Electrical Safety Testing Primer

Product Safety Tests are specified to be performed during the design, development and production stages of electrical products in order to ensure that they meet basic safety requirements. These tests aim to verify that electrical products will not jeopardize the safety of the people, domestic animals, and property of anyone who may come in contact with them. In an era of soaring liability costs, original manufacturers of electrical and electronic products must make sure every item is as safe as possible.

Electrical products are broken down into 2 categories: Class I and Class II products. Class I products are terminated in a three-pronged line cord containing a low impedance grounded connection to chassis. This connection prevents potentially lethal voltages from appearing on the chassis during a fault condition. Class II products, sometimes referred to as double-insulated products, are terminated in a two-pronged line cord without a ground connection. A Class II product's accessible live parts are encased in a chassis that is made of an insulating material, hence the term double-insulated.

Safety testing is required for both classes of products and is divided into two testing categories: design or type tests, and production line tests. Design tests are usually performed during the design phase of a product in order to verify design integrity and quality. These tests are often much more rigorous than production line tests. Production line tests are usually specified to be performed on 100% of all manufactured products before shipment.

Safety agencies which require compliance safety testing at both the initial product design stage and for routine production line testing include: Underwriters Laboratories, Inc. (UL), the Canadian Standards Association (CSA), the International Electrotechnical Commission (IEC), the British Standards Institution (BSI), the Association of German Electrical Engineers (VDE) and (TÜV), the Japanese Standards Association (JSI).

The Different Types of Safety Tests

Dielectric Withstand Test
The principle behind a Dielectric Voltage-Withstand test (also known as a Hipot test for high potential tester) is simple: if an electrical product's insulation will withstand a deliberate over-voltage condition for a specified period of time, it can be assumed that the insulation will protect a user from electric shock under normal operating conditions.

<u>Common Applications of the Dielectric Withstand Test</u>
Design (performance) testing: Determining design adequacy to meet service conditions.
Production Line testing: Detecting defects in material or workmanship during processing.
Acceptance testing: Proving minimum insulation requirements of purchased parts.
Repair Service testing: Determine reliability and safety of equipment repairs.

During a Dielectric Voltage-Withstand test, high voltage is applied from a product's mains-input lines to its chassis for a specified duration of time and the resulting leakage current is measured. If the current flow remains within specified limits during the time the component is tested, the device is assumed to be safe under normal conditions.

The equipment used for this test, a Dielectric-Withstand tester. The "rule of thumb" for testing is to subject the product under test to twice its normal operating voltage, plus 1,000 volts.

Test Voltage = Operating Voltage x 2 + 1000

The test voltage can be much higher depending on the test specification and the type of product being tested.

<u>Types of Failures Only Detectable With a Hipot Test</u>

- Weak Insulating Materials
- Pinholes in Insulation
- Inadequate Spacing of Components
- Pinched Insulation

AC verses DC Testing
Please check with the safety agency you are working with to see which of the two types of voltages you are authorized to use. In some cases, a safety agency will allow either AC or DC testing to be done. However, in other cases the safety agency only allows for an AC test. If you are unsure which specification you must comply with please contact our TECHNICAL SUPPORT GROUP at 1-800-858-TEST (8378).

AC Testing Characteristics
Most items that are Hipot tested have some amount of distributed capacitance. An AC Hipot tester cannot charge this capacitance so it continually reads the reactive current that flows when an AC voltage is applied to a capacitive load.

AC Testing Advantages
AC Hipot testing is generally accepted by safety agencies more often than DC testing since most items being tested normally operate on AC voltages. AC Hipot testing also offers the advantage of stressing the insulation alternately in both polarities, which more closely simulates stresses the product will see with real use.

Since AC testing cannot charge a capacitive load the current reading remains consistent from initial application of the voltage until the end of the test. This means that unless the product is sensitive to a sudden application of voltage the operator can immediately apply full voltage and read current without any wait time.

AC Hipot tests can often be performed relatively quickly since there is no need to discharge the device under test. AR Hipots will automatically discharge the DUT through the high voltage transformer at the end of the test.

AC Testing Disadvantages
A major disadvantage of AC Hipot testing becomes evident when testing capacitive products. Since an AC signal is constantly changing amplitude, reactive current is constantly flowing. In many cases, the reactive component of the current can be much greater than the real leakage current component. The resulting measurement made by the Hipot will include both of these current components which may not be an accurate representation of the true leakage current.

Another disadvantage of AC Hipot testing is that the Hipot has to have the capability to supply both the reactive and leakage currents continuously. This may require a current output that is actually much higher than is really required and usually much higher than would be needed with a DC Hipot. Higher output current capacity can present increased safety risks as operators are exposed to higher currents.

DC Testing Characteristics
During DC Hipot testing the item under test is charged with the application of a DC voltage. The same distributed capacitance that causes reactive current during AC testing results in initial charging current during DC testing. This charging current exponentially drops to zero as the test voltage stabilizes.

DC Testing Advantages
Once the item under test is fully charged during a DC Hipot test, the only current flowing is the true leakage current. This allows a DC Hipot tester to clearly display only the true leakage of the product under test.

Another advantage of DC testing is that the charging current only needs to be applied momentarily. This means that the output power requirements of the DC Hipot tester can typically be much lower than what would be required in an AC tester.

DC Testing Disadvantages
Unless the item being tested has virtually no capacitance, it is necessary to raise the voltage gradually from zero to the full test voltage. The more capacitive the item the more slowly the voltage must be raised.

Since a DC Hipot does charge the item under test, it becomes necessary to discharge the item after the test.

DC testing only stresses the insulation in one polarity. This becomes a concern when testing products that will actually be operated with an AC voltage.

When performing AC Hipot tests the product under test is actually tested with peak voltages that the Hipot meter does not display. This is not the case with DC testing since a sine wave is not generated when testing with direct current. In order to compensate for this most safety agencies require that the equivalent DC test be performed at higher voltages than the AC test. The multiplying factor is somewhat inconsistent between agencies which can cause confusion concerning exactly what equivalent DC test voltage is appropriate.

Insulation Resistance Test
The Insulation Resistance (IR) test provides a quantitative value of the integrity of a product's insulation. An IR tester is similar to a Hipot tester in that it applies a DC voltage across the insulation of a product. Instead of measuring leakage current, the IR tester measures the resistance of a product's insulation, usually in MΩ. IR test voltages are usually specified between 50 and 1000 volts.

Typically, higher insulation resistance values signify insulation that is in good condition. The connections used to perform the IR test are the same as the Hipot test. The measured value represents the equivalent resistance of all the insulation which exists between the two test points and any component resistance which might also be present.

Although the IR test can provide a good prediction of insulation condition it does not replace the need to perform a Hipot test.

Ground Continuity/Bond Test
The Ground Continuity test is a low current test used to verify the presence of the third-prong safety ground connection to a product's chassis. The test is used to indicate that there is a safety ground connection; it does not completely test the integrity of that connection. Although Ground Continuity testing is specified by most safety agencies as a 100% production line test, Ground Bond testing is becoming an increasingly popular alternative in the safety testing industry.

The Ground Bond test determines whether the safety ground circuit of the product under test can adequately handle fault current if the product should ever become defective. A low impedance ground system is critical in ensuring that in case of a product failure, a circuit breaker on the input line will act quickly to protect the user from any serious electrical shock.

Compliance agency requirements vary on how different products are to be tested. Most specifications call for test currents between 10 and 30 amps. Test voltages at these currents are typically required to be less than 12 volts. Maximum allowable resistance readings of the safety ground circuit are normally between 100 and 200 mΩ.

Functional Run Test
After safety testing, all manufacturers should verify the functionality of their electrical products by powering them up. In addition to running the product under test to verify its basic functionality many customers also require test data to be recorded while the product is running. A Run tester is used to provide power to an electrical product and perform useful measurements while it is running. These measurements include: amperage, voltage, wattage and power factor.

Line Leakage/Touch Current Test

Line Leakage or Touch Current test are both general term that actually describe three different types of tests: Earth Leakage Current, Enclosure Leakage Current, and Applied Part Leakage Current. The main difference between these tests is in the placement of the probe for the measuring device. The Earth Leakage test measures the leakage current that flows through the ground conductor in the line cord back to earth. The Enclosure Leakage test measures the current that flows from any enclosure part through a person back to ground if contacted by a person. The Applied Part Leakage test or Patient Lead Leakage test measures any leakage that flows from an applied part, between applied parts or into an applied part. The Applied Part Leakage test is required only for medical equipment. All of these tests are used to determine if products can be safely operated or handled without posing a shock hazard to the user.

The Line Leakage test measures the leakage current of a product through a circuit that is designed to simulate the impedance of the human body. This simulation circuit is called the Measuring Device (MD). There are several acceptable Measuring Devices each simulating different conditions. The impedance of the human body will vary depending upon point of contact, the surface area of the contact and the path the current flows. For these reasons, the specifications of the Measuring Devices are different depending upon the type of test being performed as well as the maximum allowable leakage current. Leakage current measurements are performed on products under normal conditions, single fault conditions and reversed input polarity at 110% nominal operating voltages. These conditions simulate possible problems, which could occur if the product under test is faulted or misused.

More Information

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