6.2.6 Insulation Resistance Test

Insulation resistance tests are made to determine insulation resistance from individual windings to ground or between individual windings. Insulation resistance tests are commonly measured directly in megohms or may be calculated from measurements of applied voltage and leakage current.

The recommended practice in measuring insulation resistance is to always ground the tank (and the core). Short-circuit each winding of the transformer at the bushing terminals. Resistance measurements are then made between each winding and all other windings grounded.

Windings are never left floating for insulation resistance measurements. Solidly grounded winding must have the ground removed in order to measure the insulation resistance of the winding grounded. If the ground cannot be removed, as in the case of some windings with solidly grounded neutrals, the insulation resistance of the winding cannot be measured. Treat it as part of the grounded section of the circuit.

6.2.6.1 Typical Test Connections

Following test connections shall be used depending upon the type of transformer and the number of windings.

Two winding transformer:

- (HV + LV) - GND
- HV – (LV + GND)
- LV – (HV + GND)

Three winding transformer:

- HV – (LV + TV + GND)
- LV – (HV + TV + GND)
- (HV + LV + TV) - GND
- TV – (HV + LV + GND)

Auto transformer (two winding):

- (HV + LV) - GND

Auto Transformer (three winding):

- (HV + LV) – (TV + GND)
- (HV + LV + TV) - GND
- TV – (HV + LV + GND)

Temperature of windings and insulating liquid shall be near the reference temperature of 20 ^{o}C.
Under no conditions circumstances should tests be made while the transformer is under vacuum.

6.2.6.2 Test Voltages

Test Voltages are typically 500 V, 1000V or 2500 V dc. .Voltage should be increased in increments, typically1 kV to 2.5 kV, and held for 1 min while the current is read.

The dc voltage applied for measuring insulation resistance to ground shall not exceed a value equal to the rms low-frequency applied voltage.

The test should be discontinued immediately if the current begins to increase without stabilizing.

After the test has been completed, all terminals should be grounded for enough time to allow any trapped charges to decay to a negligible value.

6.2.6.1 Interpretation of Results

The results of insulation-resistance tests generally require some interpretation, depending on the design, type of oil, the dryness and cleanliness of the insulation involved. Transformers of higher insulation class will typically have higher insulation resistance. Transformers filled with natural ester based oil generally have lower Insulation resistance compared to one with mineral oil. Comparison with factory results or previous field results is more significant than absolute value of megohms. Winding and Oil temperature also affects the reading, typically testing at higher temperature results in lower insulation resistance.

It is recommended that insulation resistance values be measured periodically (during maintenance shutdown) and plotted. Substantial variations in the plotted insulation resistance values should be investigated for cause.

When the insulation resistance falls below prescribed values, it can, in most cases of good design and where no defect exists, be brought up to the required standard by cleaning and drying the apparatus**.**

An Insulation resistance of zero or a very low value would indicate a grounded winding, a winding-to-winding short, or heavy carbon tracking.

This possibility should be confirmed with additional tests such as polarization index, insulation power factor, moisture content of oil.

6.2.6.2 Polarization Index Tests.

The polarization index is a ratio of the Insulation resistance at the end of a 10 min test to that at the end of a 1 min test at a constant voltage.

The total current that is developed when applying **a** steady state dc voltage is composed of three components:

Charging current, due to the capacitance of the insulation being measured. This current falls off from maximum to zero very rapidly.
Absorption current, due to molecular charge shifting in the insulation. This transient current decays to zero more slowly.

Leakage current, which is the true conduction current of the insulation. The leakage current varies with the test voltage. It may also have a component due to the surface leakage that is due especially to surface contamination.

Since leakage current increases at a faster rate with moisture present than does absorption current, the megohm readings will not increase with time as fast with insulation in poor condition as with insulation in good condition. This results in a lower polarization index.

An advantage of the index ratio is that all of the variables that can affect a single megohm reading, such as temperature and humidity, are essentially the same for both the 1 min and 10min readings.

$$\text{Polarization Index} = \frac{\text{10 min Insulation resistance (Meg-ohm) reading}}{\text{1 min Insulation resistance (Meg-ohm) reading}}$$

The following are guidelines for evaluating transformer insulation using polarization index values:

Less than 1 Dangerous
1.0 - 1.1 Poor
1.1 - 1.25 Questionable
1.25 - 2.0 Fair
Above 2.0 Good