Testing of Isolator

An isolator or a disconnector is a mechanical switching device, which provides in the open position, an isolating distance in accordance with special requirements. An isolator is capable of opening and closing a circuit when either negligible current is broken or made or when no significant change in the voltage across the terminals of each of the poles of the isolator occurs. It is also capable of carrying currents under normal circuit conditions, and carrying for a specified time, currents under abnormal conditions such as those of a short circuit.

High Voltage Test on Isolators is intended to evaluate

(a) the constructional and operational characteristics, and

(b) the electrical characteristics of the circuit Which the switch or the breaker has to interrupt or make.

The different characteristics of High Voltage Test on Isolators or a switch may be summarized as per the following groups.

- The electrical characteristics which determine the arcing voltage, the current chopping characteristics, the residual current, the rate of decrease of conductance of the arc space and the plasma, and the shunting effects in interruption.
- Other physical characteristics including the media in which the arc is extinguished, the pressure developed or impressed at the point of interruption, the speed of the contact travel, the number of breaks, the size of the arcing chamber, and the materials and configuration of the circuit interruption.
- The characteristics of the circuit include the degree of electrical loading, the normally generated or applied voltage, the type of fault in the system which the breaker has to clear, the time of interruption, the time constant, the natural frequency and the power factor of the circuit, the rate of rise of recovery voltage, the re striking voltage, the decrease in the a.c. component of the short circuit current, and the degree of asymmetry and the d.c. component of the short circuit current.

To assess the above factors, the main tests conducted on the circuit breakers and isolator switches are

- the dielectric tests or overvoltage tests
- the temperature rise tests,
- the mechanical tests, and
- the short circuit tests

Dielectric tests consist of overvoltage withstand tests of power frequency, lightning and switching impulse voltages. Tests are done for both internal and external insulation with the switch or circuit breaker in both the open and closed positions. In the open position, the test voltage levels are 15% higher than the test voltages used when the breaker is in closed position. As such there is always the possibility of line to ground flashover. To avoid this, the High Voltage Test on Circuit Breaker and Isolators is mounted on insulators above the ground, and hence the insulation level of the body of the circuit breaker is raised.

The impulse tests with the lightning impulse wave of standard shape are done in a similar manner as in the case of insulators. In addition, the switching surge tests with switching over voltages are done on High Voltage Test on Circuit Breaker and Isolators and isolators to assess their performance under over voltages due to switching operations.

Temperature rise and mechanical tests are type tests on circuit breakers and are done according to the specifications.

In the case of isolators, the short circuit tests are conducted only with the limited purpose to determine their capacity to carry the rated short circuit current for a given duration; and no breaking or making current tests is done.

High Voltage Schering bridge (Parallel circuit)

6.4.1 Balancing the Bridge

For ready reference Fig. 6.5 is reproduced here and its phasor diagram under balanced condition is drawn in Fig. 6.10 (*b*)

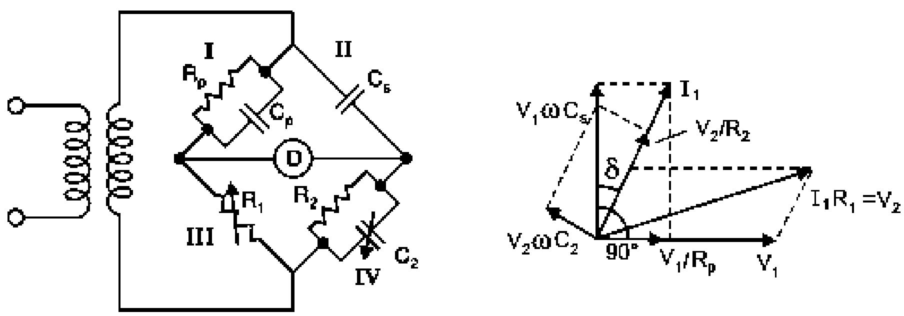


Fig. 6.10 (*a*) Schering bridge (*b*) Phasor diagram

The bridge is balanced by successive variation of R_1 and C_2 until on the oscilloscope (Detector) a horizontal straight line is observed:

At balance $$\frac{Z_I}{Z_{II}} = \frac{Z_{III}}{Z_{IV}}$$

Now $$Z_I = \frac{R_p}{1 + j\,\omega\,C_p R_p}$$

$$Z_{II} = \frac{1}{j\,\omega\,C_s}$$

$$Z_{III} = R_1 \text{ and } Z_{IV} = \frac{R_2}{1 + j\,\omega\,C_2 R_2}$$

From balance equation we have

$$\frac{R_p}{R_1\ (1 + i\omega\ C_p R_p)} = \frac{1/j\ \omega\ C_s\ (1 + j\omega\ C_2 R_2)}{R_2}$$

or
$$\frac{R_p\ (1 - j\ \omega\ C_p R_p)}{R_1 \left(1 + \omega^2 C_p^2 R_p^2\right)} = \frac{1 + j\ \omega\ C_2 R_2}{j\ \omega\ C_s R_2}$$

or
$$\frac{R_p}{R_1 \left(1 + \omega^2 C_p^2 R_p^2\right)} - \frac{j\ \omega\ C_p R_p^2}{R_1 \left(1 + \omega^2 C_p^2 R_p^2\right)} = -\frac{j}{\omega C_s R_2} + \frac{C_2}{C_s}$$

Equating real part, we have

$$\frac{R_p}{R_1 \left(1 + \omega^2 C_p^2 R_p^2\right)} = \frac{C_2}{C_s}$$

and equating imaginary part, we have

$$\frac{\omega\ C_p R_p^2}{R_1 \left(1 + \omega^2\ C_p^2 R_p^2\right)} = \frac{1}{\omega C_s R_2}$$

Now $\tan\delta$ from the phasor diagram

$$\tan\delta = \frac{V_1/R_p}{V_1\omega C_p} = \frac{1}{\omega C_p R_p} = \frac{V_2\ \omega\ C_2}{V_2/R_2} = \omega C_2 R_2$$

Also
$$\cos\delta = \frac{V_1\omega C_p}{V_1\sqrt{\left(1/R_p^2\right) + \omega^2 C_p^2}}$$

or
$$\cos^2\delta = \frac{\omega^2 C_p^2 R_p^2}{1+\omega^2 C_p^2 R_p^2}$$

or
$$\frac{\omega C_p R_p}{1+\omega^2 C_p^2 R_p^2} = \cos^2\delta \cdot \frac{1}{\omega\ C_p R_p} = \frac{R_1}{\omega\ C_s R_2 R_p}$$

or
$$C_p = \cos^2\delta\ C_s\ \frac{R_2}{R_1}$$

Since δ is usually very small $\cos\delta = 1$

Therefore
$$C_p \doteqdot C_s\ \frac{R_2}{R_1}$$

and
$$\tan\delta_p = \omega\ C_2 R_2$$

and since
$$\frac{1}{\omega\ C_p R_p} = \omega\ C_2 R_2$$

or
$$\omega^2 C_p R_p C_2 R_2 = 1$$

or
$$R_p = \frac{1}{\omega^2 R_2 C_2 C_p} \doteqdot \frac{R_1}{\omega^2 R_2 C_2 C_s R_2} \doteqdot \frac{R_1}{\omega^2 C_2 C_s R_2^2}$$

Note: For Schering Bridge (Series circuit is already discussed in Class)

For the parallel circuit the dissipation factor is given by

$$\tan\delta = \frac{1}{\omega C_p R_p}$$

and for the series circuit

$$\tan\delta = \omega\ C_s R_s$$

Example 6.3. *A 33 kV, 50 Hz high voltage Schering bridge is used to test a sample of insulation. The various arms have the following parameters on balance. The standard capacitance 500 pF, the resistive branch 800 ohm and branch with parallel combination of resistance and capacitance has values 180 ohms and 0.15 μF. Determine the value of the capacitance of this sample its parallel equivalent loss resistance, the p.f. and the power loss under these test conditions.*

Solution: Given

$$C_s = 500 \text{ pF}$$
$$R_1 = 800 \text{ ohm}$$
$$R_2 = 180 \text{ ohm}$$
$$C_2 = 0.15 \ \mu\text{F}$$

Now

$$C_p = C_s \frac{R_2}{R_1} = 500 \times 10^{-12} \times \frac{180}{800} = 112.5 \text{ pF}$$

$$R_p = \frac{R_1}{\omega^2 C_2 \, C_s \, R_2^2} = \frac{800}{314^2 \times 500 \times 10^{-12} \times 0.15 \times 10^{-6} \times 180^2}$$

$$= \frac{800}{2.3958 \times 10^{11} \times 10^{18}} = 333.9 \times 10^7 = 3339 \text{ M}\Omega$$

$$\text{p.f.} = \tan \delta_p = \frac{1}{\omega C_p R_p} = \frac{1}{314 \times 112.5 \times 10^{-12} \times 3339 \times 10^6}$$

$$= \frac{1}{117.95} \ 0.008478 \quad \textbf{Ans.}$$

Power loss

$$= \frac{V^2}{R} = \frac{33^2 \times 10^6}{3339 \times 10^6}$$

$$= 0.326 \text{ watts} \quad \textbf{Ans.}$$

What is the three electrode arrangement used in dielectric measurements? Explain with sketches the electrode arrangements for solid specimen and liquid specimen.

9.2.3 Measuring Cells

The three-terminal electrode system and the measuring cell used are shown in Fig. 9.2. The measuring cell is usually a shallow metalbox provided with insulating terminals. The box itself is connected to the guard electrode and is grounded if the guard terminal is grounded. The connecting lead for the guarded electrode is taken through a shielded wire. In case the unguarded electrode is grounded, the entire box is to be placed on insulated supports and is to be placed in a grounded shield to eliminate induced voltages, and the lead from the guard electrode is doubly shielded.

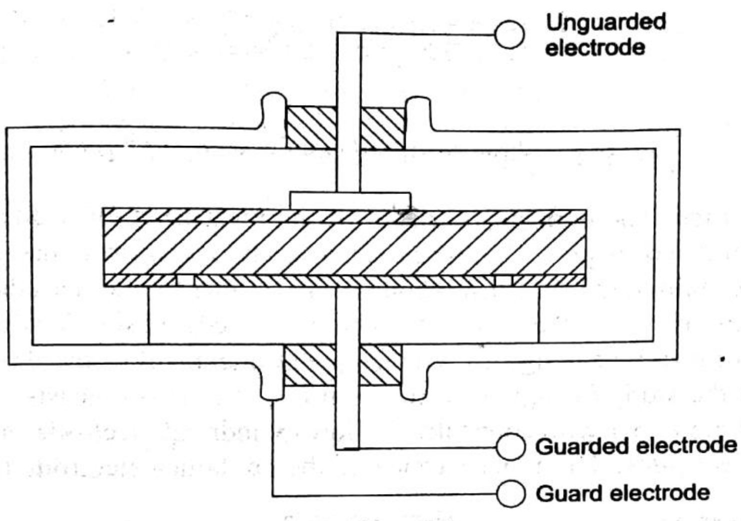


Fig. 9.2 *Three-terminal cell for study of solids*

In the simple two-terminal system, the measuring cell itself is the grounded support for the specimen and a small solid wire is connected to the high-voltage terminal of the measuring circuit, as can be seen from Fig. 9.3. This is a simple and compact arrangement for quick measurements and requires less skill.

The arrangement used for the study of liquids is shown in Fig. 9.4. This consists of an outer cylindrical case and an inner cylinder with a cylindrical

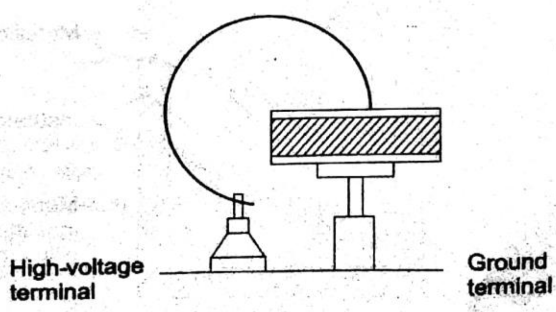


Fig. 9.3 *Stiff-wire connection for two-terminal measurement*

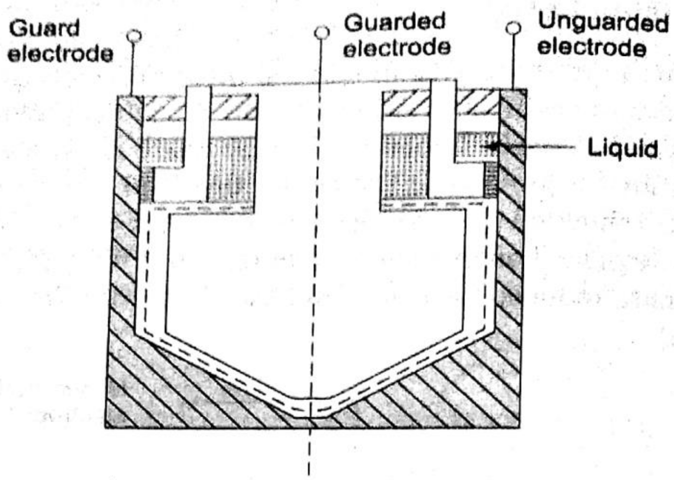


Fig. 9.4 *Three-terminal cell for study of liquids*

guard electrode. The opposing surfaces of the measuring electrodes should be carefully finished to give a polished surface, and a uniform spacing of about 0.25 mm is maintained. The insulation should be able to maintain the alignment of the electrode even at the highest temperatures used and should still allow easy disassembling and cleaning. Another simple arrangement of the three-electrode system for the study of liquids is shown in Fig. 9.5. This consists of a metallic cylindrical container with concentric hollow cylindrical electrodes as guard and guarded electrodes. The inner surface of the container electrode (unguarded)

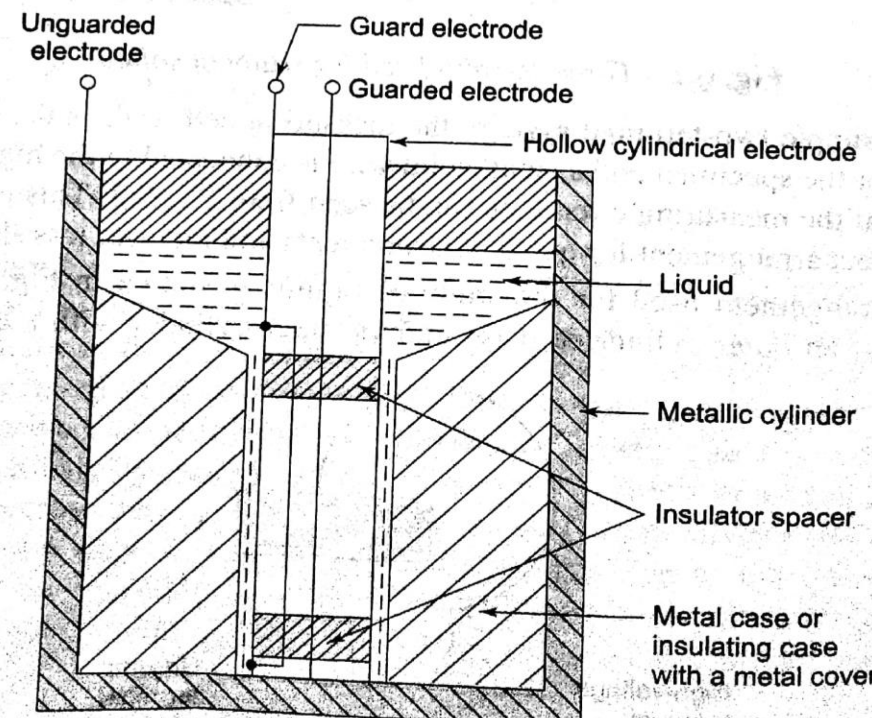


Fig. 9.5 *Three-terminal cell for study of liquids*

and the outer surfaces of the guard and unguarded electrodes should be carefully finished and a clearance of about 0.25 to 0.5 mm should be accurately maintained. The arrangement requires less liquid (usually only about 1 to 2 ml).

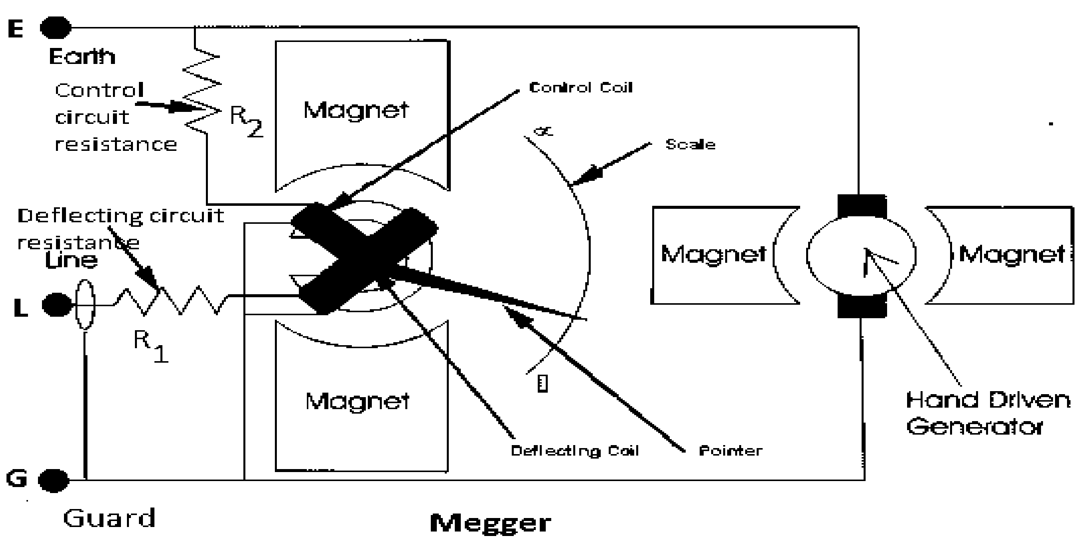
What is insulation testing? Explain how insulation quality can be tested using dc voltage.

Insulation resistance testing is used as a quality control measurement. The insulation resistance (IR) test (also commonly known as a Megger) is a spot insulation test which uses an applied DC voltage (typically either 250Vdc, 500Vdc or 1,000Vdc for low voltage equipment

DC alone is used because we need to measure only the resistance of the winding insulation. If we use AC to conduct the insulation test, we will be measuring impedance instead of the resistance as the insulation has a substantial capacitive reactance.

The health of the winding is best indicated by its resistance and not its impedance. This is why only DC is used to measure the insulation resistance. That means, the insulation resistance test measures the resistive component of the insulator. The capacitive component is ignored. The equipment is only safe if at least a given insulation resistance (a value specified by a standard) is maintained. The insulation resistance test is performed to check this resistance. If the insulation resistance test is performed using an AC voltage, we end up measuring the impedance of the capacitive component and prevents us from obtaining the required insulation resistance. This is the reason why the insulation resistance test is performed using a DC voltage.

Insulation resistance quality of an electrical system degrades with time, environmental conditions i.e. temperature, humidity, moisture and dust particles. It also deteriorates due to the presence of electrical and mechanical stress. So, its become necessary to check the IR (Insulation resistance) of the equipment at regular intervals to avoid any major electrical shock, which could be fatal.



Working Principle of Megger:

The device enables us to measure electrical leakage in wire, results are very reliable as we shall be passing electric current through device while we are testing.

- Voltage for testing produced by hand operated megger by rotation of crank in case of hand operated type, a battery is used for electronic tester.
- 500 Volt DC is sufficient for performing test on equipment range up to 440 Volts.
- 1000 V to 5000 V is used for testing for high voltage electrical systems.
- Deflecting coil or current coil connected in series and allows flow of electric current in the circuit being tested.
- The control coil also known as pressure coil is connected across the circuit.
- Current limiting resistor connected in series with control and deflecting coil to protect damage in case of very low resistance in external circuit.
- In hand operated megger electromagnetic induction effect is used to produce the test voltage i.e. armature arranges to move in permanent magnetic field or vice versa.
- Whereas in electronic type megger battery is used to produce the testing voltage.
- As the voltage increases in external circuit the deflection of pointer increases and deflection of pointer decreases with a increases of current.
- Hence, resultant torque is directly proportional to voltage and inversely proportional to current.
- When electric circuit being tested is open, torque due to voltage coil will be maximum and pointer shows ‘infinity’ means no shorting throughout the circuit and has maximum resistance within the circuit under test.
- If there is short circuit pointer shows ‘zero’, which means ‘NO’ resistance within circuit being tested.

The deflection torque is produced with megger tester due to the magnetic field produced by voltage and current, similarly like Ohm’s law Torque of the megger varies in ration with V/I, (Ohm's Law :- V = IR or R = V/I). Electrical resistance to be measured is connected across the generator and in series with deflecting coil. Produced torque shall be in opposite direction if current supplied to the coil.

1. High resistance = No current :- No current shall flow through deflecting coil, if resistance is very high i.e. infinity position of pointer.
2. Small resistance = High current :- If circuit measures small resistance allows a high electric current to pass through deflecting coil, i.e. produced torque make the pointer to set at ‘ZERO’.
3. Intermediate resistance = varied current :- If measured resistance is intermediate, produced torque align or set the pointer between the range of ‘ZERO to INIFINITY’.