

UNDERSTANDING PRODUCT SAFETY TESTING

Most companies that design, build, or sell electrically powered products are unfamiliar with all the testing required to ensure the electrical safety of their products. There are many common questions that are frequently asked. What does the Low Voltage Directive (LVD) have to do with electrical safety testing? Who defines safety specifications and the product safety tests manufacturers must meet? How do test requirements differ between products that only have two conductors power cords versus others that have three conductors power cords?

THE LOW VOLTAGE DIRECTIVE

The Low Voltage Directive (LVD) and the CE marking requirements became mandatory on January 1, 1997. Article 2 of the directive states; “Member States shall take all appropriate measures to ensure that electrical equipment may be placed on the market only if, having been constructed with good engineering practices to ensure that it does not endanger the safety of people, domestic animals or property when used in applications for which it was made.” The directive indicates that harmonized productive safety standards must be drawn up by common agreement between the bodies notified by the Member States. The Low Voltage Directive does not define the actual product safety tests that must be performed. It does state that any electrical product designed for use with a voltage rating between 50 V and 1,000 VAC and between 75 V and 1,500 VDC must comply with the unified standards if the products are to be marketed in the European Union (EU) after January 1, 1997. The following equipment is exempt from the directive:

- Electrical equipment for use in an explosive atmosphere.
- Electrical equipment for radiology and medical purposes.
- Electrical parts for goods and passenger lifts.
- Electric meters.
- Plugs and sockets outlets, for domestic use.
- Electrical fence controllers.
- Radio-electrical interference.
- Specialized electrical equipment used on ships, aircraft, or railways, which complies with the safety provisions drawn up by international bodies in which the Member States participate.

Under the Low Voltage Directive, harmonized safety standards provide one certification to comply with and to be recognized by all members of the EU. This achieves one of the goals of the EU which is “to provide a standardized means of allowing commerce between member countries”. The standards once approved by CENELEC

become the European Norm (EN) Safety Standards that define the specifications for safety of the products produced for sale within the EU.

PRODUCT SAFETY TESTING REQUIREMENTS (Production vs. Design)

Product Safety Test requirements differ from one standard to another depending upon the application or type of product being tested. The scope of these standards is to ensure that products perform their functions safely so they do not cause danger to persons or surroundings, even in the event of carelessness that may occur in normal use.

Many of the product safety test specifications are based upon the “classification” of the product. Electrical products are classified based upon their insulation level. There are typically five classes, they are as follows:

- Class 0 appliances rely on basic insulation to protect against electric shock.
- Class 01 appliances are appliances which have at least basic insulation throughout and incorporate an earthing terminal but with a supply conductor without an earthing conductor and a plug without an earthing contact.
- Class I appliances do not rely on basic insulation only, they also include an additional safety precaution. The conductive accessible parts are connected to the protective earthing conductor in the fixed wiring of the installation in such a way that conductive accessible parts cannot become live in the event of a failure of the basic insulation. Products terminated in three conductor line cords are Class I products.
- Class II appliances do not rely only on basic insulation to protect against electric shock but incorporate double insulation or reinforced insulation as an additional safety precaution. There are no provisions for protective earthing or reliance upon installation conditions. Many products that are terminated in two conductor line cords incorporate double insulation.
- Class III appliances protect against electric shock by relying upon the supply voltage to be less than 42 volts between conductors, and conductors and earth. The no-load voltage is also not to exceed 50 volts. This meets the requirements of a safety extra-low voltage circuit (SELV).

The product safety tests are either “Type Test” or “Routine Production Line Tests”. The majority of the tests that are specified in the product safety standards are Type tests. These tests can be visual, mechanical or electrical in nature.

Type tests are conducted on a representative sample of the equipment to determine if the equipment, as designed and manufactured, can meet the requirements of the standard in question. Type tests, are often conducted by an outside lab as part of the certification process, requiring skilled technicians, specialized equipment and considerable time. Type tests are much more involved than the production tests.

The routine production line tests are made on each individual product during or after manufacture to check if it complies with the requirements of the standard. These tests are normally conducted by production personnel and require much less time since the test requirements are much less stringent. Typically, production tests are designed to find

manufacturing defects, while the type tests are designed to check the integrity of the design.

WHY PRODUCTS ARE GROUNDED OR EARTHED

Most electrical distribution systems are referenced to Earth (Ground). When we say that an item is grounded it is considered to be safe to touch, (Zero Potential). The main purpose of the protective earth circuit in a product is to provide a low impedance path for current to flow back to the source, should the basic insulation within the product fail. This limits the voltage to ground and facilitates the operation of the circuit protection devices. The protective earth circuit must have the capacity to conduct any fault current that is likely to be imposed on it. Many products have metal enclosures. If the enclosure is not protectively earthed, or adequately insulated, leakage currents could flow through the product creating a shock hazard. When a product has exposed dead metal surfaces such as the case of a power tool, the ground circuit is the second line of defense in limiting exposure to an electrical shock.

Many people do not understand the importance of protective earthing circuits in Class I products, or which test provides the best assurance of a properly earthed circuit.

HOW PROTECTIVE EARTH CIRCUITS ARE TESTED

Ground Bond tests or Ground Continuity tests are normally specified to test the protective earth circuit within a product. The Ground Bond Test is specified under many European Norm (EN) standards; an example of the requirements is taken from EN 60335-1, *The Safety of Household and Similar Electrical Appliances*, states;

“A current from a source having a no-load voltage not exceeding 12 V (AC or DC) and equal to 1.5 times rated current of the appliance or 25 Amperes, whichever is the greater, is passed between the earthing terminal or earthing contact and each accessible metal parts in turn. The voltage drop between the earthing terminal of the appliance or the earthing contact of the appliance inlet and the accessible metal part is measured. The resistance is calculated from the current and this voltage drop, the resistance shall not exceed 0.1 ohms. The resistance of the supply cord is not included in the measurement.” Figure 1 shows a diagram of how the test is performed.

The reason for applying the high current to the earthing conductor is that most fuses or circuit breakers can carry a 200% overload for several minutes before they open the circuit. The resistance of this circuit must have sufficiently low impedance to limit the voltage to ground and facilitate the operation of the circuit protective devices. The reason for performing this test using a source voltage of 12 volts or less is to limit operator exposure to hazardous voltages during the test.

The Ground Bond test is often specified as a type test but may also be specified as a 100% routine production line test. Some standards may reduce the test current to a 10-Ampere level as a routine test while other standards may specify a simple continuity test.

The Ground Continuity Test may only require the use of a battery and buzzer, or a light to indicate that continuity is present. The simple continuity test does nothing to verify that the protective earth circuit is capable of handling any fault current that could be imposed on it. It only indicates that continuity is present. The Ground Bond test is a better test because it actually applies current and tests the ability the ground circuit has to

handle fault current. It can find both manufacturing defects and test the integrity of the design.

What are some of the other product safety tests that are specified under these standards and how do they relate to each other?

THE DIELECTRIC WITHSTAND TEST

Electrical products are subjected to high voltage switching transients on a daily basis. Every time an electric motor is started or stopped it produces a counter Electro Motive Force (EMF) which can generate voltage transients that can damage weak insulation. It is assumed that if a product can “Withstand” the potential applied during a Hipot test, it will withstand these switching transients that occur on a daily basis. The term Hipot is short for High Potential test.

The Dielectric Withstand or Hipot test measures the leakage current through the insulating materials between what are normally current carrying and non-current carrying conductors or ground (earth). (Figure 2). Hipot tests may also be performed between primary and secondary circuits within a product to test the isolation between these circuits, or between multiple isolated secondary circuits.

To perform a Hipot test the high voltage lead is connected to the hot and neutral conductors of the Device Under Test (DUT), which are shorted together. The power switch of the DUT is also placed in the “on” position. The return lead is then connected to any exposed dead metal of the DUT. Unlike the Line Leakage test the DUT is not running during the Hipot test. By applying high voltage to both sides of the line you are applying an equal potential across any components within the circuit under test, stressing only the insulation between the current carrying conductors and ground.

The specifications for type tests and routine tests also vary when it comes to a Dielectric Withstand test. The type test is performed by applying a sinusoidal AC voltage of at least 1,000 V for basic or operational insulation, or 3,000 V for reinforced insulation at a frequency of 50 Hz or 60 Hz. In some specifications a DC voltage may be substituted for an AC voltage. The specifications require the DC voltage to be equal to the peak of the prescribed AC test voltage to be used. The voltage is raised gradually from zero to the prescribed test voltage and held for 60 seconds. There cannot be any indication of breakdown during this test. Insulation Breakdown is considered to have occurred when the current, which flows as a result of the application of the test voltage rapidly increases in an uncontrolled manner. The insulation can no longer restrict the flow of current. Corona discharges and single momentary flashovers are not regarded as an insulation breakdown condition.

The production test is applied between the primary and accessible conductive parts, excluding secondary circuits and must be maintained for at least 1 second but not usually more than 6 seconds. The applied potential must be at least 1,500 volts AC for basic insulation and 3,000 volts AC for reinforced insulation. This test is designed to detect defects in material and workmanship such as conductor spacings that are too close and damaged insulation, which may be the result of pinched wires. AC voltage is specified more often than DC because it is felt that AC voltage stresses the insulation in a way similar to how the product is used.

How is a failure detected during a Hipot test? Insulation breakdown for production tests is any significant increase from the steady state current measured during the test. Some standards specify that the manufacturer of the DUT shall determine the trip current sensitivity setting. Most Hipot testers have an adjustable current trip range that can be set by the manufacturer of the DUT. Every product will have some AC current leakage due to the capacitance of the item under test and the applied voltage. Capacitance of the DUT can vary depending on the type of circuits used in the product. Products with RFI filter capacitors commonly used to solve Electro Magnetic Interference (EMI) problems can cause drastic increases in AC leakage during Hipot tests. If the detector is set too low, false failure indications could be produced. Some testers have ARC detection circuits. An Arc failure is a condition where the voltage discharges across or through the insulation. This may or may not cause excessive current flow. A high frequency signal appears on the AC voltage sine wave when low-level arcing occurs. The Arc detector should also be adjustable. There are no current standards in force which require arc detection. Single or momentary flashovers are not considered failures as long as it does not result in a disruptive discharge.

THE LINE LEAKAGE TEST

The Line Leakage test also measures leakage current which flows through the insulation of the product but the conditions under which the test are performed are quite different than the Dielectric Withstand test. A Line Leakage Test is performed at a much lower voltage than a Dielectric Withstand Test (Hipot Test). The Line Leakage Test monitors leakage currents from accessible parts of the DUT back to the system neutral while the product is operating under both normal and single fault conditions (figure 3). Leakage currents are monitored through a Measuring Device (MD) (figure 4) which simulates the impedance of the human body. This provides more accurate data as to the potential shock hazards the DUT could produce. The input voltage applied to the DUT is typically adjusted to 110% of the highest rated line (mains) voltage. Leakage currents are measured under all possible combinations of open and closed neutral conductors, normal and reversed polarity, and with open and closed ground connections on the input of the DUT.

The Line Leakage Test may take on many forms. It may measure the leakage current in the *Earth* conductor of a Class I product or from its metallic enclosure back to the system neutral under normal or single fault conditions. Or the test may require a measurement of the leakage current from the *Enclosure* to both sides of the line (figure 5). On Class II products a foil of approximately 10 X 20 cm is attached to the *Enclosure* of the product to simulate a hand contact. The leakage current is then measured from the foil to the system neutral under normal and single fault conditions or from the *Enclosure* to both sides of the line.

Medical products may also specify a Patient Leakage Test or a Patient Auxiliary Current Leakage Test along with the Earth or Enclosure Leakage Test. The main differences between each of these tests are the placement of the measuring device, the configuration of the measuring device, and the maximum allowable leakage currents. The leakage limits for each type of test may vary greatly depending upon the product's application. Limits for medical products are much lower than for commercial appliances.

Current leakage limits can range from 0.01mA to 5 mA depending upon the test being performed. Check the specific agency specifications for your type of product.

Leakage Tests are more often specified as Type tests. Some standards require that a sampling of the products be tested during the production process, while most medical products are tested as a production tests.

SUMMARY

It is not always possible ensure that consumers will always use products in a safe manner or that they will not defeat the safety systems. This is why modern product designs incorporate built-in safety features to protect users with several levels of protection. However simply incorporating these into the end product design is not adequate to ensure user safety. These safety systems are subject to variations in production that could render them useless. The only way to be sure that the product has actually been constructed with the intended safety built into to it is to test each product before it is shipped. The basic safety tests described in this article will help to ensure that the product your customer is using is as safe as your design engineer intended it to be.

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