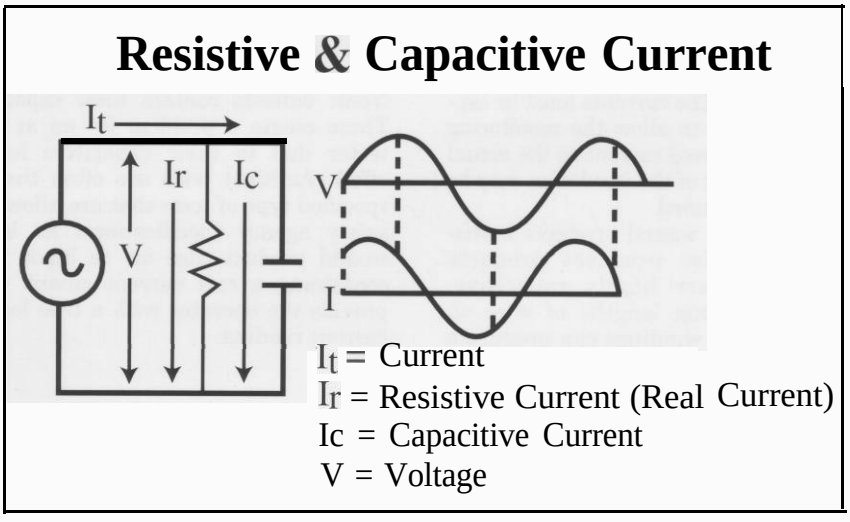
an ep&t product feature
Instrumentation and Test Equipment

Real vs total current ac hipot testing determines true insulation quality



Real current is due to the insulation resistance of the product and the applied voltage

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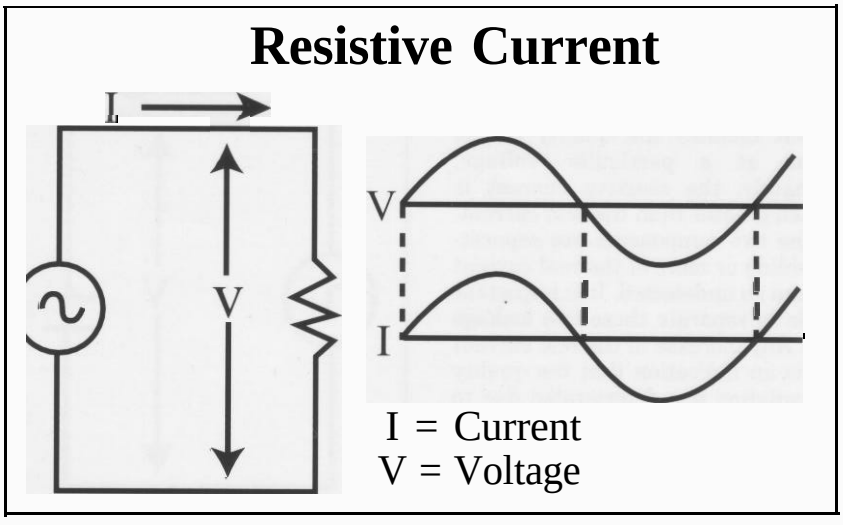
The ac dielectric withstand test (hipot) is the most commonly specified product safety test that is required as both a performance or type test, and a 100% production line test on electrical products. The test is performed on the dielectric material, or insulation of a product to determine if the material can withstand a deliberate application of high voltage without breaking down.

During normal operating conditions, the starting and stopping of electrical motors can generate switching transients in electrical products. Magnetic fields are created when current flows through inductive coils. When the power is removed the magnetic field collapses, which generates a current in the opposite direction. This current can generate a high voltage impulse on the power distribution system which causes stress to the insulation within the electrical product.

The insulation in a product of most concern is that which separates power line circuits from everything else. Examples include the secondary or low voltage circuits or isolated power supplies inside the product, whether the product is grounded or not. It is this insulation which prevents current from the incoming power source turning into a hazardous condition by finding another unintended ground path such as a human body.

When performing hipot tests, voltage is applied between current carrying conductors and accessible conductive surfaces to test the insulation of the product. Leakage current due to the insulation resistance of the product is resistive, and in phase with the applied voltage. One problem which arises is that the circuit under test is also a circuit for a capacitor, defined as two conductors separated by a dielectric material. Application of an ac test voltage to a capacitive element causes a reactive current that is 90.degrees out of phase with the applied voltage.



Leakage current ***due to the insulation resistance*** of the ***product is*** resistive, and in ***phase with the applied voltage.***

The leakage current that is read by most ac hipot testers is the vector sum or total of the reactive current, and the resistive leakage current or real current. The real current is due to the insulation resistance of the product and the applied voltage. This is why, in some applications, it is important to use a commercially available ac hipot tester with the capability to read real current.

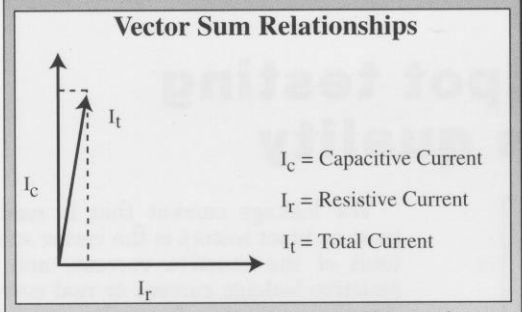
The alternative is to use a dc hipot tester. Its advantage is that once the capacitance of the item under test is charged to the test potential, the only leakage current remaining is due to the insulation resistance of the product.

Unfortunately, dc hipot tests are not always accepted by safety agencies. There are also some other disadvantages to performing dc hipot tests. The agency-specitied dc equivalent test voltage is usually a minimum of 1.414 times the ac voltage. Dc hipot testing is oRen considered to be not as stringent as an ac test because it only stresses the insulation in one polarity. The voltage must be ramped at a slow enough rate to not cause a false failure indication on the hipot due to the chargingcurrent. In addition, the item under test must be discharged at the end of the test. For these reasons many manufacturers choose ac hipot testing even if the specification they are testing to allows for dc hipot testing.

The physical design of a product is pri-

Graphic example

A graphic example of the real current issue can be seen in this circuit. A combination of resistive and capacitive currents are produced on the device under test (DUT) which will produce some level of phase shift between the voltage and current sine waves. The



total current sine wave is no longer either in phase or 90 degrees out of phase with the voltage waveform.

To determine the real current we need to sample the signal of the instantaneous voltage and current and calculate the real or average power (in watts). This includes information regarding the real current phase angle. This information is fed into the tester's CPU, which then divides the average power by the average voltage and the result is the real current.

marily the controlling factor that determines its capacitive reactance. Today many products have higher capacitive leakage currents because filter capacitors have been added to the input circuits to enable them to comply with EMC regulations. The resistive leakage current within a product is primarily dependent on the kind of insulating material that has been chosen and the applied voltage.

The exact value of the resistive leakage or real current is usually the determining factor that dictates the quality of the insulation at a particular voltage. Unfortunately, the reactive current is often much greater than the real current. Unless the two components are separated, a doubling or more of the real current leakage can go undetected. It is important to be able to separate these two leakage currents. Any increase in the real current leakage is an indication that the quality of the insulation has deteriorated due to age or workmanship issues during the manufacturing cycle.

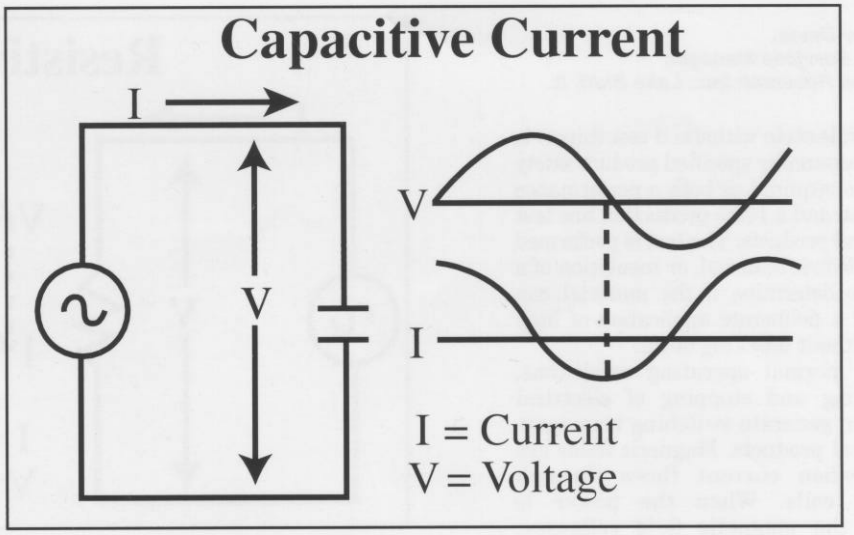
Today, there are many applications where it is necessary to separate these two leakage currents. One is in the testing of wiring harnesses. It is common for wires and cables used in the manufacturing of these harnesses to be hot-stamped with an ID or part number at fixed intervals. If done incorrectly the process can actually damage the insulation on the wire. Samples of the wire must be tested during the manufacturing process as well as the completed wire.

Due to the long lengths of these wires, the capacitance may be very large, which would make the capacitive leakage current much larger than the resistive leakage current. This makes it very difficult to determine if the insulation was damaged during the manufacturing cycle. The currents must be separated to allow the monitoring of the real current so the actual quality of the insulation may be determined.

The wound products industry also produces products that are highly capacitive. The long lengths of wire on stator windings can produce a highly distributed capacitance that results in a high total ac current leakage reading. This masks the resistive leakage current readings that indicate the true quality of the insulation system. It is usually mandated that an ac hipot tester be used in performing tests on wound products.

The US National Electrical Manufacturers Association (NEMA) specification MG 1-12.04 *Production High-Potential Testing of Small Motors* defines a dielectric failure as motors that have a real resistive leakage current exceeding 10 milliamperes. The specification states: 'A suitable evaluation of the insulation quality in production testing may be made without complete rupture of the insulation to ground. As a quality control procedure during manufacture, measurement of the resistive leakage current may be taken as a true evaluation of the effectiveness of the insulation system.'

A similar situation occurs in the lighting industry. Many products such as electronic ballasts contain filter capacitors. These create a problem for an ac hipot tester due to their capacitive loading effect. Ac hipot tests are often the only specified type of tests that are allowed by safety agency specifications. As in the wound product case an ac hipot tester containing a real current circuit would provide the operator with a true leakage current reading.



Application of an ac test voltage to a capacitive element causes a reactive current that is 90-degrees out of phase with the applied voltage.

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