

Electrical Safety & Compliance Testing for Appliance & Consumer Product Manufacturers

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INTRODUCTION

Electrical appliances, computers and peripherals, power tools and other devices found in the home and office environments must be tested to confirm adherence to a plethora of stringent certification standards.

The vast array of consumer devices for the home and office — from blenders and ovens to computers and high-definition LED TVs — are becoming increasingly sophisticated. Refrigerators, once basic electrical appliances, now often include adjustable-speed motor controls, digital displays and Bluetooth communications.

While the complexity and functionality found in this class of

devices varies extensively, there is one thing they all have in common when products enter the market: proven safety compliance. It is a foregone expectation that electrical and electronic devices designed for consumer environments will have been tested and labeled as compliant according to applicable safety standards, which means bearing the mark of a Nationally Recognized Testing Agency (NRTL). Depending on where in the world the product will be operating, the labeling could have one or many of those listed in Figure 1.



Figure 1. A sampling of NRTL product labeling certifying consumer product safety compliance.

COMPLIANCE CONSIDERATIONS

Compliance with the applicable standards, which can vary widely from country to country, typically involves both mechanical and electrical safety considerations. Manufacturers must either submit samples of their products to an NRTL for testing or secure the authorization to conduct the tests themselves.

The certification process is conducted to confirm compliance with the relevant standard(s). This compliance evaluation investigates two key areas:

- ▶ Construction - mechanical construction, spacing, clearances, etc.; and
- ▶ Safety - to ensure safe operation (even under high-stress conditions).

The following list (Table 1) outlines the details typically required in the certification process. Many of these criteria (as noted in blue type) are confirmed by using electrical safety (hipot) testing devices.

Table 1: Criteria for Product Certification

- Marking and instructions
- Protection against access to live parts
- Starting of motor-operated appliances
- Power input and current
- Heating
- Leakage current
- Creepage distances, clearances and distances through insulation
- Moisture resistance
- Resistance to rusting
- Provision for earthing
- Overload protection of transformers and associated circuits
- Terminals for external conductors, screws and connectors
- Radiation, toxicity and similar hazards
- Stability and mechanical hazards
- Mechanical strength & construction
- Supply connection & external flexible cords
- Internal wiring
- Recognized components

Table 1. Criteria for product certification with blue text indicates where hipot testing is required.

SAFETY STANDARDS

The details of what constitutes a certified product is dependent upon hundreds of safety standards and the region of the world where the device will be sold and used. Fortunately, work is being done to harmonize this daunting number of international standards. For example, a recent article entitled, "UL 60335-1" explained, "Safety of Household and Similar Electrical Appliances," points out the nearly identical counterpart in The European IEC 60335-1 standard. Here is how this harmonization is described:

- ▶ In North America, IEC 60335-1 has been used as the basis for a tri-national standard between the United States (UL 60335-1), Canada (CAN/CSA C22.2 No. 60335-1), and Mexico (NMX-J-521/1-ANCE). In the US, UL 60335-1, which is in its 6th edition, is harmonized to IEC 60335-1 as part of its participation in the HOUS (Household and Other Similar Equipment) category of the IECCE (IEC Electrical & Electronics Equipment.)
- ▶ In Europe, the harmonized standard is EN 60335-1 and defines how appliances may comply with European Directives, such as the low voltage directive. Unlike the United States, the EU recognizes most, if not all, of the 100+ part 2 standards related to specific products.

PRODUCT CLASSIFICATION

For purposes of this paper, the harmonized UL/IEC standards will be used to categorize various classes of consumer apparatus.

- ▶ Class 0 - Products are provided with basic insulation only as a provision for basic protection and have no provisions for fault protection. Due to the limited safety features, their application is limited to areas that are physically protected from the public with fences or other measures that restrict access.
- ▶ Class I - Products have basic insulation and must incorporate a protective earth (ground) connection to mitigate the risk of electric shock.
- ▶ Class II - Products feature additional safety precautions such as double insulation or reinforced insulation thereby eliminating the need for a protective earth (ground) connection. Therefore, Class II input power supplies must have a 2-pin input receptacle instead of the 3-pin input receptacles found on Class I input models.
- ▶ Class III - Products are designed to be supplied from a separated extra-low voltage power source. The voltage from a SELV supply is low enough that under normal conditions a person can safely come into contact with it without risk of electrical shock.

TYPES OF TESTS REQUIRED

Electrical safety test equipment utilized to perform the range of tests prescribed in Table 1 will need to perform one or many of the following test procedures:

- Hipot testing
- Ground bond testing
- Ground continuity testing
- Insulation resistance testing

HIPOT TESTING

Hipot is the short name for a high-potential (high voltage) dielectric withstand test. A hipot test checks for sufficient insulation and isolation between line and neutral to ground. Hipot testing is one of the minimum-production tests of consumer products. Defects that are often detected with the hipot test include contamination (dirt, debris) and lack of proper spacing (creepage and clearance) of components. Contamination would likely cause an unacceptable level of leakage current. Clearance problems could result in breakdown.

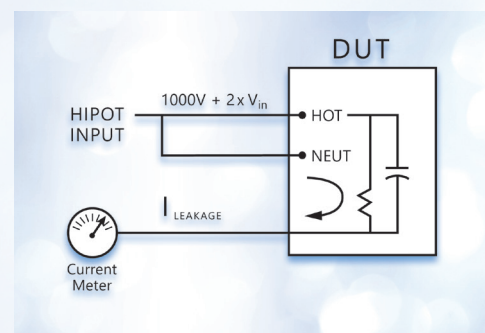


Figure 2. Hipot is applied to both conductors and leakage is measured in return circuit through the ground connection

GROUND CONTINUITY TESTING

Ground continuity testing is performed to confirm that the conductive chassis of a device is safely connected to the earth ground pin on the power plug. This assures protection against shock hazards even if the equipment suffers an internal short to the chassis. The current would be shunted via the ground wire and would likely trip the breaker or blow the fuse. Ground continuity is performed by applying a low current (e.g. 50mA) and calculating the resistance from the ground pin on the power plug to selected locations on the exposed surfaces of the device under test, or DUT.

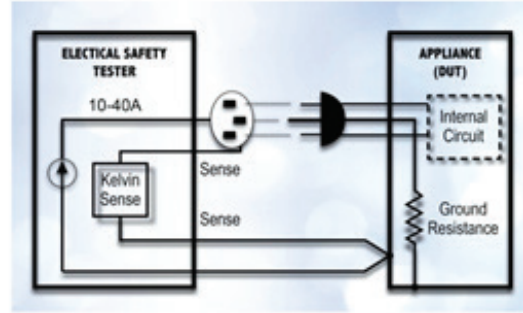


Figure 3. Ground continuity measures the resistance from the appliance's ground pin to the chassis.

GROUND BOND TESTING

Where ground continuity measures the resistance of the safety ground connection, the ground bond test assures the integrity of the connection. Using the same test setup, a high current (up to 40A) is passed through the circuit. If the ground bond is solid, the current passes without a change in resistance. If weak, the resistive heating of the current would induce a failure of the bond. This is one area where the IEC and UL specifications differ. The EU standard commonly includes ground bond testing while the UL standard does not.

INSULATION RESISTANCE TESTING

Insulation resistance testing is likely to be required in motor winding, transformer winding and other applications involving cabling or insulated wire. It typically involves confirming that the resistance exceeds a defined high-resistance value.

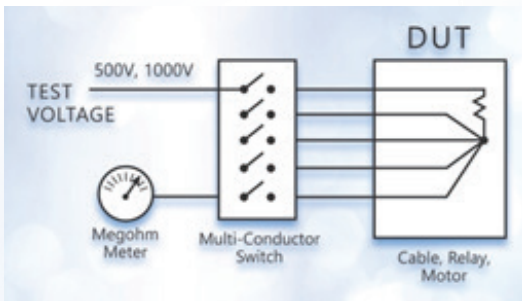


Figure 4. An insulation resistance test: voltage is applied to one conductor at a time while adjacent conductors are bundled. Resistance is calculated based on leakage current.

In many instances, insulation resistance needs to be measured between several conductors. Examples include cable/connector assemblies, multi-conductor cables and relays. To make this measurement, all the conductors except one are shorted together and the test voltage is applied from the remaining conductor across the bundled ones. Each wire is then, in turn, tested in this fashion (Figure 4.)

APPLICATION OF THE IEC/UL STANDARD

As noted, IEC/UL 60335-1 is a standard covering both mechanical and electrical aspects of the product. The specific area of the standard related to electrical conditions is Section 16.3. Common requirements for

these tests include:

- ▶ Minimum output power rating of 500 VA
- ▶ Test voltages
 - 1250VDC - Class 0 and Class I
 - 1750VDC - Class II
- ▶ Basic test sequence
 - Ramp up from 0 V to Test Voltage - 5 seconds
 - Dwell at Test Voltage - 60 seconds

The 60335-1 standard also has a specific section (Annex A) that prescribes specific test conditions and pass/fail criteria utilizing the common requirements listed previously.

- ▶ Annex A - Hipot
 - Leakage Current:
 - <5 mA (standard)
 - <30 mA (high leakage equipment)
- ▶ Annex A - Ground Bond/Continuity
 - Ground Bond Test Current: 10 A
 - Ground Continuity Resistance
 - Plug connected - <200 mΩ
 - Hard-wired - <100 mΩ

VITREK ELECTRICAL SAFETY TESTERS

Vitrek is well equipped to provide the right equipment for every consumer product test, anywhere in the world. Here's a quick summary of the Vitrek product offering:

▶ V7X Series Hipot Tester



- V7X Series offers power, speed, accuracy & resolution
- AC & DC output voltages up to 5KV
- Accuracy & speed of calculations exceed industry standard
- Color touchscreen & automated test software available

▶ 95X Series Hipot Tester



- 95X Series offers power, speed, accuracy & resolution
- Wide range of AC/DC outputs up to 30 kV AC & 15 kV DC
- Accuracy and speed of calculations exceed industry standard
- 100 pA resolution for current
- Color touchscreen & automated test software available

▶ 964i High Voltage Switching



- 964i HV switching for automated test systems
- Multi-conductor/Multi-point
- 8 channels of HV switching cards (8 per card for a total of 64 test points)
- Configurable voltage ratings - 3kV, 7kV, 10kV & 15kV

VITREK APPLICATION EXAMPLES

Vitrek is the preferred source for electrical safety testing utilized by world-class consumer product manufacturers including:

▶ Computer & Accessories

- Hewlett Packard - Palo Alto, CA
- V7X & 964i for production line hipot testing



▶ Small Consumer Appliances

- GE - Boston, MA
- V7X & 964i for production line hipot testing



▶ Large Consumer Appliances

- Sub-Zero Wolf - Madison, WI
- 95X & 951i for production line ground bond testing



CONCLUSION

Basic appliances like refrigerators, toaster ovens, air conditioners, microwave ovens and many others have evolved to include a range of embedded electronics providing graphic displays, Bluetooth communications and other features. The IEC/UL 60335-1 standard provides a comprehensive roadmap for assuring that consumer appliances and other electrical/electronic devices found in the home are safe.

Many of these requirements are confirmed, both in the design stage as well as in production, using electrical safety (hipot) testers. Vitrek's line of electrical safety testers are ideal choices for this application.

- The 95X Series hipot tester features high output power with a wide range of output voltages combined with exceptional leakage current resolution
- The V7X Series hipot tester offers outstanding performance in a lightweight, lower-cost format

Vitrek hipot testers come standard with a variety of computer interfaces to simplify test automation and can be used with Vitrek's 964i Multi-Point Switching System & QT Enterprise software for test record management. Vitrek's decades-long experience in providing reliable, accurate and affordable test equipment is complemented by its application expertise, providing a complete solution to the full spectrum of consumer product safety testing - before, during and after the sale. For a FREE Product Demonstration email info@vitrek.com, visit www.vitrek.com/applianceindustrydemo/ or call (858) 689-2755. You can also view additional industry specific information including our webinar and application flyer at <https://vitrek.com/consumer-product-appliance-industry-products/>