Electrical Safety Professional

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BEST PRACTICE GUIDE

7

ISSUE 2

TEST INSTRUMENTS FOR ELECTRICAL INSTALLATIONS

Accuracy and consistency

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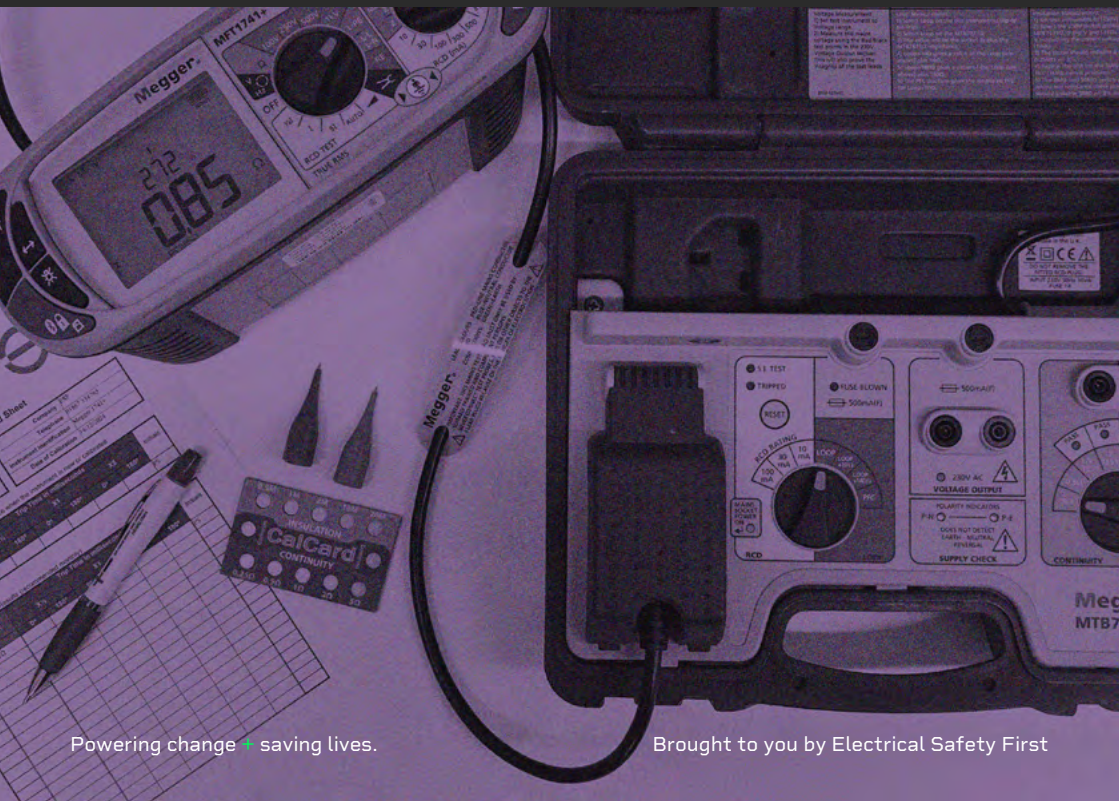

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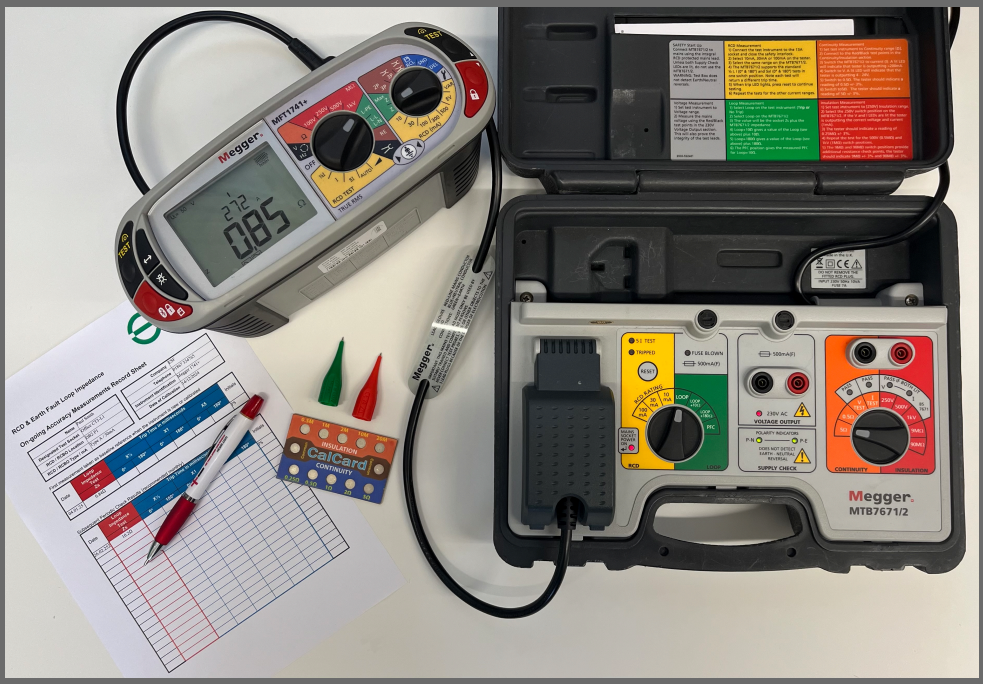
TEST INSTRUMENTS FOR ELECTRICAL INSTALLATIONS: ACCURACY AND CONSISTENCY

The aim of this Guide is to promote best practice by providing practical advice and guidance for electrical installers, verifiers, inspectors and other competent persons having responsibility for testing electrical installations.

This guidance applies to test instruments intended for use on installations operating at a nominal voltage not exceeding 1000 V a.c. or 1500 V d.c.



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1. INTRODUCTION

To comply with Regulation 643.1 of *BS 7671*, test instruments must be selected according to the relevant parts of *BS EN 61557* or, if not, they must provide an equivalent level of performance. *BS EN 61557* requires compliance with the safety requirements of *BS EN 61010*.

Test instruments must be of a category appropriate to the overvoltages likely to be encountered. The categories are shown in the diagram in Annex 1.

BS 7671 does not require regular calibration of test instruments. However, in order to maintain confidence in the accuracy of all test instruments used for initial verification and condition reporting purposes, those responsible for testing should put in place an effective system to confirm and record their continuing accuracy and consistency, so that remedial action can be taken without delay if there is any indication that an instrument is no longer sufficiently accurate.

It is important to be confident that test instruments are accurate and remain consistent. Instruments may become inaccurate for a number of reasons, such as being dropped or having a heavy object fall against them in the back of a van. In some cases, an instrument itself may remain accurate but its test leads can become loose or dirty, thereby affecting the measurements.

2. INITIAL ACCURACY

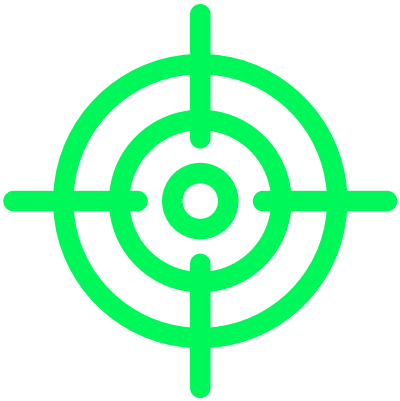
It is important to establish the accuracy of a new or repaired instrument as this establishes a reference point.

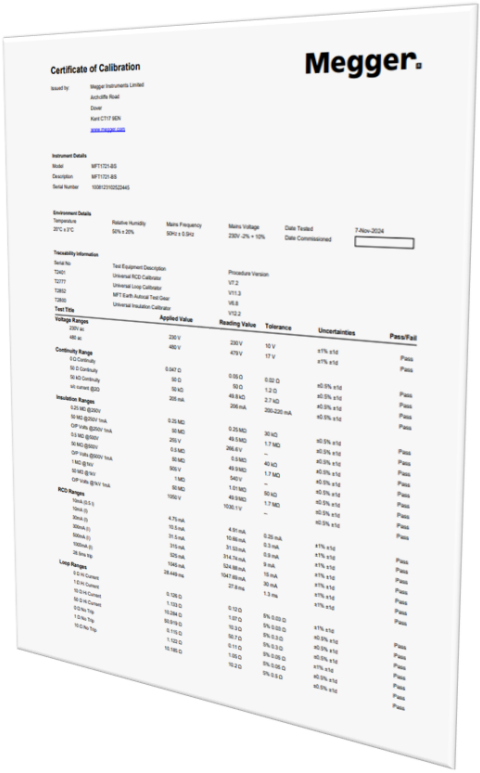
The initial accuracy of a new or repaired instrument is usually confirmed by calibration. However, a new or repaired test instrument may not be supplied with a calibration certificate unless specifically requested.

An instrument may be supplied with a Certificate of Conformity. This indicates that the accuracy of the instrument was verified as part of the manufacturing process. The verification will generally follow the same procedure as calibration, but individual calibration data is not issued.

Following the confirmation of initial accuracy, it is important to check and maintain continuing accuracy.

It is also important to treat test instruments and associated test leads and accessories with care. Many instruments are now provided with a cushioned box that helps protect them against mechanical damage.





Certificate of Calibration

Megger.

3. SYSTEMS FOR CONFIRMING ONGOING ACCURACY AND CONSISTENCY

Whichever system is used for confirming the ongoing accuracy and consistency of test instruments, it is the responsibility of the user to ensure that the system provides confidence in the test results used to verify or confirm the safety of an electrical installation.

Formal calibration/recalibration by a third party

A system for confirming the ongoing accuracy of test instruments could simply consist of maintaining records of the formal calibration/recalibration of the instruments at the intervals recommended by the instrument manufacturers, supported by calibration certificates issued by recognised organisations with measurements traceable to national standards. Calibration certificates issued by laboratories accredited by the United Kingdom Accreditation Service (UKAS) are preferable.

Calibration involves checking whether or not an instrument is still operating within the manufacturer's specification and, if not, making adjustments to bring the instrument back within specification. The test leads used with the instrument should be submitted with it.

However, given the arduous conditions in which test instruments often have to be used, such a formal calibration system cannot provide any assurance of continuing accuracy over the period (typically one year) between the calibration checks.

Many instruments used for electrical installation testing will be in regular use and be frequently transported from site to site. Should an instrument be found to be inaccurate when sent for say an annual calibration check, numerous inaccurate results may have been recorded on test schedules. This could potentially require extensive retesting to ensure that no dangerous conditions exist in installations tested with that instrument since the previous calibration check.

Therefore, when submitting an instrument for calibration, the user should ask to be advised if it was found to be inaccurate.

In-house systems

To avoid the problems that might arise if an instrument becomes inaccurate following initial or subsequent certification of conformity or calibration, 'in-house' systems of the type recognised by electrical contractor assessment bodies might be considered desirable.

Such in-house systems, however, can only provide a measure of confidence in the **consistency** of test measurements over time. The **accuracy** of each instrument needs to be confirmed before any reliance can be placed in such systems.

The frequency of ongoing accuracy checks will depend upon how often the instruments are used, how they are maintained and experience of the results of previous checks.

Where an instrument is used by one operative, the operative should be able to maintain some control over it. But where instruments are issued to different operatives on a regular basis, there may be less control. In such cases, it would be prudent for a consistency check to be made at the time of handover.

Proprietary checkbox

One recognised in-house system for checking ongoing consistency uses a proprietary checkbox. Such checkboxes are available from most instrument manufacturers and provide a checking facility for a range of test instruments: provision for continuity, insulation resistance, earth fault loop impedance and RCD tests being typical.

There are a number of proprietary checkboxes on the market, some providing more comprehensive checks than others.

Where a checkbox does not check the voltage of an insulation resistance test instrument or the open circuit voltage and short circuit current of a continuity test instrument, these checks should be made using other test instruments.

The output voltage of an insulation resistance test instrument should be not less than the range selected, when measured with a voltmeter.

The open circuit voltage of a continuity test instrument should be between 4 V and 24 V when measured with a voltmeter, and the short circuit current should be not less than 200 mA when connected to an ammeter set to an appropriate range.

If the checkbox is unable to check a loop impedance or RCD test instrument, the instruments should be checked using another system.

Consideration should be given to having checkboxes calibrated at appropriate intervals.

Comparative cross-checks

Another system is to maintain records over time of comparative cross-checks with other test instruments used by the organisation.

Where an organisation has more than one set of test instruments, comparative cross-checks on one instrument can be made using another test instrument.

In this case, the cross-checking procedure used should be recorded to help ensure that a consistent method is adopted and that all instruments are regularly checked.

It would be also prudent to check that:

- The output voltage of an insulation resistance test instrument is not less than the range selected, when measured with a voltmeter, and
- The open circuit voltage of a continuity test instrument is between 4 V and 24 V when measured with a voltmeter, and the short circuit current is not less than 200 mA when connected to an ammeter set to an appropriate range.

Larger businesses might decide to reserve a set of regularly calibrated instruments for use as the standard against which other sets of instruments are compared.

Designated reference circuits or devices

A third in-house system for checking ongoing consistency is to maintain records over time of measurements of the characteristics of designated reference circuits or devices. This system is the least preferable in terms of confirming the full range of test instrument functions.

For continuity and insulation testing, this system uses good quality resistors for both low-resistance ohmmeters (for continuity testing) and high-resistance ohmmeters (for insulation resistance testing). The choice of resistors should reflect the expected range of the instruments in question.

For example, for a low-resistance ohmmeter consistency checks, there should be at least one resistor below 0.5 Ω and another between 0.5 Ω and 1.0 Ω, as values in this range are common. If the continuity test instrument has more than one range, additional resistors should be selected to test the higher ranges.

Check resistors for high-resistance ohmmeters should at least take account of the requirements of Part 6 (Table 64) of *BS 7671* and for this 0.5 MΩ and 1.0 MΩ resistors will be required, rated at least 1000 V. However, as the measured insulation resistance values for new electrical installations are expected to be much higher than the minimum values permitted by *BS 7671*, additional check resistors should be selected (for example a 10 MΩ and 100 MΩ resistor) for the higher insulation resistance ranges.

Note: The above check resistor values are indicative only.

For checking the ongoing consistency of loop impedance test instruments, a designated socket-outlet on a non-RCD-protected circuit should be used for the check. The value of earth fault loop impedance at the socket-outlet may vary as a result of network conditions (load etc), but regular monitoring will quickly establish whether such variations are significant or not. The expected earth fault loop impedance value should be marked on or adjacent to the socket-outlet designated for the checks, or recorded in the instrument accuracy logbook.

For ongoing checks of residual current device test instruments, a designated RCD protected socket-outlet can be used. As with the arrangement for loop impedance checks, the expected tripping times should be marked on or adjacent to the designated socket-outlet, or recorded in the instrument accuracy logbook.

4.TEST EQUIPMENT

For all low voltage electrical installation verification and condition reporting work, electrical contractors and installers should, as a minimum, have the following range of test instruments:

- Continuity test instrument;
- Insulation resistance test instrument;
- Loop impedance test instrument;
- Residual current device test instrument;
- Earth electrode resistance test instrument*;
- Suitable split test leads for both the loop impedance test instrument and the residual current device test instrument;
- Voltage indicating instrument**.

** Alternatively, an earth fault loop impedance test instrument may be used. There is no commonly available alternative for confirming the accuracy of an earth electrode resistance test instrument other than calibration, although it is feasible to construct a test box for this purpose.*

*** Voltage indicating equipment does not require calibration*

Two or more of the functions of the above test instruments may be combined in a single instrument.

5. MAINTAINING RECORDS OF ONGOING ACCURACY AND CONSISTENCY

Whichever method of confirming ongoing accuracy is adopted, the results should be documented for record and audit purposes.

Each test instrument should be clearly and uniquely identified for record and traceability purposes.

Annex 2 shows a typical form for recording monthly accuracy checks.

6. SELECTION OF TEST INSTRUMENTS FOR GIVEN TESTS

Test instrument manufacturers will state to which standard their instruments conform.

BS EN 61557 is entitled *Electrical safety in low voltage distribution systems up to 1000 V a.c. and 1500 V d.c. Equipment for testing, measuring or monitoring of protective measures.* This standard includes performance requirements and requires compliance with *BS EN 61010*.

BS EN 61010: *Safety requirements for electrical equipment for measurement control and laboratory use* is the basic safety standard for electrical test instruments.

Voltage detection instruments should conform to *BS EN 61243-3: 2014 Live working. Voltage detectors - Two-pole low-voltage type.*

BS EN 61557 consists of a number of parts, some of which are indicated in Table 1.

Table 1: Example sections of *BS EN 61557*

Part #	Title
1	General requirements
2	Insulation resistance
3	Loop impedance
4	Resistance of earth connection and equipotential bonding
5	Resistance to earth
6	Effectiveness of residual current devices (RCD) in TT, TN and IT systems
7	Phase sequence

7. SOURCES OF MEASUREMENT ERRORS

Sources of error that can affect the overall accuracy of a test measurement, and even the ability to make a meaningful measurement, vary considerably.

Much depends on:

- The type of measurement being made;
- The effectiveness of the connections between the instrument and the circuit to be tested.

Measurement errors can arise from, amongst other things:

- Poor probe contact;
- Poorly nulled test leads;
- Weak crocodile clips;
- Faulty (intermittent) leads;
- Leads other than those supplied with the instrument.

Some examples of common errors for different types of measurement are detailed below:

Continuity measurement

- ***Condition of test lead connectors –*** Poorly maintained, old or worn connectors can add significant error and variability to a result. Test leads do wear out.
- ***Resistance of the test leads –*** The effect of test lead resistance (including any fuses) can be removed by the nulling (zeroing) facility provided by many test instruments.
- ***Probe contact resistance –*** This will depend on the condition of the probe tips and that of the material to which they are connected, and the pressure applied.
- ***Crocodile clips –*** One side of a clip may have a lower resistance than the other, the hinge creating the higher resistance path. This can be an issue both when nulling and when attaching the clips for measurement.

Insulation resistance

- ***In-circuit components –*** Neons, electronic components etc can significantly affect insulation resistance values.

Loop impedance testing

- ***Contact resistance –*** Low loop impedance measurements are affected in the same manner as continuity measurements.
- ***Mains noise or disturbance –*** Non-trip loop tests frequently use low test currents (15 mA) for testing RCD-protected circuits. These tests are susceptible to noise or mains disturbances, which may create variation in the results. If there is any concern about the result, the test should be repeated.
- ***Low loop impedance values and prospective fault current calculations –*** When measuring close to a transformer or other low impedance source, loop impedance values can be very low, typically less than 0.1 Ω.

As prospective fault current values are generally derived from the loop impedance measurements either directly by instruments or by manual calculation, small variations in the measurement of loop impedance values may result in significant differences in prospective fault current indications or calculations. In such cases, it may be necessary to use an alternative method of determining prospective fault current other than by a loop impedance test instrument.

- ***Instrument accuracy and resolution –*** Where circuits do not incorporate RCD protection, earth fault loop impedance measurements should be made using the higher test current range (up to about 25 A). A displayed test result less than about 0.2 Ω could be prone to significant errors. Such errors can significantly affect the calculation of prospective fault current. On the low current range (such as 15 mA), displayed test results less than about 1.0 Ω could be prone to significant errors. Such errors can significantly affect the calculation of prospective fault current.

RCD testing

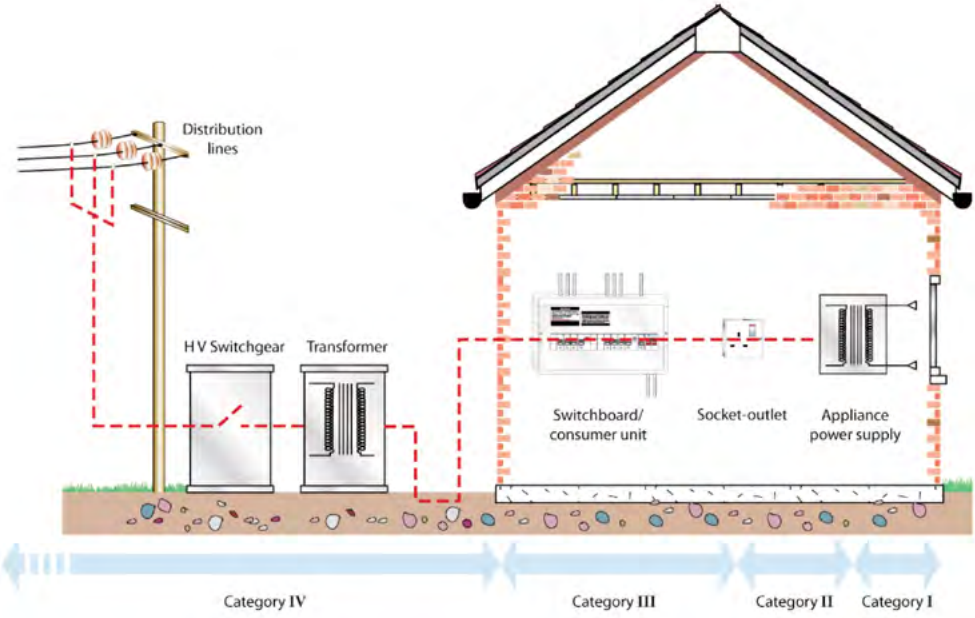
- ***Earth leakage currents –*** These can affect the trip times of RCDs, by adding to the RCD test current.

Additional information on sources of error

Additional information on sources of error can often be found in the product user guide or should be available from the instrument manufacturer.

ANNEX 1

Figure 1: Impulse withstand categories.



ANNEX 2

Figure 2: Typical form for recording monthly instrument accuracy checks
(Courtesy of NICEIC)

Test instrument accuracy record (summary)

Instrument function*:	Acquisition date:
Make:	Model:
Serial No. or other assigned identity:	

Location of any designated socket-outlet, or description of any device, used for reference checking purposes:

Date:						
Formal calibration certificate:						
Check against designated reference circuit/device:						
Cross-check against another test instrument:						
Identity of other test instrument:						
Repair:						
Remarks:						

Full details of the results of the accuracy checks, including any calibration certificates, are to be retained for record purposes in support of this summary.
*Separate records are required for each function of a multi-function test instrument.

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Electrical Safety First is the UK charity dedicated to reducing deaths and injuries caused by electrical accidents. Our aim is to ensure everyone in the UK can use electricity safely.

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