

Understanding the Abnormal Operations Test

The “Understanding the Product Safety Tests” Series

The *Abnormal Operation Test* is a test that contains many different types of “abnormal operation” conditions (aka “fault” conditions). The product safety standards require that all products comply with the 6 Hazards of Product Safety during normal operating conditions. The standards also require the product to have adequate Shock & Fire Hazard protection during all single fault conditions = the Abnormal Operation Test verifies that the single fault protection designed into the product does its job when a fault occurs.

1) The Purpose of the Test:

- The product safety standards require that the product be suitably protected from shock and fire hazards in the event of any single fault condition (abnormal operating condition).
- This test is performed on the overall product to insure that during a foreseeable abnormal operating condition, there is no Risk of Shock or Risk of Fire. Either of these hazards could cause serious injury or death, including the possibility of multiple deaths should a major fire occur.

2) The Test Method: Essentially the goal is to try any one thing that could go wrong and make sure that there is no shock or fire hazard. There are many different types of single fault conditions to consider:

1) General Fault Test Considerations:

- i. Multiple faults are never performed at the same time. However, a single fault may lead to other component failures as a result of the initial fault condition. These are considered part of the results and a skilled compliance engineer will examine the electrical schematic with an eye for identifying components to fault that could have a cascading fault effect = one short circuit could lead to excessive current through another component that fails and causes another failure, etc.
- ii. Critical limiting components must be certified in order to be relied upon. It is not considered a “fault” to bypass uncertified protection devices. For example, thermostats and temperature limiters must be certified or they will be bypassed during all tests including all abnormal operations tests. Fuses, circuit-breakers, and insulating materials must all be certified to be relied upon.
- iii. Test duration will depend on how the product responds to the fault condition. In general, the test needs to continue until ultimate results are obtained. A circuit breaker tripping or a fuse opening may remove power to all circuits thereby quickly ending a test. Other times there may be no immediately observable result, but that can change over time. Products with a fault condition have been known to sit unresponsive for a period of time before catching fire. Most standards specify waiting up to 8 hours for a fault condition to play out.
- iv. Temperatures are not monitored during most abnormal operation tests as temperatures generally are not used as risk of shock or risk of fire indicators. However, there are a few standards and types of abnormal tests that require



temperatures to be monitored during testing. This includes the overload and output short-circuit tests for isolation transformers using double or reinforced insulation systems.

- 2) Insulation Faults: Basic insulation by definition is considered a single level of protection – failure of any basic insulation is to be tested. Also, by definition, operational insulation may provide fire hazard protection. Consequently, a fault is applied to any operational insulation that may lead to a fire. The objective is to find any component faults that lead to a fire, and then verify that the product's enclosure properly contains the fire.
 - 3) Electrical Component Faults: Single component faults are to be performed on electrical components - open and short circuit conditions based on a review of the product's electrical schematic diagram. Any certified double insulated components are not faulted because that would be considered a double fault (and we only are permitted to perform single fault conditions). Certified double insulated components have already been tested to insure that if any internal single level of insulation fails, the component does not develop a shock or fire hazard.
 - i. We do not conduct component fault tests to ground – that would always blow the fuse and/or trip the breaker. Instead, for products provided with a Protective Earthing terminal (P.E.), we do testing on the ground system to insure it is reliable if there is a component fault to ground.
 - 4) Mechanical Faults: Motor locked rotor (including fan motors) and failure of other electro-mechanical parts. Overloading of mechanical parts and loading bearing systems are done separately as part of the Risk of Injury review and testing.
 - 5) Thermal Faults: Blocked vents and otherwise inhibited product ventilation from a single fault event. Worst case is often considered pushing the product into a corner or covering one set of vents - tests identified and configured such that they represent a single fault condition. Installation instructions and intended use environment should be also consulted in making these determinations.
 - 6) Other Faults: All single fault conditions that could lead to a Risk of Fire or a Risk of Shock must be identified and performed. For example, dual voltage rated products (i.e. 120/230VAC) using a voltage selector switch, voltage mismatch testing is done to represent the single fault condition of having the switch in the wrong position.
- 3) Test Configurations
- 1) Voltage Rating: For products that have a voltage rating range (i.e. 100 - 240VAC), the highest rated voltage is generally used for this testing – the goal being to have the highest available energy during the fault condition.
 - 2) All Abnormal Operation Tests: The product is to be placed on tissue paper and covered with cheesecloth = these materials serve as the “fire indicators” and are further defined with specifications in the standards. If either of these materials is charred or discolored, the standard concludes that a fire hazard has occurred - which is a test failure.
 - 3) Test Preparation: The product is subjected to the worst case normal operating conditions before the fault condition is applied. Which usually means that the product must be properly prepared so that the fault condition can be imposed while the product is operating normally. For electrical component faults, that means installing leads that extend from the product to a knife switch that can be actuated to initiate the component fault condition during normal operation.



- 4) The Test Objectives: The objective is to identify any failure of the product insulation system that could lead to a shock hazard to the user OR identify any failure in the product that could result in fire escaping the enclosure and igniting the supporting surface or nearby materials. The fault condition tests themselves do not reach these conclusions. After each fault condition, additional testing and inspection must be performed to determine if the test results are compliant. The test objectives are contained within the multiple pass/fail criteria for the fault tests.
- 1) Shock Hazard Pass/Fail: After each abnormal operation fault condition test, the product and in some cases insulating components that could be damaged by the fault condition are hipot tested (dielectric voltage withstand tested) to insure that the risk of shock insulation system remains reliable. With certain product standards/designs, leakage current testing may also be performed to determine if a shock hazard exists.
 - 2) Fire Hazard Pass/Fail: Visible internal fire and the resulting smoke are not relevant. After each abnormal operation fault condition test, the tissue paper under the product and the cheese cloth covering the product are examined for charring or other discoloring. If these materials are unaffected, the test results are compliant. Note that hot smoke will usually discolor the cheesecloth resulting in a test failure.

As you can see, we don't simply perform the tests because they are in the standard. Each test in the standard has a set of objectives that relate to the 6 Hazards of Product Safety. The Abnormal Operation Tests are performed as part of the Risk of Shock and Risk of Fire compliance review. Verifying reliability of the product's electrical insulation system is crucial to insuring the product continues to provide protection from a Risk of Shock, a potentially serious hazard that could lead to death by electrocution. We are also confirming that if any product fire occurs, it is contained within the product's enclosure so that the fire does not spread and threaten all building occupants. It is therefore an extremely important test – another test that directly saves lives.

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