

Chroma Systems Solutions, Inc.

# A Practical Guide to Dielectric Testing

**19032 Series Electrical Safety Analyzer & 19050 Series Hipot Tester  
AC/DC/IR/SCAN**

Keywords: Dielectric tests, insulation resistance tests, hipot test

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## Abstract

Most manufacturers of electrical or electronic equipment are required to make dielectric tests on the products they produce. Dielectric tests are measurements of both insulation resistance and of dielectric strength. These tests are performed in order to:

- Detect manufacturing faults on electrical equipment.
- Verify the quality of insulating material used in electrical equipment.
- Verify that electrical installation was done correctly.

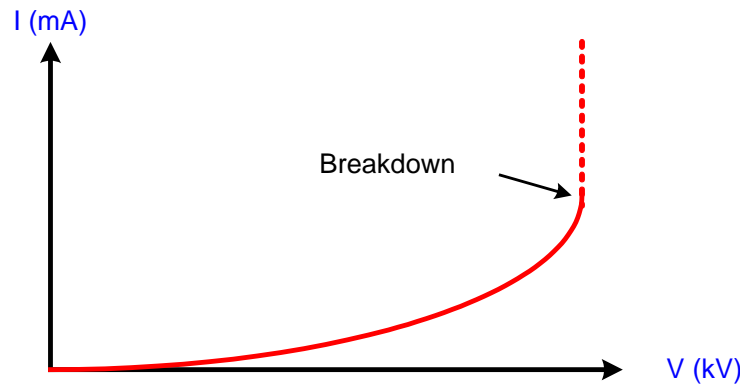
Let's look at insulation resistance testing, AC & DC Hipot testing, and some of the regulations that govern electrical safety testing (EST).

## What is an Insulation Resistance Test?

Insulation resistance (IR) is a characteristic of an insulating material that, being subject to voltage, the leakage current flowing through it stays within acceptable limits. Measuring insulation resistance is a fairly straightforward procedure. Find two conductive points between which there is insulation, connect the two points to an insulation tester (also called megohmmeter), and measure the resistance of the insulation between the two points. The leakage distance is the smallest required distance, measured on the surface of the insulating material, between two conductive points, to avoid breakdown. Dielectric strength is the ratio between the voltage at which breakdown of the insulating material occurs and the distance between the two points.

In an IR test, stable DC voltage—usually less than 1000V—is applied across the connection points to cause a small amount of current to flow through the insulating material. The insulation between two points can generally be thought of as a capacitive component; that is, when the voltage is applied, the insulation "soaks" up current (i.e., it builds up a charge). This is the leakage current. Leakage current is used to calculate the insulation resistance. When the voltage is released, the device discharges. The

voltage across the insulation, divided by the leakage current (Ohm's law,  $R = V/I$ ) equals the insulation resistance.



Insulation Breakdown (Leakage Current vs. Applied Voltage)

Cables, connectors, switches, transformers, resistors, capacitors, printed circuit boards and other devices must have a minimum insulation resistance. (To avoid damage, such a device may also be specified for test at a particular voltage.) A measurement of insulation resistance, along with experience and guidelines on what to expect, indicates whether a device meets the resistance specifications before being installed in a new product.

To avoid leakage currents being created by the measurement procedure itself, take the following precautions:

Measurement leads should have good shielding (often connected to guard potential), and be as short as possible.

The operator placing a hand close to the device under test can alter or make unstable the measurement result. Some clothing can generate static electricity or electrical fields that can alter the measurement results.

## What is a Hipot Test?

If insulation can withstand a voltage above its normal rating for a given period of time, it will function adequately at its normal voltage levels. The Hipot test (sometimes called a Dielectric Withstand test or Breakdown test) stresses the insulation well beyond what it would encounter in normal use. The Hipot test is probably the best known, the most often performed and most important production line safety test, and must be performed on every consumer and industrial appliance. The test also uncovers defects in the insulating material or physical space between conductors.

The insulation that concerns us most in an electrical product is that which isolates the power line circuit; for example, the insulation between primary and secondary windings of a transformer. Because an AC

power distribution system is ground-referenced, current will flow from a product power line to ground through the path of least resistance.

In a house, all neutral wires are connected to ground at some point. Any power line that contacts a path to ground will cause current to flow. What would happen if a household appliance with improper grounding had a breakdown of the insulation between the power line and the appliance case? And you had one hand on the appliance case and the other hand on the kitchen sink? Then you become the ground path, with shocking results! Many people have been injured as they used electrical products with faulty insulation and/or defective grounding.

Perform a Hipot test by connecting the RTN/LOW terminal of the tester to one side of the device and the HV terminal (or probe) to the other side. (When testing an appliance, the low side is usually connected to the ground and/or the exposed case of the product and the high side to the power line and neutral tied together.) To prevent damaging the device, the test voltage should be “ramped,” or increased gradually. The test instrument monitors the current for changes that exceed the limit for steady state, or short duration pulses (arcs), or both. The voltage level is maintained for a programmed duration, after which the voltage is shut off and the device discharged.

If at any time while the voltage is applied the current limit is exceeded, the high voltage is automatically turned off and a breakdown indicated. The actual voltage and current at breakdown is often indicated. If no breakdown occurs over the specified test time, the tester would indicate a PASS, signifying that the device is good. Only after the tester high voltage is turned off and the device allowed to discharge should the device be disconnected.

Since a Hipot test can be destructive, perform an insulation resistance measurement on a device before and after a Hipot test. This can be done most efficiently with a tester running Chroma’s [Captivate automatic test software](#).

## Requirements and Regulations

Government and independent testing agencies require Hipot testing on each product coming off a production test line. The specification most often used requires a product be able to withstand voltages equal to approximately twice the normal operating line voltage plus 1000 volts. Hipot test equipment must also be sensitive enough to detect brief increases, or arcs, in current flow as well as the steady-state current.

Another motivation is product liability. Any manufacturer who sells a defective product is subject to liability for physical harm caused to the user. A related factor is occupational safety. It is the responsibility of employers to provide non-hazardous tools for its employees to use and to train them in their use. Under The Occupational Safety and Health Act (OSHA) any company can use a product only if approved by OSHA regulations, including UL approval.

The amount of time a voltage must be applied is also specified in many standards. The tester must adjust the amount of time the high voltage is applied, with one second and one minute the most common durations.

**Table 1: Partial Listing of Regulatory Agencies**

Agency	Acronym	Country of Origin
Occupational Safety and Health Association	OSHA	United States
Underwriters Laboratories	UL	United States
Canadian Standards Association	CSA	Canada
International Electrotechnical Commission	IEC	Switzerland
Association of German Electrical Engineers	VDE	Germany
British Standards Institute	BSI	United Kingdom
Japanese Standards Association	JIS	Japan
International Standards Association	ISO	Switzerland

## AC or DC? That is the Question

Specifications can call for both AC and DC testing depending on the specific conditions under which power will be applied to the product. AC is often specified more than DC and can be more stressful to the product, accelerating breakdown. For example, power line consumer products are much more likely to experience AC voltage transients than DC transients. A common rule is to test a device with the same type voltage applied during its final use.

### *Advantages of AC Testing –*

- AC stresses the insulation equally in both polarities.
- No waiting required after applying a test voltage.
- Not necessary to discharge the product after testing.
- AC accelerates the breakdown in flawed material.
- Some agencies do not consider DC testing an acceptable alternative to AC testing.

### *Disadvantages of AC Testing –*

- AC Hipot tests on capacitive devices require more current (reactive current) than DC Hipot tests using the same voltage as the AC peak. (Many people feel that excessive current at high voltage through a capacitive device can damage the product or cause subtle weakening of the insulation, with failure occurring when the product is in use.)
- If a device is characterized before the Hipot test by measuring its insulation resistance and again measured after Hipot, a comparison of the two values will detect subtle failures. In many cases the apparent resistance of the dielectric will be greater after the test (due to dielectric absorption of the material). The test sequencing possible with the Chroma testers becomes that much more important in this particular situation.

### *Advantages of DC Testing –*

- DC Hipot testing is often used for non-destructive testing by raising the test voltage in small increments and waiting for the charging current to diminish after each step. Should the current rise suddenly, a breakdown can be predicted. Stopping a test at this point will prevent destruction of the material but does not tell where the breakdown would have occurred. This technique increases the required test time.
- DC testing is the only choice for testing particular device parameters such as the voltage rating of capacitors or the inverse voltage rating of diodes.

### *Disadvantages of DC Testing –*

- For highly capacitive devices DC testing is less practical since it is necessary to raise the voltage slowly, otherwise the total current can reach the leakage threshold almost instantaneously and give false indication of failure. The gradual voltage rise not only adds time to the test but requires that the test be very carefully controlled. It is then necessary to discharge the device for a considerable time afterwards.
- DC testing is not considered as an equivalent to AC testing by most agencies.
- In many cases an AC test can be used in place of a line voltage leakage test, a DC test cannot substitute for a line voltage leakage test.
- DC stresses the insulation in one polarity only versus AC, which stresses the insulation in both polarities.

## **Conclusion**

The purpose of a dielectric analyzer is to verify the quality and electrical safety of a product. The testing of dielectric materials in a production environment can be destructive to some percentage of the product. Should it be an AC or DC test? It depends on how the product will be used. Does it really have to be destructive? Non-destructive testing has become more popular when limitation of maximum current is combined with rapid removal of the voltage source.

A more acceptable technique is to perform the non-destructive insulation resistance test before and after the Hipot test. Comparing the variations before and after provides more control of product performance over the long run.



19032 Series Electrical Safety Analyzer



19050 Series Hipot Tester AC/DC/IR/SCAN

