

The IET

WIRING MATTERS

Winter 2006 Issue 21

IN SERVICE INSPECTION AND TESTING

THE EARTH CONTINUITY TEST

Multiple Earth Electrodes in a TT System for a dwelling

Site Safety Toolbox Talk
Portable Electric Tools

PART L of the Building Regulations

IN SERVICE INSPECTION AND TESTING OF ELECTRICAL EQUIPMENT

THE EARTH CONTINUITY TEST

By John Ware

Electrical equipment must be maintained so as to prevent danger. The IEE's Code of Practice for In-Service Inspection and Testing recommends that maintenance of electrical equipment is carried out in four stages: Visual inspection, Test to verify earth continuity, Test to verify insulation, and Functional test. In this article we will discuss Class I equipment and the earth continuity test.

Class I equipment

Class I equipment is defined as 'Equipment in which protection against electric shock does not rely on basic insulation only, but which includes means for the connection of exposed-conductive-parts to a protective conductor in the fixed wiring of the installation'.

Class I equipment includes appliances and tools and for such equipment protection against electric shock is provided by:

(i) using basic insulation, and

(ii) connecting metal parts to the protective earthing conductor in the connecting cable and plug and hence via the socket-outlet to the fixed installation wiring and the means of earthing.

The metal parts could assume a hazardous voltage if the basic insulation should fail.

Class I equipment may have parts with double insulation or reinforced insulation or parts operating in extra-low voltage circuits.

Where Class I equipment is intended to be used with a flexible cable, there must be a protective earthing conductor incorporated in the cable.

Class I equipment relies for its safety upon a satisfactory means of earthing for the fixed installation and an adequate connection to it, normally via the flexible cable connecting the equipment, the plug and socket-outlet and the circuit protective conductors of the fixed installation. See Figures 1 and 2.

The earth continuity test can only be applied to Class I equipment, extension cables or cords. Class I equipment is equipment that relies on a connection with earth for its safety (protective earthing) and/or needs a connection with earth for it to work (functional earthing).

Where protective earthing is provided, as is likely for many household appliances, tools and luminaires, the earth continuity test is vital as the safety of the appliance depends upon an ongoing reliable connection with the means of earthing of the fixed electrical installation.

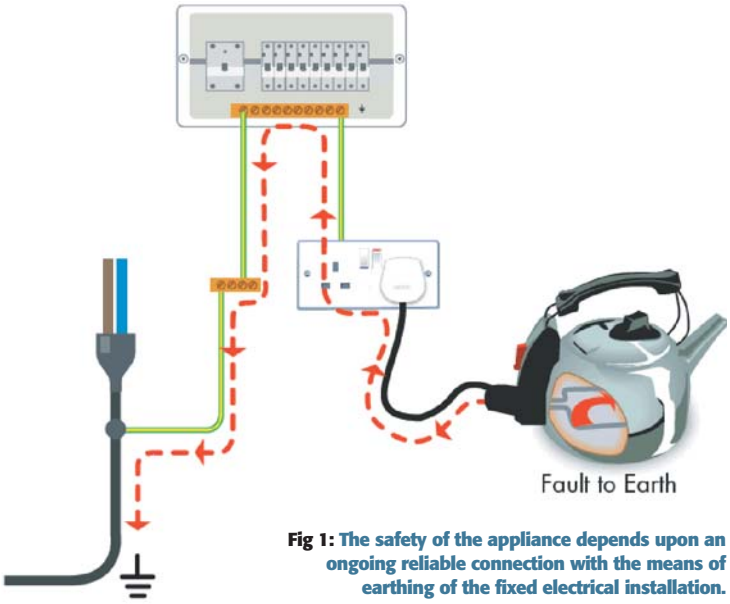


Fig 1: The safety of the appliance depends upon an ongoing reliable connection with the means of earthing of the fixed electrical installation.

The earth continuity test

One of the following two tests should be carried out.

(i) A continuity measurement with a test current up to a maximum of the order of 25 A (The hard test). A continuity measurement should be made with a test current not less than 1.5 times the rating of the fuse and no greater than 25 A for a period of between 5 and 20 seconds.

(ii) A continuity measurement with a short-circuit test current in the range 20 to 200 mA. (The soft test)

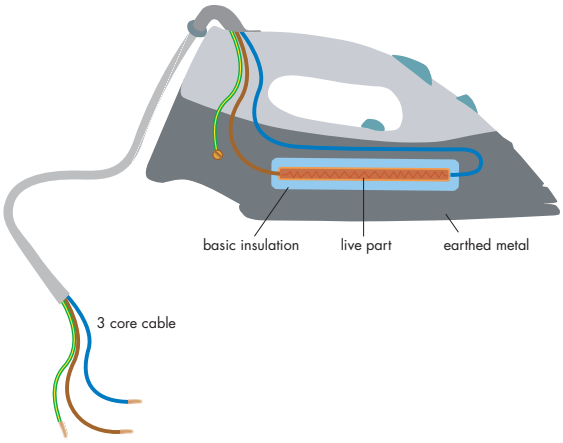


Fig 2: Class I equipment showing basic insulation and earthed metal

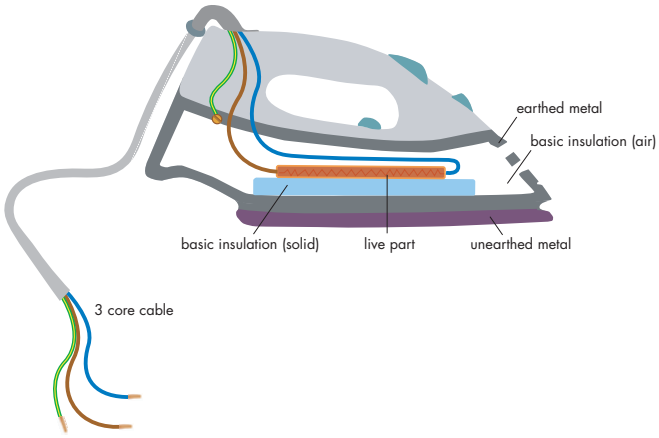


Fig 3: Class I construction incorporating unearthed metal separated from live parts by basic insulation and earthed metal

Which test to perform?

Test (i) is the preferred test. It must be remembered that some electrical test equipment can apply tests which are inappropriate and may even damage equipment containing electronic circuits, possibly causing degradation to safety. If there is a possibility that damage may result due to the test current which can be up to a maximum of 25 A when Test (i) is used then Test (ii) should be performed. Metal-cased business equipment, such as a computer mainframe, is normally tested by using Test (ii) whereas an appliance such as an electric fire, washing machine or fridge normally should be tested using Test (i).

Performing the test

The continuity test should be made between:

- All accessible earthed metal parts of the equipment (exposed-conductive-parts) and the earth pin of the plug for a plug-in appliance or
- The earthing terminal of the fixed wiring supply for equipment which is permanently-connected such as a hand drier.

Multiple continuity tests on a single appliance may be required.

Care must be taken that alternative earth paths are not provided by inadvertent contact or connection to other equipment which may provide an earth path e.g. via a signal cable. This would result in grossly false measurements.

The value of resistance measured should be observed while flexing the flexible cable at the points of entry to the equipment and to the plug. Any variation in the measured value should be investigated. The terminations should be inspected for any evidence of deterioration, poor contact, looseness, corrosion etc.

Some equipment may have accessible metal parts

Published by **IET Publishing & Information Services** Michael Faraday House, Six Hills Way, Stevenage, Herts, SG1 2AY, United Kingdom
Tel: +44 (0)1438 313311 Fax: +44 (0)1438 313465

Sales and Project Coordinator L Hall +44 (0)1438 767351 lhall@theiet.org | **Editor** G D Cronshaw +44 (0)1438 767384 gcronshaw@theiet.org | **Contributing Editors** J Ware, M Coles, J Elliott | **Design** Sable Media Solutions
IEE Wiring Matters is a quarterly publication from the Institution of Engineering & Technology (IET). The IET is not as a body responsible for the opinions expressed.

©2006: The Institution of Engineering & Technology. All rights reserved. No part of this publication may be reproduced, stored in a retrieval system, or transmitted in any form or by any means without the permission in writing of the publisher. Copying of articles is not permitted except for personal and internal use. Multiple copying of the content of this publication without permission is always illegal. Web-offset printing by Wyndeham Heron, The Bentall Complex, Colchester Road, Heybridge, Maldon, Essex, UK

Co-operating Organisations The Institution of Engineering & Technology acknowledges the contribution made by the following organisations in the preparation of this publication: British Electrotechnical & Allied Manufacturers Association Ltd – R Lewington, P D Galbraith, M H Mullins | Department for Communities and Local Government – I Drummond | Electrical Contractors Association – D Locke, S Burchell | City & Guilds of London Institute – H R Lovegrove | Energy Networks Association – D J Start | Electrical Contractors Association of Scotland SELECT – D Millar, N McGuiness | Health & Safety Executive – K Morton | Electrical Safety Council | ERA Technology Limited – M Coates | British Cables Association – C Reed | Scottish Building Standards Agency | DTI – D Tee | CORGI – P Collins | GAMBICA – K Morris.
ISSN 1749-978-X

which are earthed only for functional or screening purposes with protection against electric shock being provided by double or reinforced insulation. It is very important that these non-safety earthed metal parts are not subjected to the above test (i) otherwise damage may result. Connections may be checked using a low current continuity tester as in Test (ii).

Care should be taken to ensure that the contact resistance between the tip of the test probe and the metal part under test does not influence the test result.

The test should only be carried out for the duration necessary for a stable measurement to be made, and to allow time for flexing of the cable.

If the resistance of the protective conductor of the supply cord cannot easily be measured, Table VI (Appendix VI) (shown right) of the IEE's *Code of Practice for In Service Inspection and Testing* provides nominal cable resistances per metre length for various types of cable. The supply cord cross-sectional area must first be identified and the length measured. The resistance of the protective conductor can then be calculated.

Some portable appliance testers with go/no-go indication may fail cord-connected appliances with earth continuity resistance exceeding 0.1 ohm. If it is not possible to re-programme the appliance tester it will be necessary for a measurement of the actual resistance to be made with another instrument.

Figure 3 illustrates a Class I appliance with unearthed metal that may be in fortuitous contact with the earthed metal. A continuity test made to this 'unearthed' metal may give misleading test results. When considering safety, the 'unearthed' metal is not required to be earthed.

The measured values

The measured resistance should not exceed the values given in Table 1. In the event that a higher resistance is measured, the person testing the equipment will have to ascertain the reason for the elevated reading, decide if it can or should be corrected and, if not, decide if the appliance is safe for continued use. ■

For appliances with a supply cord	(0.1 + R) ohm where R is the resistance of the protective conductor of the supply cord
For appliances without a supply cord	0.1 ohm

Table 1: Continuity readings

APPENDIX VI from the IEE's Code of Practice for In-Service Inspection and Testing: RESISTANCES OF FLEXIBLE CABLES

Nominal resistances of appliance supply cable protective conductors
(Figures are for cables to BS 6500 or BS 6360)

Nominal conductor csa	Nominal conductor resistance at 20 °C	Length		Resistance at 20 °C		Maximum current-carrying capacity	Max. diameter of individual wires in conductor	Approx. no. of wires in conductor
mm^2	mΩ/m	m		mΩ		A	mm	
0.5	39	1 2 3 4 5	1.5 2.5	39 78 117 156 195	58.5 97.5	3	0.21	16
0.75	26	1 2 3 4 5	1.5 2.5	26 52 78 104 130	39 65	6	0.21	24
1.0	19.5	1 2 3 4 5	1.5 2.5	19.5 39 58.5 78 97.5	29.3 48.8	10	0.21	32
1.25	15.6	1 2 3 4 5	1.5 2.5	15.6 31.2 46.8 62.4 78	23.4 39	13	0.21	40
1.5	13.3	1 2 3 4 5	1.5 2.5	13.3 26.6 39.9 53.2 66.5	20 33.3	15	0.26	30
2.5	8	1 2 3 4 5	1.5 2.5	8 16 24 32 40	12 20	20	0.26	50
4	5	1 2 3 4 5	1.5 2.5	5 10 15 20 25	7.5 12.5	25	0.31	53

The Table gives figures for the nominal resistance of the protective conductor per meter length and for various lengths of cable that may be fitted as supply leads to appliances. Once an Earth Continuity Test has been performed the approximate resistance of the protective conductor can be found and deducted from the test result to give an accurate figure for the earth continuity reading of the appliance. Note: 1000 milliohms (mΩ) = 1 ohm (Ω)

MULTIPLE EARTH ELECTRODES IN A TT SYSTEM FOR A DWELLING

By Mark Coles

When installing an earth electrode it may not be easy to obtain an acceptably low value of earth electrode resistance, RA. This article looks at installations forming part of a TT system, the installation of the earth electrode and the use of multiple electrodes to achieve an acceptably low value of RA.

What is a TT System?

A TT system is defined in BS 7671 as a system having one point of the source of energy directly earthed, the exposed conductive-parts of the installation being connected to earth electrodes electrically independent of the earth electrodes of the source, see figure 1.

An example of the layout of an installation forming part of a TT system in a dwelling is shown in figure 2.

Definitions of common earthing related terms

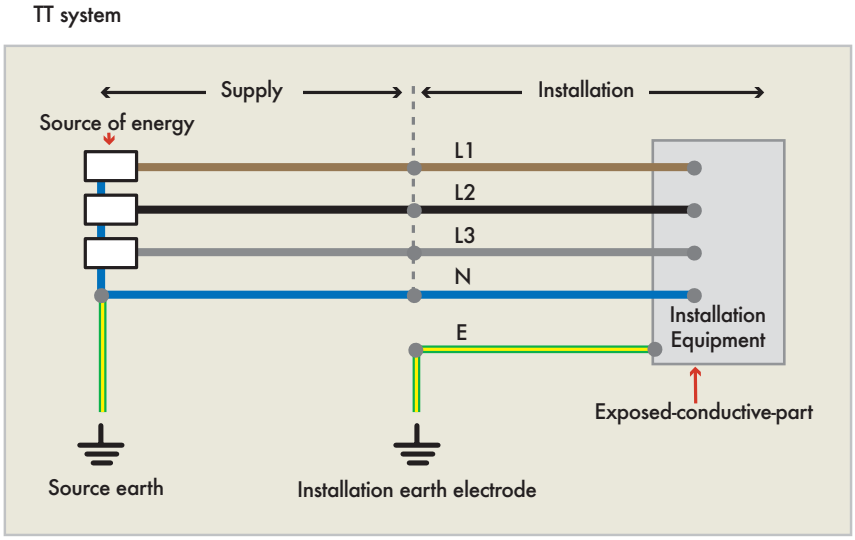
Figure 3, overleaf, is a list of terms used within this article.

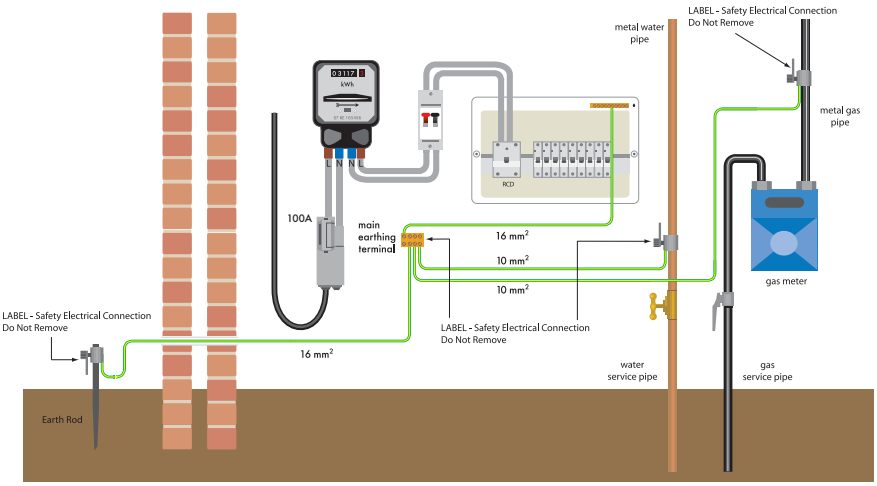
The need for a TT System

There are occasions when the electrical supplier will not provide a means of earthing with a new electrical supply to a building. This is quite acceptable, as regulation 24 (4) the Electricity, Safety, Quality and Continuity Regulations (ESQCR) states that if the supplier can reasonably conclude that it is appropriate, for reasons of safety, then a means of earthing could be refused for a new connection.

An example of this could be a house situated in the countryside which receives its electrical supply from an overhead line. The overhead supply consists simply of a phase and a neutral conductor. The supplier may state that, for safety reasons, a means of earthing for the consumer's installation will not be provided.

The owner of the installation must then provide their own means of earthing. In this instance, an earth electrode, or electrodes, could be installed to provide the means of earthing and, hence, the installation becomes part of a TT system.



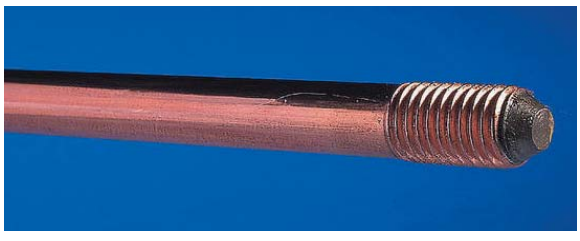


Top, Fig 1: TT system
Above, Fig. 2: Example of a TT system in a dwelling

The legal requirements

The Electricity at Work Regulations 1989 require that

Adiabatic equation	The definition of an adiabatic process is one for which no heat is gained or lost, the term "adiabatic" literally means an absence of heat transfer. Regulation 543-01-03 refers to an adiabatic equation which may be used to determine the cross-sectional area required for a protective conductor. The equation is shown here: $S = \frac{\sqrt{I^2t}}{k}$ where: S — nominal cross-sectional area of the conductor in mm^2 I — value in amperes (rms for a.c.) of fault current for a fault of negligible impedance, which can flow through the associated protective device, due account being taken of the current limiting effect of the circuit impedances and the limiting capability (I^2t) of that protective device. Account shall be taken of the effect, on the resistance of circuit conductors, of their temperature rise as a result of overcurrent - see Regulation 413-02-05. *t* — operating time of the disconnecting device in seconds corresponding to the fault current I amperes. k — factor taking account of the resistivity, temperature coefficient and heat capacity of the conductor material, and the appropriate initial and final temperatures.
Earth	The conductive mass of the Earth, whose electric potential at any point is conventionally taken as zero.
Earthing	Connection of the exposed-conductive-parts of an installation to the main earthing terminal of that installation.
Earthing conductor	A protective conductor connecting the main earthing terminal of an installation to an earth electrode or to other means of earthing
Earth electrode	A conductor or group of conductors in intimate contact with, and providing an electrical connection to, Earth
Earth electrode resistance	The resistance of an earth electrode to Earth
R_A (Ω)	The sum of the resistances of the earth electrode and the protective conductor connecting it to the exposed-conductive-parts
Ia (A)	The current causing the automatic operation of the protective device within 5 s
IΔn (A)	Rated residual operating current of the protective device in amperes





Above, Fig 3: Definitions of common earthing related terms

Left, Fig 4: Threaded rods can be used

Below Left, Fig 5: Couplers are used to join earth rods

earthing, or other suitable precautions are taken, to prevent danger arising when any conductor (other than a circuit conductor) which may reasonably foreseeably become charged as a result of either the use of a system, or a fault in a system, becomes so charged.

The reference to "other suitable precautions" means that some installations, or parts of installations, may operate without a connection to Earth and use another method as a means of protection against electric shock. However, in a dwelling, it is unlikely that any other method of protection would be used throughout the installation, therefore, to meet the requirements of the law, an electrical installation in a dwelling must be provided with a means of earthing.

Considerations

There are many different types of earth electrode, as recognised in Regulation 542-02-01, for the purpose of this article we will just consider earth rods.

Choosing the site

Regulation 542-01-07 of BS 7671 requires that the value of impedance from the consumer's main earthing terminal to Earth for TT systems is in accordance with the protective and functional requirements of the installation and considered to be continuously effective.

In reality this means that the drying of the ground, in summer, or freezing of the ground, in winter, should not adversely affect the value of earth fault loop impedance for the installation. In itself, soil temperature has little bearing on the value of R_A; it is only important just above or just below freezing point. To reflect this, BS 7430, ***The code of practice for earthing***, states that any part of an earth electrode system within one metre of the soil surface should be regarded as ineffective under frost conditions. Therefore, if the ground in which the electrodes are installed is subject to freezing, the electrodes should penetrate to depth greater than one metre.

The type of soil has a bearing on the overall efficiency of the earth electrode and BS 7430 lists the following soil types in order of preference:

1. Wet marshy ground, not naturally well drained. Avoid sites kept moist by moving or flowing water as beneficial salts, which aid the conduction of electric current, may be washed away.
2. Clay, loamy soil, arable land, clayey soil, clayey soil or loam mixed with small quantities of sand;
3. Clay and loam mixed with varying proportions of sand, gravel, and stones;
4. Damp and wet sand, peat.

Dry sand, gravel, chalk, limestone, whinstone, granite

and any very stony ground should be avoided if possible, also all locations where virgin rock is very close to the surface. If the ground has been subject to backfill or disturbed from building operations, the electrodes should be driven down until stable ground is reached. Earth rods can be extended to make longer lengths using purpose made materials; figure 4 shows an earth rod which is threaded at one end, figure 5 shows a coupler used to join two earth rods together.

In situations where the ground is impenetrable or it is found that the best conductive area of the soil is found at relatively shallow depths, rods can be driven in at an angle of approximately 30˚ to the horizontal. As stated earlier, due to the possibility of freezing, earth rods penetrating to a depth of less than one metre should not be installed in ground susceptible to freezing.

A final point to note is to be aware of what could be hidden beneath the surface of the ground. The ESQCR states that electricity distributors have a duty to make and, so far as is reasonably practicable, keep up to date a map or series of maps indicating the position of underground and overhead networks. Regulation 15.-(3) (c) states that such maps will be made available for inspection by any person who can show reasonable cause; it would be sensible to check the map prior to driving rods.

Multiple earth electrodes

Some ground conditions may warrant a number of earth rods connected in parallel in order to achieve an acceptable value of R_A. The benefit of multiple earth electrodes is that the overall resistance is then virtually proportional to the reciprocal of the number of earth rods installed provided that each is located outside the resistance area, also known as the sphere of influence, of any other.

Generally, the resistance area is deemed to be fulfilled by a separation distance equal to the driven depth of the rod. A separation distance in excess of twice the driven depth offers little benefit. Figure 6 shows two electrodes and the required separation distance.

Multiple electrodes may be connected in different arrangements; an example is shown in figure 7 of three earth rods installed in a triangular arrangement.

The earthing conductor

The earthing conductor can be sized in two ways. Firstly, the cross-sectional area may be calculated in accordance with Regulation 543-01-01, which is an adiabatic equation, or secondly, in accordance with Regulation 543-01-04, selected from a table.

Table 54A, from Regulation 542-03-01, states the

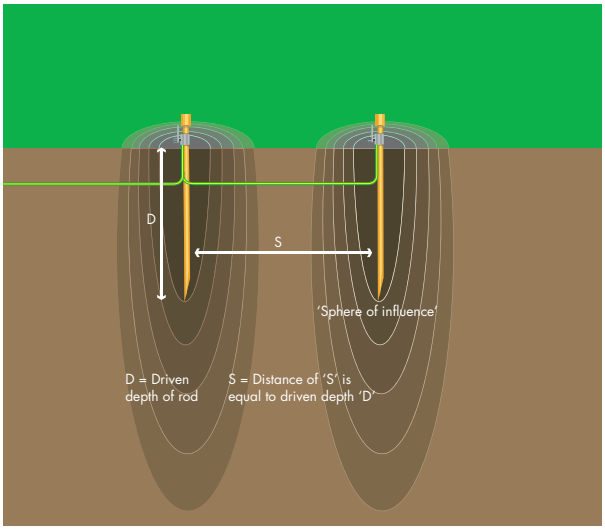


Fig 6: Image showing the separation distance of earth electrodes

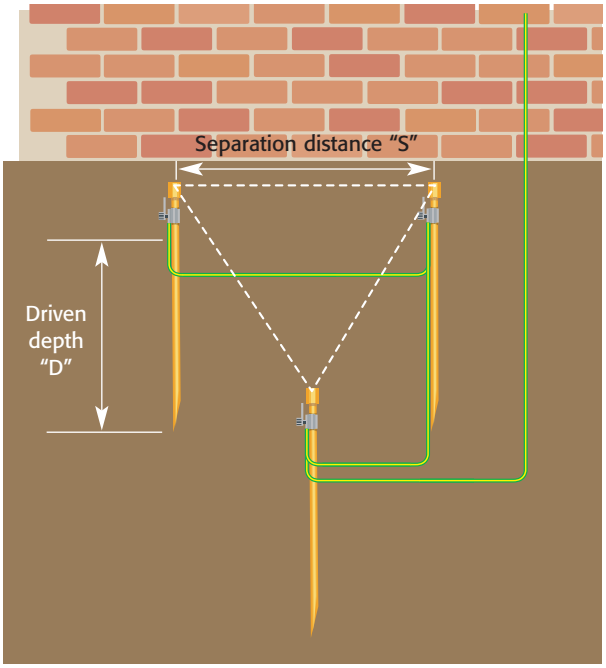


Fig 7: An example of three earth rods installed in a triangular arrangement

minimum cross-sectional areas of a buried earthing conductor. Further, Table 10C of the IEE publication, The On-Site Guide, provides a handy guide to the selection of the earthing conductor; table 10C is reproduced in figure 8.

The connection of the earthing conductor to the earth electrode should be by way of a purpose-made clamp, see figure 9. Further, the connection should be housed in a suitable earth-pit to protect the connection from damage, see figure 10.

Earthing conductor buried		
Unprotected	Protected against corrosion	Protected against corrosion and mechanical damage
25 mm²	16 mm²	2.5 mm²

Earthing conductor not buried		
Unprotected	Protected against corrosion	Protected against corrosion and mechanical damage
4 mm²	4 mm²	2.5 mm²

NOTES
1. Protected against corrosion by a sheath.
2. For impedances less than 1 Ω determine as per Regulation 543-01-02.

Fig 8: Table 10C from the IEE publication, *The On-Site Guide*, Copper earthing conductor cross-sectional area for TT supplies for earth fault loop impedances not less than 1Ω

Testing & verification

1. New installation

Regulation 713-10-01 requires that where the earthing system incorporates an earth electrode as part of the installation, the electrode resistance to earth shall be measured. This test is carried out prior to energisation of the electrical installation. Ideally, the test should be undertaken when the ground conditions are least favourable, such as during dry weather. The test requires the use of two temporary test electrodes, or spikes and is carried out in the following manner.

Connection to the earth electrode is made using terminals C1 and P1 of a four-terminal earth tester. To exclude the resistance of the test leads from the resistance reading, individual leads should be taken from these terminals and connected separately to the electrode. If the test lead resistance is insignificant, the two terminals may be short circuited at the tester and connection made with a single test lead, the same being true if using a three-terminal tester. Connection to the temporary spikes is made as shown in figure 11.

The distance between the test spikes is important. If they are too close together, their resistance areas will overlap. In general, reliable results may be expected if the distance between the electrode under test and the current spike is at least ten times the maximum dimension of the electrode system, e.g. 30 m for a 3 m long rod electrode.

Three readings are taken: with the potential spike initially midway between the electrode and current spike, secondly at a position 10% of the electrode-to-current spike distance back towards the electrode, and finally at a position 10% of the distance towards the current spike. By comparing the three readings, a percentage deviation can be determined. This is calculated by taking the average of the three readings, finding the maximum deviation of the readings from this average in ohms and expressing this as a percentage of the average.

The accuracy of the measurement using this technique is typically 1.2 times the percentage deviation of the readings. It is difficult to achieve a measurement accuracy better than 2% and inadvisable to accept readings that differ by more than 5%. To improve the accuracy of the measurement to acceptable levels, the test should be repeated with a larger separation between the electrode and the current spike.

The instrument's test current may be a.c. or reversed d.c.; reversed d.c. is used to overcome



Fig 9: Earth rod clamp

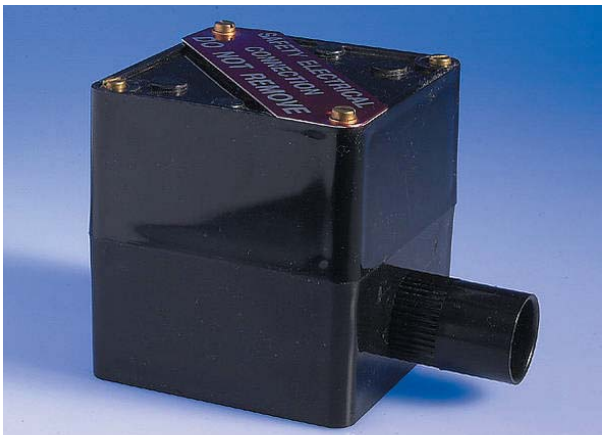


Fig 10: Earth pit

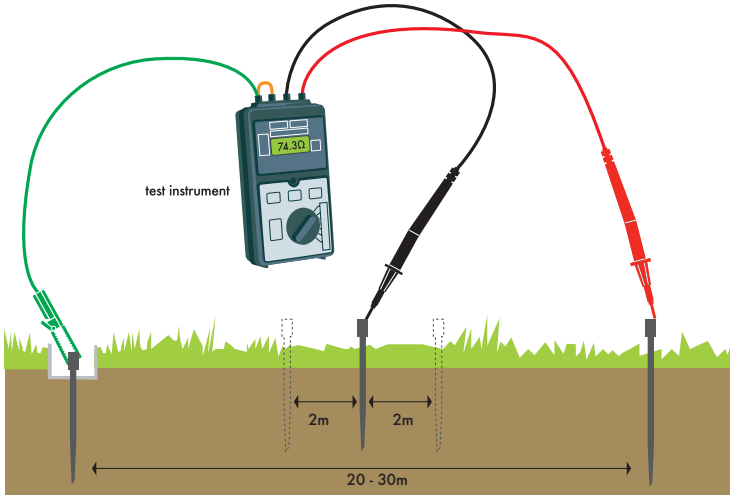


Fig 11: A four-terminal earth-electrode test instrument

electrolytic effects. As these testers employ phase sensitive detectors (PSD), the errors associated with stray currents are minimised.

The instrument should be capable of checking that the resistance of the temporary spikes used for testing are within the accuracy limits stated in the instrument specification. This may be achieved by an indicator provided on the instrument, or the instrument should have a sufficiently high upper range to enable a discrete test to be performed on the spikes.

After completion of the testing, the means of earthing for the installation must be re-established before energizing the installation.

2. Periodic inspection

When undertaking an earth electrode test as part of a periodic inspection of an installation, an alternative method would be to use an earth loop impedance test instrument. The value obtained is the earth fault loop impedance, external to the installation, Ze.

The measurement is taken between the phase conductor at the origin of the installation and the earth electrode with the test link open. This ensures that any parallel paths, such as the main equipotential bonding, are eliminated and ensures that all the test current passes through the earth electrode alone.

Before a measurement of resistance is taken, the main switch-disconnector for the installation must be in the open position to ensure that the installation is isolated. The installation will be unprotected against earth faults during the testing which is why secure isolation is essential.

Values of resistance

Regulation 413-02-20 states that, for TT systems, the value of the earth electrode resistance, R_A (Ω), multiplied by the operating current of the protective device, IΔn (A), must not exceed 50 V. Therefore, in the event of a fault to earth, the RCD must operate to prevent a danger of shock from exposed metalwork. The resistance of the earth electrode should be less than 50/IΔn Ω; with an RCD rated at 30 mA, this equates to approximately 1666 Ω.

Using this example, theoretically, it can be shown that a suitably rated RCD will permit high values of R_A, and therefore of Zs, than could be expected by using the overcurrent devices for indirect contact shock protection. Guidance Note 3 advises that in practice, however, measured loop impedance values above 200 Ω will require further investigation. ■

Sources of further information

- *BS 7671: 2001 (2004) Requirements for Electrical Installations*
- *Guidance Note 3 – Inspection and Testing, Inc AMD No.2 : 2004, IEE Publication*
- *On-Site Guide to BS 7671: 2001 (2004), IEE Publication*
- *The electrician's guide to the building regulations, IEE Publication*
- *BS 7430: 1998 Code of practice for earthing*
- *Electricity, Safety, Quality and Continuity Regulations 2002 (ESQCR) – statutory instrument 2002 No. 2665, published by Crown Copyright, can also be obtained from this url: http://www.opsi.gov.uk/si/si2002/20022665.htm*

Thanks to TLC for images used
http://www.tlc-direct.co.uk

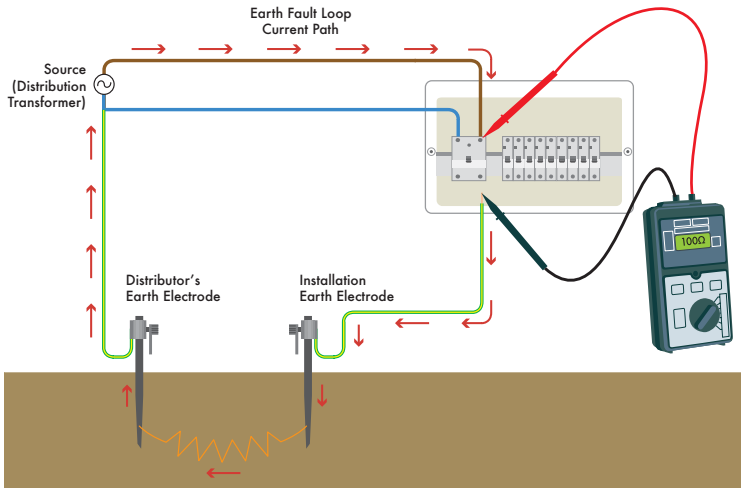


Fig 12: Measurement of Ze on a TT system

SITE SAFETY TOOLBOX TALK NO.2
PORTABLE ELECTRIC TOOLS

Electricians and supervisors are often called on to participate in or to give toolbox talks on different issues of site safety. Wiring Matters is addressing a series of safety subjects in this and subsequent issues. In this second talk we will cover the subject of portable electric tools.

Supply voltage
Before starting work, it must be established whether only 110 V tools may be used on the particular job or whether both 110 V and 230 V tools are permitted. It is always recommended to use 110 V portable electric tools.

If 230 V tools are permitted, RCD protection should be provided if the work is indoors and RCD protection must be provided if the portable electric tool is likely to be used outdoors. RCD protection must be provided by a residual current device that trips instantaneously (not a time-delayed device) and the RCD must have a rated residual operating current not exceeding 30 mA.

RCD protection is often provided by a plug-in type RCD. If there is any doubt as to whether the particular supply circuit has RCD protection, a plug-in type RCD should always be used. (Note that it is acceptable to connect two RCDs in series).

The RCD should be tested before use by pushing the test button and ensuring the device operates and disconnects the supply.

Use tools only on the correct power supply; as instructed on the maker's label.

Will the tool be used outdoors? Outdoor conditions are considerably more arduous with an increased risk of electric shock due to the possibility of :

(i) The person using the tool being in contact with Earth
(ii) The person using the tool being wet or having wet footwear
(iii) The tool, being hand held, means that should an electric shock occur, the electric shock current will pass hand-to-hand or hand-to-foot. In both cases the shock current would pass across the heart.

Construction sites. BS 7671 Requirements for Electrical Installations (The IEE Wiring Regulations) places specific requirements for tools used on construction sites. Construction site installations include installations provided for the purpose of electricity supply during the execution of the following works:

- new building construction
- repair, alteration, extension or demolition of existing buildings
- engineering construction
- earthworks
- similar works.



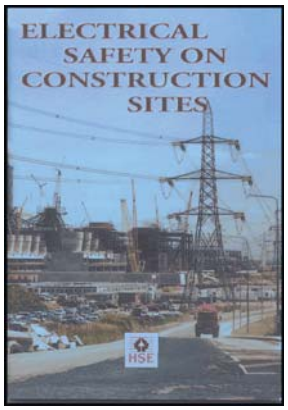
Damaged or faulty tools must be labelled and removed from service.

Requirements placed by BS 7671 include permitted voltages which are given in Regulation of 604-02-02, reproduced below:
'**604-02-02** The following nominal voltages shall not be exceeded:

SELV	Portable hand lamps in confined or damp locations
110 V, 1-phase, centre point earthed	reduced low voltage system portable hand lamps for general use portable hand-held tools and local lighting up to 2 kW
110 V, 3-phase, star point earthed	reduced low voltage system portable hand-held tools and local lighting up to 2 kW small mobile plant, up to 3.75 kW
230 V, 1-phase	fixed floodlighting
400 V, 3-phase	fixed and movable equipment, above 3.75 kW.

This requirement shall not preclude the use of a high voltage supply for large equipment where this is necessary for functional reasons.

The HSE publication: Electrical safety on construction sites gives valuable information on precautions that can be taken to reduce the risks of electrical accidents during the construction (and demolition) phase of a project.



HSG 141 Electrical Safety on Construction sites published by the HSE

The right tool for the job. A portable electric tool should only be used for its designed purpose. Never use worn, blunt or damaged bits or other accessories.

Has the tool been tested? Electric power tools should be regularly inspected, tested and maintained. A portable electric tool must have passed a Portable Appliance Test. The expiry date, which is the date when the next test is due, will be shown on a label attached to the tool. The tool must not be used if the expiry date has passed.

Is the tool damaged? The tool must not be damaged. If it is damaged, the tool must not be used, must be labelled as faulty and the defect reported immediately. Portable tools often suffer damage due to transport and handling.

Is the plug or the cable damaged? Make sure that the cable, the plug or the connector is sound and properly connected. Before plugging in the tool or switching on the supply inspect the flexible cable for damage throughout its length both by visual inspection and touch. Supply cords must not be extended by taped joints and should not exceed the length allowed by the equipment standard.

Is the cable long enough? The cable must be long enough to reach the place of work without it being strained. Cables should be kept off the floor or suitably routed so that they are not damaged by the movement of persons or vehicles. Cables must not present a trip hazard.

Extension leads. Inevitably extension leads are used with portable tools. Electrical safety must not be compromised due to the use of an extension lead. The principle safety issues concerning extension leads are:

- The length of a 230 V extension lead should not exceed the values given in Table 1. An extension lead exceeding the length given in the Table should be fitted with a 30 mA RCD manufactured to BS EN 61008 or BS EN 61009. However, three safety issues need to be considered:

(i) the equipment supplied may not function correctly due to voltage drop in the cable
(ii) there may be a risk of fire due to overloading and
(iii) under fault conditions automatic disconnection may not occur within the prescribed time.

- The lead must not be damaged
- The lead must include a protective conductor where Class I equipment is to be supplied. Two-core extension leads should be removed from service as there will always be the possibility that such a lead is inadvertently used to supply an item of Class I equipment which, as a consequence, would not be earthed
- Cable reels must be used within their coiled or uncoiled ratings as appropriate
- A cable reel must not be used outdoors unless designed for such use.

Cross-sectional area of the core	Maximum length
1.25 mm^2	12 metres
1.5 mm^2	15 metres
2.5 mm^2	25 metres

Table 1: Maximum lengths of extension leads

2.5 mm^2 extension leads are too large for standard 13 A plugs to BS 1363 although they may be used with BS EN 60309 industrial plugs

Final points:

- Never connect a portable electric tool to a lighting socket
- Never stand on a damp or wet surface when using 230 V tools



A portable tool or an extension lead must not be used outdoors unless designed for such use

- Keep the electrical tool and the item being worked on both clean and dry
- Disconnect portable tools when not in use
- Never lift or lower a portable electric tool by its cable.

Further information on portable tools and extension leads is given in the IEE's Code of Practice for In Service Inspection and Testing.



The IEE's Code of Practice for In Service Inspection and Testing

PART L OF THE BUILDING REGULATIONS AND PROVISION OF LIGHTS IN BUILDINGS OTHER THAN A DWELLING



By Jon Elliott

In the last edition of Wiring Matters the implications of the amended Approved Document L (ADL) for those involved in the provision of lights in new and existing dwellings were discussed. This article addresses the guidance given for designers and installers involved in the provision of internal and external lighting services in new and existing buildings other than dwellings given in Approved Documents L2A and L2B respectively. It also introduces the guidance produced by the Building Research Establishment (BRE) on reasonable provision of lighting controls.

Item b. of Requirement L1 in Part L (Conservation of fuel and power) states that reasonable provision shall be made for the conservation of fuel and power in buildings by providing and commissioning energy efficient fixed building services with effective controls.

Local authority Building Control departments will expect to see that measures have been implemented to satisfy this requirement as a condition to achieving Building Control approval for any proposed developments in new or existing non-domestic premises.

Definitions

Definitions are given in Section 5 of Approved Documents L2A and L2B for the following:

Daylit space – "any space:

a. within 6m of a window wall, provided that the glazing area is at least 20% of the internal area of the window wall; or

b. below rooflights and similar provided that the glazing area is at least 10% of the floor area. The normal light transmittance of the glazing should be at least 70%, or, if the light transmittance is reduced below 70% the glazing area could be increased proportionately."

Display lighting – "lighting intended to highlight displays of exhibits or merchandise, or lighting used in spaces for public leisure and entertainment such as dance halls, auditoria, conference halls, restaurants and cinemas."

Fixed building service - "any part of, or any controls associated with:

a. fixed internal or external lighting systems, but does not include emergency escape lighting or specialist process lighting; or

b. fixed systems for heating, hot water service, air-conditioning or mechanical ventilation."

General lighting efficacy in office, industrial and storage areas in all building types

For the purposes of ADL, office areas include areas that involve predominantly desk-based tasks, including classrooms, seminar rooms and conference rooms (L2A – Para 50; L2B – Para 55).

In new buildings (L2A – Para 51), and existing buildings (L2B – Para 56), it would be considered reasonable to provide lighting having an average initial

efficacy of not less than 45 luminaire-lumens/circuit-Watt as averaged over the whole area of these types of space in the building. This should allow design flexibility to vary the light output ratio of the luminaire and the luminous efficacy of the lamp.

Average luminaire-lumens/circuit-Watt is calculated by:

(Lamp lumens x LOR) summed for all luminaires in the relevant areas of the building, divided by the total circuit Watts for all the luminaires where:

a. Lamp lumens = the sum of the average initial (100 hour) lumen output of all the lamp(s) in the luminaire and

b. LOR = the light output ratio of the luminaire, i.e. the ratio of the total light output under stated practical conditions to that of the lamp or lamps contained in the luminaire under reference conditions (L2A – Para 52: L2B – Para 57).

Additionally in the case of existing buildings other than dwellings only:

c. Control factor = the factor applicable when automatic controls substantially reduce the power consumption of the luminaire when electric light is not required.

This control factor is included in L2B to allow greater flexibility and to encourage the installation and use of better controls (L2B – Para 57).

General lighting in all other types of space

Luminaires for which photometric data is not available and/or are lower powered and use less efficient lamps may be used in these areas if the installed lighting in said space has an initial (100hour) lamp plus ballast efficacy of not less than 50 lamp lumens per circuit-Watt. (L2A – Para 53: L2B – Para 58).

Controls for general lighting in all types of spaces

Lighting controls should be provided to avoid lighting being switched on when daylight levels are adequate, or when spaces are unoccupied. If automatic switching arrangements are employed the lighting control scheme should be subjected to a risk assessment wherein safety should take precedence over energy efficiency (L2A – Para 54; L2B – Para 59).

Reasonable provision of controls would be achieved by installing local switches in easily accessible positions within each working area or at boundaries between working areas and general circulation routes that are operated deliberately by occupants either manually or remotely.

Manual switches include rocker switches, push buttons and pull cords. Remote switches include wireless transmitters and telephone handset controls. It should be noted that for the purposes of Approved Document L dimmer switches constitute switches and switching includes dimming. It is emphasised that reasonable provision of dimming would be achieved by reducing rather than diverting energy supply (L2A – Para's 55 and 56; L2B – Para 60).

When viewed on a plan (that is, when viewed from above) the distance between any local switch and any luminaire which it controls should generally be not more than six metres, or twice the height of the light fitting above the floor if this is greater. Where a space is a daylit space served by side windows, the perimeter row of lighting should in general be capable of being switched separately (L2A – Para 57; L2B – Para 61).

Occupant control of local switching can be supplemented by other automatic controls which:
a. Switch off the lighting when they sense the presence of occupants; or
b. Either dim or switch off the lighting when there is sufficient daylight (L2A – Para 58; L2B – Para 62).

In the case of new buildings other than dwellings, the use of such automatic control systems can make a worthwhile contribution towards reducing the Building CO_2 Emission Rate (BER) (L2A – Para 58).

In the case of existing buildings other than dwellings L2B contains a Table 4 which gives control factors that may be applied when calculating the average luminaire efficacy provision requirements described in L2B Para 56.

BRE recommendations for lighting controls

BRE digest 498 (*Selecting Lighting Controls*) describes a process whereby the internal space of a building is categorised in accordance with its typical occupancy and usage patterns. Rooms are classified as follows:

- *owned spaces* – small rooms likely to be occupied by one or two persons, such as small offices, workshops or medical consultancy rooms. Typically, the occupants will be in a position to control the lighting within the space.
- *shared spaces* – multi-occupied areas such as open plan offices and large workshop / factory areas or hospital wards containing a number of persons. Typically the occupants will want control of the lighting in their particular area of the space.
- *temporarily owned spaces* – areas such as meeting rooms, hotel rooms, church halls and classrooms.

Typically, occupants want control of the lighting within the space when they are there.

- *occasionally visited spaces* – areas such as store rooms, plant rooms and toilets / bathrooms. Typically, occupants are only present for a limited time.
- *unowned spaces* – areas such as staircases and corridors. People expect their way to be lit and may not expect to operate lighting controls
- *managed spaces* – areas such as cinemas / theatres, hotel lounges, railway stations, restaurants, public libraries and sports halls. The occupants have no control of the lighting. Those responsible for the lighting in the space may be too busy to control it effectively.

Once an area has been categorized, BRE digest 498 makes recommendations as to which types of control or combination of types of control would be acceptable, or indeed the most appropriate for that type of space. Both manual and automatic controls are considered and are summarised below:
Manual operation - this includes rocker switches, dimmer switches and pull-cords fixed to the fabric of the building or to the light fittings and also devices that may be controlled remotely such as infra-red, radio, sonic, and ultra-sonic operated controls. Manual controls may be positioned either locally or centrally.
Automatic switch off - where artificial lighting is controlled by time switch, for example outside of normal occupancy periods, or where photoelectric control is employed to switch off / dim lighting to take account of changes in ambient daylight levels.
Occupancy detection – This may be achieved by key control, presence detection or absence detection. Key control requires a coded key fob or room card to be present in the room to allow the lighting (and indeed other electrically operated loads) to be switched on and is commonly employed in hotel rooms, student lodging blocks and nursing accommodation. Both presence and occupancy detection rely on detectors set up to either sense the presence or absence of persons in a space. Detectors are typically infra-red in operation, although microwave and ultrasonic detectors are also used.

A summary of recommendations on the most appropriate forms of control to be employed in the various types of space are provided for guidance in Table form. It is accepted that following the recommendations given in BRE digest 498 (Selecting Lighting Controls) would meet the requirements for lighting controls of ADL in both new and existing non-domestic buildings (L2A – Para 59; L2B – Para 63).

Display lighting and their controls in all types of space

In the case of display lighting reasonable provision would be to demonstrate that the average initial (100 hour) efficacy was not less than 15 lamp-lumens per circuit-watt. The power consumed by any transformers or ballasts within the system should be included when calculating this efficacy (L2A – Para 60; L2B - Para 64).

It is expected that spaces where display lighting is present will also contain general lighting to allow circulation and activities such as cleaning and restocking when premises are not open to the public. Paragraphs 50 to 59 in ADL2A and 55 to 63 in ADL2B where relevant would apply to any such general lighting (L2A – Para 61; L2B Para 65).

It is accepted that the requirement for effective control would be met if display lighting were connected in dedicated circuits that could be switched off at times when people were not inspecting exhibits or merchandise. Such control measures might in the case of retail premises include timers to switch off the display lighting outside of opening hours except for the display lighting designed to be viewed from outside the building through display windows (L2A Para 62; L2B Para 66).

Commissioning

Building services systems including fixed internal and external lighting should be subject to commissioning so that the systems are working correctly and efficiently (L2A – Para 77; L2B – Para 70).

Summary

Approved document L requires that reasonable provision should be made for energy efficient lighting and controls to limit unnecessary use of the lighting when daylight levels are sufficient or when spaces being lit are unoccupied. Lighting controls should meet the needs of the building users, be appropriate for the type of space in which they are installed and allow for the safe occupation and use of the building.

Guidance on meeting the requirements for lighting controls in new and existing buildings other than dwellings is provided in BRE Digest 498.

It should be noted that the requirements of Approved Document L do not apply to emergency escape lighting or specialist process lighting.

Publications referenced in the text

Digest 498. Selecting lighting controls, BRE, 2006

All of the Approved Documents to accompany the Building Regulations may be downloaded from www.planningportal.gov.uk/england/professionals/en/1115314110382.html