Integrated Testing

Range testing station at Whirlpool plant in Tulsa, Okla. Remotely operated Associat-ed Research testing equipment is enclosed in cabinet at lower left.

Appliance industry benefits from integrating three standard tests.

by dwayne m. davis

***Dwayne M. Davis** is the technical services manager at Associated Research, Lake Forest, Ill.*

Hipot and ground bond tests are two of the most commonly performed electrical safety tests for compliance testing to safety agency standards. These tests verify two major components of electrical products—the integrity of a product's insulation and a product's grounding circuit. The functional run test is an additional test that is typically performed after electrical safety production tests. Run tests are not safety agency specified tests but rather final quality and functional tests of the product. While the fundamentals of these tests have not changed very much there are new applications for these tests.

Hipot Test

A hipot test is the most common electrical safety test performed on appliances. The hipot test is a deliberate application of high voltage in order to stress the insulation system of an electrical or electronic product. The theory behind the hipot test is that if the insulation can handle this deliberate stress, then it should also be able to handle any stress it incurs during normal use. The insulation is tested because it is the primary system that guards against an electrical shock from an electrical or electronic product.

The hipot test can be performed in either AC or DC voltage, but most appliance standards call for AC test voltage. The hipot test is commonly performed during the engineering or design stage, also referred to as performance. The hipot test is also performed during the manufacturing stage, also known as production testing. Most hipot tests in a performance test are specified for 60 seconds or more, while most production tests only require a one second hipot test.

Performance testing measures the overall design of a product, therefore, a more strenuous test is required thus the longer test cycle. At the production stage any production flaws can usually be detected during a one second test. This reduced test time also helps manufacturers meet throughput requirements. The hipot test will detect flaws in the insulation system of the Device Under Test (DUT) including weak insulating materials, pinched or pinholes in the insulation and adequate spacing of components.

The most common method to perform a hipot test on an appliance is to apply high voltage to the line and neutral conductors connected together. The return should be connected to the exposed case or dead metal of the DUT. This allows test voltage to be applied between the current carrying conductors and any exposed dead metal. The hipot test ensures that there is proper insulation between current carrying circuits and the enclosure of the DUT. During the hipot test, the power switch of the

DUT needs to be placed in the ON position. This allows all internal circuits to be tested. This basic setup may be applied to both cord-connected and hard-wired appliances.

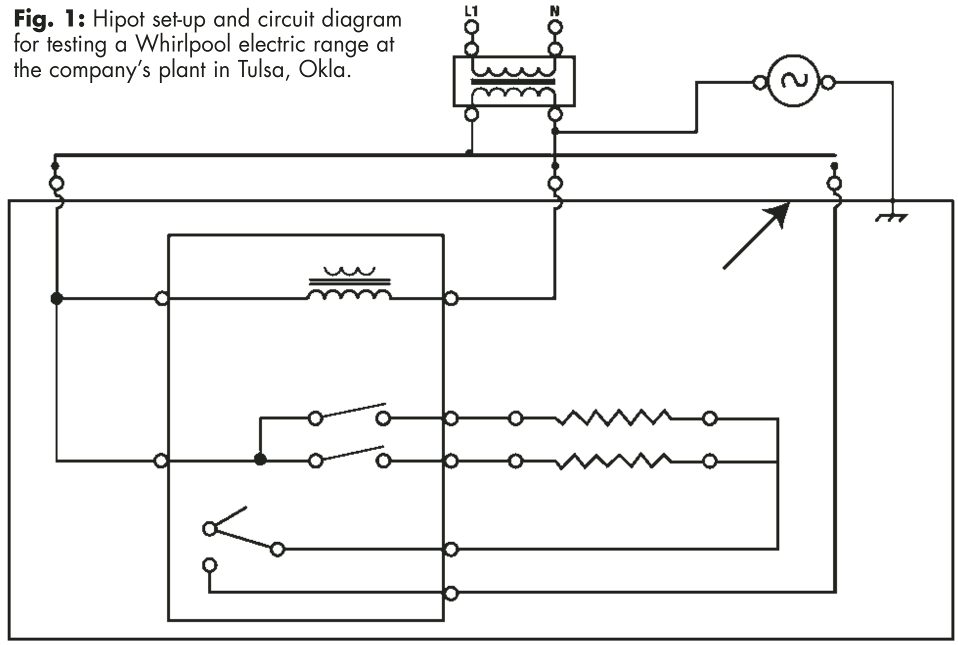
There are, of course, variations to this basic setup. For instance, some DUT circuits utilize relays to interrupt or apply power to other circuits by opening the line or neutral. The complete circuit is still tested during the hipot test as the high voltage is applied to both conductors. Some products, especially those that are powered from a 220-volt source, use relays that open both the line and the neutral. When both sides of the line are opened the circuits controlled by the relays are not tested. In order to test these circuits the relays must be closed manually or the circuits bypassed to complete the circuit so a test may be performed. However, when testing a completed product, bypassing circuits is not always an option. Many standards require that the DUT be tested only when fully assembled. In these cases, manufacturers must look for other testing solutions.

An example of another method of performing a hipot test is to run the test while the DUT is powered up. This is known as a "Hot" hipot test. The hot hipot test allows the operator to close or energize circuits controlled by relays. This is accomplished by utilizing an isolation transformer to power up the DUT. The hipot voltage is then applied between the energized circuit and the case of the DUT.

This test requirement can be found in IEC 60335-1 2001-05 Fourth Edition Annex A., as well as UL's Standard 858 for Household Electric Ranges. Whirlpool Corporation's manufacturing plant in Tulsa, Okla., which manufactures free standing ranges, both gas and electric, addressed this standard by incorporating a hot hipot test application. (See *Fig. 1.*)

Hot testing is performed by simultaneously applying power to the DUT as the hipot test is initiated. The DUT must be allowed to operate internal circuits through the Oven Control Circuit. The relays that control power to the bake element and the broil element can then be closed. Closing these relays allow the complete circuit to be tested when hipot voltage is applied. The isolation transformer is a critical part of allowing the DUT to be powered up during a hipot test. During normal DUT operation, the neutral may be at or near ground potential. Hipot test voltage is applied to both the line and neutral circuit. Since a hipot tester, in part, is used to detect failures to earth ground, without the isolation transformer, it would see the neutral connection to ground as a fault condition.

Fig. 1: Hipot set-up and circuit diagram for testing a Whirlpool electric range at the company's plant in Tulsa, Okla.



Manufacturers do need to be aware that this configuration does not eliminate risks to the operator. The use of an isolation transformer eliminates the risk of a shock hazard from the line power of the DUT. However, if an operator that is grounded comes in contact with any DUT while a hipot test is being performed, then it is possible they could be shocked, as they become the path to ground for any fault current. Care always needs to be taken to prevent operator contact with DUT's while a hipot test is being performed. One method to safeguard against this shock hazard is to run the test station remotely. This can be accomplished using automation interfaces such as GPIB or RS-232 or by simple PLC relay control.

Ground Bond Test

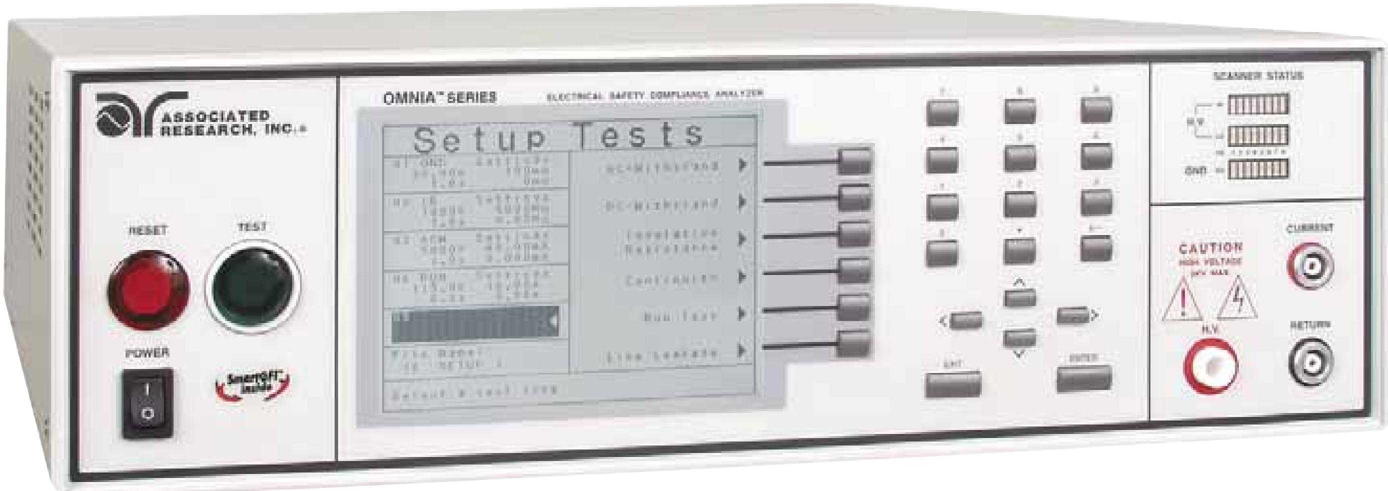
The ground bond or ground impedance test is another commonly performed electrical safety test. The ground bond test is designed to determine whether or not the safety ground circuit of the DUT can adequately handle fault current in case the DUT's insulation should ever breakdown or become defective. The ground circuit must be able to handle current for a long enough time to ensure that fuses or circuit breakers on the line will trip under a fault condition.

The ground bond test should not be confused with a simple ground continuity test. The continuity test is designed to check the presence of a safety ground system. Basic ground continuity tests are generally very loosely specified. They are typically performed at low voltages and at test currents below 1 Amp. The lower currents cannot measure the integrity of the insulation system.

For example, if only a few strands of wire maintain the ground connection then the DUT might pass a ground continuity test. However it would likely fail a ground bond test because the higher applied current would burn through a few strands of wire and display a fault condition. Despite this, most standards in the United States only require a basic ground continuity test in production. Most U.S. safety standards for performance tests usually call for a 25 Amp test, while Canadian standards require a 30 Amp test.

Ground bond test specifications may call for 1.5 to 2.0 times the rated current of the appliance. Products that have a 15 Amp current rating and need to be tested at 2 times their rated current will need 30 amps of test current. If the input current rating is higher, then additional test current will be needed. A trend has been developing in the appliance industry to begin performing ground bond tests as a routine production tests even though safety agency specifications do not require this test.

The reason may be that manufacturers realize the effectiveness of the ground bond test as compared to the basic continuity test. Many appliances are used in environments that make the safety ground circuit critically important. This would include applications where the appliance is normally exposed to water, such as



The OMNIA electrical safety compliance analyzer, from Associated Research, performs a number of electrical safety tests with a single DUT connection, eliminating the need for the interconnection of multiple instruments. The unit includes AC/DC hipot, insulation resistance, ground bond, line leakage, run tests and optional built-in scanner in a single instrument.

in washing machines. More and more manufacturers are using a ground-bond test to ensure their products are as safe as possible.

One easy and safe method of performing the hipot and ground-bond tests is to implement a test system that will perform both tests through a single DUT connection. Interconnected test systems or multi-function instruments providing a single DUT connection are the two most efficient means to perform all electrical safety tests. With a single DUT connection operators do not need to spend time with multiple connections or disconnections in order to run various tests. This also provides greater flexibility in configuring a test station to run remotely and is the safest means to perform multiple test configurations.

Functional Run Test

A functional run test is a set of tests that many manufacturers will perform after final electrical safety production tests and before their products are shipped. The functional run test is designed to make sure that a product will operate as intended. Functional run tests will measure minimum and maximum levels of voltage, wattage, power factor, leakage current and current draw. These measures will indicate that a DUT is wired correctly and make sure that it is also operating within its fuse rating.

These tests should always be performed after the electrical safety tests. As previously mentioned, a hipot test will detect line-to-ground faults. Obviously, without this test a ground-fault condition could cause safety issues if line power were applied to the DUT. Performing a hipot test first allows the ground-fault condition to be detected before line power is applied. It is important to note that functional run tests can detect line to line or line to neutral faults that cannot be detected during a normal hipot test. This is because line and neutral are already connected together during the hipot test.

The ability to perform both electrical safety tests and functional run tests through one DUT connection has been another trend in the appliance industry. This can be beneficial for a manufacturer because it will save them testing time, which in turn saves production costs.

There are two methods for performing these tests through a single DUT connection. A manufacturer can use electrical safety testers and functional run testers that can be interconnected. As discussed above, the ability to interconnect safety testers and use them as test systems was the first solution provided to manufactures that needed to perform multiple electrical safety tests with a single DUT connection.

As the functionality of these interconnection circuits were increased, later it was adapted to functional run testing. The current solution is a single instrument that performs all of these electrical safety tests with a single DUT connection. This eliminates the need for the interconnection of multiple instruments.

An example of the value of incorporating safety tests and functional tests into a system approach can be seen at one major appliance manufacturer. The company was incorporating a custom made functional run test system. This system included its own set of test leads. These leads were connected to the DUT after the electrical safety tests were completed. The electrical safety tester's test leads were not always being removed prior to the initiation of the functional run test.

As a result, line power was flowing back to ground through the electrical safety tester. The connected return circuit of the safety tester was acting as a ground path. Therefore, line power was being applied to the return lead of the electrical safety tester. The internal circuitry of the hipot tester became damaged because a hipot tester's circuits are typically not rated for line power.

The solution was for the manufacturer to implement a run test system that had a built-in switching matrix that would enable these tests to be performed with one set of test leads. As a result, they were able to perform both their safety tests and functional run tests more efficiently and safely. This, in turn, lead to increased production throughput and resulted in the manufacturer saving money in the maintenance of their production line.

The overall factor determining which product safety tests need to be performed ultimately depends upon the safety standards that define the application. However, manufacturers are finding that it is easier than ever to add tests and capabilities while still maintaining production output levels. New technology has improved the flexibility and efficiency of test instruments to meet a wider range of unique test applications.

Reprinted from
Appliance Manufacturer
© November 2003