



ONGOING ACCURACY OF TEST INSTRUMENTS

By Mark Coles

When undertaking electrical testing on an installation, how accurate are the test results? The readings obtained from a test instrument when carrying out a measurement of earth-fault loop-impedance or the operating time of an RCD – is the reading shown on the instrument correct? How do I know?

This, the second article in the series of testing & inspection, looks at what can go wrong and how to keep track of an instrument's performance.

The requirements

Anyone can make a mistake, even the most experienced of electricians. For this reason, all electrical installations, alterations and additions should be tested, inspected and subsequently certified prior to handing over to the client for use. The certificate issued describes the current operating parameters and will provide the basis for any future alteration or addition to the installation. The results of testing, contained within the certificate, must be an accurate representation of the installation. The test instrument must, of course, be accurate and the obtained results must be consistent but what are the requirements?

The requirements of BS 7671

BS 7671 requires that every installation shall be inspected and tested to verify that the Regulations have been met before being put into service. The requirements are stated in the following Regulations:

■ 133-02-01 On completion of an installation or an addition or alteration to an installation, appropriate inspection and testing shall be carried out to verify so far as is reasonably practicable that the requirements of this standard have been met.

■ 711-01-01 Every installation shall, during erection and on completion before being put into service be inspected and tested to verify, so far as is reasonably practicable, that the requirements of the Regulations have been met.

Precautions shall be taken to avoid danger to persons and to avoid damage to property and installed equipment during inspection and testing.

■ 713-01-01 The tests of Regulations 713-02 to 713-13 where relevant shall be carried out and the results compared with relevant criteria.

The tests of Regulations 713-02 to 713-09 where relevant shall be carried out in that order before the installation is energised.

If any test indicates a failure to comply, that test and any preceding test, the results of which may have been influenced by the fault indicated, shall be



repeated after the fault has been rectified.

Some methods of test are described in Guidance Note 3, *Inspection & Testing*, published by the Institution of Electrical Engineers. Other methods are not precluded provided they give valid results.

Electrotechnical Assessment Scheme (EAS)

Under the Electrotechnical Assessment Scheme (EAS), Annex 1, *Test Instruments – Calibration requirements*, it is a requirement that the *Enterprise* shall have a suitable system in place to ensure that the accuracy and consistency of all test instruments used for certification and reporting purposes is being maintained.

The Electrotechnical Assessment Scheme (EAS) specifies the minimum requirements against which an electrical installation enterprise, or electrical contractor, may be assessed in order to determine the technical competence of the enterprise. The ownership and management of the EAS was taken over by the IEE and is administered by the EAS Management Committee. An Electrotechnical Assessment Scheme was seen as necessary if the electrical industry and other interested parties were going to support the efforts of the then DETR in introducing electrical safety in to the Building Regulations.

Subsequently, the Office of the Deputy Prime Minister (successor body to the DETR) asked the EAS Management Committee to make recommendations for the technical competence of contractors to carry out electrical installation work in dwellings only without prior notification to building control.

The document 'Minimum Technical Competence of Enterprises that undertake Electrical Installation Work in Dwellings' (MTC) was prepared for this purpose and accepted by the Office of the Deputy Prime Minister. All authorised competent persons schemes are required to ensure that registered firms have the minimum technical competencies.

HSE guidance note GS 38

Electrical testing leads and accessories must be designed to provide adequate protection against danger. The HSE guidance note GS 38, *Electrical test equipment for use by electricians*, gives guidance to electrically competent people, along with advice on test probes, leads, voltage indicating devices and measuring equipment.

What can go wrong with test instruments?

Problems with test instruments are not always immediately obvious so it is important that any irregularities are discovered as early as possible.

What can go wrong?

Damage to the instrument

Consider the scenario; a test instrument was calibrated by a calibration house six months ago and is still within the stated 12-month calibration period. It appears to be working well but, unbeknownst to the contractor, five months ago it had a collision with a conduit bender in the back of the firm's van and is now out of calibration. Many, many jobs have been tested with this instrument since the incident occurred and, hence, many certificates and forms have been issued. The certificates and forms, of course, are worthless as the test results contained within would not be representative of the installation. Therefore, it is extremely important that the instrument is regularly assessed.

Connecting leads and the importance of 'nulling'

Often, problems associated with test instruments can be traced to faulty leads. The leads suffer a great deal of punishment, constant flexing and pulling, uncoiling and recoiling, squashed into boxes, etc. As testing probes are repetitively changed and replaced with gripping 'crocodile' clips, over time, contact resistance at the point of connection can increase, which could throw doubt on the results obtained. The springs that maintain the gripping pressure of the crocodile clips can suffer fatigue with age or when not adequately maintained. Foreign bodies and particles, such as brick dust, can clog the connections and moving parts, again, increasing contact resistance. It is well documented that the leads should be 'nulled' prior to use and there is a correct way of nulling.

Fig 1 shows the correct method of connection when nulling test leads. Note that the current flow is directly from lead to lead.

Fig 2 shows the incorrect method of connection when nulling test leads. Note that the current flow is across two hinges. When the leads have been nulled with this method of connection, a value of resistance will be subtracted from the final test result.

Should the leads be re-connected in the correct manner and a measurement of resistance taken, the instrument may give an error message or show a value of 'negative' resistance.

Fig 3 shows that the leads have been nulled with the incorrect method of connection. The instrument shows the value of resistance as 0 Ω .

Fig 4 shows that when the leads are re-connected in the correct manner, a value of 'negative' resistance may be obtained.

The value of negative resistance is due to the

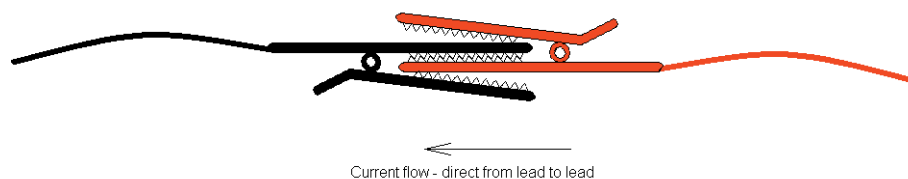


Fig 1: Correct method of connection

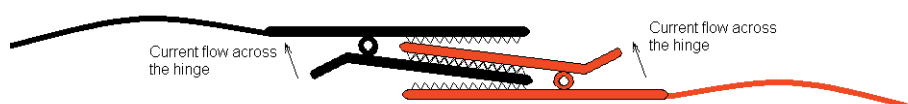


Fig 2: Incorrect method of connection

resistance of the hinges subtracted from the value of zero resistance. Hence, in this instance, the hinges would subtract a value of 0.08Ω from the final result.

Often, 'hybrid' connecting leads are assembled in an ad hoc fashion from the remnants found in the bottom of a drawer. Obviously, these types of leads are extremely unreliable and the manufacturer's recommended leads should always be used. Adequate numbers of leads, along with a selection of the relevant spares should be retained.

Fused connecting leads and internal fuses

The probes and gripping clips of some connecting leads are fitted with fuses. The fuses protect the user and the equipment from high currents that may be unexpectedly encountered. Suitably rated high-breaking capacity (HBC) or high-rupturing capacity (HRC) fuses should be used, usually not exceeding 500mA but the manufacturer's instructions should always be followed.

Test instruments are protected by internal fuses, commonly rated at 440V 10kA. The impedance of the test leads will limit the maximum current that could flow through the internal fuse. In the case of a fault, this current will be limited to 10 kA.

If the manufacturer states that sufficient protection is provided by the fuse within the instrument then fused connecting leads could be omitted.

Batteries

One final point on problems with items of test equipment is batteries. The test instrument may be in good working order but will be unreliable unless fitted with working batteries. Commonly, a low battery symbol will appear in the instrument's display panel, warning that the cells are nearly exhausted. Sufficient quantities of new batteries



Fig 3: Leads nulled in the incorrect manner



Fig 4: Leads reconnected in the correct manner

should be kept with the instrument as spares to be used for this purpose only.

Types of instruments and the associated standards

When deciding which test instruments to purchase, it is important to ensure that the instruments are fit for purpose and fulfil the testing requirements of BS 7671. The basic instrument standard is BS EN 61557: Electrical safety in low voltage distribution systems up to 1000V a.c. and 1500V 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.

The following list shows the test instrument along

with the associated harmonised standard:

■ Low-resistance ohmmeters	BS EN 61557-4
■ Insulation resistance ohmmeters	BS EN 61557-2
■ Earth fault loop impedance testers	BS EN 61557-3
■ Earth electrode resistance testers	BS EN 61557-5
■ RCD testers	BS EN 61557-6
■ Voltage indicators	Consult guidance note GS 38 – <i>Electrical test equipment for use by electricians</i>

Manufacturers will state which standard, or standards, the instrument conforms to. Other standards or directives that the instrument may conform to, such as emissions and immunity standards EN50081-1: 1992, EN50082-1: 1992 or EN61326-1: 1997 will be stated within the instruments documentation.

Calibration

Historically, many electrical contractors have had test instruments calibrated on an annual basis. The instrument would be sent away to a calibration house and it would arrive back, some time later, with a certificate stating the date of calibration, the time period for which the certificate would be valid along with the findings of the assessment in the form of a table of results. The certificate would state that the instrument was within calibration parameters at that time only; it certainly could not guarantee that the instrument would still be fit for purpose at any time after that.

Ongoing accuracy and maintaining records

Establishing an effective method of proving the accuracy of test instruments is of paramount importance. BS 7671 offers no guidance as to the method that should be employed to ensure consistency and accuracy other than requiring that the results of testing are compared with the relevant criteria.

One method of assessing the on-going accuracy of test instruments is to maintain records, over time, of measurements taken from designated circuits of reference. Before such a system is implemented, the accuracy of each test instrument must be confirmed; this could only be carried out by a formal calibration house. An important point to note is that test leads should be assessed at the time of calibration.

The following examples are methods in which the on-going accuracy of test instruments may be assessed.

In each instance, the designated circuit or socket-outlet must be used for every subsequent assessment.



Fig 5: Proprietary checkbox

[Image courtesy of Seaward Instruments. Model shown – Checkbox 16]

To avoid ambiguity, the relevant testing points should be labelled allowing other operatives, who may not usually be charged with the task of test instrument assessment, to follow the system. Should the results waver by $\pm 5\%$, the instrument should be recalibrated. If the results remain within the $\pm 5\%$ limits then the instrument could feasibly go for a number of years without the need of calibration assessment by a calibration house. For some businesses, this could be a major cost saving.

It is worth noting that changes to the electrical supply network could affect the actual supply characteristics at the installation.

Many test instrument manufacturers produce proprietary 'checkboxes' (see fig 5) that incorporate many testing functions, such as high and low resistance, earth fault loop impedance and RCD testing.

Such instruments could be used in conjunction with the following systems.

Other equally effective methods of assessment could be utilised.

Resistance Ohmmeters

Once a month, take a measurement of each resistor and record the results in tabulated form. Over a period of time, the table will show how the instrument is performing.

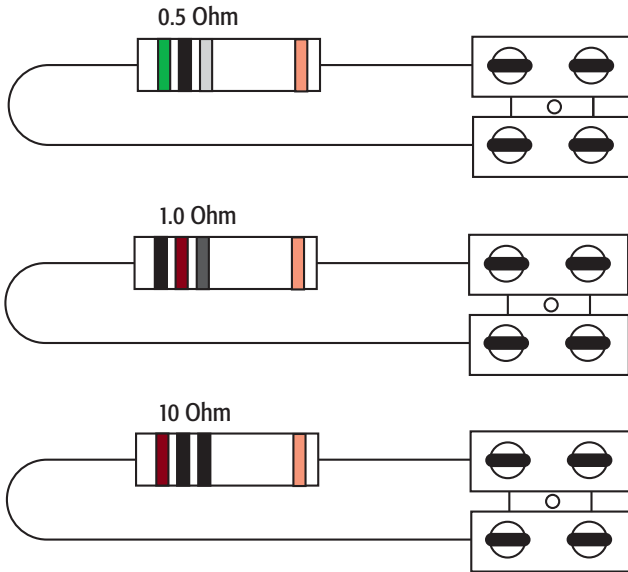


Fig 6: Set of low-value resistors

i.) Low-resistance ohmmeters (fig 6)

A set of suitable resistors could be used to assess the instrument; suitable values could be 0.5Ω, 1.0Ω and 10Ω.

i.) High-resistance (insulation resistance) ohmmeters (fig 7)

A set of suitable resistors could be used to assess the instrument; suitable values could be 0.5MΩ, 1.0MΩ and 10MΩ.

The resistor values chosen merely reflect common bands of resistance that are generally encountered when testing electrical installations. Other values of resistance, indeed, greater numbers of resistors, could be used to assess resistance ohmmeters across the spectrum of resistance.

Earth fault loop impedance test instruments

Earth fault loop impedance test instruments could be checked by carrying out tests on a designated socket-outlet, not RCD protected as unwanted tripping may occur. Once a month, take a measurement of earth fault loop impedance and record the result on a test-record sheet.

RCD test instruments

RCD test instruments could be checked by carrying out a test on an RCD, ideally from a socket-outlet. Once a month, perform an RCD test and record the tripping time on a test-record sheet. The instrument could be set to test at the rated tripping current, $I_{\Delta n}$, of the RCD. An example of a testing record sheet is shown (right). ■

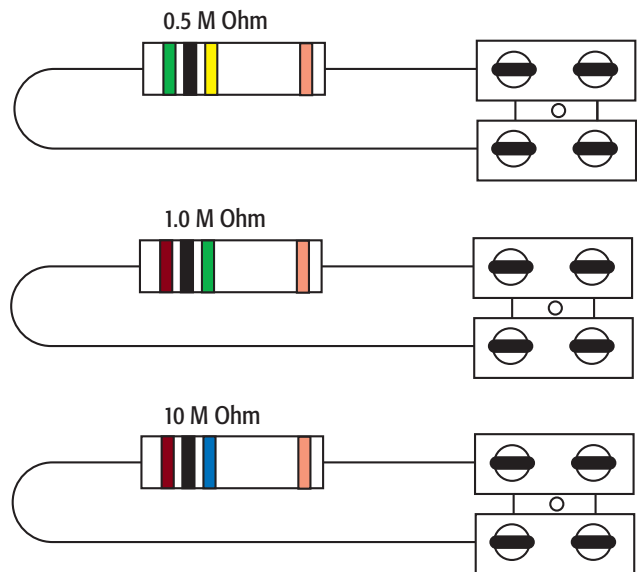


Fig 7: Set of high-value resistors

Test Instrument Record

Company:	Phil Lament & Sons Electrical Contractors Unit 1, Industrial Estate, Workington, Cumbria	Tel:	01234 56789	Phil Lament & Sons Electrical Contractors
Address:		Mob:	079 1234 5678	
		Fax:	01234 56788	

Type:	EFLI		Model:	UJO Meters Ltd EFL1			Serial:	RI 01234			Last Calibration:	9/01/05		Asset:	PL01	
Month	1	2	3	4	5	6	7	8	9	10	11	12				
Date of Test	9/01/04	10/02/04	10/03/04	9/04/04	10/05/04	10/06/04	9/07/04	10/08/04	10/09/04	09/10/04	10/11/04	10/12/04				
Result (Ω)	1.01	1.03	1.02	1.04	1.01	1.03	1.02	1.0	1.03	1.02	1.04	1.02				
Deviation ±%	N/A	2%	1%	3%	0	2%	1%	1%	2%	1%	3%	1%				
Notes:	Designated test socket - labelled as "EFLI - Testing Point" above desk. Batteries replaced 10/03/04. New test leads purchased 10/08/04. (Pete Way - Storeman)															

Type: RCD	Model: UJO Meters Ltd RCD1				Serial: RCD01234			Last Calibration: 9/01/05			Asset: PL02	
Month	1	2	3	4	5	6	7	8	9	10	11	12
Date of Test	9/01/04	10/02/04	10/03/04	9/04/04	10/05/04	10/06/04	9/07/04	10/08/04	10/09/04	09/10/04	10/11/04	10/12/04
Result (mS)	49	50	51	60	X	48	49	50	47	46	49	49
Deviation ±%	N/A	2%	4%	18%	X	N/A	2%	4%	2%	4%	2%	2%
Notes:	Designated test socket - labelled as "RCD - Testing Point" below main consumer unit. Instrument sent for repair and re-calibration 12/04/04, returned and put back in service 8/06/04. (Pete Way - Storeman)											

Test Instrument Record

Company:	Phil Lament & Sons Electrical Contractors Unit 1, Industrial Estate, Workington, Cumbria	Tel:	01234 56789	Phil Lament & Sons Electrical Contractors
Address:		Mob:	079 1234 5678	
		Fax:	01234 56788	

Type:	Insulation Resistance		Model: UJO Meters IR1		Serial: IR 01234			Last Calibration: 9/01/04			Asset: PL 01	
Month	1	2	3	4	5	6	7	8	9	10	11	12
Date of Test	9/01/04	10/02/04	20/03/04	9/04/04	16/05/04	9/06/04	28/07/04	10/08/04	10/09/04	19/10/04	10/11/04	25/12/04
Low Resistance												
0.5Ω	0.5	0.51	0.51	0.52	0.5	0.49	0.5	0.52	0.52	0.52	0.5	0.51
Deviation ±%	N/A	2%	2%	4%	0	2%	0	4%	2%	2%	0	2%
1.0Ω	1.0	1.02	1.0	1.0	1.02	1.01	1.02	1.04	1.03	1.02	1.03	1.01
Deviation ±%	N/A	2%	1%	0	2%	1%	2%	4%	3%	2%	3%	1%
10Ω	10	10	10.05	10.2	10.05	10.09	9.99	9.85	10.01	10.01	10	10.23
Deviation ±%	N/A	0	1%	2%	1%	1%	1%	2%	1%	1%	0	3%
High Resistance												
0.5MΩ	0.5M	0.48M	0.49M	0.48M	0.5M	0.51M	0.52M	0.5M	0.5M	0.51M	0.51M	0.5M
Deviation ±%	N/A	4%	2%	4%	0	2%	4%	0	0	2%	2%	0
1.0MΩ	1.0M	1.0M	1.0M	0.99M	0.98M	1.01M	1.01M	1.04M	1.02M	1.04M	1.03M	1.04M
Deviation ±%	N/A	0	0	2%	2%	1%	1%	4%	2%	4%	3%	4%
10MΩ	10M	10.04M	10M	10M	10M	9.98M	9.99M	9.99M	9.98M	9.97M	9.96M	10M
Deviation ±%	N/A	4%	0	0	0	2%	1%	1%	2%	3%	4%	0
Notes:	Resistor test-board kept in test-meter cupboard. Key held by Phil Meggs, Qualified Supervisor.											