Weekly Whitepaper
Week #55

Understanding Transformer Abnormal Testing

The "Understanding the Product Safety Tests" Series

Transformer Abnormal Testing is required on "safety isolation transformers" to insure that the transformer output remains below hazardous voltage levels during fault conditions in the secondary circuit. Worst case fault conditions are imposed at the output of the transformer = short-circuit conditions and separate overload conditions. These tests can be severe on the transformer, so it is very important to understand product design considerations that impact the test results.

Safety Isolation Transformers: In most standards, transformers that isolate the mains and transformers that are part of creating a SELV circuit (Safety Extra Low Voltage; or PELV), must successfully pass short-circuit and overload fault conditions. These tests are also part of the process of verifying the reliability of double and reinforced insulation systems in isolation transformers.

Purpose of the Test: To verify that there is adequate insulation in the transformer to withstand fault conditions in the secondary circuit without causing serious damage to the insulation system. Damage to the insulation system can cause the output voltage of the transformer to become a shock hazard.

Transformer Protection Method: In order to identify the appropriate test method, the transformer protection means must be identified. How the transformer is protected can impact the test method for these tests. This is especially true for the overload test with the load current dependent on how the transformer is protected:

a) Inherently limited transformers are usually overload tested to their maximum capable output power level.
b) Transformers protected by an external overcurrent device are usually tested with the overload current set to the level that would cause the overcurrent protection to trip in 1 hour. To determine what that current level is, the trip curve for the overcurrent device must be obtained and reviewed. During the test, the overcurrent protection device is replaced by a shorting device.
c) Transformers protected by an integral manual reset thermal limiting device are overload tested until the device operates.
d) Transformers protected by an integral auto-reset thermal limiting device are overload tested for an extended period of time causing the limiting device to cycle many times.
e) Transformers for switching power supplies are frequently protected by circuitry (i.e. crowbar and foldback circuits). The overload is applied to the power supply output and the current is raised to the point just before this protection operates.

Test Variations:

1) Switching Power Supplies: Most standards specify to apply the load during overload testing to the output of the power supply rather than directly to the output of the transformer.
2) Multiple Secondary Windings: For transformers with multiple secondary windings, only one winding should be tested at a time. While testing one winding, all other windings should be loaded or not loaded, whichever load condition of normal use is worst case. "Normal Use" means that you can only adjust the other winding loads as permitted thru a normal use action of the product. For example, if there is a means to turn a feature up/down or turn

on/off that causes the output of the other winding to go up/down, this should be included as part of the test.

3) Transformer Replacement: A new transformer may be used for each winding tested and for each fault condition.

Test Method:

1) Sample Preparation: Leads are attached to the transformer output that are then routed and extended out of the product for connection to either a knife switch (short circuit test) or load (overload test).
2) Temperature Measurement: If your standard requires the temperature be monitored on the transformer during testing, incorporate the appropriate temperature measurement means.
3) Short Circuit Test:
    a) The output of each winding is separately tested to simulate faults in the load.
    b) Protection devices are allowed to remain in place during this test. For this reason, short-circuit testing is usually over quickly when the protection device trips. Otherwise, the test is allowed to proceed until thermal stability is achieved.
4) Overload Test:
    a) The output of each secondary winding is separately overload tested to simulate fault conditions in the load that could cause the transformer to deliver more output power than intended.
    b) The load is to be adjusted to the level identified in the standard based on the transformer application and means of protection.
    c) External protection devices are replaced by shorting devices to prevent tripping during the overload condition = load currents are set based on the trip curve characteristics of the devices and therefore, they are no longer needed in the circuit.
    d) Most standards specify to adjust the load quickly to the determined set point and readjust the load only once at the 1 minute point. No further adjustment of the load is generally permitted.
    e) The test is allowed to proceed until thermal stability is achieved.

Pass/Fail Criteria:

1. Temperature Limits: Some standards have temperature limits on the transformer insulation during the test.
2. Open Winding Condition: Some standards permit a winding to open as long as the transformer passes the hipot test. Other standards define a winding opening during the test as a test failure.
3. Dielectric Voltage Withstand (Hipot) Test: In all cases, the transformer should be hipot tested while still heated immediately after powering off the product.

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 Transformer Abnormal Tests are performed as part of the Risk of Shock compliance review. Verifying reliability of the safety isolation transformer'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. It is therefore an extremely important test – another test that directly saves lives.