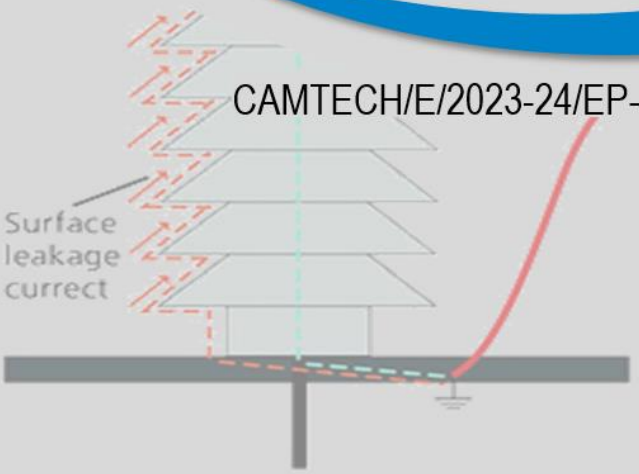
DRY TYPE TRANSFORMER 11kV, 415V





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END USER GENERAL SERVICE MAINTENANCE ENGINEER & STAFF

INDIAN RAILWAYS

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Booklet on

Dry Type Transformer 11kV/ 415V

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DISCLAIMER

It is clarified that the information given in this booklet does not supersede any existing provisions of Indian Standards (IS) on the subject, related matters, and other existing provisions laid down by the Railway Board, RDSO. This is not a statuary document and instructions given are for the purpose of guidance only. If at any point contradiction is observed, then Indian Standards, regulations issued by Government bodies, Railway Board/RDSO guidelines shall be referred.

PREFACE

Dry-type transformers are widely used in various industries and applications that require high safety, reliability, and environmental compatibility. They can operate in harsh conditions such as high humidity, fire risk, and seismic events without compromising their performance or posing any hazard to people or property. Some of the common applications of dry-type transformers are Chemical, oil, and gas industry, Fire-risk areas, Renewable generation**.** They are also used in other applications such as traction systems, marine systems, mining systems, data centers, etc.

A dry type transformer is defined as a transformer that does not use any liquid as an insulating or cooling medium for its windings or core. Instead, the windings and core are enclosed in a sealed tank that is filled with air or gas under pressure.

These are being used in Indian Railways in tunnels, big buildings like Rail Bhavan, Metros and at other big stations for upgrading their electrical system to provide the safe environment to staff and public.

CAMTECH has prepared this booklet on “Dry Type Transformer 11 kV/ 415 V” with the objective to disseminate specific information on the subject. This Booklet comprises general introduction, various Types like Vacuum Pressure Impregnated, Cast Resin Type, applications, transportation, inspection & storage, commissioning, testing, periodic maintenance along with troubleshooting and safety precautions. This booklet will be useful for general services maintenance engineers and technical staff.

I am thankful to all field personnel & Shri Himanshu Singh Rajput, SSE/Electrical/ CAMTECH for their continuous efforts in making this booklet.

Technological up-gradation & learning is a continuous process. Please feel free to write to us for any addition/ modification in this booklet. We shall highly appreciate your contribution in this direction.

Date: 29.02.2024
CAMTECH/ Gwalior

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CHAPTER 1
GENERAL

1.1 INTRODUCTION

A dry type transformer is defined as a transformer that does not use any liquid as an insulating or cooling medium for its windings or core. Instead, the windings and core are enclosed in a sealed tank that is filled with air or gas under pressure.

Dry type transformers are widely used in various industries and applications because of their safety, reliability, and environmental benefits. They can operate in harsh conditions such as high humidity, fire risk, and seismic events without compromising their performance or posing any hazard to people or property.



Figure 1: Dry Type Distribution Transformer

1.2 ADVANTAGES

Some of the main advantages of dry type transformers are:

- ✓ They are safe for people and property because they do not contain any flammable or toxic liquid that can leak or catch fire.
- ✓ They are maintenance-free and pollution-free because they do not require any oil changes, oil tests, oil spills cleanup, or special disposal methods.
- ✓ They are easy to install because they do not require any vaults or special foundations.
- ✓ They can be placed close to the load to reduce the need for long and costly low voltage cables.

- ✓ They are environmentally friendly because they do not emit any harmful gases or contribute to the greenhouse effect.
- ✓ They have an excellent capacity to support overloads because they have better heat dissipation and thermal endurance than oil-filled transformers.
- ✓ They have reduced costs on civil installation works and fire protection systems because they do not need any oil containment pits, fire walls, fire extinguishers, or sprinklers.
- ✓ They have excellent performance in the case of seismic events because they have a rigid structure that can withstand vibrations and shocks.
- ✓ They have no fire hazard because they have self-extinguishing properties and do not produce any smoke or flames in case of faults.
- ✓ They have excellent resistance to short-circuit currents because they have low impedance and high mechanical strength.
- ✓ They are long-lasting due to low thermal and dielectric heating because they have high-quality insulation materials that can withstand high temperatures without degrading.
- ✓ They are suited for damp and contaminated areas because they have high moisture ingress protection and corrosion resistance.

1.3 DISADVANTAGES

Some of the main disadvantages of dry-type transformers are:

- ✓ They are more expensive than oil-filled transformers for the same power and voltage rating because they require more materials and labor for manufacturing.
- ✓ They are larger and heavier than oil-filled transformers for the same power and voltage rating because they have more air gaps and insulation thickness.
- ✓ They are more sensitive to dust, dirt, and vermin because they have open ventilation that can allow the entry of foreign particles that can damage the windings or cause short circuits.
- ✓ They are noisier than oil-filled transformers because they have higher magnetostriction and vibration that can produce audible sounds.

1.4 TYPES

There are two main types of dry type transformers:

i. Cast resin dry type transformer (CRT) and
ii. Vacuum pressure impregnated transformer (VPI)

1.4.1 Cast Resin Dry Type Transformer (CRT)

A cast resin dry type transformer (CRT) is a type of transformer that uses epoxy resin to encapsulate its primary and secondary windings. This protects the windings from moisture, dust, corrosion, and other environmental factors that can affect their insulation and performance.

A CRT is suitable for high humidity areas, indoor installations, and fire-risk areas because it is non-hygroscopic, non-inflammable, and maintenance-free. It can also withstand overloads, partial discharges, and low losses, resulting in high efficiency and long service life.

A CRT is available in ratings from 25 kVA to 12,500 kVA, with insulation class of F (90°C temperature rise).



Figure 2: Cast Resin Dry Type Transformer

1.4.2 Vacuum Pressure Impregnated Transformer (VPI)

A vacuum pressure impregnated transformer (VPI) is a type of transformer that uses class H polyester resin to impregnate its windings under vacuum and pressure. This eliminates any air gaps or voids in the insulation, enhancing its mechanical strength, dielectric strength, and thermal stability.

A VPI is suitable for outdoor installations, seismic events, and temperature fluctuations because it has a robust construction, a moisture-resistant enclosure, and a low thermal expansion coefficient. It also has easy maintenance, low fire risk, and high resistance to short circuit currents.

A VPI is available in ratings from 5 kVA to 30 MVA, with insulation class of F (155°C) or H (180°C), and protection up to IP56.



Figure 3: VPI Dry Type Transformer

1.5 APPLICATIONS OF DRY TYPE TRANSFORMERS

Dry-type transformers are widely used in various industries and applications that require high safety, reliability, and environmental compatibility. Some of the common applications of dry-type transformers are:

- ✓ **Chemical, oil, and gas industry**

  Dry-type transformers are used to supply power to various equipment and processes that involve flammable or explosive substances, such as refineries, petrochemical plants, pipelines, offshore platforms, etc.

- ✓ **Environmentally sensitive areas**

  Dry-type transformers are used to protect the environment from oil spills or leaks that can contaminate water sources, soil, or wildlife habitats, such as water protection areas, forests, wetlands, etc.

- ✓ **Fire-risk areas**

  Dry-type transformers are used to prevent fire hazards or minimize fire damage in areas that are prone to fire outbreaks or have strict fire regulations, such as indoor substations, underground substations, hospitals, schools, hotels, shopping malls, etc.

- ✓ **Renewable generation**

  Dry-type transformers are used to connect renewable energy sources to the grid or to the load, such as wind turbines, solar panels, hydroelectric plants, etc.

- ✓ **Other applications**

  Dry-type transformers are also used in other applications that require high performance, low maintenance, or special features, such as traction systems, marine systems, mining systems, data centers, etc.

CHAPTER 2

CONSTRUCTIONAL FEATURES

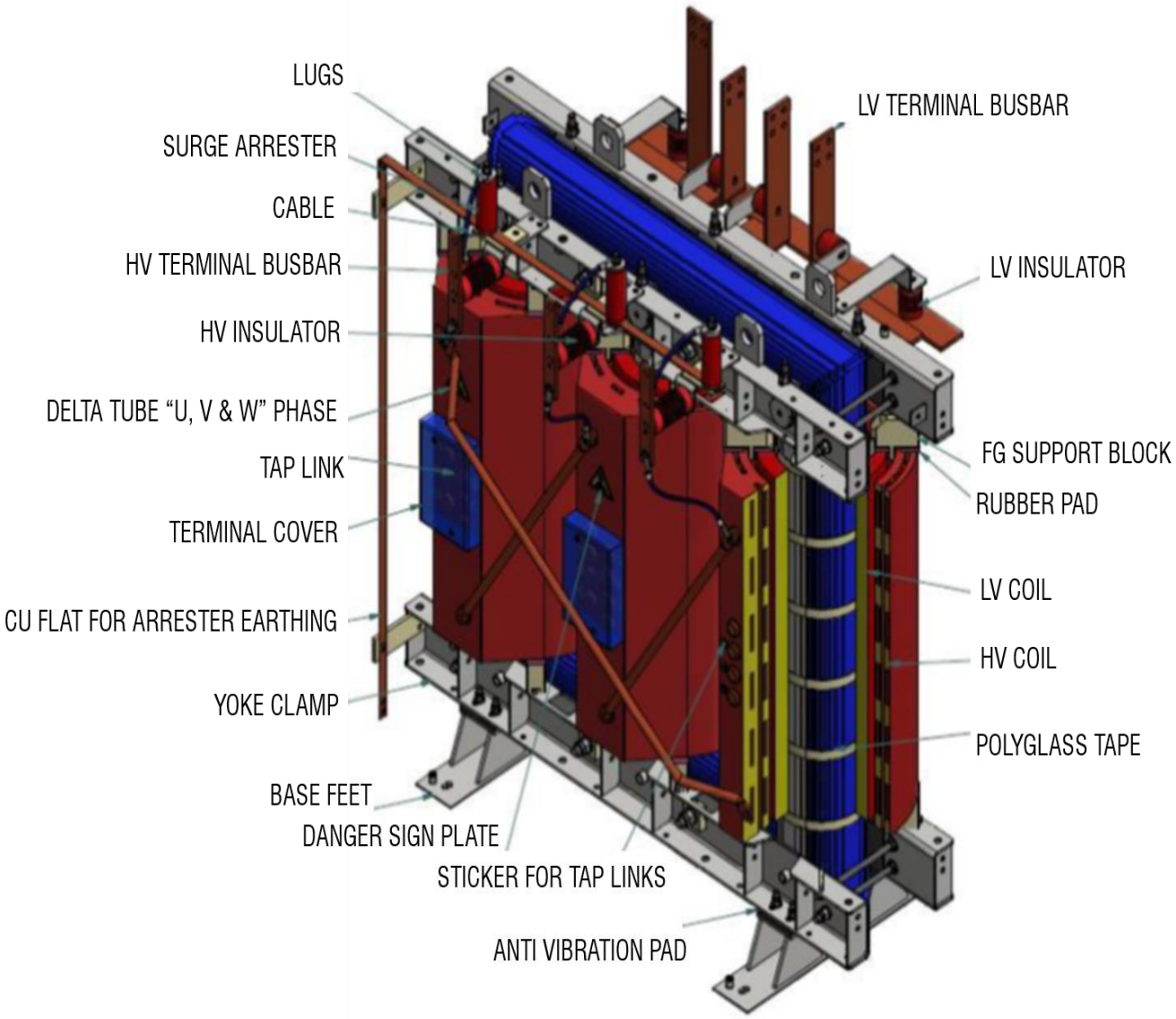


Figure 4: CRT Dry Transformer

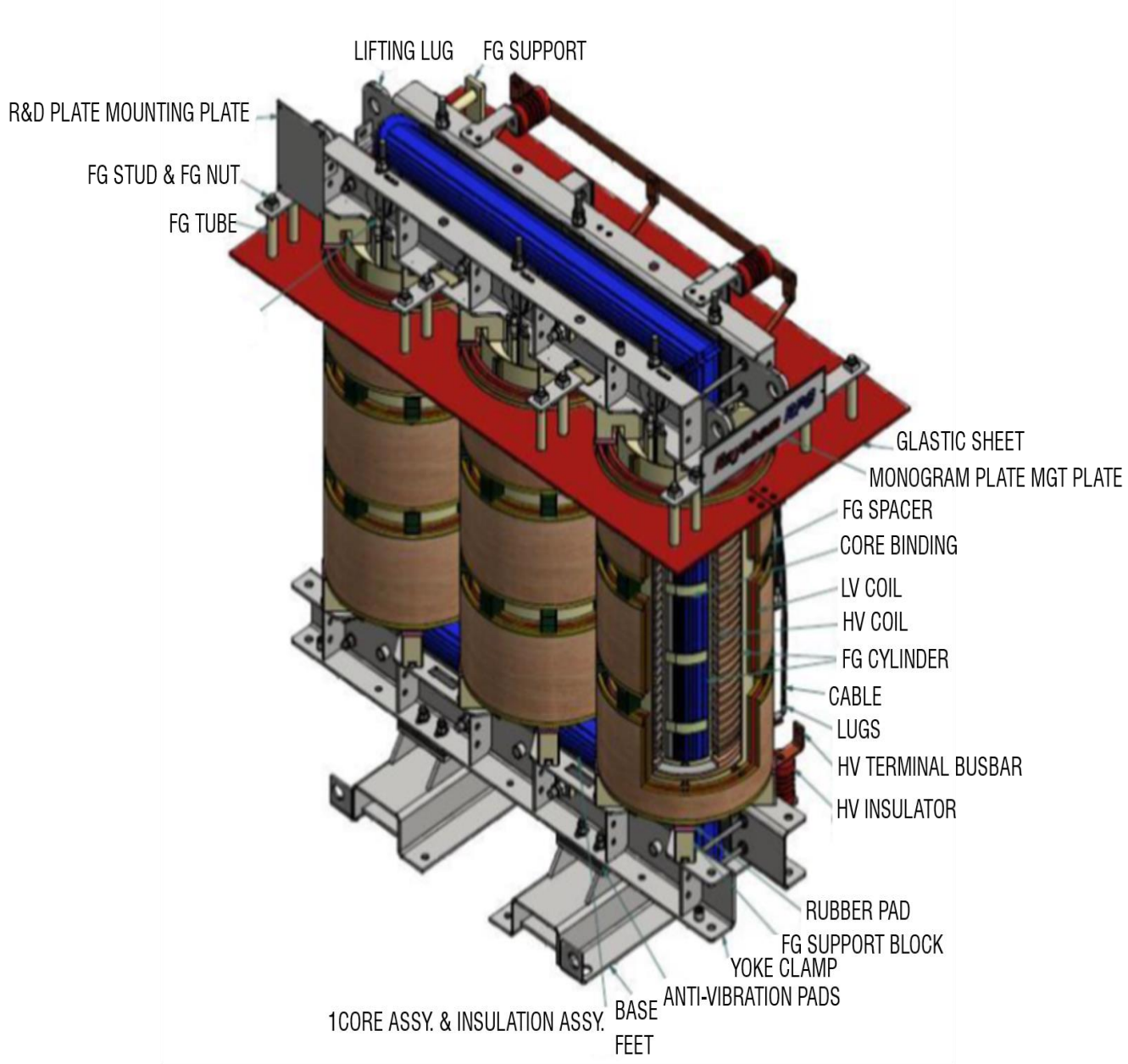


Figure 5: VPI Dry Transformer

CHAPTER 3

SELECTION CRITERIA

3.1 CLASSIFICATION OF TRANSFORMER

The transformers are classified into the following groups:

- ✓ Distribution transformers (up to and including 1600 kVA) &
- ✓ Power transformers (above 1600 kVA)

3.2 CRITERIA FOR SELECTION OF DISTRIBUTION TRANSFORMERS [UP TO AND INCLUDING 1600 KVA]

3.2.1 Rating

The kVA ratings should comply with IS: 2026 (Part-1)-1977. The no-load secondary voltage should be 433 volts for transformers to be used in 415 V system. For transformers requiring to be operated in parallel, the voltage ratio should be selected in accordance with guidelines given in 12.0.1 and 12.0.1.1 of IS: 10028 (Part-2)-1981-1.

3.2.2 Taps

The transformers of these ratings are normally provided with off-circuit taps on HV side. The standard range for off-circuit taps which are provided on HV side should be ± 2.5 percent and ± 5.0 percent. In case of on-load tap changers, the taps may be in steps of 1.25 percent with 16 steps.

3.2.3 Connection Symbol

The two winding transformers should be preferably connected in delta/star in accordance with IS: 2026 (Part-4)-1977. The exact connection symbol (Dyn 11 or Dyn 1) is to be specified depending upon requirements of parallel operation with other transformers in accordance with guidelines given in 12.0.1 and 12.0.1.1 of IS: 10028 (Part-2) 1981and 4 of IS: 10561-1983.

3.2.4 Impedance

Consideration shall be given in the selection of impedance for the standard available rating of the switchgear on the secondary side and associated voltage drops. However, the impedance values shall, as far as possible, conform to those specified in Table 3 of IS: 2026 (Part-1)-1977. For transformers requiring to be operated in parallel, the percentage impedance should be selected in accordance with guidelines given in 12.0.1 and 12.0.1.1 of IS: 10028 (Part 2)-1981.

3.2.5 Termination Arrangement

The HV and LV terminals may be bare outdoor bushings, cable boxes or bus trunking depending upon the method of installation. Wherever compound filled cable boxes are used, it is preferable to specify disconnecting chamber between transformer terminals and cable box to facilitate disconnection of transformer terminals without disturbing the cable

connections (see also IS: 9147-1979). In case of extruded insulation cables with connections in air, a separate disconnecting chamber is not necessary.

Note

A separate specification for cable end boxes for oil-immersed transformers suitable for extruded insulated cables is under preparation.

3.2.6 Cooling

The transformers covered in this group are generally ONAN, AN or ANAN cooled. Standard service conditions are given in 3 of IS: 2026 (Part-1) 1977. For service conditions different from these, selection of temperature-rise limits should be in accordance with IS: 2026 (Part-2) 1977 or IS: 11171-1985 as applicable.

3.2.7 Fittings and Accessories

- **For Oil Filled Transformers**

  The fittings and accessories should be as specified in Appendix C of IS: 2026 (Part 1) 1977. Explosion vent should be specified for all 11 kV transformers above 400 kVA rating and all 33 kV transformers. When radiators are required to be detached for transportation, isolating valves should be specified. Alarm and trip contacts for oil temperature indicator, winding temperature indicator and gas actuated relay may be specified when monitoring and control devices are available for the transformer application.

- **For Dry Type Transformers**

  Fittings under serial No. 6, 12 and 15 of C-1 and serial No 1, 6 and 7 of C-2 of IS: 2026 (Part-1) 1977 are not required for dry type transformers.

Note:

- Specification for cable sealing boxes for oil-immersed transformers suitable for paper-insulated lead-sheathed cables for highest system voltages from 12 kV up to and including 36 kV.

3.3 CRITERIA FOR SELECTION OF POWER TRANSFORMERS (ABOVE 1600 KVA)

3.3.1 Ratings

The secondary no-load voltage should be specified 5 percent more than the nominal voltage to compensate the transformer regulation partly. For transformers requiring to be operated in parallel, the voltage ratio should be selected in accordance with guidelines given in 12.0.1 and 12.0.1.1 of IS 10028 (Part-2) 1981.

3.3.2 Taps

On-load tap changers on HV side should be specified, wherever system conditions warrant. For interconnecting auto-transformers with on-load tap changer, system conditions may warrant tapping on low voltage side. In case of OLTC, the total number of taps should be 16 in steps of 1.25 percent. The distribution on positive and negative taps shall be decided to suit the system conditions. Off-circuit taps, when specified, should be in the range of ± 2.5 percent and ± 5 percent provided on the HV side.

3.3.3 Connection Symbol

The preferred connections for two winding transformers up to 66 kV high voltage (HV) side rating are delta/star (Dyn) and star/star (YNyn). For higher voltages, connections star/star (YNyn) or star/delta (YNd) may be preferred. The selection of connection group should be made taking into consideration the requirements of parallel operation with other transformers as given in 12.0.1 and 12.0.1.1 of IS: 10028 (Part-2) 1981. For transformers of ratings up to 50 MVA, three limb (Yy0) construction, no stabilizing winding is required unless the tertiary winding is required for auxiliary loads. In case of unloaded tertiary winding, one terminal should be brought out for testing purposes.

3.3.4 Impedance

The transformer impedance is decided taking into consideration the secondary fault levels and the voltage dip. The typical impedance values are given in Table 3 of IS: 2026 (Part-1) 1977. For transformers requiring to be operated in parallel, the percentage impedance should be selected in accordance with guidelines given in 12.0.1 and 12.0.1.1 of IS: 10028 (Part-2) 1981.

3.3.5 Termination Arrangement

Primary and secondary terminals may be bare bushings, cable boxes or bus trunking depending upon the method of installation. Wherever compound filled cable boxes are used, it is preferable to specify disconnecting chamber between transformer terminals and cable box to facilitate disconnection of transformer terminals without dismantling the cable connections (see also IS: 9147-1979). In case of extruded insulation cable connections in air, a separate disconnecting chamber is not necessary.

For transformers up to 33 kV, porcelain bushings and for transformers of 66 kV and above, oil-filled condenser type bushings should be specified. For installation in polluted atmospheres, the bushings should be specified with extra creepage distances as given in IS: 2099-1973.

3.3.6 Cooling

The type of cooling may be ONAN, ONAN/ ONAF, ONAN/ONAF/OFAF or OFWF. Standard service conditions are given in 3 of IS: 2026 (Part-1) 1977. For service conditions different from these, selection of temperature-rise limits should be in accordance with IS: 2026 (Part-2) 1977.

Table 1: Type & Circulation of Cooling Medium

SN	Description	Type	Symbol
1.	Type of Cooling Medium	Air	A
		Water	W
		Oil	O
2.	Type of Circulation	Natural	N
		Forced	F

The following cooling arrangements are recommended:

SN	Rating, MVA	Voltage Class, kV	Cooling Type	Equipment
(i)	Up to 10	Up to 66	ONAN	
(ii)	12.5 to 40	Up to 132	ONAN (60 percent)/ ONAF	
(iii)	50 to 100	Up to 220	✓ ONAN (50 percent)/ ONAF (62.5 percent) ✓ OFAN (62.5 percent)/ OFAF	✓ 100 percent bank with two 100 percent pumps (one running and one standby) ✓ One standby fan or two 50 percent banks with two 100 percent pumps. (one running and one standby) ✓ Two standby fans, one in each 50 percent bank.
(iv)	Above 100	Upto 400	✓ ONAN (50 percent)/ ONAF (62.5 percent) ✓ OFAN (62.5 percent)/ OFAF OR OFAF/ ODAF OR OFWF/ ODWF	✓ Same as (iii) ✓ Three 50 percent OFAF coolers ✓ Two 100 percent OFWF coolers

Note

- The manufacturer should be asked to confirm the available rating under complete failure of 50 percent cooling.

3.3.7 Fittings and Accessories

The fittings and accessories should be as specified in Appendix C of IS: 2026 (Part-1) 1977. The following, should in addition, be specified:

- Skids and hauling lugs
- Rollers (bidirectional, if required). If flanged rollers are required, rail gauge should be specified
- Winding temperature indicator with electrical contacts for alarm/ trip and controlling fans and pumps
- Accessories for cooling arrangement

CHAPTER 4
DESIGN PARAMETERS

The important design parameters for a dry-type transformer are given below.

4.1 CHOICE OF INSULATION TYPE

The insulation classes F and H have temperature withstand capacities of 155˚C and 180˚C respectively, and generally, F and H classes of insulation are used to insulate the primary and secondary winding. The other factors like mechanical strength, thermal shock, and dielectric strength of insulation must be considered while designing the dry-type transformer.

Table 2: Thermal class equivalents for insulating material (Ref: IS 8504-6: 2012 Table B.1)

ATE/ RTE °C		Thermal Class °C	Letter designation
≥90	<105	90	Y
≥105	<120	105	A
≥120	<130	120	E
≥130	<155	130	B
≥155	<180	155	F
≥180	<200	180	H
≥200	<220	200	N
≥220	<250	220	R
≥250	<275	250	

Note

- ✓ **ATE (assessed thermal endurance index)**
  Numerical value of the temperature in degrees Celsius, up to which the reference electrical insulating material possesses known, satisfactory service performance in the specified application.
- ✓ **RTE (relative thermal endurance index)**
  Numerical value of the temperature in degrees Celsius at which the estimated time to endpoint of the candidate electrical insulating material is the same as the estimated time to endpoint of the reference electrical insulating material at a temperature equal to its assessed thermal endurance (ATE).
- ✓ If desired, the letter designation may be added in parentheses, e.g. Class 180 (H). Where space is a factor, such as on a nameplate, the product TC may elect to use only the letter designation.
- ✓ Designations of thermal classes over 250 shall increase by increments of 25 and be designated accordingly.

4.2 SELECTION OF WINDING MATERIAL

Copper and aluminum are used to make the winding or coil. Even though copper is a better conductor, the aluminum conductor wound transformer has lower cost and weight. The transformer winding with a copper conductor has less cross-section area for the same current rating as compared to the aluminum conductor. The copper coils also provide more mechanical strength compared to the aluminum coil.

4.3 SELECTION OF CORE MATERIAL OF LOW HYSTERESIS LOSS

The core of the transformer must have high permeability and less hysteresis loss in order to have better efficiency. The CRGO steel is used for the core material. The CRGO steel offers higher permeability and minimum hysteresis loss.

4.4 REGULATION

The leakage reactance of the transformer must be as minimum as possible to get better voltage regulation of the transformer. The regulation of the transformer shows drops in the secondary voltage with an increase in loading on the transformer. The leakage reactance is generally kept within 2 % during transformer design.

4.5 LIFE EXPECTANCY

The life of the transformer depends upon the useful life of the insulation. The life of the insulation is dependent on the temperature. The rise in temperature cause deterioration in the insulation value which may further cause the breakdown of the insulation. Insulation class B, F, and H is preferred for the dry-type transformer to withstand higher temperature. The temperature rise must be calculated during the design stage of the transformer to get a higher life expectancy of the transformer.

4.6 LOSSES

The no-load losses of the transformer depend on the eddy current and hysteresis loss. The no-load losses can be minimized by the use of the CRGO core and by keeping the leakage reactance as minimum as possible. The load losses depend on the resistance of the conductor. Thus, by keeping the winding resistance within moderate value losses, voltage regulation and the efficiency of the transformer can be improved.

4.7 OVERLOADING

If the load on the transformer increases above its rated kVA, the transformer is said to be overloaded. The overloading cause rise in the temperature of the transformer which reduces the useful life of the transformer. The cooling system should be designed to cater to the temporary overloading of the transformer.

4.8 K-FACTOR

If the dry type transformer is to be used for supplying the current to non-linear loads the temperature rise takes place due to harmonics in the current waveform. The transformer for such applications must be assigned K-factor.

4.9 INSULATION LEVEL

In transformer design, insulation level adjustment is an important factor. Generally, insulation level is chosen as per basic impulse level and system overvoltage. A strong insulation level increases the life of a transformer.

CHAPTER 5

TRANSPORTATION & INSTALLATION

5.1 TRANSPORTATION

The engineer should obtain, well in advance, all relevant information about the overall dimensions, weight for transport, dimensions of the transport, installation, etc, of the transformer in question. Often, it is necessary to check up with rail or road authorities and enlist their cooperation for the purpose of transporting transformers to the site. This may involve procurement of trans-shipment facilities, special wagons or trailers, checking up of capacity of bridges, railway loading gauge, and similar matters. it is also desirable to check with the insurers regarding conditions there may be; to be complied with, during transportation.

It is recognized that specific guidelines and strict rules cannot be specified in this standard regarding the method to be adopted for transportation. Keeping this in view, it is suggested that while assistance can be taken from the following, it shall also be borne that each individual consignment has to be worked out as a special case and details decided between the buyer and the seller.

5.2 PACKING AND DISPATCH

Transformer & its accessories shall be well packed at factory premises and further dispatched from the factory for taking into service at required site according to the transport facilities available for the route, transformers are transported by either rail, road or sea.

5.2.1 Packing

- ✓ Transformers after processing and testing are dispatched from the factory.
- ✓ In case of large transformers some of the accessories are dispatched separately.
- ✓ When any internal parts like tap changers or insulating items are removed for transportation, suitable measures taken so that they transported without any damages.
- ✓ All fragile parts such as temperature indicators, bushings, etc, shall be carefully packed to avoid breakage in transit.

5.2.2 Transport

- ✓ Generally, road transport is resorted to in the case of smaller units or where rail links are not available or where well, developed road systems exist.
- ✓ Multi-axle tractor driven low-platform trailers are used for road transport.
- ✓ The tractors are to have adequate hauling capacity and the trailers loading capacity.
- ✓ Large transformers are transported by rail due to considerations in weight, dimensions and economy.
- ✓ In cases of transformers where the weight and dimensions of the main body exceed limits, special well wagons are employed.
- ✓ Detached parts are packed/crated and normally dispatched along with the main body of the unit, so that all the parts are received at the destination station with the unit.

5.2.2.1 Route Survey

Table 3: The road system is examined in detail on the following points

SN	Item	Remarks
1	Width of the road	Normally not less than 5 m.
2	Bridges and culverts	To have sufficient strength to take the moving load. Consultation with the Highways Department is necessary.
3	Encumbrances enroute	Like telephone, telegraph traction and electric utility wires, avenue trees, cross beams of bridges, sub-ways, aqueducts, etc, across the roadway.
4	Sharp bends and gradients	Steep gradients up or down and sharp bends with respect to the manoeuvrability of the tractor-trailer.
5	Road worthiness and load bearing capacity of the road	Of the route like sandy stretches, water logged areas, crowded localities like market places, schools and other public places.
6	Operational	Constraints of the tractor trailer to be used. To clear up any doubts as to the feasibility of the route, a rehearsal drive of the tractor-trailer unit is performed.

5.2.2.2 Strengthening the Route

- ✓ Such of those bridges and culverts, which require strengthening, are strengthened by adopting suitable measures like propping up using timber and steel in consultation with the Highways Department.
- ✓ In some cases, an alternative route bypassing such bridges and culverts may be cheaper than propping up.

5.2.3 Movement

- ✓ A pilot vehicle with all tools and tackles like jacks, sleepers, chequer plates, crowbars, etc, and sufficient trained staff should be run in front of the vehicle. Red flags and danger lamps should be exhibited at prominent places to warn traffic on the route.
- ✓ The branches of avenue trees that are likely to foul the equipment should be cleared while the load is moved. Electric utility power lines likely to foul should be switched off and lifted temporarily dismantled while the load is moved.
- ✓ After moving the load for a short distance, tightness of the lashings should be checked.
- ✓ In the case of night halt or stoppage of the loaded trailer for a long duration, the trailer should be supported either by sleepers or providing supporting jacks on all sides thus releasing the load from the tyres.
- ✓ Danger lights should be displayed in the front and rear of the vehicle.
- ✓ For the normal running, it is desirable not to run the vehicle over 15/ 20 km per hour with no load and 10/ 15 km with loads on good surfaced roads. For bad roads, it is desirable to run the vehicle at much lower speeds.
- ✓ The brake system on the tractor-trailer has to be carefully operated whenever the vehicle is running with load.
- ✓ While running over any bridge or culvert the vehicle should be run only at a very slow speed. Long before the approach to the bridge, the speed should be brought down and

the vehicle allowed to proceed over the bridge without creating any impact, which is sometimes caused by applying brakes when running at high speeds. Till all the wheels of the tractor trailer are clear of the bridge, the speed should not be increased.

- ✓ Transportation should be avoided during heavy rains and foggy weather.
- ✓ In cases of the vehicle getting locked up in a slipping soil, the safest procedure would be to detach the tractor after the trailer had been anchored suitably by sleepers. The tractor may be moved forward and anchored suitably with sufficient sleepers. The trailer can be pulled up by winches in the rear of the tractor.

5.2.4 Loading

- ✓ Some of the manufacturers have their own railway siding and transformers are loaded at their works using their cranes.
- ✓ In cases where separate siding facilities are not available, road tractor-trailers are used for the transport from works to loading railway stations.
- ✓ Mobile cranes and railway cranes are also used for loading the units onto the wagons.
- ✓ In the absence of any crane facility, the transformers are unloaded from the trailers near the railway track onto a platform of adequate height, built up of wooden sleepers.
- ✓ Jacks and pull lifts chain pulley block of adequate capacity are used to slide the transformer over a pair of rails placed on the sleeper platform bridging the trailer width in full.
- ✓ To prevent the trailer from toppling when the transformer is moved to the platform, the stage end of the trailer is supported by a sleeper pack. From the platform the transformer is slid onto the wagon taking care to have the rails for the full width of wagon.
- ✓ The rails are greased for easy movement.
- ✓ The rollers of the transformer are removed before leaving the works.
- ✓ While providing a sleeper stage it should slightly be at a higher level to allow for the increase in height of the trailer while the load is released due to the springs getting relaxed.

5.2.5 Lifting and Jacking

- ✓ Transformers should be lifted by the lugs or shackles provided for the purpose and simultaneous use should be made of all such lugs or shackles in order to avoid any unbalance in lifting.
- ✓ Before lifting the complete transformer it should be ensured that all cover bolts are tightened.
- ✓ Apart from the main lifting points designed to take the total weight of the unit, the transformer has subsidiary lifting points suitable for particular components only.
- ✓ It is advisable to use a spreader between slings so that the lift on the hooks is in the vertical direction. The slinging angle is not to exceed 60°.
- ✓ Safe loads of wire ropes and the multiplying factor to be used corresponding to the lifting angles shall be kept in view. Gunnies are used on the slings to avoid metal contact and consequent damage to the slings.
- ✓ Where it is necessary to use jacks for lifting, only the projections provided for the

purpose of jacking should be used. Jacks should never be placed under valves or cooling tubes. Not more than two jacks should be operated at the same time. When two jacks are being operated the opposite side of the transformer should be firmly supported by sleepers. Jacks are also not to be left in position with load for a long time. The transformer should always be handled in the normal upright position.

- ✓ During the handling Operation care shall be taken to prevent overturning.
- ✓ Loading on the railway wagons is done as centrally as possible to distribute the weight equally on all axles and wheels. Manufacturer‘s drawing in this regard is to be referred to. It is desired that the transformer is loaded longitudinally on the wagon. To prevent damage to the transformer base, the unit is loaded on a row of sleepers or wooden planks placed on the wagon floor.

5.2.6 Lashing

- ✓ The transformer is lashed on all four sides by wire ropes or chain of adequate size and are tightened using turnbuckles with locking facility/ wooden props.
- ✓ After the movement of the wagon for a short distance, the tightness of the lashing is to be checked. When enroute transhipment is involved, lashing is to be checked again.

5.2.7 Unloading at Site

- ✓ In cases where the substations are having adequate crane facility, the transformer is unloaded by crane. Alternatively, mobile cranes are used.
- ✓ Where no crane facility is available, a trench is dug to a depth equal to the height of the trailer platform and the transformer is slid to position.
- ✓ If this also is not possible, the transformer is unloaded onto a sleeper platform and gradually lowered to plinth level.
- ✓ The sleeper platform level is to be at a slightly higher level to allow for the increase in height of the trailer while the load is released due to the springs getting relaxed. Winches are to be used for putting the transformer into position.

5.3 INSPECTION AND STORAGE

5.3.1 Inspection

- ✓ Transformers are liable to get damaged during transit and therefore it is recommended that immediately on arrival, the transformer should be unpacked and examined for any sign of damage in transit, particular attention being paid to the following:
  - Tank sides or cooling tubes dented,
  - Protruding fittings damaged,
  - Bushings cracked or broken,
  - Bolts lose due to vibration in transit, and
  - Damage to auxiliaries.
- ✓ If it is suspected that the transformer has suffered material damage, suitable action shall be taken.
- ✓ Serious damages - Serious damages should be reported to the manufacturer. It is advisable to wait till the representatives of both the manufacturer and the transporter are present before lifting the core and coils from the tank for further inspection.

- ✓ Slight damages - Damage which does not appear to be serious but which indicates heavy knock should be treated with caution. The core of the transformer should be lifted from the tank/ enclosure in the presence of the representatives of both the manufacturer and the transporter and examined for any damage to ensure that they have not been damaged.
- ✓ The report of this examination should be made to manufacturer as well as to the transporter.
- ✓ No damage -If there are no external damages, it is advisable to leave the transformer in its tank/ enclosure without making any attempt to look inside.
- ✓ The presence of rust and condensation anywhere either within or outside the tank.
- ✓ At the time of receipt, transformer to be tested through various checks and tests.

5.3.2 Storage

- ✓ Transformers received at site and not expected to be installed immediately are likely to damage.
- ✓ Indoor type transformers should be stored under cover.
- ✓ Transformers which are required to be kept in storage for long periods should preferably store in a room or if it is necessary to store item outdoors, these should be covered.

CHAPTER 6

INSTALLATION, TESTING & COMMISSIONING

6.1 INSTALLATION

A set of record plans should be available, which clearly indicating the complete layout of the installation.

A schedule of the works to be carried out with time required shall be charted-out.

6.1.1 Precaution

- ✓ As far as possible no work shall be done during rainy condition for outdoor installation or if it is necessary take precautions to avoid physical damage and water ingress in enclosure of transformer.
- ✓ Extreme care shall be taken to prevent any foreign material from being dropped into the transformer. Workmen having access to the interior of a transformer should empty their pockets of all loose materials. Any spanners or other tools used shall be securely tied so that they can be recovered easily if accidentally dropped.
- ✓ All components dispatched separately shall be cleaned inside and outside before being fitted.
- ✓ If any internal temporary transportation braces are provided, they are to be removed without disturbing any permanent internal arrangements.
- ✓ The transformer shall be erected on a level foundation.

6.1.2 Handling

- ✓ Transformers should be lifted by the lugs or shackles provided for the purpose and simultaneous use should be made of all such lugs or shackles in order to avoid any unbalance in lifting. Before lifting the complete transformer, it should be ensured that all cover bolts are tightened.
- ✓ Where it is necessary to use jacks for lifting, the projections provided for the purpose of jacking should be used. Jacks should never be placed under valves or cooling tubes.

6.1.3 Site Preparation

Since all electrical installations shall comply with the requirements of the Indian Electricity Act and Rules made thereunder, it is essential that they are complied with.

All tools, tackles and other equipments required for the erection work may be arranged at the site before the work is started. The list of items that will be generally required is given in Appendix A.

6.1.3.1 Indoor Site

- ✓ The most important thing to be ensured with transformer installed indoors is proper ventilation, that is, free moment of air round all the four sides. The level of the transformer base should be higher than the highest flood and storm water level of that area.

NOTE

(i) As a thumb rule, an area of at least 2 m^3 for outlet and 1 m^3 for inlet per 1000 kVA of transformer capacity should be provided in the sub-station. For large transformer units, it may not be practicable to design the sub-station to admit the requisite quantity of air for natural circulation. Therefore, in such cases fans shall be provided.

(ii) Where transformers are required to be installed in basements, special care shall be taken to ensure prevention of flooding.

✓ The transformers should be kept well away from the wall. The minimum recommended spacing between the walls of the transformer periphery from the point of proper ventilation have been shown in Fig. 6 below. However, the actual spacing may be different than those given in Fig. 6 below, depending on the circumstances, such as access to the accessories.

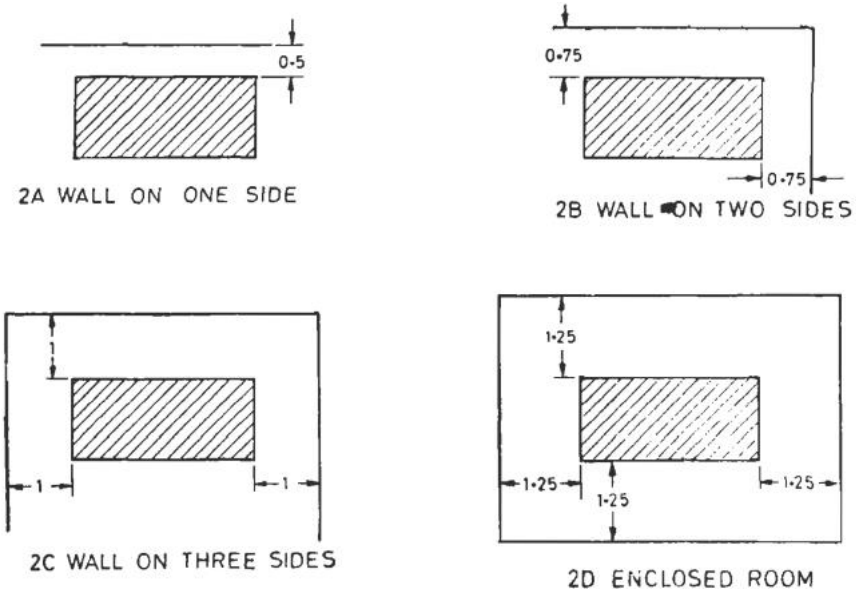


Figure 6: Minimum recommended spacing between the walls and transformer periphery

✓ The site should be so chosen that it is not normally damp because besides corroding the tank body and tubes, the dampness may find its way to the bushings and may cause them to flash over. There shall be no chance of water dripping either on the transformer or anywhere in the transformer room itself. Chemical fumes, particularly acid fumes, should not be allowed in the transformer room as they corrode the tank and also cause the oil to deteriorate.

✓ For indoor installations the air inlets and outlets shall be of adequate sizes and so placed as to ensure proper air circulation for the efficient cooling of the transformers. The inlets should preferably be as near the floor as possible and the outlets as high as the building allows to enable the heated air to escape readily and be replaced by cool air.

✓ Minimum clearance between the highest point of the transformer to the ceiling of the transformer room should be sufficient to remove the mounting on the transformer like enclosure etc. However, this clearance should not be less than 0.5 m.

✓ In this connection, consideration should be given to the heat output from the transformer, which affects the surrounding atmospheric temperature. Approximate heat output of transformer, when delivering full rated load for different ratings of the transformer, is given in table below.

Table 4: Heat output according to the rating of Transformer

SN	Rating kVA	Heat Output kW
1	16	0.75
2	25	1
3	63	2
4	100	3
5	160	4
6	200 to 1000	2 + 1.5 per hundred kVA

- ✓ The transformer should be so installed that severe vibrations are not transmitted to its body.

6.1.3.2 Outdoor Site

- ✓ Only transformers designed for outdoor use should be installed outdoors. In case of locations where the atmosphere is polluted, it is desirable that the transformer is located in suitable covered shelter to minimize adverse effects of polluted atmosphere.

6.1.4 Foundation

- ✓ Since the transformers, operate without moving parts, generally a simple foundation is satisfactory provided it is firm, horizontal and dry. The transformer should not rock or bed down unevenly so as to tilt, as this may strain the connections. The base should be horizontal to keep the oil level correct.
- ✓ For outdoor installations, a level concrete plinth above the maximum flood or storm water level of the site, of correct size to accommodate the transformer in such a way so that no person may step on the plinth, with, if necessary, bearing plates of sufficient size and strength should be provided for transformers. Where rollers are fitted, suitable rails or tracks should be provided and when the transformer is in the final position, the wheels should be locked by locks or other means to prevent accidental movement of the transformer. Where full height partition walls are built, adequate clearances as for indoor transformers should be provided.
    - Flat paving stones may also be used for making platforms provided they are laid on a firm foundation and can provide drainage and withstand the weight of the transformer.
- ✓ For installing pole-mounted transformers, as far as possible, junction poles, subsidiary poles, and street lighting poles should not be used as transformer poles. Where this is unavoidable, special care should be taken to maintain proper climbing space and to avoid crowding of wire and equipment. Transformers should be installed only on poles strong enough to carry their weight. Transformer poles should be straight and, where necessary, guyed to prevent learning or raking of the pole after the transformer is hung. Double cross-arms should be provided for each transformer installation. The climbing Space should be carefully maintained so that it should not be necessary for a lineman to come close to the transformer tank in climbing up or down a pole. A suitable anti-climbing device should be provided.

6.1.5 Cabling

- ✓ Cable trenches inside sub-stations and switch stations containing cables shall be filled with sand, pebbles or similar non-inflammable materials, or completely covered with non-inflammable slabs. In many installations it may be advisable, for reasons of ease of

maintenance to locate equipment centrally with cable galleries serving the purpose of cable trenches.

- ✓ Cables may also be carried along the walls clamped on the vertical supports at suitable intervals depending on the cable sizes. The cables, when arranged in a vertical plane, should run clear off the walls. Many types of Special clamps for this purpose are now available. Where a large number of cables have to be carried and it is not desirable for some reason to have a portion of the wall face covered with cables, these may be run in cable trays or racks. Where a number of cable trays or racks are used, the spacing between them should be 150 mm or more, depending on the cable sizes. The cables should be laid in a single layer and the routings should be preplanned so that crossovers are kept to minimum. The trays may be made from suitable materials such as galvanized iron or aluminium sheets or expanded metal. The expanded metal affords better ventilation for the cable. In view of economy and compactness, control and power cables are laid in the same trench, care shall be taken to segregate them in separate racks, with the control cables effectively screened. DC control cables, ac power circuits and instrument transformer circuits shall be segregated from one another.
- ✓ The cables should not be exposed to heat from other equipment. The cable trenches should be suitably sleped and arrangements should be made for draining them or preventing them from getting filled with water.

6.1.6 Bushings and Cable Boxes

6.1.6.1 Bushings

If bushings are removed from the transformer, they should be carefully inspected for cracks or chips before installing them and making sure that gaskets are in proper places. Often the leads are trapped between two nuts, the at nut holding the bushing stem while the second nut holds the connection. One nut should be held with a thin spanner whilst tightening the other. Nuts or bolts which exert pressure on the porcelain should be tightened evenly or else bushing may crack.

6.1.6.2 Cable Boxes

If the transformer is fitted with cable boxes and is to be connected by cables, the cable ends should be sealed to prevent their absorbing moisture. The cable boxes should be filled with compound or oil as required, after making the connections. PVC and XLPE cable boxes need not be filled with compound or oil.

6.1.7 Connection

6.1.7.1 Medium Voltage

- ✓ Both cable and bare connections may be used. Where cables or wires other than metal-sheathed or armoured cables are run in metallic casings, all three phases and the neutral shall be run in the same metallic casing. Where metallic casings are used, no joints should be made in the cable or wire. All metallic casings, fittings, sheathing and armouring shall be effectively earthed.
- ✓ In the case of transformers of capacity 750 kVA and above, for feeding the medium voltage supply, the method of connection is generally by single core lead covered cable. Bus Duct connection is also one of the desirable practices.

6.1.7.2 High Voltage

- ✓ The connection by insulated cables for the high voltage side of the transformer, if laid in a covered trench inside a building, shall be by suitable paper-insulated lead-sheathed and armoured or aluminium-sheathed, or other suitable types of cable. If the

connecting cable is paper-insulated lead covered and if accessible or laid in ground, it shall be armoured or provided with metallic covering. All cable boxes, and metallic sheathing and armouring shall be efficiently earthed. Where bare conductors are used for connections, these shall be inaccessible. The conductors and their supports should be designed to safely withstand stress under short-circuit conditions.

6.1.7.3 Bare Connections

- ✓ In medium and high voltage sub-stations, particularly where the magnitudes of currents are large, bare conductors of copper or aluminium may have to be used for connection to be transformer terminals. These may be of the flexible type or of the rigid type having rectangular or hollow circular cross-section. Where connections are rigid and more than 3 to 4.5 m long, special expansion type of connectors are recommended to prevent the terminal bushings being unduly stressed due to thermal expansion. If aluminium or ACSR conductors are used for connection to the transformer terminals made of copper, suitable bimetallic type of connectors should be used to prevent electrolytic corrosion at the contact surfaces of dissimilar metals and necessary precautions taken in making these joints.

6.2 PRECAUTIONS AGAINST RISK OF FIRE

- ➢ In order to limit the spread of fire in the event of ignition, insulating oil, oil filled switchgear and transformer units should be segregated in groups of moderate capacity; where the size and importance of the plant warrants-it, this may be achieved by segregation in separate enclosure. Alternatively, fire-resisting barriers may be provided between transformers or sections of switchgear.
- ➢ Cables and cable trenches shall be laid in accordance with IS: 2274-1963.
- ➢ In sub-stations or transformer chambers situated below blocks of buildings which are ordinarily frequented by many people or in places where the fire risk is considerable, the following precautions are recommended:

(i) The structure and, in particular, any partition walls or doors should be of such construction as to be capable of resisting the effects of fire for a considerable period, and

(ii) Independent ventilation of the chamber should be provided and any trunking which is in communication with other parts of the building should be excluded therefrom. Access doors to the chambers where the equipment is installed should be provided.

(iii) In exceptional cases the following precautions may also be taken:

- ✓ Remote indication of undue rise of the temperature inside the transformer room,
- ✓ Remote disconnection of the Supply, and
- ✓ Fixed automatic fire-fighting equipment shall, wherever necessary be installed. The fire extinguishing medium (for example, water Spray, foam and carbon dioxide) and the means and methods of applying the same should be chosen carefully to suit each installation. Such equipment should be supplemented by suitable portable extinguishers. A number of these should be kept adjacent to but not inside the area of risk, so that access to them is not impeded when a fire has already started.

NOTE

- ✓ The importance of the fire extinguisher to be used for various types of electrical fires cannot be overemphasized; for instance spraying of water on live parts of electrical apparatus on fire would charge the pipe-work and may endanger the lives of fire fighting staff.
- ✓ For large outdoor sub-Stations, protection may also be provided by the installation of a sprinkler system, activated by fire-detecting units.
- ✓ Reference may be made to IS: 1646-1961* for general guidance on fire safety.

6.3 SAFETY PRECAUTIONS

- ✓ The transformer should be so installed that there is no risk of anyone receiving an electric shock. Although, with all metal parts of the metal tank bonded together and properly earthed, the tank may be considered quite safe, yet consideration should be given to the arrangement of the connections.
- ✓ With the use of cable boxes and terminal boxes or suitable bushings the terminals are well protected. However, if the metal ends of the bushings are exposed, precautions shall be taken to protect the persons working near the transformer from accidentally touching the live parts. For complete safety, it may be necessary to provide an enclosure to the transformer with door or gate which may be kept locked when the transformer is energized.

6.4 COMPLETION OF ERECTION WORK

Completing the work such as wiring of various alarm/ trip contacts, fan motors, pump motor and other apparatus, earthing of neutral and tank is completed. Tank surface is retouched with paint wherever required and transformer is made ready for commissioning tests.

6.5 TESTING AND COMNIISSIONING

6.5.1 Parallel Operation

- ➢ For satisfactory operation in parallel, the concerned transformers shall have identical
  - ✓ Phase displacement,
  - ✓ Voltage ratio, and
  - ✓ Equal percentage impedance within permissible tolerances.
  - ✓ Polarity and phase rotation are identical.

- ➢ Provided the polarities of the winding correspond, transformers with the following connections operate satisfactorily in parallel. Connections in Group A shall not be paralleled with those in Group B.

Group A- star/star, delta/delta, and delta/zig-zag.
Group B - delta/star, star/delta, and star/zig-zag.

- ➢ Transformers designed for parallel operation shall not be required to divide the load within limits closer than to permit an individual variation from the rated output of any transformer of the group amounting to ±10 percent of such rated output when the total load on the group is equal to the sum of the rated outputs of all the transformers so connected. In addition, the rated outputs of the smallest transformer in the group should be not less than 33 percent of the rated output of the largest transformer in the group.

6.5.2 Polarity and Phasing Out

- When connecting a new transformer special care should be taken to do so in accordance with the diagram of connections supplied by the manufacturer taking into account, at the same time, the phase sequence of the supply. In case of three-phase transformers, if connections are not made in the correct phase sequence, the outgoing supply may also be of wrong phase sequence. This would necessitate breaking down of connections and remaking the high voltage cable connections.
- It is immaterial whether the phase rotation is clockwise or anti-clockwise so long as it is the same for all the transformers that have to work in parallel. However, it is recommended that the standard phase sequences in accordance with the Indian and International practice, namely, red, yellow and blue sequences in the anti-clockwise direction, should be adopted. A positive check will help in ensuring correct external corrections. The simplest way is to connect two transformers in parallel on primary sides: connect the secondary terminals of one transformer to its bus-bars, and connect one terminal of the second transformer to the bus-bars, which, it is assumed, corresponds to the equivalent terminal of the first transformer. After ensuring that both transformers are on the same tap, voltage readings between the remaining secondary terminals of the two transformers and the bus-bars be taken. If both readings are zero, the transformers are of the same polarity and phase rotation and the connections may be made permanent.
- In the case of star connected secondaries, an alternative arrangement to the secondary connections indicated above is to connect the star points to each other. (This connection may be via earth in which case, of course, none of the secondary terminals will be connected to the bus-bars before closing).

NOTE

It should be noted that under the above circumstances it is also possible for the voltage reading to be double of the secondary voltage which will be when the voltage reading happens to be across unlike phases. It is, therefore, necessary that care is taken to see that the range of the voltmeter is equivalent to the sum of the secondary voltages of the two transformers.

6.6 TESTING BEFORE COMMISSIONING

The tests to be carried out at site before commissioning the transformer will depend upon the voltage and kVA rating of the transformer, facilities available at site.

6.6.1 Typical Tests carried out before commissioning/ energizing of DTs

Table 5: Testing & Checks of Distribution Transformer before commissioning

SN	Inspection	Items
1	General inspection	a) Control and relay panels, etc. b) Junction boxes and marshalling kiosks.
2	Secondary injection	On all transformer protection relays
3	Primary injection (also to be repeated at the end of all other commissioning tests)	a) Tests on operation and stability of earth fault relays on high voltage side. b) Tests on line directional elements of high-voltage line relays. c) Tests on high speed neutral ammeter. d) Tests on overcurrent relays on low- voltage side.

		e) Tests on operation and stability of earth fault relays on low-voltage side. f) Tests on operation of standby earth fault relay on low-voltage, side. g) Tests on overcurrent relay on high- voltage side (when current transformers are not in transformer bushings). h) Voltage compensation.
4	Ratio tests	a) With 415 V applied on high-voltage side, measure the voltage between all phases on the low-voltage side for every tap position. b) To check phasing, measure volts : A to a, b and c B to a, b and c C to a, b and c Where A, B and C are the terminals of three phases on high-voltage side and a, b and c are the corresponding terminals on low-voltage side. c) Magnetic balance test.
5	Tripping tests	a) High voltage. b) Low voltage. c) Inter-tripping tests. d) Winding temperature trips.
6	Calibrate earthing resistance	---
7		
8	Alarm circuits	a) Winding temperature thermo- meter. b) Cooling gear failure.
9	Fans and pumps	a) Check that the oil valves are open in cooling circuit. b) Check the rotation of pumps, automatic starting overload devices, etc.
10	Tap changing tests to check mechanism, indication, buzzer, lamp, etc.	---
11	Phasing tests	a) At 4 15 V [see 4 (b) above]. b) Between transformers in a bank. c) To prove internal and external connection for parallel operation. d) On auxiliary supplies and voltage transformers.
12	Insulation tests	a) On high and low voltage windings. b) On current and voltage transformers, circuits, etc.
13	Voltage compensation test (if compensating current transformers are fitted)	a) Primary injection [see 3 (h) above]. b) Load tests [see 20 (g) below]. c) If necessary, switch in with relays connected to correctly compensated voltages from the other transformer.
14	See that neutral earthing switches are closed before making alive.	---
15	Check transformers on equal taps before switching in.	a) For transformers in a bank. b) For transformers in parallel.
16	Set down relays before closing in-advise control	---
17	If necessary, arrange temporary protection for soaking and switching in, for example unrestricted	---

	earth fault, if soaking from low voltage side with 113 V and 213 V open	
18	Set up relays after soaking and before going on load-advise control.	---
19	Load tests	a) Voltmeter, ammeters, etc., on both high and low voltage sides. b) Overcurrent. c) No spill in high voltage star point. d) No creeping of contacts on both high and low voltage earth fault relays e) Voltages on relays. f) Directional elements - low voltage, directional overcurrent and the earth- fault relays (if fitted). g) Voltage compensation.
20	Tap changing test on load over full range of taps	---
21	Advise control of any new equipment commissioned	---
22	If possible for transformers rated above 1000 kVA, when being energized for the first time, the voltage should be built up gradually	---
23	Low voltage excitation current	---
24	Single-phase, magnetic balance Test	---

6.6.2 LIST OF TOOLS FOR COMMISSIONING, TESTING & TROUBLESHOOTING

LIST OF TOOLS			
SN	Tools	SN	Tools
1	Special tools for dismounting of the OLTC.	17	Screwdrivers -various sizes
2	D shackles -1 ton	18	Hacksaw frame standard size
3	D shackles -5 ton	19	Hacksaw blades HSS type
4	D shackles – Max. load /3, multiple quantities	20	Tommy bars -20 mm dia 3 ft' lon
5	Slings - 1 ton (wire rope/ nylon)	21	Chisels: 1 in wide, 2' wide
6	Slings – 5 tons (wire rope/nylon)	22	No. punch (8x8) various sizes
7	Slings – Max load/3, (wire rope) 4 nos.	23	Flat files (small & regular
8	Extension board – 3 ph& 1 ph	24	Half round files (small & regular)
9	Spanners DE type (size : 8-9 to 32-36	25	Round files (small & regular

10	Spanners ring type (size : 8-9 to 32-36)	26	Welding machine
11	Ring & DE spanner 55 size	27	Drilling machine
12	Box spanner (size : 8-9 to 32-36)	28	Grinding machine
13	Torque spanner with pressure gauge meter.	29	Gas cutting set with cylinders
14	Sledge hammer – 5 kg	30	Pipe 3” dia 5 ft. long
15	Hammer - 1 kg	31	Knives for paper cutting etc.
16	Mallet		
SPECIAL TOOLS			
1	Winding lifting arrangement	9	Wooden / MS pallets for lamination storage
2	Lead cutting tools	10	Fans
3	Brazing machine	11	Torches
4	Brazing rods	12	Vacuum cleaners
5	Brazing torch nozzles and oxy-acetylene cylinders	13	Lamination stack tying arrangement
6	Hydraulic Crimping Tools (cutting tools & crimping dies)	14	Asbestos sheets for heat insulation during brazing.
7	Stools for yoke unlacing of adequate height and wt. capacity	15	Dry air generator and compressor setup.
8	Nylon slings for tying the winding to lifting frame	16	Scaffolding arrangement for access to the active part during
TEST INSTRUMENTS			
1	2 kV test set	7	Dew point meter
2	Megger 1 kV	8	Tan delta kit
3	Megger 5 kV motorized	9	Clamp meters
4	Ratio meter	10	Variac 1 phase and 3 phase
5	Winding resistance kit	11	Continuity tester
6	Millimetre		

CHAPTER 7

MAINTENANCE & TROUBLESHOOTING

7.1 FACILITIES FOR MAINTENANCE

- In the case of heavy units of equipment, adequate passageways, doorways, or trap doors should be provided, where practicable, to allow the passage of the equipment to its operating position. The possible need for facilities for removing the equipment at a later date for repairs or maintenance should be considered in relation to the accessibility of the equipment. For lifting the transformer core and handling heavy equipment, it is often advisable to arrange for the incorporation of a lifting beam in the structure of the building, the beam being located at a suitable height immediately over such parts of the equipment as may require attention and being capable of supporting the maximum weight involved.
- The transformer should be so installed that the thermo-meter, winding temperature indicator may be safely examined with the transformer energized.

7.2 MAINTENANCE PROCEDURE

7.2.1 Safety Precaution

Arrangements shall be made to carry out the maintenance of transformers in safety. Before starting any maintenance work, the transformers shall be isolated from the supply and the terminals earthed. No fire shall be kept near the transformer while maintenance work is going on.

7.2.2 Rollers

After a transformer has been in service for a long period, rollers should be examined carefully. They should be greased.

7.2.3 Transformer Body

- The transformer tank and other parts should be inspected periodically for any rust or leak. Rusted portions. if any. should be cleaned thoroughly and repainted with proper paints. Transformer should be completely painted at proper intervals. If any leak is found, it should be investigated. If it is due to defective welding, the same should be rectified after consulting the manufacturers. Leaking Joints can be rectified by tightening the bolts to the correct pressure or by replacing the gaskets.

- **Internal Inspection**

  The core and windings should be lifted from the tank. Only if necessary, in suitable condition. The surrounding atmosphere should not be humid and should be free from dust dirt etc. Suitable lifting device depending on the weight of the core and coil should be arranged. Before disturbing anything, the insulation resistance of the transformer should be measured.

- **Opening the Transformer**

  Before opening the tank cover, it should be properly cleaned removing any dust, moisture, etc, from the top. All nuts and bolts, etc, should be removed from top of the cover before removing it.

- **Removing the Cover**

  The method of removing the cover depends on the construction of the transformer. If the core and windings are separate from the cover and if there are bushings mounted on top, then first bushings should be dismounted and stored carefully and then the cover should be carefully removed. If however, the core and windings are suspended from the tank cover. Substantial lifting lugs, usually in the form of eye bolts, are provided on the cover. While lifting the cores from the eye-bolts care should be taken that the core is removed vertically.

7.2.4 Core and Winding

7.2.4.1 Lifting the Core and Coils

- ✓ The core and coils, if not suspended from the cover, are held in the tank by a bolt or other suitable fixing devices at each end near the top. These should first be removed If there are bushings provided on the tank walls, these should also be removed by undoing the connection. Mechanical connection to the tap changing switch handle, if provided, should be removed.
- ✓ The core and coils should then be lifted vertically by slinging it from the lifting lugs provided on the core, making sure that the sling does not foul against bushing connections, tapping switch, etc, as it pulls tight.
- ✓ After allowing the core and coils to drain into the tank, for some time, they should be lowered preferably on beams placed in a metal tray filled with saw dust or sand.

7.2.4.2 Inspection

- ✓ After removing the core and coils from the tank, the following should be carefully checked making sure that nothing is disturbed unnecessarily and that the leads are not pulled out of their places unless they are unsatisfactory:
  - (i) All bolts and nuts should be adequately tight. If they are too tight clamps etc, may bend.
  - (ii) The windings should be firmly clamped without any movements. There should be no loose spacers or end blocks. If loose windings or spacers are noticed, the vertical tie-bars which put pressure on the coil stacks should be adjusted. Special coil adjustment bolts if provided should also be tightened properly.
  - (iii) Proper operation of tap changing switch may also be checked.
  - (iv) All connections should be tight and clear.
  - (v) Do the insulation resistance tests if the test gives satisfactory value, then it is ok otherwise do the investigation with the manufacturer.
- ✓ It is recommended that the core and winding be removed from the tank for visual inspection as per time schedule given in the inspection table. Any loose nuts and bolts should be tightened.
- ✓ Before lifting the core and winding from the tank, it is usually necessary to disconnect the windings from the bushings are cable boxes inside the tank to disconnect the off-circuit tap switch handle or leads of the on-load tap changer and to remove any earthing strips between the core clamps and the tank.

- ✓ The core and windings shall be removed with great care. It should be placed under cover and in a safe place.

7.2.5 Bushings

- ✓ Clean the bushing porcelains and examine them for cracks and chips. Very slight chips may be ignored but any serious damage will require a new porcelain, which must be obtained from the manufacturer. It is recommended to have a spare in stock.
- ✓ In some cases the porcelain only may be changed while in other cases the conducting rod is cemented into the porcelain and the complete bushing requires to be changed.
- ✓ If only the porcelain is supplied it may not be necessary to undo the internal bushing connection, for, in some cases the bushing stems are joined by an insulated bar to prevent them from turning when the nuts are undone. All the nuts at the top of the bushing should be removed and the old porcelain lifted straight up over the central stem, which remains in place. Slide the new porcelain down over the stem and replace the nuts. Too much strain on the porcelain should not be applied when tightening the connections. Change only one porcelain at a time, replacing the nuts at the top of the stern before removing those on the next bushing. If the insulated bar between the bushing stems is not provided, the internal connections should be undone and the whole bushing removed before the porcelain is changed.
- ✓ When a complete bushing is supplied the internal connection to the bushing should be undone. If the replacement bushing has a socket at the bottom end, the old bushing should be unclamped and withdrawn from the tank, the internal lead being flexible and long enough to allow this. This lead may now be unplugged from the old bushing and plugged into the new one, which is then lowered into the hole in the tank and rec-lamped firmly but not too tightly.

7.2.6 Cable Boxes

- ✓ The seating arrangements for filling holes should be checked each year. When screwed plugs are seated with a bituminous compound, the compound should be examined for cracks. If the compound has cracked it should be replaced as the cracks may lead to an accumulation of water around the plug. Gasketed joints should be examined and tightened whenever required.

7.2.7 External Connections

- ✓ All connections should be tight. If they appear blackened or corroded undo the connection and clean down to bright metal with emery paper. Remake the connection and give it a heavy coating of grease. It is particularly important that heavy-current carrying connections should be properly maintained. If the metal has the characteristic bluish tinge which Indicates that it has been hot, then in most cases the connection shall not be considered satisfactory. Either it has become loose or dirty, or the conductor is not suitable for carrying the current.
- ✓ The earth connections shall be properly maintained. A small copper loop to bridge the top cover of the transformer and the tank may also be provided to avoid earth fault current passing through the fastening bolts when there is a lightning surge, high-voltage surge or failure of bushings.

7.2.8 Temperature Indicators

- ✓ At each maintenance inspection, Check the thermometer, dial glasses should be kept clear and if broken, replaced as soon as possible to prevent damage to the instrument.

Temperature indicators should be calibrated with standard thermometer if seems that the thermometer shows the reading incorrectly.

7.2.9 Coolers and Cooling Fans

- ✓ There is a variety of coolers. For radiator type coolers, maintenance primarily consists of replacing damaged elements, cleaning the outer surface to remove settled dust, repainting, etc.
- ✓ Fan blades are cleaned to remove dust. Bearings of the fan motors should be lubricated occasionally. Grease should not be added while the motor is running. For other coolers, manufacturers, instructions should be followed.
- ✓ Other precautionary measures, such as checking of correct operation of indicators shall be taken.

7.3 CHECK LIST FOR DISTRIBUTION TRANSFORMERS

7.3.1 For Dry Type Transformers

SN	Type of Check	Item	Frequency	Points to be checked	Action to be taken in case of any anomaly
1	Physical Condition	HV-LV bushings	Yearly	b) Check for any crack/ flash mark on HV-LV bushings if any c) Check for dust on HV-LV bushing.	a) Defective Bushing to be replaced. b) Bushing to be cleaned with dry cloths.
2	Physical Condition	Enclosure, Doors, marshalling Box	Yearly	a) Check for dust & rust on enclosure & HV-LV Cable box.	a) Enclosure & HV-LV cable box to be cleaned.
3	Physical Condition	Enclosure doors & marshalling box Door	Yearly	d) Check for doors are properly closed or not. e) There should not be any open space at cable (HV & LV) inlet & earthing strip.	a) Ensure all doors shall be properly closed. b) Any open space/gap to be filled with insulating material.
4	Physical Condition	Marshalling Box	Yearly	a) Check for working/ setting for thermostat. b) Check for working and physical condition of energy meter. c) Check for working for lamp.	a) Proper setting to be done if required. b) Energy meter should be in working condition. c) Lamp should be switched off when door is closed.
5	Physical Condition	Active part	Yearly	Check for dust deposition over core coil assembly of transformer.	Dust cleaning to be done with the help of air blower if required.
6	Physical Condition	Enclosure Earthing	Yearly	a) Enclosure should be earthed at two placed with separate earthing point.	a) If not, tank body earthing to be done at two places.
7	Physical Condition	Neutral earthing	Yearly	a) Neutral should be earthed at two placed with separate earthing point.	a) If not, neutral earthing to be done at two places.

8	Electrical	Earth resistance	Yearly	a) Earth resistance should be = <1 Ohm	a) If not, then check for earthing pit or go for new earthing.
9	Electrical	IR Value	Yearly	a) IR value shall be equal for all three phases for HT-E, LT-E and HT-LT. b) Normally IR value shall be minimum 100 MΩ for HV & 50 MΩ for LV windings at temp of 50°C.	a) If not then recheck the IR values. b) If value is lower than the values specified then plan for overhauling /replacement.
10	Mechanical	HV-LV termination	Yearly	a) Check for intactness of HV-LV termination b) Check for any tension on HV-LV terminals due to cable.	a) If not tightening, HV-LV nut-bold and accessories to be done. b) Tension on HV-LV terminals due to cable to be rectified.
11	Mechanical	Vibration in transformer	As and when required/ yearly	a) Check for any abnormal sound from transformer. There should be a healthy humming sound.	a) If abnormal sound observed then keep Watch/ plan for overhauling/replacement.
12	Electrical	Thermo scanning	As and when required/ Half yearly	a) Check for thermo scanning half yearly/before and after of planned maintenance during pre and post maintenance visit.	a) Take corrective action if hot spot and other abnormality detected.
13	Electrical	Exhaust fan	As and when required/ Half yearly	a) Check for working of exhaust fan.	a) Ensure for working of exhaust fan.

7.4 MAINTENANCE SCHEDULE

- Recommended maintenance schedules for all types of transformers of rating less than 1000 kVA and for ratings of 1000 kVA and above are given in tables below respectively. The hourly and daily inspection recommended are applicable for attended substations only. However, for unattended substations, these items should be inspected as frequently as possible.

- In addition to the schedule recommended in Tables, it may be necessary to inspect for other details in the case of specific types of transformers. In all such cases, the manufacturers instructions shall be followed.

7.4.1 Maintenance Schedule for DTs of capacity less than 1000 KVA (As per IS 10028 Part-III 1981)

SN	Inspection Frequency	Items to be inspected	Inspection Note	Action required if Inspection shows unsatisfactory conditions
1	Online status monitoring through	1. Load (Amp.) 2. Temperature 3. Voltage	• Checks against rated values • Oil/ambient temperature. • Check against rated figures.	• Check for reasons

SN	Inspection Frequency	Items to be inspected	Inspection Note	Action required if Inspection shows unsatisfactory conditions
	Communicating /Smart Meters (AMI/ AMR)			
2	Monthly status monitoring	Dehydrating breather (if available) 1. Oil 2. Connection Bushing 3. Unbalancing	• Check air passage and color of silica gel • Check oil level. • Check tightness. • Check load on all the three phases and neutral current	• If Silica gel is pink, change by spare charge. The pink gel may be re- activated for reuse. • If low, top up with dry oil and examine cause of leak. • If loose, tighten. • If unbalancing is found, action should be taken for balancing of load in all phases.
3	Quarterly	Bushing	• Examine for physical cracks and dirt deposits. • Check load on all the three phases and neutral current • Check for thermo graphic scanning of Critical DTs	• Clear or replace. • If unbalancing is found, action should be taken for balancing of load in all phases.
4	Half Yearly	1. Non-conservator transformer 2. Cable box, gasketed joints. 3. Gauges, Painting.	• Check for moisture under cover. • Inspect. • Inspect.	• Improve ventilation, check oil. • Attend to remove defects. • Attend to remove defects.
5	Yearly	1. Oil in transformer 2. Earth resistance 3. Relays, alarm and their circuits etc.	• Check for dielectric strength, water content, acidity and sludge. • Examine relays and alarm contacts, their operations and fuses etc. • Checks relay accuracy.	• Take suitable action to restore quantity and quality of oil. • Take suitable action if earth resistance is high. • Clear the components and replace contacts and fuses, if necessary, Change the setting, if necessary.
6	2 Yearly	Non-Conservator transformer	• Internal inspection above core.	• Filter the oil regardless of condition.
7	5 Yearly		• Overall inspection	

7.4.2 Maintenance Schedule for Transformer of Capacity 1000 KVA and above

Table 6: Maintenance Schedule for Transformer of Capacity 1000 kVA and Above

SN	Inspection Frequency	Items to be inspected	Inspection Note	Action required if Inspection shows unsatisfactory conditions
1	Online through Communicating	1. Ambient Temperature	• Check if temperature rise is reasonable.	• Nil

	Meters (AMI/AMR)	2. Winding and oil temperature 3. Load (ampere) and voltage.	• Check against rated figures.	• Shut down the transformer and investigate if either is persistently higher than normal. • Nil
2	monthly	1. Oil level in bushing 2. Relief diaphragm 3. Silica gel breather	• Check against transformer oil level. • Check the air passage for free; • Check Color of the active agent.	• If low, top up with dry oil, examine the transformer for leaks. • Replace if found cracked or broken. • If Silica gel is pink, change by spare charge. The pink gel may be re-activated for reuse.
3	Quarterly	1. Bushing 2. Oil in transformer 3. OLTC 4. Indoor transformer	• Examine for physical cracks and dirt deposits. • Check for dielectric strength and water content. • Check oil in OLTC and driving mechanism. • Check ventilation. • Check for thermo graphic scanning of Critical DTs	• Clear or replace. • Take suitable action to restore quantity of oil. • Replace burst or worn parts or other defective parts. • Nil
4	Half Yearly	1. Oil Cooler	• Test for pressure.	• Nil
5	Yearly	1. Oil in transformer 3. Oil filled bushing Cable boxes 4. Gasket joint 5. Surge deviator 6. Relays, alarm and their circuits etc. 7. Earth resistance 8. Cable boxes 9. Gasket joint 10. Surge deviator 11. Relays, alarm and their circuits etc. 12. Earth resistance	• Check for dielectric strength, water content, acidity and sludge. • Test oil. • Inspect. • Examine for cracks and dirt deposits. • Examine relays and alarm contacts, their operations, fuses etc. • Inspect. • Examine for cracks and dirt deposits. • Examine relays and alarm contacts, their operations, fuses etc.	• Take suitable action to restore quality of oil. • Filter or replace. • Nil • Tighten the bolts evenly to avoid uneven pressure. • Clean or replace. • Clear the components and replace contacts and fuses, if necessary. • Take suitable action if earth resistance is high. • Nil • Tighten the bolts evenly to avoid uneven pressure. • Clean or replace. • Clear the components and replace contacts and fuses, if necessary. • Take suitable action if earth resistance is high.
6	5 Yearly	1000 KVA to 2500 KVA	• Overall inspection including lifting of core coil unit.	• Wash by housing down with clean oil.
7	7 to 10 Yearly	Above 2500 KVA	• Overall inspection	--

7.5 TROUBLE-SHOOTING IN TRANSFORMERS

Faults observed during the periodic maintenance schedules are to be rectified as per the suggested action required. However, certain chance troubles and major faults in

performance of the transformer shall have to be attended to in a desired sequence, as per manufacturer's instructions or ready reference manuals. Guidance to manage electrical and mechanical troubles normally encountered in all types of transformers are provided in Table below.

7.5.1 Troubleshooting Chart

SN	Trouble	Cause	Remedy
I	**Rise in temperature**		
1	High temperature	Overvoltage	Check the circuit voltage or transformer connections to avoid over excitation.
		Overcurrent	If possible, reduce load. Heating can often be reduced by improving power factor of load. Check parallel Circuits for circulating currents which may he caused by Improper ratios or impedances.
		High Ambient temperatures	Either improve ventilation or relocate transformer in lower ambient temperature.
		Insufficient cooling	If unit is artificially cooled, make sure cooling is adequate
		Lower Liquid Level	Fill to proper level.
		Sludge oil	Use filter press to wash off core and coils. Filter oil to remove sludge.
		Short circuited core	Test for exciting current and no-load loss. If high, inspect core and repair.
II	**Electrical Troubles**		
1	Winding Failure	Lighting, Short-circuit	Usually, when a transformer winding falls, the transformer is automatically disconnected from the power source by the opening of the supply breaker or fuse. Smoke or cooling liquid may be expelled from the case, accompanied by noise. When there is any such evidence of a winding failure, the transformer should not be re-energized at full rated voltage, because this might result in additional internal damage. Also it would introduce a fire hazard in transformers. After disconnection from both source and load, the following observations and test are recommended. a) External mechanical or electrical damage to bushings, leads, potheads, disconnecting switches, or other accessories b) Level of insulating liquid In all compartments, c) Temperature of insulating Liquid wherever it can be measured. d) Evidence of leakage of insulating liquid or scaling compound.
		Overload	
		Oil of low dielectric strength	
		Foreign material	
2	Core Failure	Core-insulation break down (Core, bolts, clamps, or between laminations)	
3	High exciting current	Short-circuited core	Test core loss. If high, it is probably due to a short-circuited core. Test core insulation. Repair if damaged. If laminations are welded together, refer to manufacturer.
		Open core joints	Core-loss test will show no appreciable increase. Pound joints together and retightens clamping structure.

SN	Trouble	Cause	Remedy
4	Incorrect Voltage	Improper ratio	Change terminal-board connection or ratio-adjuster position to give correct voltage.
		Supply voltage abnormal	Change tap connections or readjust supply voltage.
		High-resistance joint/ connection inside DT main tank	Joints through proper lugs to avoid leakage/high resistance or may use tight screw joint.
5	Audible internal arcing and radio interference	Isolated metallic part	The source should be immediately determined. Make certain that all normally grounded parts are grounded, such as the clamps and core.
		Loose Connections	Same as above. Tighten all connections.
		Low liquid level, exposing live parts	Maintain proper liquid level.
6	Bushing flashover	lightning	Provide adequate lightning protection
		Dirty Bushings	Clean bushing porcelains, frequency depending on dirt accumulation.
		No/ insufficient amount of dielectric / insulating material near collar region	Provide proper/ sufficient amount of dielectric/ insulating material.
III	**Mechanical Troubles**		
1	Leakage through screw joints	Foreign material in threads. Oval nipples, Poor threads, Improper filler, Improper assembly.	Make tight screw joints or gasket joints.
2	Leakage at gasket	Poor scarfed joints, insufficient or uneven Compression, Improper preparation of gaskets and gasket surface.	Tighten the gasket joints by applying a uniform pressure with uniform tightening by torque spanner having pressure gauge.
3	Leakage in welds	Shipping strains, imperfect weld	Repair leaks in welds.
4	Pressure-relief diaphragm cracked	Improper assembly. Mechanical damage	Replace diaphragm. Inspect imide of pipe for evidence of rust or moisture. Be sure to dry alit transformer if there is a chance that drops of water may have settled directly on windings or other vulnerable locations, as oil test may not always reveal presence of free water.
5	Pressure-relief diaphragm ruptured	Internal fault In conservator transformer- obstructed oil flow or breathing	Check to see that valve between conservator and lank is open and that ventilator on conservator is not blocked.

SN	Trouble	Cause	Remedy
		In gas-seal transformer- obstructed pressure relief valve	Make certain that relief valve functions and their valves In discharge line are open.
		In sealed transformer- liquid level too high	Liquid level should be adjusted to that corresponding With liquid temperature to allow ample space for expansion of liquid.
6	Moisture condensation in open- type transformers and air filled compartments	Improper or insufficient ventilation	Make sure that all ventilator openings are free.
7	Moisture condensation in sealed transformers	Cracked diaphragm	See remedies above for cracked and ruptured diaphragms.
		Moisture In oil	Filter all.
8	Audio noise	Leaky gaskets and joints. Accessories and external transformer parts are set Into resonant vibration giving off loud noise	Make certain all joints are tight. Tighten loose parts. In some cases parts may be stressed into resonant slate. Releasing pressure and shimming will remedy this condition.
9	Rusting and deterioration of paint Finish	Abraded surfaces and weathering	Bare metal or mechanical parts should be coveted With grease.
10	Fractured metal or porcelain parts of bushings	Unusual strains placed on terminal connections	Cables and bus-bars attached to transformer terminals should be adequately supported. In the case of heavy leads, flexible connections should be provided to remove strain on the terminal and bushing porcelain.

7.5.2 Causes & Effects

SN	Abnormality	Causes/ Effect	Preventive-Corrective action plan	Abnormality
1	Electrical Stress	1. Flash over due to Phase to phase & Phase to earth clearance at cable termination	Ensure sufficient clearance	Electrical Stress
		2. Termination failure due to Core crossing above cut back area at cable termination	Ensure core crossing below cut back area at cable termination	2. Termination failure due to Core crossing above cut back area at cable termination

SN	Abnormality	Causes/ Effect	Preventive-Corrective action plan	Abnormality
		3. Termination failure due to Contaminated surface of terminations	Ensure cleanliness of terminations	3. Termination failure due to Contaminated surface of terminations
		4. Cable failure due to Cable testing at high voltage (DC)	Ensure Testing at Recommended Voltage	4. Cable failure due to Cable testing at high voltage (DC)
2	Mechanical Stress	1. Stress develop due to Improper Bending Radius	Ensure Proper Bending radius	Mechanical Stress
		2. Stress develop due to Mechanical vibrations	Ensure proper depth	2. Stress develop due to Mechanical vibrations
		3. Stress develop due to Improper cable supports	Ensure proper span length	3. Stress develop due to Improper cable supports
3	Thermal Stress	1. Insulation degradation due to overloading	Ensure Recommended Loading	Thermal Stress
		2. Insulation degradation due to Hot spot at joints & Terminations	Ensure proper Tightening/ crimping of Lugs & Ferrules	2. Insulation degradation due to Hot spot at joints & Terminations
		3. Insulation degradation due to Improper Earthing connections	Ensure Cable earthing connected with Sub-station earthing	3. Insulation degradation due to Improper Earthing connections
4	External damage	Insulation Damaged by external agency	Ensure Patrolling of cable routes	External damage
5	Water ingress	Leakage current through the cable insulation/ cable failure, Corrosion in cable conductor & Armour due ingress of water	Ensure Lug seal to be intact at outdoor termination.	Water ingress

7.6 LIST OF TOOLS FOR MAINTENANCE & TROUBLESHOTING

Complete list of items given in chapter 5 Commissioning & Testing para no. should be followed.

REFERENCES

1. Indian Standard IS 2026- Part 1 (2011)/ RA 2021
2. Indian Standard IS 2026- Part 11 : 2021
3. Indian Standard IS 2026- Part 12 : 2018
4. Indian Standard IS 10028- Part 1 (1985)/ RA 2021
5. Indian Standard IS 10028- Part 2 (1981)/ RA 2021
6. Indian Standard IS 10028- Part 3 (1981)/ RA 2018
7. CEA “Guidelines and Best Practices for Operation & Maintenance of Distribution Transformer” March-2023.
8. O&M Manual of M/s Raychem RPG (P) Ltd, Pune dtd 22-08-2023
9. O&M Manual of M/s Kirloskar Electric Company Ltd, Bengaluru
10. BSES Rajdhani Power Ltd. Technical Specification NO. GN 101-03-SP-79-03/ R3 dtd. 28.10.2021

NOTES

CONTACT US

CAMTECH is continuing its efforts in the documentation and up-gradation of information on maintenance practices of electrical assets. Over the years a large number of publications on electrical assets have been prepared in the form of handbooks, pockets books, pamphlets and video films, etc. These publications have been uploaded on the internet as well as rail net.

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