

Transformer Testing | Type Tests and Routine Tests of Transformer

For confirming the specifications and performances of an electrical power transformer it has to go through a number of testing procedures. Some tests are done at a transformer manufacturer premises before delivering the transformer.

Transformer manufacturers perform two main types of transformer testing – type test of transformer and routine test of transformer.

Some transformer tests are also carried out at the consumer site before commissioning and also periodically in regular and emergency basis throughout its service life.

Type Test of Transformer

To prove that the transformer meets customer's specifications and design expectations, the transformer has to go through different testing procedures in manufacturer premises. Some transformer tests are carried out for confirming the basic design expectation of that transformer. These tests are done mainly in a prototype unit not in all manufactured units in a lot. Type test of transformer confirms main and basic design criteria of a production lot.

Routine Tests of Transformer

Routine tests of transformer is mainly for confirming the operational performance of the individual unit in a production lot. Routine tests are carried out on every unit manufactured

Special Tests of Transformer

Special tests of transformer is done as per customer requirement to obtain information useful to the user during operation or maintenance of the transformer.

Pre-Commissioning Test of Transformer

In addition to these, the transformer also goes through some other tests, performed on it, before actual commissioning of the transformer at the site. The transformer testing performed before commissioning the transformer at the site is called the pre-commissioning test of transformer. These tests are done to assess the condition of transformer after installation and compare the test results of all the low voltage tests with the factory test reports.

Type tests of transformer include:

1. Winding resistance test of transformer
2. Transformer ratio test
3. Transformer vector group test
4. Measurement of impedance voltage/short circuit impedance (principal tap) and load loss (Short circuit test)
5. Measurement of no-load loss and current (Open circuit test)
6. Measurement of insulation resistance
7. Dielectric tests of transformer
8. Temperature rise test of transformer

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4. Measurement of impedance voltage/short circuit impedance (principal tap) and load loss (Short circuit test)
5. Measurement of no-load loss and current (Open circuit test)
6. Measurement of insulation resistance
7. Dielectric tests of transformer.
8. Tests on on-load tap-changer.
9. Oil pressure test on transformer to check against leakages past joints and gaskets

That means Routine tests of transformer include all the type tests except temperature rise and vacuum tests. The oil pressure test on transformer to check against leakages past joints and gaskets is included.

Special Tests of transformer include

1. Dielectric tests.
2. Measurement of zero-sequence impedance of three-phase transformers
3. Short-circuit test
4. Measurement of acoustic noise level
5. Measurement of the harmonics of the no-load current.

Various Types of Transformer Testing Methodology

Transformer Winding Resistance Measurement

Transformer winding resistance measurement is carried out to calculate the I²R losses and to calculate winding temperature at the end of a temperature rise test. It is carried out as a type test as well as routine test. It is also done at site to ensure healthiness of a transformer that is to check loose connections, broken strands of conductor, high contact resistance in tap changers, high voltage leads and bushings etc.

There are different methods for measuring of the transformer winding, likewise:

Current-voltage method of measurement of winding resistance.

Bridge method of measurement of winding resistance.

Kelvin bridge method of Measuring Winding Resistance.

Measuring winding resistance by Automatic Winding Resistance Measurement Kit.

Note: Transformer winding resistance measurement shall be carried out at each tap.

Transformer Ratio Test

The performance of a transformer largely depends upon perfection of specific turns or voltage ratio of transformer. So transformer ratio test is an essential type test of transformer. This test also performed as a routine test of transformer. So for ensuring proper performance of electrical power transformer, voltage and turn ratio test of transformer one of the important tests.

The procedure of the transformer ratio test is simple. We just apply three phase 415 V supply to HV winding, with keeping LV winding open. We measure the induced voltages at HV and LV terminals of the transformer to find out actual voltage ratio of the transformer. We repeat the test for all tap position separately.

Magnetic Balance Test of Transformer

Magnetic balance test of transformer is conducted only on three-phase transformers to check the imbalance in the magnetic circuit.

Procedure of Magnetic Balance Test of Transformer

Keep the tap changer of transformer in normal position.

Now disconnect the transformer neutral from ground.

Then apply single phase 230 V AC supply across one of the HV winding terminals and neutral terminal.

Measure the voltage in two other HV terminals in respect of neutral terminal.

Repeat the test for each of the three phases.

transformer testing table

In case of an autotransformer, a magnetic balance test of transformer should be repeated for LV winding also.

There are three limbs placed side by side in a core of the transformer. One phase winding is wound in one limb. The voltage induced in different phases depends upon the respective position of the limb in the core. The voltage induced in different phases of a transformer in respect to neutral terminals given in the table below.

Magnetizing Current Test of Transformer

Magnetizing current test of transformer is performed to locate defects in the magnetic core structure, shifting of windings, failure in between turn insulation or problem in tap changers. These conditions change the effective reluctance of the magnetic circuit, thus affecting the current required to establish flux in the core.

Keep the tap changer in the lowest position and open all HV and LV terminals

Then apply three phase 415 V supply on the line terminals for three-phase transformers and single phase 230 V supply on single phase transformers

Measure the supply voltage and current in each phase

Now repeat the magnetizing current test of transformer test with keeping tap changer in normal position

Repeat the test while keeping the tap at highest position

Normally, there are two similar higher readings on two outer limb phases on transformer core and one lower reading on the center limb phase, in the case of three phase transformers.

An agreement to within 30% of the measured exciting current with the previous test is usually considered satisfactory. If the measured exciting current value is 50 times higher than the value measured during factory test, there is a likelihood of a fault in the winding which needs further analysis.

Caution: This magnetizing current test of a transformer is to be carried out before DC resistance measurement.

Vector Group Test of Transformer

In a 3 phase transformer, it is essential to carry out a vector group test of transformer. Proper vector grouping in a transformer is an essential criteria for parallel operation of transformers.

There are several internal connections of three-phase transformer are available on the market. These several connections give various magnitudes and phase of the secondary voltage; the magnitude can be adjusted for parallel operation by suitable choice of turn ratio, but the phase divergence cannot be compensated.

So we have to choose a transformer suitable for parallel operation whose phase sequence and phase divergence are same. All the transformers with the same vector group have same phase sequence and phase divergence between primary and secondary.

Before procuring an electrical power transformer, you should ensure the vector group of the transformer, whether it will be matched with his or her existing system or not. The vector group test of transformer confirms his or her requirements.

Insulation Resistance Test or Megger Test of Transformer

Insulation resistance test of transformer is essential type test. This test is carried out to ensure the healthiness of the overall insulation system of an electrical power transformer.

Procedure of Insulation Resistance Test of Transformer

Disconnect all the line and neutral terminals of the transformer

Megger leads to be connected to LV and HV bushing studs to measure insulation resistance IR value in between the LV and HV windings

Megger leads to be connected to HV bushing studs and transformer tank earth point to measure insulation resistance IR value in between the HV windings and earth

Megger leads to be connected to LV bushing studs and transformer tank earth point to measure insulation resistance IR value in between the LV windings and earth

NB: It is unnecessary to perform insulation resistance test of transformer per phase wise in three-phase transformer. IR values are taken between the windings collectively as because all the windings on HV side are internally connected together to form either star or delta and also all the windings on LV side are internally connected together to form either star or delta.

Measurements are to be taken as follows:

For autotransformer: HV-IV to LV, HV-IV to E, LV to E.

For two winding transformer: HV to LV, HV to E, LV to E.

Three winding transformers: HV to IV, HV to LV, IV to LV, HV to E, IV to E, LV to E.

Oil temperature should be noted at the time of insulation resistance test of the transformer, since the IR value of transformer insulating oil may vary with temperature.

IR values to be recorded at intervals of 15 seconds, 1 minute and 10 minutes.

With the duration of application of voltage, IR value increases. The increase in IR is an indication of dryness of insulation.

Absorption coefficient = 1 minute value/15 secs. value.

Polarization index = 10 minutes value/1 minute value.

Dielectric Tests of Transformer

Dielectric test of a transformer is one kind of insulation test. This test is performed to ensure the expected overall insulation strength of the transformer. There are several tests performed to ensure the required quality of transformer insulation; the dielectric test is one of them. Dielectric test of the transformer is performed in two different steps.

First one is called Separate Source Voltage Withstand Test of transformer, where a single phase power frequency voltage of prescribed level, is applied on transformer winding under test for 60 seconds while the other windings and tank are connected to the earth, and it is observed that whether any failure of insulation occurs or not during the test.

The second one is the induced voltage test of Transformer where, three-phase voltage, twice of rated secondary voltage is applied to the secondary winding for 60 seconds by keeping the primary of the transformer open circuited.

The frequency of the applied voltage should be double of power frequency too. Here also if no failure of insulation, the test is successful.

In addition to dielectric tests of transformers, there are other types of test for checking insulation of transformer, such as lightning impulse test, switching impulse test and partial discharge test.

Induced Voltage Test of Transformer

The induced voltage test of the transformer is intended to check the inter-turn and line end insulation as well as main insulation to earth and between windings-

Keep the primary winding of transformer open circuited.

Apply three-phase voltage to the secondary winding. The applied voltage should be twice of the rated voltage of secondary winding in magnitude and frequency.

The duration of the test shall be 60 seconds.

The test shall start with a voltage lower than 1/3 the full test voltage, and it shall be quickly increased up to the desired value.

The test is successful if no breakdown occurs at full test voltage during the test.

Temperature Rise Test of Transformer

Temperature rise test of transformer is included in type test of transformer. In this test, we check whether the temperature-rising limit of the transformer winding and oil as per specification or not.

In this type test of the transformer, we have to check oil temperature rise as well as winding temperature rise limits of an electrical transformer.

Short Circuit Test on Transformer

The connection diagram for the short circuit test on the transformer is shown in the figure below. A voltmeter, wattmeter, and an ammeter are connected in HV side of the transformer as shown. A low

voltage of around 5-10% is applied to that HV side with the help of a variac (i.e. a variable ratio auto transformer). We short-circuit the LV side of the transformer. Now with the help of variac applied voltage is slowly increased until the wattmeter, and an ammeter gives reading equal to the rated current of the HV side.

After reaching the rated current of the HV side, we record all the three instrument readings (Voltmeter, Ammeter and Watt-meter readings). The ammeter reading gives the primary equivalent of full load current I_L . As the voltage applied for full load current in a short circuit test on the transformer is quite small compared to the rated primary voltage of the transformer, the core losses in the transformer can be taken as negligible here.