# TESTING OF BUSHINGS

Bushings are an integral component of high voltage machines. A bushing is used to bring high voltage conductors through the grounded tank or body of the electrical equipment without excessive potential gradients between the conductor and the edge of the hole in the body. The bushing extends into the surface of the oil at one end and the other end is carried above the tank to a height sufficient to prevent breakdown due to surface leakage.

**Following tests are carried out on bushings:**

**(i) Power Factor Test**

The bushing is installed as in service or immersed in oil. The high voltage terminal of the bushing is connected to high voltage terminal of the Schering Bridge and the tank or earth portion of the bushing is connected to the detector of the bridge. The capacitance and p.f. of the bushing is measured at different voltages as specified in the relevant specification and the capacitance and p.f. should be within the range specified.

**(ii) Impulse Withstand Test**

The bushing is subjected to impulse waves of either polarity or magnitude as specified in the standard specification. Five consecutive full waves of standard wave form (1/50 μ sec.) are applied and if two of them cause flash over, the bushing is said to be defective. If only one flash

**(iii) Chopped Wave and Switching Surge Test**

Chopped wave and switching surge of appropriate duration tests are carried out on high voltage bushings. The procedure is identical to the one given in (ii) above.

**(iv) Partial Discharge Test**

In order to determine whether there is deterioration or not of the insulation used in the bushing, this test is carried out. The shape of the discharge is an indication of nature and severity of the defect in the bushing. This is considered to be a routine test for High voltage bushings.

**(v) Visible Discharge Test at Power Frequency**

The test is carried out to ascertain whether the given bushing will give rise to ratio interference or not during operation. The test is carried out in a dark room. The voltage as specified is applied to the bushing (IS 2099). No discharge other than that from the grading rings or arcing horns should be visible.

**(vi) Power Frequency Flash Over or Puncture Test**

(Under Oil): The bushing is either immersed fully in oil or is installed as in service condition. This test is carried out to ascertain that the internal breakdown strength of the bushing is 15% more than the power frequency momentary dry withstand test value.

**Testing Of power capacitor**

power capacitor are one of part of the modern power system. These are used to control the voltage profile of the system. Following tests are carried out on shunt power capacitors (IS 2834):

**(i) Routine Tests**

Routine tests are carried out on all capacitors at the manufacturer‘s premises. During testing, the capacitors should not breakdown or behave abnormally or show any visible deterioration.

**(ii) Test for Output**

Ammeter and Voltmeter can be used to measure the kVAr and capacitance of the capacitor. The kVAr calculated should not differ by more than –5 to +10% of the specified value for capacitor units and 0 to10% for capacitors banks. The a.c. supply used for testing capacitor should have frequency between 40 Hz to 60 Hz, preferably as near as possible to the rated frequency and the harmonics should be minimum.

**(iii) Test between Terminals**

Every capacitor is subjected to one of the following two tests for 10secs:

(iii) D.C. test; the test voltage being $V_t = 4.3\ V_0$

(iv) A.C. test $V_t = 2.15\ V_0$,

where $V_0$ is the rms value of the voltage between terminals which in the test connection gives the same dielectric stress in the capacitor element as the rated voltage

$V_n$ gives in normal service.

### (iv) Test between Line Terminals and Container (For capacitor units)

An a.c. voltage of value specified in column 2 of Table 5.1 is applied between the terminals (short-circuited) of the capacitor unit and its container and is maintained for one minute, no damage to the capacitor should be observed. Figures with single star represent values corresponding to reduced insulation level (Effectively grounded system) and with double star full insulation level (non-effectively grounded system).

### (v) IR Test:

The insulation resistance of the test capacitor is measured with the help of a megger. The megger is connected between one terminal of the capacitor and the container. The test voltage shall be d.c. voltage not less than 500 volts and the acceptable value of IR is more than 50 megohms.

### (vi) Test for efficiency of Discharge Device:

In order to provide safety to personnel who would be working on the capacitors, it is desirable to connect very high resistance across the terminals of the capacitor so that they get discharged in about a few seconds after the supply is switched off. The residual capacitor voltage after the supply voltage is switched off should reduce to 50 volts in less than one minute of the capacitor is rated up to 650 volts and 5 minutes if the capacitor is rated for voltage more than 650 volts. A d.c. voltage 2 × rms rated voltage of the capacitor is applied across the parallel combination of R and C where C is the capacitance of the capacitor under test and R is the high resistance connected across the capacitor. The supply is switched off and the fall in voltage across the capacitor as a function of time is recorded. If C is in microfarads and R in ohms, the time to discharge to 50 volts can be calculated from the formula $t = 2.3 \times 10^{-6} CR (\log_{10} V - 1.7)$ secs Where V is the rated rms voltage of the capacitor in volts.

## Type Tests

The type tests are carried out only once by the manufacturer to prove that the design of capacitor complies with the design requirements:

**(i) Dielectric Loss Angle Test (p.f. test):**

High voltage Schering Bridge is used to measure dielectric power factor. The voltage applied is the rated voltage and at temperatures 27°C ± 2°C. The value of the loss angle tan δ should not be more than10% the value agreed to between the manufacturer and the purchaser and it should not exceed 0.0035for mineral oil impregnates and 0.005 for chlorinated impregnates.

**(ii) Test for Capacitor Loss:**

The capacitor loss includes the dielectric loss of the capacitor and the V2/R loss in the discharge resistance which is permanently connected. The dielectric loss can be evaluated from the loss angle as obtained in the previous test and V2/R loss can also be calculated. The total

power loss should not be more than 10% of the value agreed to between the manufacturer and consumer.

**(iii) Stability Test:**

The capacitor is placed in an enclosure whose temperature is maintained at ±2°C above the maximum working temperature for 48 hours. The loss angle is measured after 16 hours, 24 hours and 48 hours using High voltage Schering Bridge at rated frequency and at voltage 1.2 times the rated voltage. If the respective values of loss angle are tan δ1, tan δ2 and tan δ3, these values should satisfy the following relations (anyone of them):

(a) $\tan \delta_1 + \tan \delta_2 \leq 2 \tan \delta_2 < 2.1 \tan \delta_1$ or (b) $\tan \delta_1 \geq \tan \delta_2 \geq \tan \delta_3$

**(iv) Impulse voltage test between terminal and container:**

The capacitor is subjected to impulse voltage of 1/50 μ sec. Wave and magnitude as stipulated in column 3 of Table 5.1. Five impulses of either polarity should be applied between the terminals (joined together) and the container. It should withstand this voltage without causing any flash over.