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Improving the Efficiency of Electrical Safety Testing

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The integration of multifunction and interconnected electrical safety tests enables safer and more-reliable testing.

The integration of multiple electrical safety compliance tests into a single test system has proven to be more accurate, more efficient, and safer than individual testers for many manufacturers. Tests such as ac hipot, dc hipot, insulation resistance, ground bond, line leakage, and functional run tests can be performed in any order, and some can be executed simultaneously without the need for multiple connections to the device under test (DUT). In some applications, this integration is accomplished through the interconnection of several instruments, and in others a multifunction all-in-one instrument may be used. This article discusses some real-world solutions that interconnected and multifunction instruments have provided for electronic safety testing.

Testing Bomb-Detection Equipment

A unique application that has become more common due to increased security issues is the electrical safety testing of bomb-detection equipment. Bomb-detection equipment was originally conceived to detect explosive devices in airport terminals. After 9/11, the use of this type of equipment in a number of different applications has dramatically increased worldwide. For instance, bomb-detection equipment is commonly used in government applications such as high-volume mailrooms, courthouses, and police facilities. This equipment also has commercial applications such as the cruise industry, railroad and bus terminals, and industrial shipping and receiving applications.

To ensure the electrical safety of the bomb-detection equipment, the products are tested according to the IEC standard 1010 and UL standard 508. These standards specify both type (design) and routine tests (production line) that a manufacturer must perform on the equipment to ensure compliance with the safety standards. According to IEC 1010, the manufacturer is required to perform a 25-A ground bond test and a dielectric withstand test at 2121 V dc as a routine test.

Ground Bond Test. The ground bond test is designed to verify that the impedance of the ground (earth) circuit of the DUT is low enough to limit the voltage to ground. It also verifies that the circuit has the capacity to conduct any fault current that is likely to be imposed upon it should the product's primary insulation fail. The impedance is specified not to exceed 0.1 Ω during the test. Test current is specified either as 25 A at rated mains frequency or as a current equal to twice the rated current of the DUT. The test current used must be whichever is the greater of these two conditions.

Dielectric Withstand or Hipot Test. The dielectric withstand or hipot test is one of the most commonly specified electrical safety tests. It is designed to test the primary insulation of a product, which provides the main protection against electrical shock. The concept behind hipot testing is rather simple. A product's insulation system is simply overstressed by applying much more voltage than would occur at normal operating voltages.

The theory is that if a product's insulation system can withstand this higher voltage for a specified period of time, then it should be safe indefinitely in normal operating conditions. The hipot test detects several types of failure conditions. Failures can include a short circuit between current-carrying and non-current-carrying components of the DUT or an arc breakdown, which is voltage flashing over from a current-carrying component to a non-current-carrying component.

One problem that a leading bomb-detection equipment manufacturer encountered was efficiently moving its equipment through a product safety test station. Bomb-detection equipment is rather large, and moving it through a typical test station was not viable for the manufacturer. Therefore, the

Figure 1. Multifunction single instrument shown testing a common small appliance.

manufacturer had to look at a slightly unconventional means to test its products effectively.

Instead of moving the bomb-detection manufacturing line through a product-safety test station, the product-safety test station was moved past the bomb-detection equipment. A mobile electrical safety test station was designed so that the test equipment was actually rolled on a cart to the bomb-detection equipment. The manufacturer integrated these tests on this mobile test station by using an electrical safety tester that would perform both dielectric withstand and ground bond tests, among others.

Without being able to integrate multiple tests into a single DUT connection, the manufacturer would have been forced to employ two instruments with multiple connections. Multiple instruments would have increased the size of a test station and the amount of time it would have taken to run a test. This combination would have resulted in a larger, less-efficient test station and would have made the testing process more cumbersome.

Appliances

Appliance manufacturers are another example of those that have been able to integrate multiple product safety tests to improve their testing process (see Figure 1). One manufacturer of coffeemakers and other small home appliances was having difficulty with its production-line hipot testing and its functional run testing. In addition to electrical safety tests, many products must undergo functional run testing to verify that they are in proper working condition and meet published specifications.

Functional Run Test. The functional run test is normally performed after the electrical safety tests. For safety reasons, it is impractical to apply line power to a DUT that could have a fault. A faulted DUT could then expose an operator to a shock hazard if the normally non-current-carrying enclosure becomes energized. One of the most common measurements made during a functional run test is to measure current draw. This test is performed to ensure that the DUT is operating within its fuse rating.

In addition, the functional run test can also monitor minimum and maximum levels of voltage, wattage, power factor, and leakage current. This information allows the operator to verify that the products are wired correctly. It is important to note that electrical safety tests such as a hipot test do not measure these parameters. A hipot test ensures that the product is electrically safe for normal use; however, it is not designed to, and will not, determine whether a product is operating correctly.

For example, a common fault condition that occurs is a short circuit across the hot and neutral conductors. During a hipot test, the hot and neutral conductors are normally connected together, which would mask this fault. However, when the product is connected to line power, the short-circuit condition causes input circuit breakers or fuses to trip. This problem, not evident in hipot testing, is easily detected by a functional run test. Functional run testing is very common for appliance manufacturers. This testing provides the assurance that shipped products will work properly once they reach the consumer.

One appliance manufacturer was having a problem that was the direct result of using a homemade functional run tester to test its products after the electrical safety tests. In other words, there were two separate instruments each with its own test connection points to the DUT. The manufacturer was running the functional run test without first disconnecting the test leads from the electrical safety testing equipment. As a result, line power was coming back into the return circuit of the electrical safety tester when a faulty product was tested. This condition was causing damage to the electrical safety testing instruments. The solution was an electrical safety test system that integrated a functional run tester and provided a single DUT connection.

Developing a test station that performs both electrical safety tests and functional run tests with a single DUT connection can save a great deal of time and money for a manufacturer. Figure 2 shows an interconnected test system. Improperly designed test stations result in production downtime, decreased throughput, and additional expenses to repair damaged electrical safety testers. Products were being tested more quickly and accurately with the new solution in place. The amount of downtime for the manufacturer decreased, and all of the problems were eliminated.

Medical Electronics

In addition to integrating multiple testing instruments as a solution, the use of multifunction or all-in-one instruments is also becoming a common way to efficiently combine electrical safety tests. Multifunction instruments can also include advanced technologies that make electrical safety testing safer and more convenient. One benefit of a multifunction electrical safety compliance analyzer is the ability to store different tests in any order. Data can be stored in multiple memory locations and recalled to test several products to different standards or to perform several different tests on a single product. This option can provide a more efficient process for manufacturers that test a diverse range of products.

IEC 60601-1 is one of many medical specifications that require manufacturers to perform multistep line leakage tests in addition to some of the more common safety tests such as dielectric withstand and ground bond. Some line leakage tests can involve 10 or more steps to sequence through the required test conditions. If not done efficiently, this sequencing could

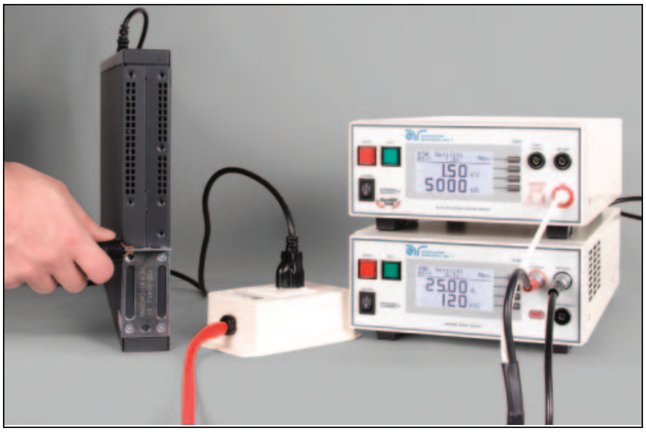

Figure 2. Interconnected system being used to evaluate a typical DUT.

equate to a very complicated test process. The integration of multifunction electrical safety testers has provided the medical industry with a quick and efficient means to quickly perform multistep tests.

Line Leakage Test. The line leakage test is actually a general term that describes four different types of tests: earth leakage test, enclosure leakage test, patient leakage (applied part) test, and patient auxiliary leakage test. These tests are all used to determine whether products can be safely operated or handled without posing a shock hazard to the user or the patient. They all employ a measuring device that represents a model of the human body's impedance.

The earth leakage test is performed to determine the amount of current that flows through the ground circuit back to the system neutral. This test is performed with every combination of open and closed earth conductors, with normal and reversed polarity conditions, and with the neutral conductor open and closed.

The enclosure leakage test measures current between various points of the DUT chassis and the system neutral. This test is performed on both Class I and Class II products and have very specific leakage limits. Class I products are products that provide protection against electrical shock from the basic insulation of a product. They also provide protective grounding of conductive accessible parts. Class II products provide protection against electrical shock from the basic insulation as well as the reinforced or double insulation of the product. On Class I products, the entire enclosure of the DUT is measured for leakage current. This is illustrated in Figure 3. On Class II products, a foil of approximately 10 × 20 cm is attached to the enclosure of the product to simulate hand contact. The leakage current is then measured from the foil to the system neutral under normal and single-fault conditions.

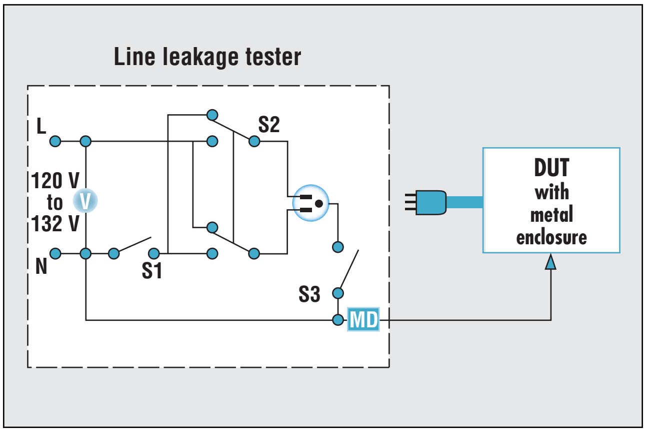

Figure 3. The entire enclosure of a Class I product is measured for leakage current.

The patient (applied part) leakage test measures the leakage current from the patient lead connections back to the neutral conductor and between patient leads. The patient auxiliary leakage test measures the leakage current through connections designed to be connected to the patient. In all line leakage tests performed on Class I products, there are a minimum of eight possible combinations for each type of test. Additional tests are specified for applied parts.

There are stringent standards in place for medical equipment manufacturers. This is mainly due to the prolonged contact such products have with patients who may be in a weakened condition. However, this does not mean that the electrical safety testing of medical equipment needs to be a tedious task. Today's technology allows standards to be met with much greater ease. Multifunction electrical safety compliance analyzers is one technology that can ease this testing process.

Several medical equipment manufacturers have found that integrating a multifunction electrical safety tester into their production line has lessened the burden of performing multiple tests. A manufacturer can use one DUT connection to perform each test. Otherwise, this same series of tests would have to be performed with separate dielectric withstand, ground bond, and line leakage testers. Separate testers can make the testing process complicated and tedious for many manufacturers. The integration of all these tests into a single instrument means greater throughput and efficiency as well as savings in terms of time and money.

Conclusion

New technologies are continually being developed to provide manufacturers with safer, easier, and more efficient ways to perform their electrical safety compliance tests. Through the integration of several instruments with a single DUT connection, tests are controlled by a single host instrument. A fully integrated multifunction all-in-one instrument enables manufacturers to see greater efficiencies. Both solutions mean that safer and more-reliable testing is being performed.

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