FLUKE®

Basic electrical installation testing

Application Note

Growing concern for public safety and the increasing complexity of today's fixed electrical installations in domestic, commercial and industrial premises places extra responsibility on electrical test engineers who are charged with verifying conformity to today's stringent international standards.

It is therefore important to have suitable test tools for carrying out the stringent tests imposed by the International Electrotechnical Commission (IEC) and the European Committee for Electrotechnical Standardization (CENELEC).

IEC 60364, and its various associated national equivalent standards that are published throughout Europe (see table 1), specifies the requirements for fixed electrical installations in buildings. Section 6.61 of this standard describes the requirements for the verification of the compliance of the installation with IEC 60364.

Table 1

European equivalents of IEC 60364 (6.61)

Austria	ÖVE/ÖNORM E8001
Belgium	A.R.E.I. / R.G.I.E.
Denmark	Stærkstrømbekendtgørelsen 6
Finland	SFS 6000
France	NF C 15-100
Germany	DIN VDE 0100
Italy CEI	64-8
Netherlands	NEN 1010
Norway	NEK 400
Portugal	HD 384
Spain	UNE 20460
Sweden	SS 4364661 / ELSÄK-FS 1999:5
Switzerland	NIN / SN SEV 1000
UK	BS 7671 / 16th Edition IEE Wiring Regulations

The basic requirements of IEC 60364.6.61

Many electrical contractors may already be familiar with IEC 60364.6.61 or its national equivalents. It states that verification of the installation shall be carried out in the following sequence:

1. Visual inspection
2. Testing of the following:
   - continuity of protective conductors;
   - insulation resistance;
   - protection by separation of circuits;
   - floor and wall resistance;
   - automatic disconnection of supply;
   - polarity;
   - functional performance;

   In addition to this the following tests are under consideration:
   - electric strength test;
   - voltage drop.

To test the protective measures as described above, IEC 60364.6.61 refers to the IEC / EN 61557.

The basic requirements of IEC/EN 61557
The European Norm EN 61557 addresses the requirements for test equipment used in installation testing. It consists of general requirements for test equipment (part 1), specific requirements for combined measuring equipment (part 10) and covers the specific requirements for measuring/testing:

1. Insulation resistance (part 2)
2. Loop impedance (part 3)
3. Resistance of the earth connection (part 4)
4. Resistance to earth (part 5)
5. RCD performance in TT and TN systems (part 6)
6. Phase sequence (part 7)
7. Insulation monitoring devices for IT systems (part 8)

The Fluke 1650 Series multifunction installation testers are measuring equipment as described in part 10 of EN 61557 and the three different models in the series comply with specific parts of this norm. They are specifically designed to carry out the tests specified in IEC 60364.6.61, and all local standards/ regulations derived from it, in the safest and most efficient way. They are lightweight, and feature a unique ergonomic 'curved' form that, when carried by the neck strap, makes operation in the field more comfortable.

Testing an electrical installation
The visual inspection is first carried out to confirm that permanently wired electrical equipment is in compliance with the safety requirements and not visibly damaged, and that fire barriers, protective-, monitoring-, isolating and switching devices, and all relevant documentation are present. After this inspection, electrical testing may commence. Note that the test methods described are given as reference methods in IEC 60364.6.61. Other methods are not precluded provided they give equally valid results. Only with the appropriate experience and training, safe clothing, and the right test tools is a person considered competent to test installations to IEC 60364.6.61. When testing is undertaken it should be ensured that adequate precautions are taken to avoid damage or injury to people, equipment or property, and ensured that unauthorized persons are kept away from danger.

Continuity
Testing the continuity of protective conductors is normally carried out with an instrument being able to generate a no-load voltage in the range 4 to 24 V (DC or AC) with a minimum current of 0.2 A. The most common continuity test is measuring the resistance of protective conductors, which involves first confirming the continuity of all protective conductors in the installation, and then testing the main and supplementary equipotential bonding conductors. All circuit conductors in the final circuit are also tested. As continuity testing measures very low resistances, the resistance of the test leads must be compensated for. The 1650 has a time-saving auto-null feature that, by simply touching the test leads together and pressing the zero button, measures and stores the test lead resistance, even after the instrument has been switched off.

Insulation resistance of electrical installation
Insulation integrity is critical to prevent electric shock. It is generally measured between live conductors; and between each live conductor and earth. To measure the insulation resistance between live conductors and earth, the complete installation must be switched off, all lamps removed and all equipment disconnected. All fuses must be left in, circuit breakers closed and final circuit switches closed.

Measurements are carried out with direct current using an instrument capable of supplying a test voltage of 1000, 500 or 250 V depending on the nominal circuit voltage. On single phase supply systems, insulation testing is normally undertaken using a test voltage of 500 V. Before testing, it is necessary to disconnect equipment and take measures to prevent the test voltage damaging voltage-sensitive devices such as dimmer switches, delay timers, and electronic starters for fluorescent lighting.

The 1650 Series generates the required test voltages (selectable) and, uniquely for an installation tester of this type, the models 1653 and 1654 also have 50 and 100 V test voltages as required for testing telecommunications installations. To enhance safety, 1650 Series installation testers have a live voltage indicator to warn users if a live voltage is still present. Testing is inhibited if a voltage is detected. When taking a measurement, the dual display indicates both the insulation resistance and the applied test voltage.

According to IEC 60364.6.61 the resistance values should be greater than 1 megohm for 1000 V test voltage, 0.5 megohms for 500 V, and 0.25 megohms for 250 V.

Protection by separation of circuits
The separation of the live parts from those of other circuits and from earth should be verified by a measurement of the insulation resistance. The resistance values obtained should be identical with the values mentioned previously with all appliances, as far as possible, connected.

Floor and wall resistance
If applicable, at least three floor and wall resistance measurements need to be made per location, one being approximately 1 metre from any accessible extraneous-conductivepart in the location, with the remaining two measurements taken at greater distances. The series of measurements is repeated for each relevant surface of the location.

The 1650 Series insulation test function with a no-load voltage of 500 V (or 1000 V if the rated voltage of the installation exceeds 500 V) is used as a DC source. The resistance is measured between a test electrode (such as a 250 mm square metallic plate with a 270 mm square of damped water-absorbent paper from which surplus water has been removed) and a protective conductor of the installation.

Verifying protection by automatic supply disconnection
Verification of the effectiveness of the measures for protection against indirect contact by automatic disconnection of supply depends on the type of system. In summary, it is as follows:

- **For TN systems:** measurement of the fault loop impedance; and verification of the characteristics of the associated protective device (i.e. visual inspection of the nominal current setting for circuitbreakers, the current ratings for fuses and testing RCDs).
- **For TT systems:** measurement of the earth electrode resistance for exposed-conductive-parts of the installation; and verification of the characteristics of the associated protective device (i.e. RCDs by visual inspection and by test).
- **For IT systems:** Calculation or measurement of the fault current.

Measurement of the earth electrode resistance
Measurement of the resistance of an earth electrode is made by an appropriate method, for example, using two auxiliary earth electrodes or 'spikes'. These electrodes are available as an accessory kit for use with the 1653 and 1654 model. Before testing, the earthing rod must be disconnected from the installation's main earthing terminal. In doing this, the installation will consequently have no earth protection and therefore must be completely deenergised prior to testing. Earth resistance testing must not be carried out on a live system.

One auxiliary electrode is placed at a set distance from the earth electrode, and the other at 62 percent of the distance between the two in a straight line. The test measures the earth resistance and also detects the voltage between the auxiliary electrodes, and if this exceeds 10 V, the test is inhibited.

Measurement of fault loop impedance
Measurement of the fault loop impedance is carried out using the same frequency as the nominal frequency of the circuit (50 Hz). The earth-loop impedance test measures the resistance of the path that a fault current would take between line and protective earth, which must be low enough to allow sufficient current to flow to trip a circuit protection device such as a MCB (Miniature Circuit Breaker). In addition, the 1654 has a mΩ resolution for measuring short earth loop paths when close to a supply transformer. The 1650 Series instruments carry out this test using three separate test leads or the lead fitted with a mains plug. It calculates the Prospective Fault Current (PFC), and this appears in the lower part of the dual display. Determining the PFC is important to ensure that the capability of fuses and over-current circuit breakers is not exceeded. The 1650 Series instruments can also measure the earth resistance component of the total loop resistance, and line impedance (source impedance between line and neutral, or the line-to-line impedance in three-phase systems) as well as calculate the Prospective Short Circuit current (PSC) which could flow when there is a short circuit between line and neutral.

Measuring loop impedance can actually trip RCDs in the circuit being tested, preventing further measurement. To prevent this the Fluke 1650 uses innovative and patented technology. This means more consistent and highly repeatable results.

Testing RCDs
Residual Current Operated Devices (RCDs) are often fitted for additional protection, where they detect currents flowing to earth that are too small to trigger over-current operated protective devices or to blow fuses, but would still be sufficient to cause a dangerous shock or generate enough heat to start a fire. Basic testing of RCDs involves determining the tripping time (in milliseconds) by introducing a fault current in the circuit.

The 1650 Series multifunction testers also perform a pre-test to determine if the actual test will cause a fault voltage exceeding a 50 V or 25 V safety limit. To manually measure the tripping time, the RCD's tripping current rating, a test current multiplier, the RCD type and the test current phase setting are selected using the menu buttons. Because some RCDs are more sensitive in one half cycle than the other, the test is carried out for both 0 and 180°phase settings. The longest time is recorded.

To simplify testing, the 1652, 1653 & 1654 models have an auto mode for measuring RCD tripping time in which six tests are automatically carried out in sequence. This means the test engineer does not need to keep returning to the installation tester after resetting a tripped RCD. The instrument senses when the RCD has been reset and initiates the next test in the sequence. Results are held in temporary memory, and viewed by stepping through with the arrow buttons. The 1653 and 1654 also have internal memory for storing results for later recall. The 1652, 1653 & 1654 can also measure RCD tripping current (commonly referred to as a ramp test) by gradually increasing an applied current until the RCD trips.

Polarity test

Where local regulations forbid the installation of single-pole switching devices in the neutral conductor, a test of polarity must be made to verify that all such devices are connected in the phase only. Incorrect polarity results in parts of an installation remaining connected to a live phase conductor even when a single-pole switch is off, or an over-current protection device has tripped. The 1650 Series multifunction testers test for correct polarity using the continuity mode.

Functional test

All assemblies, such as switchgear and control gear assemblies, drives, controls and interlocks, should be functionally tested to show that they are properly mounted, adjusted and installed in accordance with the relevant requirements of the standard. Protective devices must be functionally tested to check whether they are properly installed and adjusted.

The 1650 Series multifunction testers

The 1650 Series multifunction testers measure up to 500 V AC, and the instruments simultaneously display line voltage level (primary display) and frequency (secondary display). They are easy to set up for making measurements, with a clearlymarked rotary control for setting the range, and a straightforward user interface with simple menus for setting test conditions. The display's wide viewing angle also contributes to user convenience. The control panel markings are available in five languages (English, French, German, Italian and Spanish), and with universally recognized graphical symbols.

There are four models to choose from: the 1651 performs all basic installation tests; the 1652 has additional RCD test functions; and the 1653 also offers low voltage insulation resistance and earth resistance measurements and a phase sequence indication for three phase systems. Next to this the 1653 features an internal memory for storing up to 444 measurements. Both the 1653 and 1654 have a PC interface for extra convenience in documentation and reporting. This simplifies generating reports (in combination with the optional FlukeView™ Forms software or DMS software) to comply with legal requirements for documented results. The 1654 has the addition of a mΩ resolution earth-loop impedance test, can test smooth dc sensitive RCDs (Type B) and has a 1500 record memory. All models feature a special probe design with an integral test button that simplifies one-handed measurements on hard-to-reach test-points, thereby enhancing safety by reducing the risk of accidentally touching a live conductor. In addition to the smart probe, a full set of test leads plus crocodile clips, heavyduty carrying case, neck strap, and an appropriate standard mains connection lead, are supplied. A quick reference guide and an operating manual on CD-ROM are included. The 1653 & 1654 also have an IR adaptor for PC connection.

Caution!

This Application Note is not intended to replace or supercede the recognized standards in IEC 60364 (or its national equivalents), but to provide a summary of the general requirements.
Note that not all tests are mentioned. If in any doubt, always consult the appropriate standards publication.

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