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SARI / Energy

"Distribution Equipments - Technology and Applications"

Training Module for

DISTRIBUTION TRANSFORMER

- Transformer specification
- Transformer design
- Manufacturing / quality control
- Testing in the Works
- Transportation
- Erection at site
- Testing at site
- Commissioning
- Maintenance
- Trouble Shooting
- Transformers Failure Analysis and Preventive Actions
- New development in Transformer Technology

TRANSFORMER SPECIFICATION

- Capacity : 1000 KVA
- Rating : 11 / 0.433 KV
- Group : Dy11
- %Z : %5
- {Tapping Range} : ±5% by off-circuit, in steps of 2.5 %

TRANSFORMER SPEC. FOR SPECIFIC REQUIREMENT:

- KVA,
- VOLTAGE RATIO,
- INDOOR / OUTDOOR INSTALLATION,
- VECTOR GROUP,
- FREQUENCY,
- COOLING,
- TAPPING RANGE,
- TERMINATION REQUIREMENT FOR HV / LV,
- TEMPERATURE RISE OF OIL / WINDING ,
- NO LOAD / LOAD LOSS,
- IMPEDANCE,
- PROTECTIVE ACCESSORIES,
- ANY OTHER SPECIAL REQUIREMENTS.

TRANSFORMER DESIGN

STEPS:-

- Calculation of volt per turn
- Calculation of H.V. & L.V. current
- Calculation of core area and core diameter
- Select the winding
- Calculation of turns for H.V. & L.V.
- Calculation of conductor area & diameter
- Winding arrangement for H.V. & L.V.
- Calculation of the impedance of the winding
- Calculation of losses
- Calculation of core steps
- Calculation of tank height
- Calculation of gradient
- Calculation of radiator bank
- Calculation of efficiency at all loads

MANUFACTURING / QUALITY CONTROL

- Winding / Core
- Coil pressing
- Core coil assembly
- Ovening
- Tanking
- Testing
- Material inspection at venders' end
- Incoming material inspection,
- In-process quality inspection

  Final inspection

TESTING IN THE WORKS

Transformer being an inherent part of any kind of electrical industry, forms one of the most important equipment. Before a transformer can be connected to the external circuits, the internal connections within the transformer must be known so that the compatibility of the transformer with respect to the external circuit is checked and ensured. From a series of tests at factory site, it is necessary to ascertain that the transformer will function smoothly throughout its useful life span (for 30 years or more).

All Transformers are to be tested in accordance with IS 2026 (Part I to Part V)

The final testing of completely assembled transformers is classified into three categories as below:-

ROUTINE TESTS

The routine tests are conducted to ensure the particular transformer is free from manufacturing defects

TYPE TESTS

The type tests are conducted to check the particular design parameters

SPECIAL TESTS

The special tests are conducted depending upon the need for particular test-as per site conditions

ROUTINE TESTS

- Measurement of insulation resistance
- Measurement of winding resistance
- Measurement of voltage ratio
- Verification of polarity and vector group
- No-load loss and excitation current measurement
- Load loss and impedance voltage measurement
- Separate source voltage withstand test
- Induced over voltage tests
- Testing of transformer oil BDV
- Mag.balance & measurement of magnetizing I.

OVER AND ABOVE ALL ROUTINE TESTS, FOLLOWING ARE CHECKED IN THE WORKS:

- All protection equipments (BR, OTI / WTI, PRV, MOG, dehydrating breather), RTCC panel & its components and wiring
- OLTC operation on all taps (both extreme ends for its limit switch operation)
- All set points

TYPE TESTS

- Temperature rise test
- Impulse voltage withstand test
- Short-circuit withstand capability test

SPECIAL TESTS:

The special tests are conducted depending upon the need for particular test - as per site conditions. The transformer shall pass the appropriate di-electric tests specified in IS 2026 Part III of 1977. The dielectric test may be type test, routine test or special tests.

NOTE: -The special tests have to be agreed between the purchaser and supplier. Hence purchaser should clearly specify conducting special tests in the P.O.:

- Dynamic short circuit test
- Measurement of noise level
- Measurement of Zero sequence impedance
- Measurement of harmonics
- Partial discharge measurement
- Measurement of tan delta

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- Measurement of noise level
- Measurement of Zero phase sequence impedance
- Measurement of harmonics
- Partial discharge measurement
- Measurement of capacitance & tan delta
- Aux. loss measurement
- 2 KV core test

GENERAL REQUIREMENTS FOR TYPE, ROUTINE AND SPECIAL TESTS:

a) Tapped windings shall be connected on their principal tapping unless the relevant test clause requires otherwise

b) The test basis for all characteristics, other than insulation, is the rated condition unless the test clause states otherwise

c) Where it is required, test results shall be corrected to a reference temperature of 75^0C.

TRANSPORTATION

- Transportation normally by road
- Above 1000 KVA capacity, transformers are dispatched with their external fittings dismantled
- Transformers are dispatched either completely filled with oil or oil covering top yoke of transformer leaving top space exposed to atmospheric air or entire transformer filled with inert nitrogen gas at certain pressure (0.2 Kg / cm^2 or so).

ERECTION AT SITE

- Inspect for any transit damage before unloading
- Loose cases should be handled in their upright position
- Ensure proper ventilation to dissipate heat for smooth functioning and prolonged life
- Clear gap of 1250 mm on all sides of the transformer should be maintained if it is enclosed in a room. Ground clearance from open live part should not be less than 2.75 m.
- If rollers are fitted, suitable rail should be provided
- After keeping main tank in its permanent position, lock the rollers with anti-earthquake clamps to prevent any accidental movement on rail
- sufficient clearance for safe maintenance, provision for draining the oil

TESTING AT SITE

All routine tests performed at works are normally repeated at site, except those requiring special testing facility (no-load loss test, load-loss or short circuit test, induced over voltage, etc.)

COMMISSIONING

After checking the following, the transformer may be energized:

- General observation
- Oil level,
- Oil leakage
- All protection equipments (BR, OTI / WTI, PRV, MOG, dehydrating breather), RTCC panel & its equipments (for proper functioning)
- All set points
- Earthing and "Danger-High Voltage" label

COMMISSIONING

- Breaker and other associated operation and annunciation by actuating tripping relay
- All field tests by shorting associated contacts
- Removal of BR / MOG float locking
- HV / LV connection perfectness and tightness, etc.
- In case of parallel operation, fulfillment of conditions
- Air release of bushings
- Distances of arching horns of the bushings
- Control instruments such as thermometers, relays, oil level indicators have to be checked and adjusted, if necessary

- Functioning of over load protection of the transformer. Adjustment of time and current values have to be done

- The proper position and locking of the line connection to the bushings

- Due consideration of the points stated above, is indispensable for commissioning the transformers. Questions, over and above, the scope of this regulation may have to be judged and decided in accordance with the conditions at site

- Before putting the transformer in to service, all air may have collected in the Buchholz Relay should be allowed to escape through the top petcock

After energizing the transformer, it should be kept charged for minimum 4 hours and only after checking the following, it should be loaded gradually:

- Humming and stray sound
- No-load / charging current
- OTI / WTI temperature rising
- Operation of OLTC
- All radiators are evenly hot

MAINTENANCE

- If a transformer is to give long and trouble free service, it should receive a reasonable amount of attention and maintenance

- Maintenance consists of regular inspection, testing and reconditioning where necessary

- Records should be kept giving details of any unusual occurrence and also of any test results taken

- The principal object of maintenance is to maintain insulation in good condition. Moisture, dirt and excessive heat are the main causes of insulation deterioration and avoidance of these will in general keep the insulation in good condition

MAINTENANCE -- OIL

- All minor leaks or sweating should be repaired as quickly as possible
- Sample of oil should be taken at regular interval and tested for BDV and acidity
- It should be noted that reconditioning by centrifugal separation or by filtration does not remove the acidity from the oil but will remove sludge, dust, etc. and will tend to retard process of deterioration
- Filters with fullers earth will reduce acidity in the used oil and in addition improve the resistivity
- Dielectric strength – 60 KV r.m.s. per min. (Transformer manufacturers' practice is to supply fresh oil with BDV of 70 KV r.m.s.)
- Acidity – 0.05 mg of KOH. If increasing rapidly, treatment is required

Periodically proper checks for following should be made for smooth functioning and for any physical damage:

- Tap changer
- Bushings
- Cooling Equipment
- Conservator
- Oil gauges
- Dehydrating Breather
- Buchholz Relay
- Explosion Vent
- Gasket
- Temperature Indicators
- Valves

RECOMMENDED MAINTENANCE SCHEDULE

To check

Hourly- Winding temperature

- Oil Temperature
- Load (amps)
- Voltage
- Position of Tap switch

Daily - Inspect general condition, see if there is any unusual noise and check

- Oil level in conservator
- Oil level in bushing
- Explosion vent diaphragm
- Dehydrating breather – check colour / air passage

Quarterly

- Bushing
- Oil in Transformer for BDV
- OLTC (if applicable) check oil in OLTC driving mechanism
- Indoor – Check Ventilation

Yearly

- Oil in Temperature for acidity and sludge
- Winding for IR value
- Oil filled bushing (Test oil)
- Gasket joints
- Cable boxes
- Relay, Alarms and their circuits
- Earth Resistance

- 5 Yearly - 1 MVA to 3 MVA - Over all inspection by lifting core coil assembly

- 7-10 Yearly - Over all inspection by lifting core coil assembly and overhauling

TROUBLE SHOOTING

- High temperature
- Winding Failure
- Core Failure
- High Exciting current
- Audible internal arcing
- Bushing flash over
- Leakage through gasket / welding
- Low oil alarm

TROUBLE SHOOTING

- *Oil sample failure*
- *High acidity*
- *Low IR value*
- *Variation in the ratio*
- *Frequent change in colour of gel*
- *Presence of water inside the tank*
- *Unusual noise*
- *Relay not operating*
- *OLTC failure*

Sl. No.	Trouble	Cause	Necessary action
1.	Overloading	Overloads, Failure of Cooling System, High ambient temperature	Check cooling system, whether fans are operating, whether cooling oil / water is circulating. Reduce the load on the transformer. If temperature of oil is high, switch off transformer till safe temperature reached. If over load problem is occurring for long duration, install another transformer in parallel. If ambient temperature is higher than the considered in specification of transformer, de-rate the transformer

Sl. No.	Trouble	Cause	Necessary action
2.	Sustained higher voltage on primary resulting in overheating of core due to over fluxing.	Poor voltage control of power system use of shunt reactor and tap changing transformers to control bus bar voltage within specified limit.	Transformers fail due to sustained over voltage, provide over fluxing protection and over voltage protection for bus bar. Flux density depends upon E/f ratio. Generator transformers get over fluxed during low frequency operation

Sl. No.	Trouble	Cause	Necessary action
3.	Frequent external short circuits.	Insufficient clearance on overhead lines, accumulation of dust on insulators,	Transformer windings should be capable of withstanding repeated external short- circuits without failure. Transformer should be provided with over current protection
4.	Short circuit between adjacent turns, usually high voltage winding	Sharp corners on conductors cutting the insulation. External short circuits, Moisture in oil, Fluctuating loads. Transient over voltage	Buchholz relay should operate and sound alarm. Over current and differential protection should operate and open the circuit breaker

Sl. No.	Trouble	Cause	Necessary action
5.	Internal short circuit	Sustained overload and insulation failure Fault in tap changer. Failure of end turns of coil due to over voltage surges. Bad solder joints causing local overheating and open circuit. Ageing of insulation, abrasion of insulation resulting in internal short circuits.	Over current protection, Earth-fault protection, Differential protection

Sl. No.	Trouble	Cause	Necessary action
6.	Moisture in oil	Moisture in oil while filling. Breather saturated. Defective seals	Oil should be filtered. Silica gel, gaskets should be replaced. Transformer should be dried out
7.	Rapid deterioration of oil	Excessive over-loading. Presence of moisture. Poor quality of oil	Cause should be determined and corrective action to be taken

Sl. No.	Trouble	Cause	Necessary action
8.	Carbon and other conducing particles in oil	Sparking in oil, excessive temperature of oil	Conducting particles on insulation surface causing reduction in insulation resistance and failure by tracking. Transformer overhauling
9.	Loss of voltage on secondary side	Break in the windings	Apply megger or measure winding resistances and locate a point of interruption. Inspect transformer active parts.

Sl. No.	Trouble	Cause	Necessary action
10.	Leakage of oil	Oil leakage through sealed joints	Tighten up bolts in sealed joints or replace sealing gasket.
11.	Damage to porcelain bushing	Mechanical damage	Replace porcelain or entire bushing
12.	Uneven noise inside transformer	Power supply upset and load, Loose parts	Restore normal condition, Tightening of loose parts

FAILURE ANALYSIS:

Failure in the Magnetic circuit:

1) Break down of core bolt insulation

2) Failure of insulation of laminations and of insulation between the yokes and yoke clamping frame.

3) Improper clamping of yoke laminations.

4) Burrs in lamination.

5) Abnormal air gaps in corner butt joints, while core building and yoke filling.

6) Variation in thickness of laminations and reduced core area than designed area.

7) High flux density.

8) Ageing of laminations.

Failure in the electric circuit:

1) Inter turn / Inter layer short in winding.
2) Conductor insulation failure due to caesarian effect while over clamping
3) Moisture penetration between turns causing insulation failure.
4) Frequent Electrical or Magnetic shock
5) Excess hot spot Temperature
6) Lack of transposition in multi parallel high current spiral winding
7) Poor soldering / bracing joints
8) Non coaxial assembly of HV / LV coils
9) Sustained over load

Failure in the dielectric circuit:

1) Moisture entry during breathing.
2) Excessive heat and high oil temperature accelerates formation of sludge , and other contaminants.
3) Contamination or occluded air in press board (during manufacture) used for cylinder, tubes, terminal boards.
4) Improper earth shield between primary and secondary.
5) Narrow oil ducts are a serious menace to serviceable life of Transformer.
6) Occasionally metallic particles are found in press boards, causing puncture.
7) Solder or bracing rod splash on coil due to careless workmanship.
8) Oil level below top of the header of radiator, causing over heat.
9) Insufficient inter phase clearance and improper positioning of barrier
10) Wooden cleats used for terminal supports, not properly dried.

Failure due to structural or other reasons

1) MS clamping ring insulation failure, causing short circuited turn effect.

2) In sufficient clamping of lead from winding to terminal.

3) Tanks having bad porous welding.

4) Bushing flashover due to deposit of dust and salt spray.

5) In furnace Transformers, improper bracing of lead to terminal from multiple disc paralleling, causing unequal sharing of load in conductors of lead.

6) In adequate space around and improper ventilation.

7) As vapour at the top of the tank in oil filled transformer may be of the explosive nature, no naked light is to be used to examine internal connection

Failure of Transformer Main components

Transformer Part	Trouble	Causes
Windings	Turn-to-turn short circuit	Natural ageing or wear of insulation: repeated over loads; dynamic forces due to complete short-circuit.
	Breakdown fault, Inter-phase short- circuit	Ageing of insulation; high moisture content of oil; low oil level. Internal and external over voltages; deformed windings due to heavy short circuit currents
	Open-circuit	Burnt-off leads on windings due to poor quality of brazed / crimped joints or electro-dynamic forces in the wake of a complete short- circuit

Transformer Part	Trouble	Causes
Tap changer	No contact, Fused contact surface	Maladjustment of tap changer Thermal effect of short-circuit currents on contact
Terminal bushings	Electric breakdown (flashover) to shell	Cracks in porcelain shells; low oil level in transformer and dirt on internal surfaces of porcelain shells
	Electric breakdown of insulation on inter- phase connections.	Damaged insulation on leads to terminal bushings or to tap changer

Transformer Part	Trouble	Causes
Core	Burnt iron	Improper insulation between laminations or clamping bolts; loose laminations; short circuit in grounding of the core on the lead side of the HV and LV windings
Tank and fittings	Oil leak through welded and flanged joints	Impairment of welded or flanged joints as a result of mechanical or temperature factors
	Oil leak from plug cock	Poor fit between the plug and the cock body; damaged gasket under its flange

Certain causes of failure of Transformers in service:

- Prolonged over heating
- Single phase loading
- Unbalanced loading
- Faulty termination
- Power theft and Hooking
- Wrong earth connection
- Prolonged short circuit
- Inadequate maintenance
- Operation of Tap switch on load
- Poor quality of LT cable
- Improper installation

New development in Transformer Technology

1) 23ZDKH90 / Hi-B (Laser Scribed) ultra low core loss a electrical sheet steel, laser irradiation to reduce the width of magnetic domain

2) Step lapped construction for energy saving

3) Foil winding having better short circuit withstand capability

4) Transformer life extension using ON line Trans-former dry out system using super dry cartridges, without heat or vacuum, ensuring dry oil with normal characteristics and enhanced IR value of the insulation system of the Transformer

New development in Transformer Technology

5) Open ventilated dry type vacuum pressure impregna-ted Transformer having numerous advantages over resin cast transformers

6) Amorphous core technology

7) Hermitically sealed type construction

8) Corrugated tank

Certain points to be remembered regarding basic characteristics of Transformer

1) Magnetizing current of central limb in core type construction will be 60 to 70% of that of extreme turn limbs

1) Core bolt used in the yoke or leg lamination will be non magnetic steel used adequately insulated

1) Yoke channels insulated from lamination, but earthed

4) By varying voltage per turn and reactive length, variation in impedance is achievable.

POINTS TO BE REMEMBERED

- A transformer which has been commissioned and later withdrawn from service for any considerable time should be rechecked as when commissioned
- It is preferable not to mix oil from different suppliers
- IS : 335, IEC : 296 , BS :148, etc. –- Transformer oil
- IS : 1886 – 1961 –- Code of practice for maintenance of insulating oil
- IS : 1886–1967 –- Code of practice for maint. of Trans
- IS : 2026, IS : 1180 –- Transformer

OPEN FORUM

THANK YOU ALL

FOR

PATIENT HEARING

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For more details contact:anitagupta@ieema.org