirements:

HV and LV Bushings:

The bushing shall be made in two parts. The outer bushing shall be of porcelain. The dimensions of the outer bushing shall conform to relevant part/section no. of IS 3347 depending on the voltage class. The internal bushing shall be of either porcelain or tough insulating material, like epoxy and shall have embedded stem. Metal portion of the internal HV and LV bushing inside the tank shall remain dipped in liquid in all operating conditions.

**NOTE —** Any other suitable arrangement can be used subject to agreement between the user and the supplier.

**10.1.4** Gaskets shall be made of synthetic rubber or synthetic rubberized cork resistant to hot transformer ester liquid.

**10.1.5** The dimensions of bushings of the following voltage classes shall conform to the following Indian Standards mentioned against them:

|  |  |  |
| --- | --- | --- |
| *Voltage Class* | *For Porcelain Parts* | *For Metal Parts* |
| Up to 1.0 kV bushings | IS 3347 (Part1/Sec 1) | IS 3347 (Part1/Sec2) |
| 3.6 kV bushings | IS 3347 (Part 2/Sec 1) | IS 347 (Part 2/Sec 2) |
| 12 kV bushings  24 kV bushings | IS 3347 (Part 3/Sec 1)  IS 3347 (Part4/Sec 1) | IS 3347 (Part 3/Sec 2)  IS 3347 (Part 4/sec 2) |
| 36 kV bushings | IS 3347 (Part 5/Sec.1) | IS 3347 (Part 5/Sec.2) |

NOTES

**1** For heavily polluted atmosphere, dimensions of bushings shall confirm to IS 8603.

**2** Cast resin or polymer bushing can also be used with performance requirements as per IS 2099 and IS 7421.

**10.2** **For Single Phase Transformers**

For 11/√3, 22/√3, and 33/√3 transformers, neutral end of the HV winding shall be brought out to Neutral through 1.0 kV bushing. Neutral terminal shall be connected to tank by a tinned copper strip of adequate size.

For 11, 22, 33 kV transformers, two HV bushings shall be used for termination of both ends of HV winding.

The HV bushings shall be fixed to the top cover and the LV bushings of 1.0 kV class shall be fixed to the transformer tank on sides.

**10.3** **Marking and relative Positions of Terminals**

Appropriate characters in accordance with IS 2026 (Part 1) shall be indelibly marked upon or adjacent to terminals.

**11 MINIMUM CLEARANCES IN AIR**

The minimum phase-to-phase and phase-to-earth external clearances for LV & HV bushings shall be as per Table 10.

**Table 10 External (Air) Clearances between Bushings Mounted on Transformers**

*(Clause* 11)

|  |  |  |
| --- | --- | --- |
| **Nominal System Voltage** | **Phase to Phase clearance in mm** | **Phase to earth clearance in mm** |
| Up to 1.1kV | 75 | 40 |
| 11 kV | 255 | 140 |
| 22 kV | 330 | 230 |
| 33 kV | 350 | 320 |

**11.1** For transformers with air filled cable-end box/connection chamber, the phase-to-phase and phase-to-earth clearance shall be as per Table 11.

**Table 11 Air Clearances in Cable Box**

(*Clause* 11.1)

|  |  |  |
| --- | --- | --- |
| **Nominal System Voltage** | **Phase to Phase Clearance in mm** | **Phase to Earth Clearance in mm** |
| Up to 1.1kV | 25 | 20 |
| 11 kV | 130 | 80 |
| 22 kV | 240 | 140 |
| 33 kV | 350 | 220 |

**12 CONNECTORS (APPLICABLE FOR BARE BUSHING TERMINATIONS ONLY)**

Wherever specified, suitable bimetallic connectors (clamp type) shall be provided on both HV and LV side in order to ensure sound and robust connection.

**13 MARKING**

**13.1** **Rating Plate**

Each transformer shall be provided with rating plate made of anodized aluminium / stainless steel material securely fixed on the outer body, easily accessible, showing the information given in Fig. 1 for 3 phase transformers and Fig. 2 for single phase transformers. The entries on the rating plate shall be indelibly marked for example, by etching, engraving or stamping.



LIQUID oC

LIQUID



Fig. 1 Rating plate for 3 phase transformers



LIQUID



LIQUID oC

FIG.2 RATING PLATE FOR SINGLE PHASE TRANSFORMERS

**13.2** **Terminal Marking Plate**

Each transformer shall be provided with a terminal marking plate in accordance with Fig. 3 to Fig. 5 whichever is applicable.



All dimensions in mm

FIG. 3 TERMINAL MARKING PLATE FOR 3 PHASE TRANSFORMERS WITHOUT TAPS



All dimensions in mm

FIG. 4 TERMINAL MARKING PLATE FOR 3 PHASE TRANSFORMERS WITH TAPS

.

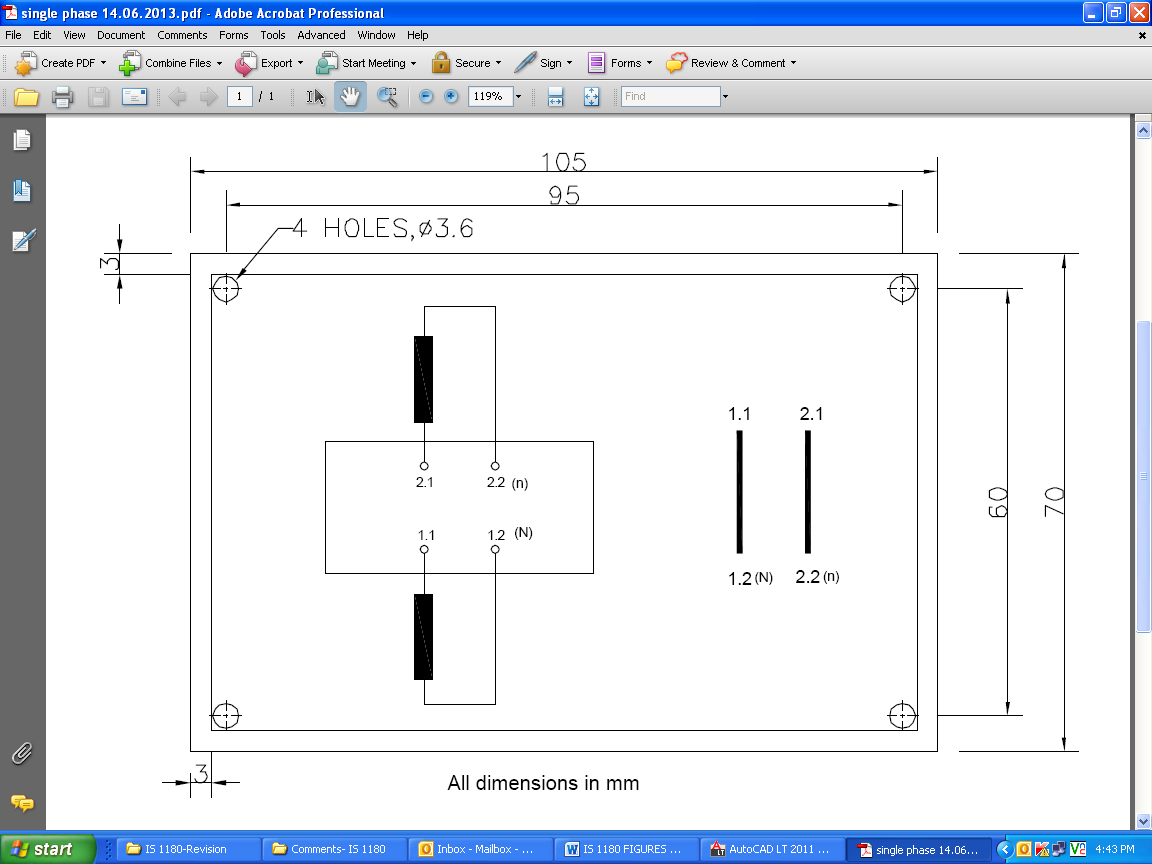


FIG. 5 TERMINAL MARKING PLATE for SINGLE PHASE TRANSFORMERS

**13.3** The rating and terminal marking plates may be combined into one plate at the option of the manufacturer.

NOTE **—** Dimensions of Rating Plate, Terminal Marking Plate and Combined Rating and Terminal Plate can be changed subject to agreement between the user and the supplier.

**13.4** The Distribution Transformer may also be marked with the Standard Mark.

**13.4.1** The use of the Standard Mark is governed by the provisions of the *Bureau of Indian Standards* Act, 2016 and the Rules and Regulations made thereunder. The details of conditions under which the licence for the use of the Standard Mark may be granted to manufacturers or producers may be obtained from the Bureau of Indian Standards.

**14 MOUNTING ARRANGEMENT**

**14.1** The under-base of all three phase transformers upto 200kVA ratings shall be provided with two channels of minimum size 75 × 40 mm as shown in Fig. 6 to make them suitable for fixing to a platform or plinth.

All dimensions in millimetres

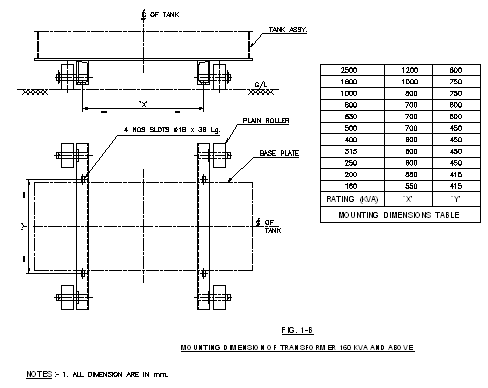


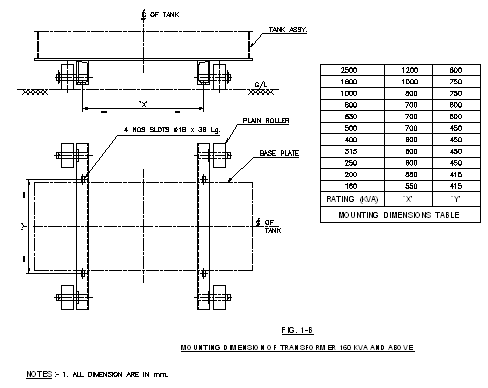
NOTE **—** Any other mounting dimensions are subject to agreement between the user and the supplier.

FIG. 6 MOUNTING DIMENSION OF TRANSFORMERS UP TO 200 kVA

**14.2** The under base of all transformers beyond 200 kVA may be as per Fig. 7 to make them suitable for mounting on flat rollers

|  |  |  |
| --- | --- | --- |
| Rating (kVA) | X | Y |
| 2 500 | 1200 | 800 |
| 2 000 | 900 | 800 |
| 1 600 | 900 | 800 |
| 1 250 | 800 | 800 |
| 1 000 | 800 | 800 |
| 800 | 800 | 800 |
| 630 | 800 | 800 |
| 500 | 700 | 450 |
| 400 | 700 | 450 |
| 315 | 600 | 450 |
| 250 | 500 | 415 |





All dimensions in Millimetres

NOTES

1 Bidirectional rollers can also be used as per mutual agreement between the user and the supplier.

2 Any other mounting dimensions are subjected to agreement between the user and the supplier.

FIG. 7 MOUNTING DIMENSIONS OF TRANSFORMERS BEYOND 200 kVA

**14.3** Suitable Pole mounting arrangement may be alternatively provided for 3 phase transformers upto 500 kVA, subject to agreement between the user and the supplier.

**14.4** Single phase transformers are pole mounted type and shall be provided with two mounting lugs suitable for fixing the transformer to a single pole by means of two bolts of 20 mm diameter.

Both mounting lugs are made with steel of minimum 5 mm thickness.

**14.5** For pad mounted transformers other constructional features and fixing details shall be subject to agreement between the user and the supplier.

**15 TRANSFORMER TANK**

**15.1** **Construction**

**15.1.1** For non-sealed or sealed type transformer, Transformer tank can be of plain tank configuration with/without radiator fins or cooling tubes. The tank can also be made of corrugated panels of adequate thickness, also used for cooling. The transformer tank covers shall be bolted/clamped alternatively welded with tank rim so as to make a leak proof joint. The curb design in case of welded construction shall be such that it is possible to remove the weld and reweld the tank at least two times.

NOTE **—** Minimum thickness of corrugations shall be 1.0 mm

**15.1.2** The transformer tank shall be of adequate mechanical strength to withstand positive and negative pressures built up inside the tank while the transformer is in operation.

**15.1.3** All welding operations shall be carried out by qualified welders.

**15.1.4** The tank design shall be such that the core and windings can be lifted freely.

**15.1.5** For single phase sealed type transformers, the circular base plate edges of the tank shall be folded upward for at least 25 mm, to have sufficient overlap with vertical sidewall of the transformer.

**15.2** **Pressure and Vacuum Requirements**

**15.2.1** **‘**For single phase transformers up to 25 kVA, the plain tank shall be capable of withstanding a pressure of 100 kPa and a vacuum of 760 mm of mercury. There should be no deformation of the tank.

For single phase transformers from above 25 kVA to 100 kVA, the plain tank shall be capable of withstanding a pressure of 80 kPa and a vacuum of 250 mm of mercury. Limiting values of deflections are specified in **21.5.3.1.**

**NOTE —** For single phase transformers up to 100 kVA, the transformer tank shall be of robust construction generally round/ rectangular in shape.

**15.2.2** For three phase transformers up to 2 500 kVA, transformer tanks with corrugations shall be designed for a pressure of 15 kPa measured at the top of the tank with no leakage.

For single phase transformers up to 100 kVA, transformer tanks with corrugations shall be designed for a pressure of 15 kPa measured at the top of the tank with no leakage.

**NOTE —** For single phase transformers up to 100 kVA, the transformer tank shall be of robust construction generally round/ rectangular in shape.

**15.2.3** For three phase sealed type transformers with cover welded to the curb of the tank shall be of sound and robust construction so as to withstand pressure of 80 kPa without any deformation.

**15.2.4** For single phase transformers of sealed type construction, when the space on the top liquid is filled with inert gas, the inert gas plus liquid 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/cm2 positive or negative.

**15.3**  All bolts/nuts/washers exposed to atmosphere shall be as follows.

a) Size 12 mm or below – stainless steel.

b) Above 12 mm – steel with suitable finish like electro galvanized with passivation or hot dip galvanized.

**15.4** Gaskets wherever used shall conform to Type III as per IS 11149 / Type C as per IS 4253 (Part 2).

**15.5** Inside of tank shall be painted with varnish or liquid resistant paint. For external surfaces one coat of thermo setting powder paint or one coat of epoxy primer followed by two coats of polyurethane base paint shall be used. Table 12 shall be referred to for paint thickness for normal to medium corrosive atmosphere. For highly polluted atmosphere and special application external paint work shall be subject to agreement between the user and the transformer manufacturer.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **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. | Liquid Paint   1. Epoxy (primer)   b) Polyurethane (Finish coat)  c) Hot liquid resistant paint / Varnish | outside  outside  inside | 01  02  01 | 30  25 each  35 / 10 |

**Table 12 Paint scheme for Distribution Transformers**

*(Clause* 15.5)

*Note: It is recommended to choose paint shade of the transformer as green 218 following IS 5.*

**16 CONSERVATOR FOR NON-SEALED TYPE TRANSFORMERS**

**16.1** Transformers of ratings 63 kVA and above with plain tank construction, the provision of conservator is mandatory. For sealed type transformers with or without inert gas/N2 cushion, conservator is not required.

**16.2** When a conservator is provided, liquid gauge and the plain or de-hydrating breathing device shall be fixed to the conservator which shall also be provided with a drain plug and a filling hole (1¼ normal size thread) with cover. The capacity of a conservator tank shall be designed keeping in view the total quantity of liquid and its contraction and expansion due to temperature variations. In addition, 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.

**16.3** The inside diameter of the pipe connecting the conservator to the main tank should be 25 to 50 mm and it should be projected into the conservator so that its end is at least 20 mm above the bottom of the conservator so as to create a sump for collection of impurities. The minimum ester liquid level corresponding to -5°C should be above the sump level.

**17 ABILITY OF TRANSFORMERS TO WITHSTAND EXTERNAL SHORT CIRCUIT**

The performance of transformer under external shortcircuit conditions shall be in accordance with IS 2026 (Part 5).

**18 EFFICIENCY AND REGULATION**

When statements of efficiency and regulations are required they shall be based on specified loading at the rated kVA and unity power factor and computed in accordance with Annex B and Annex C respectively.

NOTE — Efficiency and regulations at other power factors as agreed between the user and supplier shall also be computed.

**19 TOLERANCES**

The tolerance on electrical performance excluding losses shall be as given in IS 2026 (Part 1).

**20 FITTINGS**

**20.1** **Standard Fittings**

The following standard fittings shall be provided:

a) Two earthing terminals with the earthing symbol ╧;

b) Liquid level gauge indicating liquid level at minimum, 30°C and maximum operating

temperature;

NOTES

**1** Minimum and maximum positions correspond to the operating temperature of -5°C and 90°C respectively (for non-

sealed type Transformer).

**2** Only minimum position corresponding to the operating temperature of 30°C (for sealed type transformers).

1. Air release device (for non-sealed type Transformers)
2. Rating and terminal marking plates;
3. Dehydrating breather shall be provided for non-sealed type transformers.
4. Drain-*cum*-sampling valve preferably steel with plug for three phase transformers (for transformers above 500 kVA).

NOTE— Valve size shall be as per agreement between the user and the supplier.

g) Thermometer pocket with cap

h) Ester/Nitrogen/Air filling hole having (11/4 nominal size thread) with cover (for sealed type transformers without conservator)

j) Lifting lugs for the complete transformer as well as for core and winding assembly

k) Pressure relief device or explosion vent [for sealed type transformers (for all ratings) and non-sealed type transformers (for ratings above 200 kVA)]

m) One filter valve on the upper side of the tank (for transformers above 200 kVA)

n) HV side neutral grounding strip (where one of the HV bushing terminal is connected to earth)

p) LV earthing arrangement for single phase transformers

q) Buchholz relay for transformers above 1 000 kVA *and*

r) Arcing horns for HT side (one number per phase)

NOTE — For cable box/ busduct arrangement, Arcing horns are not required.

**20.2 Optional Fittings**

The following shall be available as additional fittings at the option of the user wherever specified:

1. Dehydrating breather in lieu of plain breathing device for transformers up to 200 kVA
2. Filter valve for transformers up to 200 kVA

NOTE — Valve size shall be as per agreement between the user and the supplier.

1. Suitable rating lightning arrestors for HT side (one number per phase).

d) Bird Guard

e) Terminal connectors

f) Liquid temperature indicator and winding temperature indicators for transformers above 200 kVA.

g) Jacking pads (for transformer above 1 600 kVA)

h) Buchholz relay (for transformers above 200 kVA)

j) Magnetic liquid level gauge (for transformer above 1 600 kVA) with low liquid level alarm contact.

k) Non return valve (for conducting pressure test).

m) Pressure relief device or explosion vent (up to 200 kVA for non-sealed type transformers).

n) Protection relay for sealed type transformers for internal parameters that is pressure, temperature, liquid level and gas detection

p) 4 No’s Anti-Theft stainless steel Fasteners with breakaway nut shall be provided at top cover (up to 200 kVA)

q) Unidirectional flat rollers (for transformers above 200 kVA)

r) Drain-cum-sampling valve preferably steel with plug for three phase transformers (for transformers up to 500 kVA)

NOTE— Valve size shall be as per agreement between the user and the supplier.

NOTE — IS 3639 describes some of the fittings and accessories

s) Self protection/disconnection devices subject to agreement between the user and the supplier:

1) Thermo-magnetic circuit breaker as self protection device on secondary side as per IS/IEC 60947-2 : 2003; and

2) Expulsion fuse as disconnection device on primary side as per IS 9385 (Part 2) : 1980.

NOTE— Additional requirements for transformers with self protection/disconnection devices are under preparation.’

**21. TESTS**

**21.1** **General**

All routine, type and special tests as described in **21.2** to **21.4** shall be performed as per relevant parts of IS 2026. Pressure and ester liquid leakage test shall be conducted as per **21.5**.

**21.2 Routine Tests** (to be conducted on all units)

The following shall constitute the routine tests:

1. Measurement of winding resistance [IS 2026 (Part 1)]
2. Measurement of voltage ratio and check of phase displacement IS 2026 ( Part 1)
3. Measurement of short-circuit impedance (principal tapping, when applicable) and load loss at 50 percent and 100 percent load IS 2026 (Part 1)
4. Measurement of no-load loss and current IS 2026 (Part 1)
5. Measurement of insulation resistance IS 2026 ( Part 1 )
6. Induced over-voltage withstand test IS 2026 ( Part 3 )
7. Separate-source voltage withstand test (IS 2026 Part 3)

NOTE — For single phase transformer with 11/√3 or 22/√3 or 33/√3 kV and with 1.0 kV neutral bushing, this test shall be conducted at test voltage of neutral (3 kV rms for 1 min).

1. Pressure test (*see* **21.5**)
2. Ester liquid leakage test (*see* **21.5**)

**21.3 Type Tests** (to be conducted on one unit)

The following shall constitute the type tests:

1. Lightning impulse test IS 2026 ( Part 3)
2. Temperature-rise test IS 2026( Part 2)
3. Short-circuit withstand test [IS 2026 (Part 5)] (up to 200 kVA) *and*

NOTE **—** Routine tests before and after short circuit test shall be conducted as per IS 2026 (Part 1).

1. Pressure test (*see* **21.5**)

**21.4 Special Tests** (to be conducted on one unit)

The following constitute the special tests which may be carried out subject to mutual agreement between the user and the supplier:

1. Determination of sound levels [IS 2026 (Part 10)];
2. Short-circuit withstand test [IS 2026 (Part 5)] (above 200 kVA);

NOTE**–** Routine tests before and after short circuit test shall be conducted as per IS 2026 (Part 1)

c) No load current at 112.5 percent voltage (*see* **6.9.2**, **7.9.2**, **8.9.2**);

d) Paint adhesion test

The test is performed as per ASTM D3359 (Standard Test Methods for measuring

adhesion by tape test).

NOTE **—** The conformance criterion is subject to agreement between the user and the supplier.

e) BDV and Moisture content of liquid in the transformer (IS 16081, IS 16099 and IEEE C57.147).

**NOTE —** Tests at d) and e) may be carried out on more than one unit subject to agreement between user and supplier

**21.5 Pressure and Ester liquid leakage Test**

**21.5.1** *For Transformers up to 200 kVA*

**21.5.1.1** *Pressure test (type test)*

For non-sealed and sealed type transformers, the transformer tank shall be subjected to air pressure of 80 kPa for 30 min (25 kPa for 30 min for corrugated tanks) and vacuum of 250 mm of mercury for 30 min. There should not be air leakage at any point.

The permanent deflection of flat plates, after pressure / vacuum has been released, shall not exceed the values given below.

|  |  |
| --- | --- |
| *Length of Plate* | *Deflection* |
| Up to 750 mm | 5.0 mm |
| 751 to 1 250 mm | 6.5 mm |
| 1 251 to 1 750 mm | 8.0 mm |

NOTES

**1** Permanent deflection is not applicable for corrugations.

**2**  Vaccum is not applicable for corrugations

**21.5.1.2** *Pressure (routine test)*

1. *Non-sealed type transformers (plain tanks)*

The transformer with bolted cover shall be tested at an air pressure of 35 kPa above atmosphere pressure maintained inside the tank for 10 min. There should be no leakage at any point.

b) *Corrugated tanks*

The corrugated transformer tank shall be tested for air pressure of 15 kPa above atmosphere pressure maintained inside the tank for 10 min. There should be no leakage at any point.

c) *Sealed type transformers*

The transformer with welded cover shall be tested at an air pressure of 80 kPa above atmosphere pressure maintained inside the tank for 10 min. There should be no leakage at any point.

**21.5.1.3** *Ester liquid leakage test (routine test)*

The assembled transformer for non-sealed and sealed type with all fittings including bushings in position shall be tested at a pressure equivalent to twice the normal head measured at the base of the tank for 8 Hrs. There should be no leakage at any point. Tank with corrugations shall be tested for ester liquid leakage test at a pressure of 15 kPa measured at the top of the tank for 6 Hrs. There should be no leakage at any point.

**21.5.2** *For Transformers above 200 kVA and up to including 2500 kVA.*

**21.5.2.1** *Pressure test (Type test)*

For non-sealed and sealed type transformers, the transformer tank shall be subjected to air pressure of 80 kPa for 30 min (25 kPa for 30 minutes for corrugated tanks) and vacuum of 500 mm of mercury for 30 min. There should not be air leakage at any point. The permanent deflection of flat plate, after pressure / vacuum has been released, shall not exceed the values given below.

|  |  |
| --- | --- |
| *Length of Plate* | *Deflection* |
| Up to 750 mm | 5.0 mm |
| 751 mm to 1 250 mm  1 251 mm to 1 750 mm  Above 1 751 mm | 6.5 mm  8.0 mm  9.0 mm |

NOTES

**1** Permanent deflection is not applicable for corrugations.

**2**  Vaccum is not applicable for corrugations

* + - 1. *Pressure test (routine test)*

a) *Plain tanks*

The transformer tank with welded / bolted cover shall be tested at a pressure of 35 kPa above atmosphere pressure maintained inside the tank for 10 min. There should be no leakage at any point.

b) *Corrugated tanks*

The corrugated transformer tank shall be tested for air pressure of 15 kPa above atmosphere pressure maintained inside the tank for 10 min. There should be no

leakage at any point.

**21.5.2.3** *Ester liquid leakage test (routine test)*

The assembled transformer for non-sealed and sealed type with all fittings including bushing in position shall be tested at a pressure equivalent to twice the normal head measured at the base of the tank for 8 h. There should be no leakage at any point. Tank with corrugations shall be tested for Ester liquid leakage test at a pressure of 15 kPa measured at the top of the tank for 6 h. There should be no leakage at any point.

**21.5.3** *For Single Phase Distribution Transformers up to Including 100 kVA.*

**21.5.3.1** *Pressure test (type test)*

*For transformers up to 25 kVA*

The transformer tank shall be subjected to air pressure of 100 kPa for 30 min (15 kPa for 30 min for corrugated tanks) and a vacuum of 760 mm of mercury for 30 min. There should be no leakage at any point and there is no deformation of tank.

NOTE — Vacuum is not applicable for corrugations.

*For transformers above 25 kVA up to and including 100 kVA*

The transformer tank shall be subjected to air pressure of 80 kPa for 30 min (15 kPa for 30 min for corrugated tanks) and vacuum of 250 mm of mercury for 30 min. There should be no air leakage at any point. The permanent deflection of flat plates, after pressure/vacuum has been released, shall not exceed the values given below:

|  |  |
| --- | --- |
| *Length of Plate* | *Deflection* |
| Up to 750 mm | 5 mm |
| 751 mm to 1 250 mm | 6.5 mm |
| 1 251 mm to 1 750 mm | 8.0 mm |

**NOTES**

1. Permanent deflection is not applicable for corrugations.

2. Vaccum is not applicable for corrugations.

**21.5.3.2** *Pressure (routine test)*

*For transformers up to 25 kVA*

` The transformer tank shall be tested at a pressure of 35 kPa for 10 min (15 kPa for 10 min for corrugated tanks). There should be no leakage at any point.

*For transformers above 25 kVA up to and including 100 kVA*

The transformer tank shall be tested at a pressure of 35 kPa for 10 min (15 kPa for 10 min for corrugated tanks). There should be no leakage at any point.

**21.5.3.3** *Ester liquid leakage test (routine test)*

*For transformers up to and including 100 kVA*

The assembled transformer for with all fittings including bushings in position, shall be tested at a pressure equivalent to twice the normal head measured at the base of the tank for 6 h. There should be no leakage at any point. Tankwith corrugations shall be tested for oil leakage test at a pressure of 15 kPa measured at the top of the tank for 6 h. There should be no leakage at any point.

**22. INFORMATION REQUIRED WITH ENQUIRY AND ORDER**

**22.1** The information to be supplied by the manufacturer with enquiry and order to the purchaser shall be in accordance with Annex D.

**ANNEX A**

(*Clause* 2)

**LIST OF REFERRED INDIAN STANDARDS**

|  |  |
| --- | --- |
| ***IS No.*** | ***Title*** |
| IS 191: 2007 | Copper |
| IS 554 : 1999 | Dimensions for pipe threads where pressure tight joints are required on the threads |
| IS 1576 : 1992 | Solid pressboard for electrical purpose |
| IS 1608 : 2005 | Mechanical testing of metals – Tensile testing |
| IS 1747 : 1972 | Nitrogen |
| IS 1885 (Part 38) : 1993 | Electrotechnical vocabulary- Part 38: Power transformers and reactors |
| IS 1897 : 2008 | Copper strip for electrical purpose |
| IS 2026 | Power transformers |
| (Part 1) : 2011 | General |
| (Part 2) : 2010 | Temperature rise |
| (Part 3) : 1962 | Insulation levels, dielectric tests and external clearances in air |
| (Part 5) : 2011 | Ability to withstand short circuit |
| (Part 8) : 2009 | Application guide |
| (Part 10) : 2009 | Determination of sound levels |
| IS 2099 : 1986 | Bushings for alternative voltages above 1 000 volts |
| IS 3024 : 2006 | Grain oriented electrical steel sheets and strips |
| IS 3347 | Dimensions for porcelain transformer bushings for use in lightly polluted atmospheres |
| (Part 1/Sec 1) : 1979 | Part 1 Up to and including 1 kV – Section 1 : Porcelain parts |
| (Part 1/Sec 2) : 1979 | Part 1 Up to and including 1 kV – Section 2 Metal parts |
| (Part 2/Sec 1) : 1979 | Part 2 3.6 kV bushings – Section 1 Porcelain parts |
| (Part 2/Sec 2) : 1979 | Part 2 3.6 kV bushings- Section 2 Metal parts |
| (Part 3/Sec 1) : 1988 | Part 3 17.5 kV bushings- Section 1 Porcelain parts |
| (Part 3/Sec 2) : 1988 | Part 3 17.5 kV bushings- Section 2 Metal parts |
| (Part 4/Sec 1) : 1988 | Part 4 24 kV bushings- Section1 Porcelain parts |
| (Part 4/Sec 2) : 1982 | Part 4 24 kV bushings- Section 2 Metal parts |
| (Part 5/Sec 1) : 1979 | Part 5 36 kV bushings- Section 1 Porcelain parts |
| (Part 5/Sec 2) : 1979 | Part 5 36 kV bushings- Section 2 Metal parts |
| IS 3639 : 1966 | Fittings and accessories for Power Transformers (under revision) |
| IS 4253 (Part 2) : 2008 | Cork Composition Sheet Part 2 Cork and Rubber |
| IS 6162 (Part 1) : 1971 | Paper-Covered Aluminum Conductors – Part 1 Round conductors |
| IS 6162 (Part 2) : 1971 | Paper-covered Aluminum Conductors – Part 2 Rectangular conductors |
| IS 7404(Part1) : 1991 | Paper covered copper conductors – Part 1 Round conductors |
| IS 7421 : 1988 | Porcelain bushings for alternating voltages up to and including 1000 V |
| IS 8999 : 2003 | Gauging practice for pipe threads where pressure tight joints are required on the threads |
| IS 9335 (Part1) : 1979 | Cellulosic papers for electrical purposes: Part 1 Definitions and general requirements |
| (Part 2) : 1998 | Cellulosic papers for electrical purposes : Part 2 : Methods of test |
| (Part 3/Sec 1) : 1984 | Cellulosic papers for electrical purposes: Part 3 Specifications for individual materials, Section 1 General purposes electrical paper |
| ( Part 3/ Sec 3) : 1984 | Cellulosic papers for electrical purposes: Part 3 Specifications for individual materials, Section 3 Crepe paper |
| ( Part 3/ Sec 5) :1985 | Cellulosic papers for electrical purposes: Part 3 Specifications for individual materials, Section 5 Special papers |
| IS 11149 : 1984 | Specification for Rubber Gaskets |
| IS 12444 : 1988 | Continuously cast and rolled electrolytic copper wire rods for electrical Conductors |
| IS 13730(Part 0/Sec 1) : 2012 | General requirements, Section 1 Enamelled round copper wire (First Revision) |
| IS 13730(Part 0/Sec 2) : 2011 | General requirements, Section 2 Enamelled rectangular copper wire (First Revision) |
| IS 13730(Part 0/Sec 3) : 2012 | General Requirements Section 3: Enameled round Aluminum wire |
| ( Part 17) : 1996 | Particular Types of Winding Wires : Part 17 Polyvinyl acetal enameled rectangular copper wire, Class 105 |
| (Part 27) : 1996 | Specification for Particular Type of Winding Wires – Part 27 : Paper Covered Rectangular Copper Wire |
| IS | Thermally Upgraded Paper (TUP) |
| IS 16081 : 2013 | Insulating Liquids - Specification for Unused Synthetic organic Esters for Electrical Purposes |
| IS 62770  *Under print*  ETD 03 (6755) | Insulating Liquids – Specification for unused synthetic organic Natural Esters for Electrical purposes |
| IS 13503 | Classification of Insulating liquids |
| IS 16099 | Synthetic organic esters for electrical purposes – Guide for maintenance of transformer |
| IS 2026 (Part 14)  *Under print*  ETD 16 (10669) | Power Transformers – Part 14 Liquid immersed power transformers using high-temperature insulation materials |

**ANNEX B**(*Clause* 2)

**LIST OF INTERNATIONAL STANDARDS**

1. IEC 61039 Edition 2.0 2008, Classification of insulating liquids.
2. IEEE Std. C57.147 – 2008, IEEE Guide for acceptance and maintenance of Natural Ester liquids in Transformers
3. Cigre Brochure 443(Working Group D1.32), DGA in Non-Mineral oil and Load Tap changers and improved DGA diagnosis criteria
4. Cigre Brochure 436, WG A2.35, October 2010, Experiences in service with new insulating liquids.
5. ASTM D 6871-03, Standard specification for natural (vegetable oil) ester liquids in electrical apparatus
6. ANSI C57.12.22 – 1989, Pad-mounted, Compartmental type self-cooled Three-phase Distribution Transformers with High-Voltage Bushings, 2500 kVA and smaller
7. IEEE Std. C57.12.28, IEEE standard for Pad-mounted Equipment – Enclosure integrity
8. IEEE Std. C57.12.29: 2005, IEEE standard for Pad – Mounted Equipment – Enclosure integrity for Coastal Environment.
9. IEEE Std. C57.155:2014, IEEE guide for interpretation of gases generated in Natural Esters and Synthetic organic Esters immersed transformers.

**ANNEX C**

*(Clause 18)*

**METHOD OF DECLARING EFFICIENCY**

**B-1**  **EFFICIENCY**

**B-1.1** The efficiency to be declared is the ratio of the output in kW to the input in kW and calculated as under.



Total losses comprise:

1. No-load loss, which is considered to be constant at all loads : and
2. Load loss, which varies with load.

The total loss, on load is the sum of (a) and (b).

**ANNEX D**

*(Clause 18)*

**CALCULATION OF INHERENT VOLTAGE REGULATION**

**C-1INHERENT VOLTAGE REGULATION**

**C-1.1** The inherent voltage regulation from no-load to a load of any assumed value and power factor may be computed from the impedance voltage and corresponding load loss measured with rated current in the winding [see also IS 2026 (Part 8)]

Let

*I*  = rated current in winding excited;

*E* = rated voltage of winding excited;

*Isc* = current measured in winding excited

*Ezsc* = voltage measured across winding excited (impedance voltage);

*Psc* = watts measured across winding excited

√

*Exsc* = reactance voltage = *E*2zsc –

*P* = Psc corrected to 75oC, and from current *Isc* to *I;*

*Ex* = Exsc ×

*Er* = *P*

*I*

**C-1.2** For rated load at unity power factor, the percentage regulation is approximately equal to

Er% + (Ex%)2

200

*Ex%* = 100 *Ex/E*;

*Er%* = 100 *Er/E*

*n* = Ia/I; and

*Ia* = current in the winding excited during the short circuit tests

corressponding to that obtained when loading at the assumed load on

the output side and with rated voltage on the input side.

**C-1.3** For rated load any power factor cosφ, the percentage regulation is approximately equal to:

*Er*% cosφ + *Ex* % sin φ +

(*Ex*% cosφ - *Er*% sin φ)2

200

**C-1.4** For any assumed load other than rated load and unity power factor, the percentage regulation is approximately equal to;

*n.Er*% + (*n. Ex*%)2

200

**C-1.5** For any assumed load other than rated load and at any power factor cosφ, the percentage regulation is approximately equal to:

*n.Er*% cosφ + *n. Ex*% sin φ +

(*n. Ex*% cosφ - *n. Er*% sinφ)2

200

**C-1.6** The above formulae are sufficiently accurate for transformers covered by this specification.

**ANNEX E**

(*clause* 22.1)

**INFORMATION REQUIRED WITH ENQUIRY AND ORDER**

1. Normal Information

The following information should be given in all cases:

1. Particulars of the specification to be complied with;
2. Application of Transformer for example. normal Distribution Transformer, Solar duty, wind application, Motor starting etc.
3. Single or three phase unit;
4. Number of phases in system;
5. Frequency;
6. Indoor or outdoor type;
7. Type of cooling (KNAN);
8. Rated power (in kVA)

j)Rated voltages (for each winding);

k)State if tappings are required and if on-load or off-circuit tap-changers, or links are required.

m)Highest voltage for equipment (for each winding);

n)Method of system earthing (for each winding);

p)Insulation level (for each winding), power frequency test level/impulse level;

q)Connection symbol;

r)Neutral terminals, if required (for each winding) and their insulation level to earth;

s)Special requirements of installation, assembly, transport and handling;

t)Fittings required and an indication of the side from which meters, rating plates, liquid-level indicator, etc. may be readable.

u) Natural ester liquid or Synthetic organic ester liquid

1. Special Information

The following additional information may be required to be given:

1. If a lightning impulse voltage test is required, whether or not the test is to include chopped waves [*see* IS 2026 (Part 3)].
2. Impedance voltage at rated current, if specific value is required;
3. Altitude above mean sea-level, if in excess of 1 000 m;
4. Whether transformers will be subjected to frequent overcurrent, for example, furnace transformers and traction feeding transformers;
5. Any other exceptional service conditions;
6. Whether noise level measurement is to be carried out;
7. Vacuum withstand of the transformer tank, if a specific value is required;
8. Type of Tap-changer controls required (if OLTC is provided);

j) Type of mounting for example pole mounted, ground mounted etc.

## k) Any other appropriate information, including reference to any special tests not referred to

## above which may be required.

**ANNEX F**

**ADDITIONAL INFORMATION ON LEAKAGE TEST**

**(Cl. 21.2 j, 21.5.1.3, 21.5.2.3 and 21.5.3.3)**

***E-1 Calculation of Gauge pressure during ester liquid leakage test from Normal static head***

***Hydrostatic pressure in liquid is given by:***

P=ρgh

Where,

P = Pressure at a point (Pa)

ρ=Density of liquid (kg/m3) (Ref. relevant standard or supplier’s test certificate).

g = acceleration due to gravity (9.81 m/s2)

h = height of liquid column at a particular point (m) (measured from top)

E-2 As per **21.5.1.3**, **21.5.2.3** and **21.5.3.3**, the amount of pressure application during the leakage test on assembled transformer for non-sealed and sealed type transformers with all fittings including bushing in position is summarized below:

a) Tank without corrugations:

Pressure equivalent to twice the normal head measured at base of tank for 8 h (for 3 phase transformer) and 6 h (for 1 phase transformers)

b) Tank with corrugations

15 kPa measured at top of the tank for 6 h for both 3 phase and 1 phase transformer

E-3 Position of Pressure gauge is not specified. Based on facility available,the pressure gauge can be mounted near the base of the tank or near the top cover(or on the cover)

The depth of static head at bottom gauge position shall be the height from highest liquid level to base of tank

The depth of static head at top of the tank shall be the height from highest liquid level in conservator up to tank top gauge location.

In case the conservator is not provided, (eg. Single phase transformers and small 3 phase transformer below 63 kVA) and pressure gauge is mounted on cover of tank, a pressure equivalent to one static head (tank height in this case) shall be applied since as per requirement test pressure is equivalent to twice the static head.

E-4 Sample calculation of pressure for a transformer having ester liquid level of 1000 mm:

Density of ester liquid, ρ = 1.0 g/cc = 1000 kg/m3

Ester liquid level in the T/F, h = 1000 mm = 1 m

Hence, normal head pressure = (1000 x 9.81 x 1) Pa = 9810 Pa ≈ 9.81 kPa

Twice the normal head pressure = 2 \* 9.81 kPa = 19.62 kPa

Hence, Pressure to be measured in the gauge is,

19.62 kPa, if gauge is fixed at base of tank and

9.81 kPa, if gauge is fixed at top