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Application note

Portable appliance testing –
The earth continuity test (IET Code of Practice section 15.4)

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High or low current bond testing?

All portable appliance testers are equipped with a bond test (also called an earth continuity test). This test is provided to establish the existence of a suitably low resistance connection from extraneous metal parts (of a class I device) or the continuity of the earth conductor in an extension lead or power cord, to the earth of the fixed electrical installation.

This path ensures that, should any extraneous metal part become live the current in the earth path will rupture a fuse or operate other protective devices such as an MCB or RCD.

To confirm the adequacy of this connection, two types of test are available. The IET Code of Practice Edition 4 refers to them as a "Hard" test and a "Soft" test. In reality these are a high current test or a low current test. Both tests are performed at low test voltages, typically 4V to 24V and either AC or DC test current.

The "Hard" continuity or "Bond" test:

This test uses a high test current, typically not less than 1.5x the fuse rating of the equipment under test (EUT), but not exceeding 26A. Most commonly this is a 25A AC test of around 4 to 7V.

Arguments in favour of the "Hard" test are:

a) it will breakdown surface oxidisation to give an accurate and repeatable measurement on a wide range of surfaces

b) under limited circumstances it may have the necessary current to rupture thin wire strands that may be providing an artificial earth path

c) As an AC test (there are few high current DC testers on the market) there is no polarity issues eg forward and reverse current

In reality the high test current will overcome poor contact resistance. It may even rupture a single strand of copper wire, but not reliably. The example below has just 4 strands making contact, which withstood a 5second 25A tests.

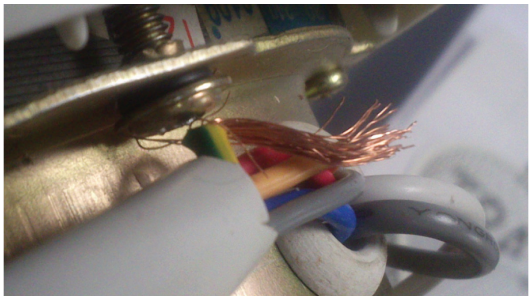
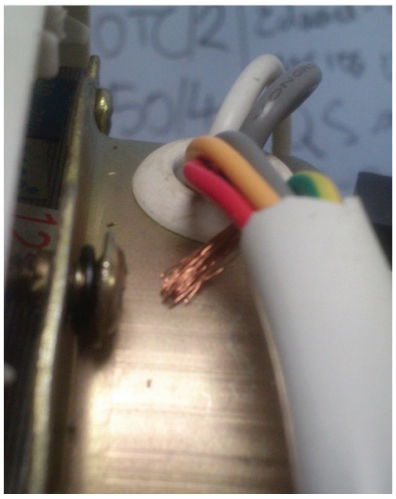


Figure 1. 4 strands making contact

The high current can, however create a temporary "weld" between two touching surfaces, say a screw terminal that has not been tightened on a wire. The result would be a very low (pass) resistance that, if tested with a "Soft" test may otherwise have returned a high resistance and recorded as a fail.

The following results demonstrate this point:



Both hard and soft measurements were made on a loose earth connection shown left. The earth conductor was touching the metalwork but not secured. Consequently only a surface contact was made.

Figure 2. Surface contact made

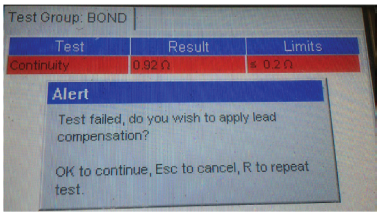


Figure 3. Tested with low (200mA) test current

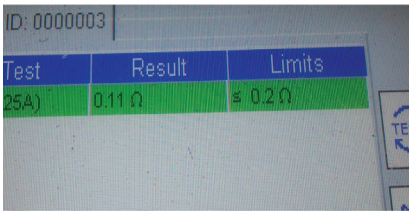


Figure 4. Tested with high (25A) test current.

As is clear from the results, the different tests provided contradictorily results, with the high current test passing fundamentally dangerous Class I equipment.

Also, if applied inappropriately, such as on the earth path of a personal computer charger, it can damage signal tracks. These tracks are provided to allow the EUT to function rather than to carry high currents for fault protection.

Finally, the high current requires a large transformer, significant amounts of space, adds greatly to the weight of the test equipment and usually has to be mains powered, requiring a suitably convenient 230V power outlet.

The "Soft" continuity test

This test uses a low test current, typically between 20mA and 200mA, but at the same test voltage of between 4V and 24V. Most commonly this is a DC test of around 4 to 7V.

Arguments in favour of the "Soft" test are:

a) it is unlikely to cause any damage if applied inappropriately, say to a functional earth

b) poor contacts are not "welded" so return a less "conditioned" measurement

c) it can be powered from batteries rather than mains power

d) the test can automatically test in forward and reverse polarity modes

Test connections can be more problematic, as a good surface contact is needed if this is not to interfere with the measurement accuracy.

Usually this test is a DC test which may be a single polarity test (test current flows in one direction only) or bi-directional (test current flows in both directions). The advantage of the bi-directional test is that the circuit is tested in both directions and the highest measured resistance is recorded. This is usually automatic, and not visible to the operator.

Example:

If a monitor has been left connected to a PC via the VGA lead whilst the Monitor is PAT tested. In the dual polarity test one direction may measure 0.1ohm but in the reverse polarity it can measure greater than 12ohms.

This may easily be missed in a single polarity test.

Summary

It is far more important that one of the tests is performed, rather than no test. However when choosing test equipment it is worth bearing in mind the following:

For those professional PAT users where the type of equipment tested may be:

- extremely varied
- undergoes tough use and abuse and

and where the operator has significant field experience, it makes sense to use a portable appliance tester that can provide both the Hard and Soft types of test.

For small organisations that wish to test their own equipment, for contractors who only occasionally provide a PAT service or the availability of a mains power source is limited or undesirable, then test equipment with the low current Soft test is the sensible choice.

It is worth ensuring the Soft test is bi-directional, as this will pick up issues with equipment that may well be missed with a single direction soft test.

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