DIELECTRIC WITHSTAND TEST

The **Dielectric Withstand Test** is the third test required by the electrical safety testing standards.

The **Dielectric Withstand Test** consists in measuring the current leak of a device under test, while phase and neutral are short circuited together. The measure result of a **Dielectric Withstand Test** is a current value, which has to be lower than the indicated limit from the international standards.

A **Dielectric Withstand Tester** (also called hipot tester, dielectric strength tester, flash tester, high voltage tester) is then used to measure this current.

DIELECTRIC WITHSTAND TEST VOLTAGES

It is performed in AC or DC with voltages varying from some hundred volts to several tens of kilovolts. The choice of the nature and value of the test voltage is determined by standards which apply to the product tested.
In the absence of standards, the following rule of thumb is used: the test is always performed with a voltage of same nature as that under which the sample operates. Example: Direct for a battery. Alternating for a transformer.

The maximum value is given by the formula: U test = 2 x U operating +1000 V.

A manufacturer of laundry-iron will therefore perform the test under a voltage:
Utest = 2x230VAC + 1000VAC
= 1460 VAC.

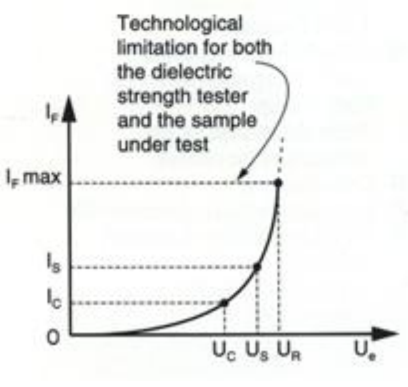
The dielectric strength test can be made to be destructive or non-destructive.

DESTRUCTIVE TESTS

Certain standardized tests require the application of a high power source to the sample to which the dielectric strength test is applied. This entails the destruction of the equipment tested, through carbonization of the insulating material. These tests are above all used to test components or equipment employed in electricity or electro-technology of medium and high power (circuit-breakers, switches, transformers, insulators, etc...).

NON-DESTRUCTIVE TESTS

Diagram 1: Evolution of leakage current as a function of test voltage.



It is in this area that the hipot tester evolved most and obtained increasingly higher performance in the accuracy of the measurements made and the number of possibilities offered to the user.

Non-destructive tests feature the use of low power dielectric strength testers whose short-circuit current does not exceed a few milliamps and whose accurate and swift detection system provides for the immediate suppression of the test voltage upon a breakdown.

This rapid vanishing, combined with a current limitation, in most cases avoids the creation of irreparable perforations in the insulators and the formation of furrows or faults with deposits of carbonated residues on the surface or inside the dielectrics. The systematic testing of components or equipment during manufacturing makes this non-destructive condition mandatory when testing a sample.

DETECTION OF DIELECTRIC STRENGTH BREAKDOWNS

The exact determination of the breakdown voltage must therefore be attached to the measurement of an electrical value characteristic of the dielectric breakdown phenomenon. This parameter is the current flowing through the sample subjected to the dielectric. Two detection modes are actually available on measuring instruments:

- current threshold detection
- current variation detection

CURRENT THRESHOLD DETECTION

When a test voltage is applied to a sample, you observe - up to a certain value of the latter - a proportional increase in the leakage current; this current is due to the insulation resistance and/or the capacitance of the item tested (with AC, or by load effect in DC). As shown in Diagram 1, as from the voltage Uc, the leakage current increases very swiftly and the breakdown voltage is reached for value Ue.

The current is then at a maximum; its value is determined by the current capacitance of the dielectric strength test station, or - an instantaneous value - by the discharge current of the capacitive element of the sample (value that cannot be tested by the dielectric strength tester and which can in certain cases involve destruction of the insulator). Current threshold detection consists in choosing a value Is of the leakage current, corresponding to a voltage Us very similar to Ur, and to consider as bad any sample whose leakage current exceeds the value Is chosen as detection threshold. The most widespread value of the threshold current, and the one generally adopted for non-destructive tests, is 1mA.

Although the use of this detection method and the choice of this value does not offer any difficulty for DC tests on purely resistive components (Ic being around ten micro-amps), it becomes inaccurate and delicate to use for AC tests on capacitive elements.

CURRENT VARIATION DETECTION

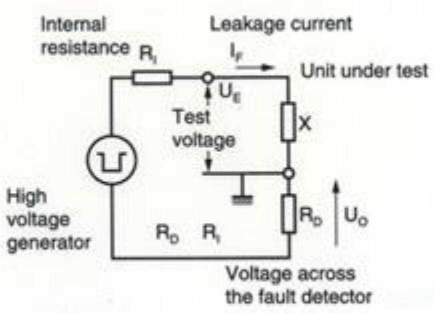


Diagram 2: Simplified test loop

This mode of detection cuts out the defects of the previous method; it is justified by the actual nature of the breakdown phenomena. Through observation of the breakdown phenomena, via oscilloscopic methods, it is possible to assert that they are featured by very sharp variation in current in the test circuit; this latter consists of the dielectric strength test station and the sample tested (Diagram 2). The breakdown is always preceded by partial discharge phenomena that we shall analyze further on.

The breakdown current in itself generally has the form of an extremely steep positive-going edge pulse, lasting about 1 micro-second or even less, whose peak value is limited by the combined characteristics of the test station and the sample being tested. As shown in Diagram 3, the discharge pulse has practically no steady level and the pseudo - exponential negative - going edge whose time constant is variable (it depends on the transfers of energy in the dielectric at the time of the breakdown).

The use of detectors which only take into account the rapid variations in the leakage current can eliminate the causes of error due to the permanent current flowing through the sample (impedance of the element).

ΔIr = 1 mA variation is the value most currently employed to characterize a breakdown. It must be linked to the detector's response time. The response time is very important in determining the breakdown voltage. In fact, an over-rapid detection (less than 1 micro-second) would make the apparatus sensitive to the partial discharge phenomena preceding the breakdown. In return, a slow detection (more than some tens of micro-seconds) can make the apparatus insensitive to certain breakdowns whose energy (produce $\Delta If^2.\Delta t$) will be sufficient to be destructive, but whose duration is too short to be taken into account by the detector. The detector's response time should however be very short to avoid micro-carbonation phenomena on certain insulators or the definitive destruction of others.

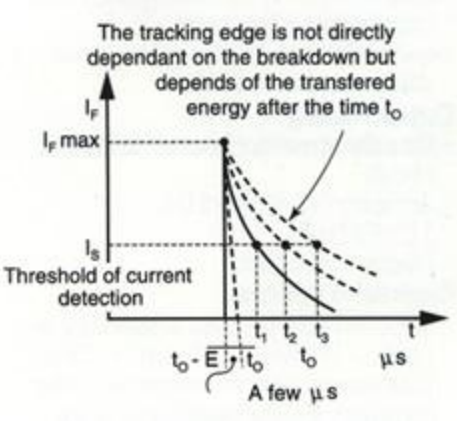


Diagram 3: Typical waveform of the leakage current variation during a breakdown .

For this reason and especially since 20 years ago (commercialization of the first ΔI current variation detectors), the response times lie between 19 and 20µs. Here again a different setting on precise and clearly defined grounds may be considered necessary. Nevertheless the availability of this parameter to an uninformed operator risks making the breakdown station systematically destructive and the results obtained perfectly incoherent, if the initial conditions and the reasons for their choice have not been clearly indicated. Moreover, it is easy to imagine the divergence of views which would not fail to arise between customers and suppliers and also between production and "quality control" departments. Numerous observations on a very broad variety of components and sub-assemblies have fixed an optimum response time of around 10 µs.