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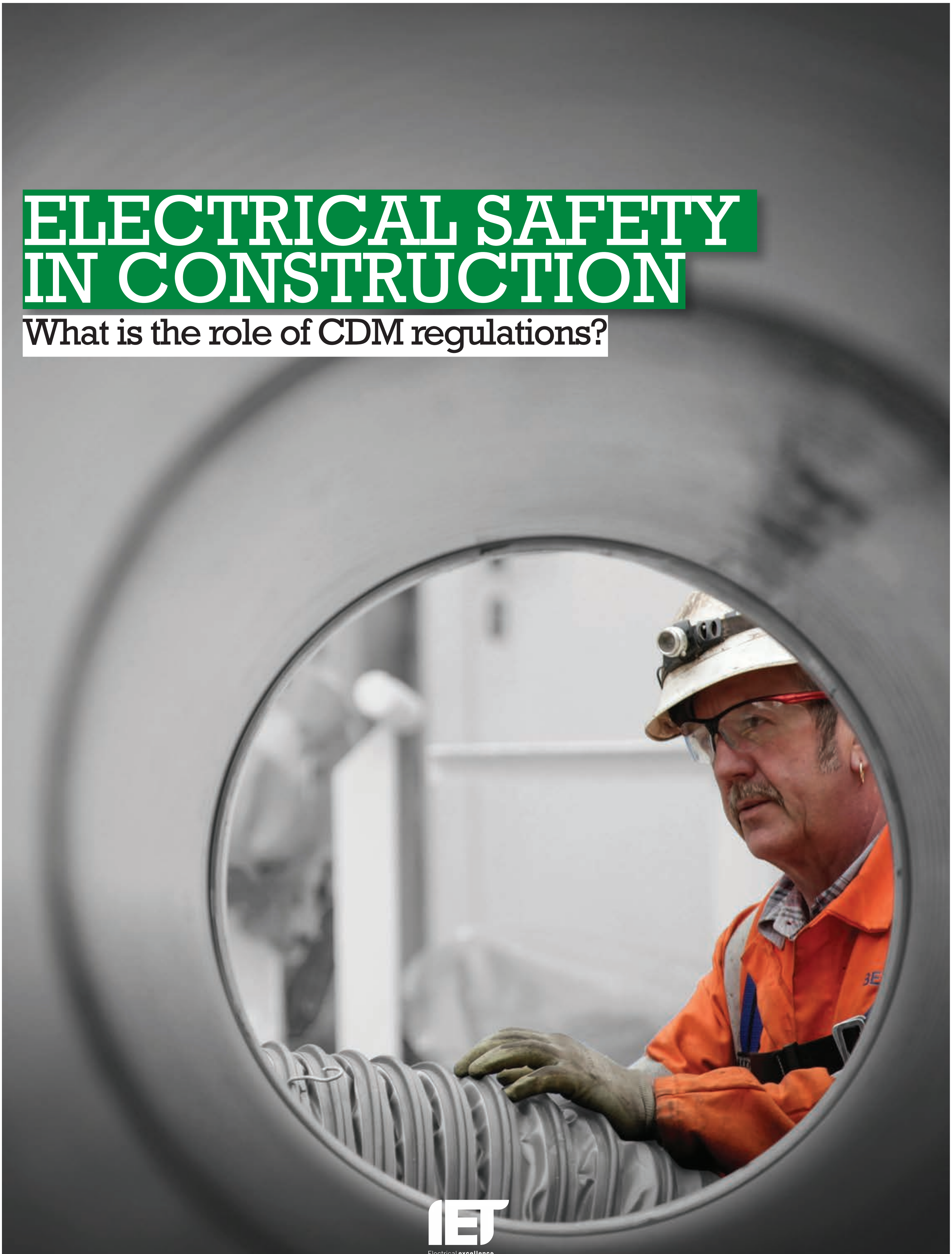
ELECTRICAL SAFETY IN CONSTRUCTION

What is the role of CDM regulations?



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WiringContents #44

EDITORIAL: A FEW CHANGES...

The new 'loop stitching' on the side of this issue (for easier filing!) is not the only change you will notice in *Wiring Matters*. The September edition marks a new chapter in the magazine's development. At the IET we're justly proud of *Wiring Matters*. The magazine has a readership in the tens of thousands, and enjoys a reputation as an authoritative read throughout the electrical installation industry.

One key element of the magazine's success lies in the close involvement of the engineers of the IET's Technical Regulations department. Tech Regs plays a vital role in electrical installation standards and safety, managing the national committee JPEL/64 and publishing the IET Wiring Regulations BS 7671:2008(2011). The Tech Regs engineers have been responsible for the great majority of the articles in *Wiring Matters* and, as the IET's chief electrical engineer within Tech Regs, I have acted as the magazine's editor. Satisfying though this involvement with *Wiring Matters* has been, it has always been an adjunct to our primary role of supporting and developing electrical standards. Unfortunately, we've only been able to give a limited portion of our time to the magazine, and this has acted as a break on the magazine's development.

As part of a significant investment in *Wiring Matters*, the IET has appointed Roger Dettmer as editor. Roger was, for many years, features editor of the IET's members' magazine, and, as such, has a wealth of editorial experience. He will be helping the engineers of Tech Regs get their articles into print, along with working to develop the magazine generally – encouraging and supporting external authors and developing new features within the magazine. Along with a change in editor, there's also been an investment in the look of Wiring Matters – a new design and an upgrade in paper quality.

We're confident that these changes will make for an even better magazine. As always, change involves an element of risk, and it's important to emphasise that the essential nature of *Wiring Matters* – a magazine shaped and mediated by the country's experts in electrical installation and safety – will remain unaffected. The Tech Regs engineers will still be writing many of the magazine's articles, and we'll be actively supporting Roger, identifying promising external contributors, and generally keeping the content relevant and useful.

We will also be looking to promote greater involvement with our readership. If you have any thoughts on the new design, or you think you've an idea for a promising article, then do get in touch. Our new email address is wiringmatters.editor@theiet.org.


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OPINION

Steve Brawley is CEO of the JIB. Further information on the ECS card scheme is available from www.escard.org.uk

STEVE BRAWLEY
JOINT INDUSTRY BOARD

What is an electrician? Qualification and assessment procedures that have been developed by the industry provide a clear answer.

MARCO SCHAARF @NBILLUSTRATION

THERE IS OFTEN confusion over what an electrician is and what qualifications someone working on electrical systems should have. However, the electrical industry has recognised formal qualifications that provide a clear qualification route for an electrician.

Standards for electrotechnical qualifications have been defined through industry consultation by government agencies for many years. The industry expects all operatives that are working unsupervised in the electrotechnical sector to be qualified to the industry-recognised NVQ level 3 qualification. The Joint Industry Board (JIB) recognises these standards in the Electrotechnical Certification Scheme (ECS). To qualify for the ECS card as an electrician, a relevant industry level 3 qualification (or recognised equivalent for pre-NVQ) is required which includes the necessary underpinning knowledge and competency assessment.

For all new entrants to become recognised as an electrician the Level 3 NVQ Diploma in Installing Electrotechnical systems and equipment (building structures and the environment) is required. Alternatively, it may be possible to meet the ECS card requirements with the level 3 NVQ in Electrotechnical Services (Electrical Installation – Buildings & Structures) with the necessary underpinning knowledge qualification (or technical certificate) at level 3 and the AM2 assessment.

Individuals who have some previous experience need an interview with an assessor to develop an individual assessment plan without the need to go back to college to train in the classroom. This is in line with the normal industry qualification requirements, and only focuses on the required part of the assessment. The value of this is that the competence the individual has already achieved is credited toward achieving the full industry qualification.

Qualifications such as the standalone 17th Edition of the IET Wiring Regulations, the Certificate in Fundamental Inspection and the Certificate in the Certification of Electrical Installations (inspection, testing and certification of electrical installations) are designed as professional development for qualified electricians, and, as such, are unsuitable for unqualified personnel or new entrants into the industry. On their own they do not demonstrate the industry-required qualification and competence needed to be recognised as an electrician.

Any reference to Part P of the building regulations is for a company to comply with the legislative requirement (within England and Wales) and is not a general requirement for individually qualified electricians employed within the industry. Short 'Part P' training programmes are only for individuals who have been working within the industry for at least two years and wish to be registered as a Qualified Supervisor for their company. These courses do not qualify individuals as electricians because the training is focused on the requirements of the Building Regulations. Operatives who are already formally qualified to the NVQ Level 3 do not need to re-qualify if they are the proposed Qualified Supervisor for their company, but will need to demonstrate their knowledge of the Building Regulations during their company's Part P assessment visit by the relevant Competent Persons Scheme provider.

The future training requirements of the industry remain much the same as they were when the electrical apprenticeship was first introduced. Electricians still need a good grounding in electrical theory, which will provide the basis of integrating new and emerging technologies into electrical installations. Electricians also continue to need a full working knowledge of the wiring regulations in order to ensure that their work meets the required British Standards and is safe in its operation.

The JIB has supported apprentice training from its inception in 1968 and some 160,000 installation electricians have been trained under JIB Apprentice Training Schemes. This represents a tremendous achievement by the JIB and the electrical industry in terms of the people who were trained, the companies who employed them and UK plc in terms of their real contribution to the economy over the years.

The best way to train new entrants into the electrical industry is through a formal industry apprenticeship, but there are also opportunities for people to prove their competence through site assessment.

The JIB has a long history of accrediting the formal qualifications held by professional electricians through the ECS card. Anyone who holds an ECS can easily demonstrate that he or she has met the requirements to truly be called an electrician. *

CONSTRUCTION SITE ELECTRICAL INSTALLATIONS

The role of the CDM regulations in ensuring electrical safety on construction sites. By Geoff Cronshaw

THE CONSTRUCTION (Design and Management) Regulations 2007 (CDM Regulations) place responsibilities on most installation owners and their professional design teams to ensure a continuous consideration of health and safety requirements during the design and construction of, and throughout the life of, an installation, including maintenance, repair and demolition.

The scope of these responsibilities includes the design of electrical installations and the selection and erection of electrical equipment. Design work should take into account the practicalities of the installation, and allow adequate access for the operation and maintenance requirements of all equipment. It is important that all those who can contribute to the health and safety of a construction project understand what they and others, need to do under the CDM regulations, and discharge their responsibilities accordingly.

For example, designers must consider the need to design, as far as practicable, in a way that avoids foreseeable risks, so that the projects they design can be constructed, operated and maintained safely.

Under the CDM regulations the Health and Safety Executive (HSE) must be notified of projects where construction work is expected to last more than 30 days or involve more than 500-person days. Almost everyone involved in construction work will have a legal duty placed on them under the regulations. Those with legal duties are commonly known as 'dutyholders'. Dutyholders under the CDM Regulations include:

- **Client** Anyone having construction or building work carried out as part of their business. This could be an individual, partnership or company, and includes property developers or management companies for domestic properties.

- **CDM coordinator** Has to be appointed to advise the client on projects that involve more than 30 days or 500-person days of construction work. The CDM coordinator's role is to advise the client on health and safety issues during the design and planning phases of construction work.

- **Designer** The term 'designer' has a broad meaning and relates to the function performed, rather than the profession or job title. Designers are those who, as part of their work, prepare design drawings, specifications, bills of quantities and the specification of articles and substances. This could include architects, engineers and quantity surveyors.

- **Principal contractors** Has to be appointed for projects which last more than 30 days or involve 500 or more person days of construction work. The principal contractor's role is to plan, manage and coordinate health and safety while construction work is being undertaken. The principal contractor is usually the main or managing contractor for the work.

- **Contractor** A business involved in construction, alteration, maintenance or demolition work. This could involve building, civil engineering, >

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WHAT DOES YOURS SAY?

For further information refer to:

Electricity at Work Regulations 1989
Memorandum of guidance on the Electricity at Work Regulations 1989 (HSR25).
Managing health and Safety in construction (L144)
The Construction (Design and Management) Regulations 2007
BS 7671:2008 incorporating Amendment 1

Special thanks to Mr Ken Morton of the HSE

< mechanical, electrical, demolition and maintenance companies, partnerships and the self-employed.

■ **Worker** Anyone who carries out work during the construction, alteration, maintenance or demolition of a building or structure. A worker could, for example, be an electrician, as well as those supervising the work, such as chargehands and foremen.

THE ELECTRICITY AT WORK REGULATIONS 1989

Persons involved in electrical installation work must be competent. The Electricity at Work Regulations 1989 imposes duties on persons involved in electrical work commercially, whether employers, the self-employed or employees, including most trainees.

Regulation 16 (Persons to be competent to prevent danger and injury) states: "No person shall be engaged in any work activity where technical knowledge or experience is necessary to prevent danger or, where appropriate, injury, unless he possesses such knowledge or experience, or is under such degree of supervision as may be appropriate having regard to the nature of the work."

The Memorandum of guidance on the Electricity at Work Regulations 1989 (HSR25, HSE: 1989) states that: "the object of the regulation is to ensure that persons are not placed at risk due to a lack of skills on the part of themselves or others in dealing with electrical equipment".

It continues:

"the scope of 'technical knowledge or experience' may include:

(a) adequate knowledge of electricity;

(b) adequate experience of electrical work;

(c) adequate understanding of the system to be worked on and practical experience of that class of system;

(d) understanding of the hazards which may arise during the work and the precautions which need to be taken;

(e) ability to recognise at all times whether it is safe for work to continue."

BS 7671:2008 INCORPORATING AMENDMENT 1:2011

Construction sites are potentially dangerous in many ways. Four factors contribute to the high risk of electric shock on a construction site:

1 the possibility of damage to cables and equipment.

2 the widespread use of hand tools with trailing leads (this problem is mitigated by the increasing use of battery operated tools).

3 the accessibility of many extraneous-conductive parts, which cannot practically be bonded.

4 the works are generally open to the elements.

Construction sites are potentially dangerous, with a high risk of electric shock

Section 704 of Amendment 1 of BS 7671:2008 prescribes particular measures to reduce the risks caused by this harsh environment. For example: BS 7671 strongly prefers the reduced low voltage system to supply portable hand lamps for general use and portable hand tools and local lighting up to 2kW, while SELV is strongly preferred for portable hand lamps in confined or damp locations.

It is usually impracticable to comply with the bonding requirements of the Electricity Safety, Quality and Continuity Regulations on construction sites for PME. Hence BS 7671:2008(2011) states that a PME earthing facility shall not be used for the means of earthing for a construction site installation unless all extraneous-conductive-parts are reliably connected to the main earthing terminal. See Regulation 704.411.3.1

Section 704 prohibits the protective measures of obstacles and placing out of reach (Section 417), non-conducting location (Regulation 418.1), and earth-free local equipotential bonding (Regulation 418.2).

Cables on a construction site location should preferably not be installed across walkways or site roads as they are susceptible to mechanical damage. If cables are installed in this manner they require the appropriate level of mechanical protection.

For reduced low-voltage systems flexible thermoplastic cables rated at 300/500V and suitable for low temperature (BS 7919) should be used. These cables remain flexible at lower temperatures than standard PVC cables, and are ideal for outdoor use. They are referred to as arctic-grade cable and typically have yellow (refer to section 4.6 of IET Guidance note 7) or blue sheaths.

For cables used for applications exceeding reduced low voltage, flexible cables rated at 450/750V that are resistant to abrasion and water should be used, type H07RN-F (BS EN 50525 part 2.21). (Please note, whilst BS7019 is still current, it is expected to be withdrawn end of December 2012). These are heavy duty rubber insulated and sheathed flexible cables suitable for outdoor use.

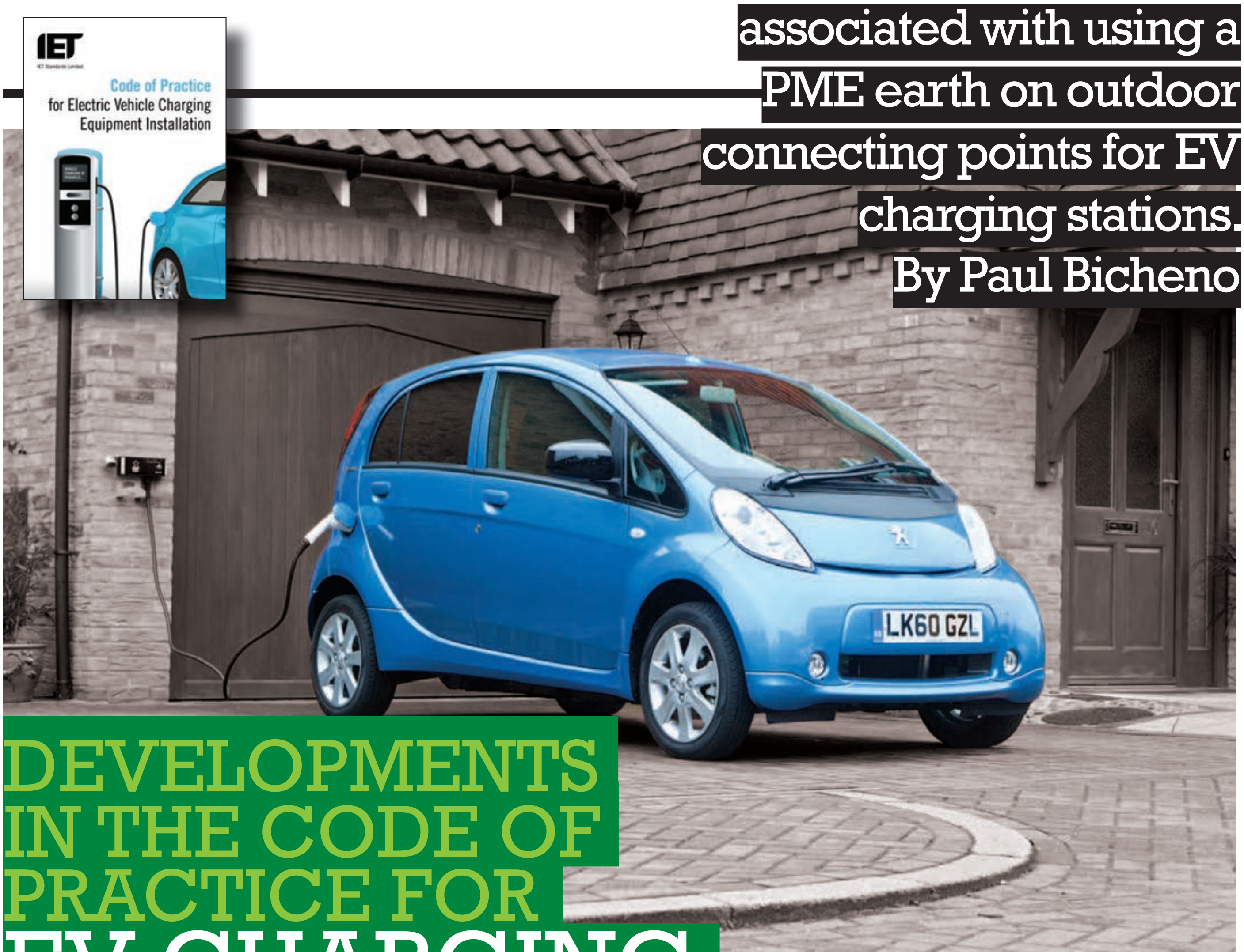
All equipment that is part of the movable installation should have a degree of protection appropriate to the external influences. Equipment for external use should be at least IP44. However, equipment installed in a weather protected location, such as an office being refurbished, should be at least IP 2X (see BS 7671 for exact requirements).

It is recommended that the maximum period between inspections of construction site installations is three months.

Fixed installation RCDs should additionally be tested daily (using the integral test button). Should RCDs be used as supplementary protection to protect mobile equipment they must be tested by the operative before each period of use (again using the integral test button) and by the responsible person every three months (using an RCD tester).

WiringFeature #44

A report will quantify risks associated with using a PME earth on outdoor connecting points for EV charging stations. By Paul Bicheno



DEVELOPMENTS IN THE CODE OF PRACTICE FOR EV CHARGING EQUIPMENT INSTALLATION

THE 'IET CODE of Practice on Electric Vehicle Charging Equipment Installation', published in January 2012, provides guidance on what earthing arrangement should be used when installing charging equipment at a domestic premise with a Protective Multiple Earth (PME) supply.

For connecting points installed such that the vehicle can only be charged within the building, the PME earth may be used. However, the development committee responsible for the Code of Practice agreed that for outdoor connecting points the situation was different. There is in this case a risk of electric shock associated with the potential failure of the Protective Earth Neutral (PEN) conductor of the PME supply cable.

The development committee agreed that the charging circuit would need to be part of a TT system, subject to certain assessment criteria being met, otherwise the whole installation would need to adopt a TT system. The committee adopted this approach to outdoor connecting points because of the absence of risk data associated with the failure of PEN conductors for a PME supply.

Without data, the committee was unable to conclude that the risk of using a PME earth was low enough to consider a PME earthing arrangement suitable to supply charging equipment for outdoor connecting points.

Subsequent to this decision, and recognising that there are limited options available to the installer, as well as other risks associated with using a TT system, IET Standards Ltd agreed to commission a risk analysis to determine the risk associated with using PME supplies. The objective is to carry out a quantitative evaluation of the increased level of risk associated with using a PME supply for outdoor connecting points.

IET Standards Ltd has commissioned the Health and Safety Laboratory (HSL) to carry out this work. The programme started in July and is due to finish in September. The findings of the HSL will be published in a report, which will be made publicly available.

Subsequent to the report being published, IET Standards Ltd will liaise with the development committee stakeholder organisations to determine the implications for the Code of Practice.

IET Standards Ltd would like to thank the Energy Networks Association, Energy UK and the Society of Motor Manufacturers & Traders who have jointly funded the risk analysis activity
Web address for the Code of Practice: www.theiet.org/resources/standards/ev-charging-cop.cfm

WiringFeature #44

A new edition of one of the IET's Codes of Practice aims to stem unacceptable practice in PAT testing, and in this article we look at the changes.

By Richard Townsend

CHANGES TO THE IET'S CODE OF PRACTICE FOR IN-SERVICE INSPECTION AND TESTING OF ELECTRICAL EQUIPMENT

ON 28 NOVEMBER 2011, the Lofstedt report was published, highlighting a significant level of legislative over-compliance by industry. One key issue identified in the report was confusion over PAT testing – widely misunderstood as a requirement to carry out inspection and testing annually, regardless of equipment type, usage or environment.

In fact, inspecting or testing annually has never been a requirement, and the new Code of Practice has been updated to emphasise and expand on this. >

RISK ASSESSMENT

The fourth edition of the Code of Practice for In-Service Inspection and Testing of Electrical Equipment has been written to emphasise the need to 'risk assess' the requirement for any inspections and tests. Risk assessments are vital to understanding what can affect any electrical equipment in use, and to be sure of its continued safe use.

Any risk assessment process must be carried out by the duty holder, because he or she is solely responsible for the safety and maintenance of equipment in his or her care. A duty holder may use an outside consultant to advise on the type and frequency of any inspections or tests; however, the duty holder is responsible in all cases, regardless of any consultant's advice.

In the past PAT testing has, in the majority of cases, been conducted by external contractors. These contractors have then, quite wrongly, set the frequency of the subsequent inspections and tests without consultation or input from the duty holder, and without an adequate – if any – risk assessment.

In many cases, Table 7.1 in the Code of Practice was used or misinterpreted as a definitive frequency chart. This is unnecessarily costing UK businesses a great deal of money each year. It has always been stressed that Table 7.1 is only intended to provide guidance on initial frequencies, and should only be used as a starting point where previous inspection and testing records and risk assessments are not available. Ongoing frequencies should be determined from a risk assessment.

IN THE OFFICE

Interestingly, there is a common misperception that general office areas are high-risk environments. In fact, office areas in general present very low levels of risk, and subsequent risk assessments and frequencies should reflect this. The HSE publication INDG236: 'Maintaining portable electrical equipment in low-risk environments', gives further guidance and information on these types of environments. Risk levels are, in practice, also generally low for large sever rooms in data storage, handling and call centres, etc, where, owing to the sensitive and critical nature of the information held, access is limited to persons directly responsible for upkeep and repair.

EXTERNAL CONTRACTORS

When external contractors are used to carry out PAT testing they should, in the first instance, be contracted to carry out inspections and testing only on equipment identified by the duty holder based on a risk assessment.

Duty holders can be the only persons with a knowledge of the factors that affect the equipment in their care, and not the contractor. If duty holders opt to use any information they receive from contractors to aid them with their risk assessment, they are clearly free to do so. However, the liability of responsibility will still remain with them, regardless of marketing claims made by any external contractors to the contrary. Duty holders need to be aware that in some instances equipment frequencies should be increased if evidence of significant deterioration of equipment or appliances is present.

There is a myth that PAT testing must be carried out by an external contractor. This is not the case. If duty holders consider that suitably trained and competent persons exist within their organisations, they can, if they wish, take advantage of these resources in order to meet their obligations to adequately maintain equipment.

It is also possible that in-house competent persons could carry out less complex parts of the PAT procedure, such as inspections, even if their skill levels do not extend to complex testing. This could help to further reduce costs by only requiring more skilled and competent persons, possibly outside contractors, to carry out testing that falls outside of the competency of in-house staff.

Many duty holders believe that their insurance policy requires appliances to be inspected and tested annually; this is not the case. This was made clear by the Association of British Insurers (ABI) in the HSE press release, issued on 2 May 2012. Copies of this press release can be downloaded from the HSE website: www.hse.gov.uk/press/2012/hse-pattesting.htm.

The change in emphasis, from the wrongly perceived need for automatic annual inspection and testing, to inspection and testing schedules based on risk assessment, will empower duty holders and building managers to significantly reduce their proactive maintenance costs, and improve their understanding of their environment and the equipment they use in it. The HSE has already taken a large step in this direction, by reviewing the inspection and testing processes within its own business unit. The same approach is also being applied in the IET's operating centres.

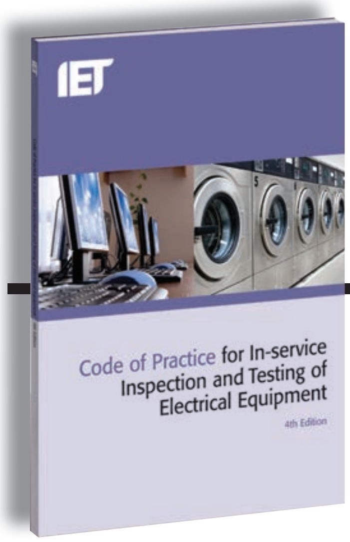
Local authorities are encouraged to adopt these new practices to help reduce their costs in line with government directives. Leicester City Council is adopting the new risk-based approach to PAT testing when tendering for building services contractors. It is looking to halve its annual PAT testing costs in the short term, and aiming to develop its PAT testing processes to further reduce costs.

The importance of the new approach to local authorities is clear in the following statement from Anthony Carter, interim director of property for Leicester City Council: "If adopted by all local authorities this more risk-based approach will lead to significant reductions in the unnecessary spending of tax payers' money. This money can then be put to better use elsewhere."

LABEL FORMS

A significant change in the fourth edition of the Code of Practice is the modification of the model 'PASS' label forms. These no longer carry a 'next test due' date. The new labels carry only the equipment ID number, inspector or tester's initials, and the date of the initial test. This is to force duty holders to rely on their equipment registers to assess the next inspection or test date, and to move away from the unacceptable practice of non-duty-holding contractors setting the frequency of inspection and testing.

It is also a popular industry misconception that appliances should be labelled. There is no legal requirement to label appliances; however, it is good practice to do so, in order that records and ongoing maintenance can be demonstrated. Where labels are used they should be



durable and in an appropriate position on the equipment.

In addition to the changes to the model PASS label form, the 'Equipment register' has now become the 'Equipment formal visual and combined inspection and test record', and has been redesigned to improve usability and reflect industry requirements and practices.

HIRED EQUIPMENT

When equipment is hired for a particular task or contract, it becomes the responsibility of the hirer or duty holder to include it on their equipment register when relevant. Guidance on how this should be dealt with is contained within the Code of Practice. In essence, equipment that is hired for periods of more than one week should be assessed for risk of use and to determine adequate frequencies of inspection and testing. This assessment may be incorporated into the contract, lease or hire agreement provided it is relevant to the equipment, its users and the environment the equipment is to be used in. In all cases it remains the responsibility of the duty holder, or person hiring the equipment, to monitor any ongoing maintenance requirements.

Hired equipment can take the form of a number different equipment types, such as vending machines, water coolers and audio visual equipment. It is important that hired equipment is adequately controlled when used for long periods of time.

RENTING

Equipment supplied with rented accommodation is now covered in the fourth edition of the Code of Practice, which details the responsibility of landlords to maintain equipment in a usable and safe condition. In the case of rented accommodation, landlords are the duty holders. If a landlord provides any electrical appliances as part of a tenancy, the Electrical Equipment (Safety) Regulations require the landlord to ensure that the appliances are safe when first supplied. Supplied equipment could for example include cookers, fridges, washing machines and kettles.

PRE-USED EQUIPMENT

Second-hand equipment is now defined, and guidance on the requirements for persons passing on second-hand equipment for commercial gain is now covered. This will help to promote the re-use and recycling of equipment that would otherwise either be sold untested, possibly in an unsafe state, or scrapped, even though it was still fit for its intended purpose and safe for continued use.

The new guidance has particular relevance with the increasing popularity of Internet auction sites and the prevalence of second-hand shops beginning or looking to sell pre-used electrical equipment and appliances.

FIXED EQUIPMENT

Fixed equipment has been defined and added as an equipment type, and guidance on the inspection and testing of this type of installed equipment is given. It is important that fixed equipment is dealt with and incorporated on a maintenance schedule, as it is frequently incorrectly inspected and tested, or ignored completely.

The inspection and testing of fixed equipment can be more complex than non-fixed equipment, given the higher level of competency required when carrying out safe isolation and reconnection; duty holders need to be aware of the increased skill sets required.

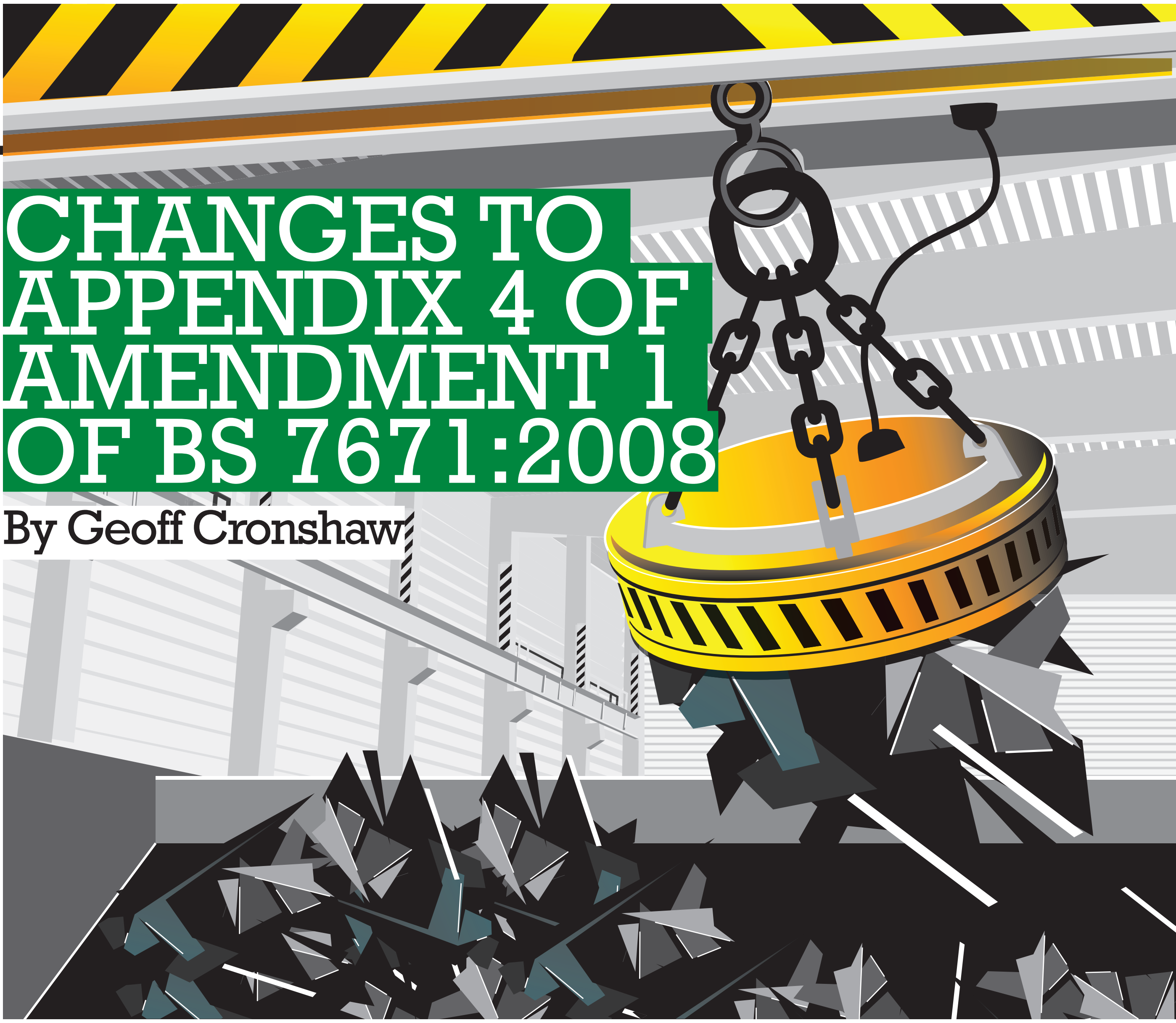
EXTENSION LEADS

RCD extension leads and multi-way extension leads have more guidance on safe usage, taking into account current industry trends and providing clearer and more detailed advice on their use in office areas that have changed use from initial design, leaving a deficiency of fixed socket-outlets, etc. There is also a more detailed explanation of the tests required for RCD extension leads.

Much of the publication's electrical testing information remains unchanged, with additions for new test types and better explanations for usages of touch testing, etc. The controversial microwave leakage testing section was initially updated, but subsequently removed completely from the Code of Practice. It was felt that microwave leakage testing was not a test of an appliance's electrical safety but was a secondary test that should be separate from the PAT-type electrical safety test. Microwave leakage testing should be carried out separately to PAT testing as it has a plethora of different implications for a very varied industry usage. As microwave leakage testing is important it should be carried out after a robust risk assessment. This is required to ensure the safe and continued use of equipment based on the environment, its users, its build quality, its frequency of use, etc. The type of equipment used for leakage testing should also be carefully chosen, as many low cost devices may not meet the required standards for leakage testing.

The IET is confident that the changes it has made to the Code of Practice for In-service Inspection and Testing of Electrical Equipment, fourth edition, will benefit the whole of industry and contribute to the safe reduction of costs at a time of severe financial constraints. This view is strongly endorsed by Peter Brown, Head of the HSE's Work Environment Division. Commenting on the HSE's support for the changes he said: "We welcome this revised Code of Practice. It complements HSE's guidance on maintaining portable electrical equipment and provides sensible, proportionate advice so that those who create the risks know how to manage them effectively. By emphasising a balanced risk-based approach to determine how frequently equipment should be maintained, it should help reduce the likelihood of businesses wasting money on unnecessary portable appliance testing."

Further guidance on PAT testing can be found in 'INDG236: Maintaining portable electrical equipment in low-risk environments', and the updated HSE publication 'INDG231: Electrical safety and you', both available free from the HSE website: www.hse.gov.uk
The Lofstedt report, and 'The Government's Response to The Lofstedt report', can be downloaded free from the Department for Work and Pensions website: www.dwp.gov.uk
The Code of Practice for In-service Inspection and Testing of Electrical Equipment, fourth edition is available to pre-order on the IET website, www.theiet.org/cop-inspection, and will be published in early November.



CHANGES TO APPENDIX 4 OF AMENDMENT 1 OF BS 7671:2008

By Geoff Cronshaw

Amendment 1 of the 17th edition of the Wiring Regulations brought changes to Appendix 4: selection of conductor cross sectional area (article excludes voltage drop and fault current calculations)

THE CURRENT-CARRYING capacity of a cable corresponds to the maximum current that can be carried in specified conditions without the conductors exceeding the permissible limit of steady-state temperature for the type of insulation concerned. The values of current tabulated represent the effective current-carrying capacity only where no rating factor is applicable.

A rating factor has to be applied where the installation conditions differ from those for which values of current-carrying capacity are tabulated in Tables 4D1A to Tables 4J4A of Appendix 4. The first significant change introduced in the 17th edition, compared with the 16th edition, is the large number of rating factors related to cables buried in the ground.

Selection of conductor cross-sectional area with overload protection

The required tabulated current rating (I_t) of a cable where overload protection is to be provided is given by:

$$I_t \geq \frac{I_n}{C_g C_a C_i C_f C_s C_c C_d}$$

Where:

I_t is the tabulated current-carrying capacity of a cable found in Appendix 4 of BS 7671;

I_n is the rated current or current setting of the overcurrent device;

C_g is rating factor for grouping;

C_a is rating factor for ambient temperature;

C_i is rating factor for conductors surrounded by thermal insulation;

C_f is rating factor for semi-enclosed fuses (BS 3036);

C_s is rating factor for thermal resistivity of soil;

C_c is rating factor of 0.9 for cables buried in the ground (otherwise 1);

C_d is rating factor for depth of buried cable.

Note: when overload protection is required the current carrying capacity of the cable has to be related to the current rating of the overload protective device (I_n). The correction factors are applied as divisors to I_n. For example, the circuit breaker standard (BS EN 60898) refers to 1.45 multiplied by I_n as the conventional tripping current which must open the circuit breaker contacts within the conventional time. This is defined as one or two hours depending on the current rating of the circuit breaker. The factor of 1.45 ensures that deterioration of cables does not result from small overloads.

Selection of conductor cross-sectional area for circuits not requiring overload protection

Regulation 433.3 describes the circumstances where overload protection may be omitted. If a load cannot vary, especially increase, overload protection may not be necessary; however, fault protection (short-circuit and earth fault) will still (with a few exceptions, see Regulation 434.3) be required.

Overload protection may be omitted where:

I_t is not needed (Regulation 433.3.1);

Unexpected disconnection could cause danger or damage (Regulation 433.3.3).

Note: This omission of overload protection must not be applied to installations situated in locations presenting a fire risk, or risk of explosion, or where the requirements for special installations and locations (Part 7 of BS 7671) specify different conditions.

Regulation 433.3.3 allows the omission of devices for protection against overload for circuits supplying current-using equipment where unexpected disconnection of the circuit could cause danger or damage. For example, the supply circuit of a lifting magnet. Electromagnets are used, for example, in scrapyards to lift and carry loads. If such a magnet is de-energised while in operation this could cause damage or injury.

Note: In such situations consideration should be given to the provision of an overload alarm.

Omission of the need for overload protection simplifies the equation for the required tabulated current rating, as C_f and C_c are unity.

The equation for required I_t then becomes:

$$I_t \geq \frac{I_b}{C_g C_a C_i C_s C_d}$$

Where:

I_t is the tabulated current-carrying capacity of a cable found in Appendix 4 of BS 7671;

I_b is the design (load) current of the circuit;

C_g is rating factor for grouping;

C_a is rating factor for ambient temperature; >

C_i is rating factor for conductors surrounded by thermal insulation;

C_s is rating factor for thermal resistivity of soil;

C_d is rating factor for depth of buried cable.

Note: where the cable will not be subject to overload and there is no need for overload protection, the correction factors are simply applied as divisors to the design current (load current) of the circuit (I_b) to ensure the correct current carrying capacity of the cable is determined for the installed conditions.

Cable grouping (C_g)

Appendix 4 contains group rating factors contained in Tables 4C1 to 4C6. The 17th edition, published in 2008, introduced new grouping factors for buried cables. Two important points to note regarding grouping factors are:

Note 1 to Table 4C1 of BS 7671,which advises that the rating factors are applicable to uniform groups of cables, equally loaded. Regulation 523.5 states: the group rating factors, see Tables 4C1 to 4C6 of Appendix 4, are applicable to groups of non-sheathed or sheathed cables having the same maximum operating temperature. For groups containing non-sheathed or sheathed cables having different maximum operating temperatures, the current-carrying capacity of all the non-sheathed or sheathed cables in the group shall be based on the lowest maximum operating temperature of any cable in the group together with the appropriate group rating factor.

Clearly, care has to be taken in its application to groups of cables with different sizes. For example, thermosetting and thermoplastic cables should not be grouped unless the thermosetting cables' cross-sectional areas are selected as for thermoplastic cables.

Section 2.3.3 of Appendix 4 of BS 7671 provides guidance on grouping of different sized cables. The group rating factor for groups in conduit, trunking or ducting systems is given by:

$$F = \frac{1}{\sqrt{n}}$$

Where:

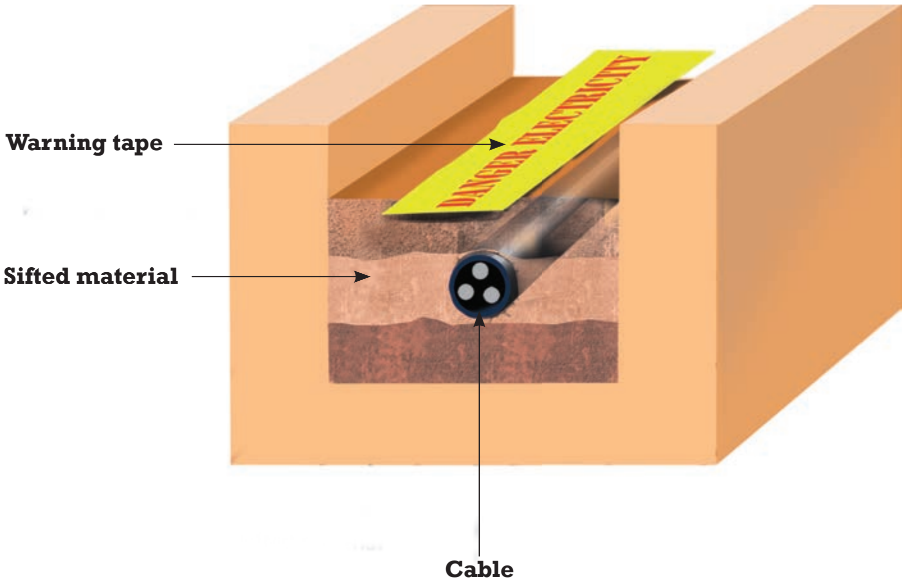
F is the group rating factor (C_g);

n is the number of circuits in the group.

The second important note, Note 9 to Table 4C1, is especially significant. It notes that cables with a loading of less than 30 per cent of the grouped rating may be discounted (ignored) and the rating of the remaining cables calculated as if the lightly loaded cables were not included in the group.

Ambient temperature (C_a)

Appendix 4 includes tabulated current-carrying capacities for some of the most commonly used cables in the electrical installation industry. These tabulated current carrying capacities are based upon a 30°C ambient temperature for



cables (other than buried in the ground) and 20°C ambient ground temperature for cables buried in the ground. Where the installation conditions differ, a correction factor has to be applied – detailed in Tables 4B1 and 4B2 of appendix 4. Note that where the ambient temperature varies over the route of the cable, the highest ambient temperature likely to be accounted has to be used as the basis for determining the current-carrying capacity.

Thermal insulation (C_i)

Regulation 523.9 states: For a single cable likely to be totally surrounded by thermally insulating material over a length of 0.5m or more, the current-carrying capacity shall be taken, in the absence of more precise information, as 0.5 times the current-carrying capacity for that cable clipped direct to a surface and open (Reference Method C).

Where a cable is to be surrounded by thermal insulation for less than 0.5m the current-carrying capacity of the cable shall be reduced depending on the size of cable, length in insulation and thermal properties of the insulation.

The derating factors in Table 52.2 (reproduced below) are appropriate to conductor sizes up to 10mm^2 in thermal insulation having a thermal conductivity (λ) greater than 0.04Wm^{-1}K^{-1}.

One important point to note is that

TABLE 52.2 – Cable surrounded by thermal insulation

Length in insulation (mm)	Derating factor
50	0.88
100	0.78
200	0.63
400	0.51

a rating factor only has to be applied where the installation conditions differ from those for which values of current-carrying capacity are tabulated in the tables of Appendix 4. Therefore this correction factor (C_i) needs to be applied with great care as a number of tabulated current ratings in Appendix 4 already allow for contact with some thermal insulation. For example, Table 4D5 gives values of current-carrying capacity for cables in contact with thermal insulation, and, where these are used, no further correction needs to be made.

Rewireable fuse (C_f)

Those fuses referred to as 'rewirable fuses' are correctly termed semi-enclosed fuses (complying with BS 3036) as they are partially enclosed within the fuse-carrier. Regulation 533.1.1.3 of Amendment 1 of BS 7671:2008 states that a fuse shall preferably be of the cartridge type (but this does not preclude the use and installation of semi-enclosed fuses). The regulation states that where a semi-enclosed fuse is selected, it shall be fitted with an element in accordance with the manufacturer's instructions, if any. In the absence of such instructions, it shall be fitted with a single element of tinned copper wire of the appropriate diameter specified in Table 53.1.

The size needed for a conductor protected against overload by a BS 3036 semi-enclosed fuse can be obtained by the use of a rating factor, 1.45/2 = 0.725, which results in the same degree of protection as that afforded by other overload protective devices.

Cables buried in the ground - ambient ground temperature related to overload protection (C_c)

It is important to note that the tabulated current-carrying capacities for cables direct in ground or in ducts in the ground, given in Appendix 4, are based on an ambient ground temperature of 20°C. The factor of 1.45 that is applied in Regulation 433.1.1 when considering overload protection assumes that the tabulated current-carrying capacities are based on an ambient air temperature of 30°C. To achieve the same degree of overload protection for an ambient temperature of 20°C, a rating factor of 0.9 is applied as a multiplier to the tabulated current carrying capacity.

Cables buried in the ground - depth of cable (C_d).

Where cables are at depths other than 0.7m, direct buried or buried in ducts, Table 4B4 gives rating factors (C_d)

Cables buried in the ground – soil thermal resistivity (C_s)

The current-carrying capacities tabulated for cables in the ground are based upon a soil thermal resistivity of 2.5K.m/W and are intended to be applied to cables laid in and around buildings, i.e. disturbed soil.

In locations where the effective soil thermal resistivity is higher than 2.5K.m/W, an appropriate reduction in current-carrying capacity should be made. Rating factors for soil thermal resistivities other than 2.5K.m/W are given in Table 4B3.

OVERCURRENT PROTECTIVE DEVICES – CIRCUIT BREAKERS

There are many types of circuit breaker available, the most common being the 'thermal magnetic circuit breaker'. 'Miniature circuit breakers' (MCBs) should comply with BS EN 60898, entitled: 'Circuit-breakers for Overcurrent Protection for Household and Similar Installations'. The scope identifies they are designed for use by an uninstructed person. The maximum rated current permitted is 125A.

Thermal trip

A thermal bi-metallic trip is used to protect against overload currents. The bimetallic or thermal sensing element deflects mechanically as current passes through it. The higher the overcurrent, >

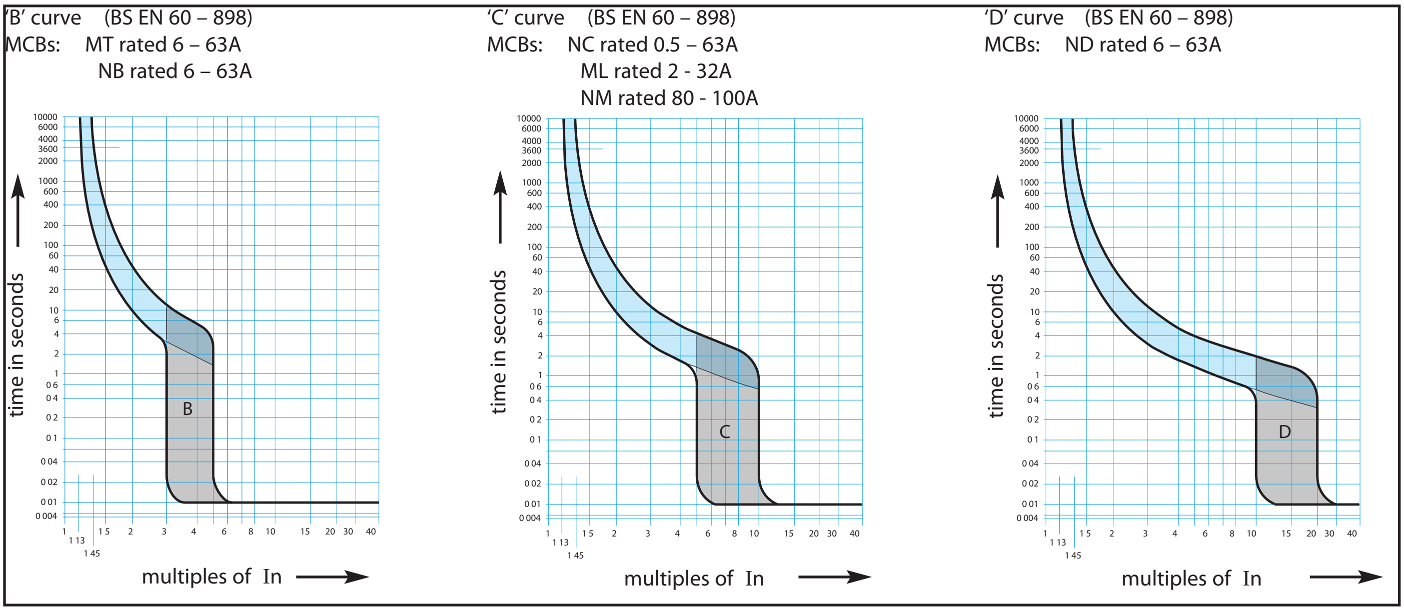


Fig 2: Circuit breaker curves

the greater the deflection. At a predetermined point the element will actuate a tripping mechanism, open the contacts and disconnect the circuit. This action is represented by the inverse time characteristic (curved section) of the circuit breaker - see Fig 1. The Standard BS EN 60898 refers to 1.45I_n as the conventional tripping current which must open the circuit breaker

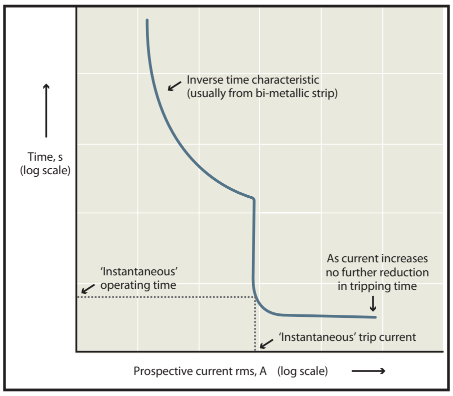


Fig 1: Circuit breaker

contacts within the conventional time. This is defined as one or two hours.

1.45I_n relates directly to circuit design, in section 433 protection against overload current, regulation 433.1.1 states that: "the operating characteristics of a device protecting a conductor against overload shall satisfy the following conditions:

(i) the rated current or current setting of the protective device (I_n) is not less than the design current (I_b) of the circuit, and

(ii) the rated current or current setting of the protective device (I_n) does not exceed the lowest of the current-carrying capacities (I_z) of any of the conductors of the circuit, and

(iii) the current (I_2) causing effective operation of the protective device does not exceed 1.45 times the lowest current carrying capacities (I_z) of any of the conductors of the circuit."

The factor 1.45 ensures that deterioration of cables does not result from small overloads. This is based upon practical studies and experience that has shown when a current of 1.45 times the current carrying capacity of the cable is interrupted within the conventional times, there is no significant deterioration in the working life of the cable.

Magnetic characteristic

The magnetic characteristics on BS EN 60898 circuit breakers are fixed. Devices with a common nominal current rating are available in three different types. A letter preceding the nominal current rating i.e. B20 for a 20A type B circuit breaker denotes the type of device. The letters B, C, or D relate to the magnetic trip setting or characteristic curve, see Fig 2.

This component of the circuit breaker is constructed using a coil or solenoid, which is designed to operate the tripping mechanism when the overcurrent reaches a set magnitude. This magnetic component is specifically designed to deal with fault current. As can be seen from the graphs, (Fig 2) the letter B, C, or D represents a multiple of I_n. When the current rises to this multiple value, the magnetic trip operates instantaneously to open the contacts.

Conclusion

Please note this article is only intended as a brief overview of some of the changes introduced into Appendix 4 by amendment 1 of the 17th edition of the wiring regulations. Circuits must be designed that are fit for purpose and suitable for the load they are intended to supply. They should be correctly designed in accordance with BS 7671.

Chapter 43 deals with protection against overcurrent and also thermal constraints, chapter 42 has requirements for protection against thermal effects, chapter 41 deals with protection against electric shock and gives the disconnection times that must be met whilst section 525 deals with voltage drop. In addition, sections 526 and 512.1.5 have requirements for the temperature of conductors connected to equipment terminals. Appendix 4 gives tabulated current carrying capacity and voltage drop for cables.

All these areas need to be taken into account when determining the cable size for a particular circuit. For more information refer to Amendment 1 of BS 7671:2008.

Special thanks to Hager for some of the images and information in the article.

LEADING LIGHTS?

LED lights are being promoted as the ultimate in eco-friendly lighting. But are they as energy-efficient as we think? By Rebecca Pool

Confusion around how LED light output is measured may be misleading consumers

PHILIPS

TO CELEBRATE the Queen's Diamond Jubilee and Olympics, London's Tower Bridge was adorned with thousands of LED lights. Described by London Mayor,Boris Johnson as "bathing Tower Bridge in eco-friendly light" the LEDs will continue to illuminate the bridge, even providing firework-like displays, for the next 25 years.

Crucially, the lighting scheme providers, GE and EDF Energy, claim the 1,800 LED lights and 2,000m of LED linear lights will reduce the energy used to light the bridge by some 40 per cent compared with the previous system. "Thanks to its state-of-the-art lighting, Tower Bridge has further reduced its carbon footprint to become a standout symbol of sustainability," enthused EDF chief executive Vincent de Rivaz.

London leaders are not alone in fitting famous landmarks with "energy-saving" LED lights. The US Empire State Building owners recently gave their tower a so-called "energy-efficiency retrofit", replacing 400 conventional lamps with 1,200 LED fixtures and claiming 75 per cent savings in annual energy costs. The Singapore Flyer, Stockholm's Globe Arena and Canada's CN Tower are but a few of many landmarks also decked out with the apparent cost-cutting light alternative.

Clearly, people at home and work are eager to ditch the unloved CFL and the not-so-efficient halogen and slot in the small, ready-to-glow semiconductor diode, be it to boost energy efficiency, cut energy consumption or even glow a brighter shade of green. But does the LED live up to its glowing reputation? Not yet.

As one disappointed user recently wrote on a LED web forum: "I bought 12 LED GU10 lamps about 18 months ago of which around half no longer work, two only lasted for 48 hours. The light output is nowhere near what is claimed either, even using 3 by 3W LEDs does not equal the equivalent 50W light bulb."

A matter of quality

The disappointed LED lamp user's comments are not unusual by any stretch of the imagination. Iain Macrae, president of the Society of Light and Lighting and global technical manager of Thorn Lighting, supplier of luminaires and lighting controls, says: "High-quality players will have great performing LEDs, tell you the truth and be able to back it up. At the lower end of the market, players have more poorly performing LEDs – quite rightly so at the price point – but they won't always tell you about it."

According to Macrae, confusion exists around how light output is measured, and this has been exploited to fool the customer. Typically, two light figures are quoted by LED and luminaire (complete light fittings) manufacturers: lumens per watt and luminaire lumens per watt.

The former, lumens per watt, refers to the ratio of light output from the actual LED to the power consumed; the higher the value, the more energy efficient >

Consumers don't always register the fact that product and chip efficiencies are two different things

the LED (see 'Know your Lumens'). The second is the light from the LED that makes it out of the luminaire for the amount of power you put in. Depending on the actual fixture in which the LED is fitted, this figure will be lower, as it takes into account thermal, control and optical losses that vary from fitting to fitting.

"A manufacturer [of a light fitting] will want to know the raw figure before he designs the luminaire around it, but the end user wants the light output [from the fitting] onto the desk," says Macrae. "A lot of people are supplying different customers and haven't quite figured out the different languages yet."

Mike Simpson, technical and design director at Philips UK agrees. Philips Lighting is driving the LED lighting 'revolution', but as Simpson explains, the industry has suffered some confusion.

"When LED lights first came out, people were talking about efficiencies and everyone said wow, 150 lumens per watt," he says. "When they got the real lighting products they said 'but this is nothing like it'. Of course industry had been referring to the chip efficiencies and now we try to make it clear that product and chip efficiencies are two different things."

Simpson emphasises that the consumer, be it the luminaire manufacturer or an end user, must make sure they get the efficiency of the actual product they are buying. But, given the consumer understands the difference, is he or she still going to get the promised energy savings?

Earlier this year, BBC News ran a story based on a report from the Energy Savings Trust and stating: "[LEDs are] are much more energy efficient, using up to 90 per cent less energy than incandescent bulbs." However, the jury is out on exactly how much energy will be saved by switching to LED lighting.

"LEDs push light out in one direction," Simpson explains. "So if you compare an application where you want directional light, say spot lighting in your home, the LED produces more light for the power that goes in and is more effective at producing light in one direction, than a filament bulb in a reflective light fitting."

But what if the user doesn't want a directional spotlight? Indeed, in the rush to slash energy bills and make instant savings, owners of shops, hotels, office blocks, even lifts, have been whipping out the 50W tungsten filament

and plugging in a 10W LED, often with disappointing results.

As Macrae says: "In spotlights, where you want a focused beam, or [in] architectural lighting, where you want to pick something out, the LED is absolutely superb. But here in my office I have a couple of [fluorescent] luminaires with soft ambient light drifting out of them: LEDs many not be the answer here."

Fanciful figures?

Simon Robinson is technical director of property and development at engineering consultant group, WSP UK. His experience indicates that in some cases, LEDs are used inappropriately as the sellers of LED lighting don't always understand what they are selling. What's more, while the figures they provide for, say, efficiency and energy savings are true, they do not relate to what the general public understands.

"Why not have the manufacturers of LED products reference the lighting output of their products to something the general public understands?" he asks. "This would be what the classic GLS lightbulb is; a 100W or 60W lamp equivalent."

Failure to meet part L of the UK building regulations, which demands luminaires in commercial properties deliver at least 55 luminaire lumens per watt, is another issue his clients have faced. Often LEDs have been fitted into poorly designed luminaires, or simply retrofitted into fluorescent light fittings, giving inadequate light output.

"There is nothing illegal about selling a luminaire that doesn't meet Part L; it is the fitting of it that counts," he explains. "And, because clients see LEDs as efficient, they assume the entire light fitting will meet building requirements; not always so."

Colour temperature and colour rendering have been another bone of contention among users of LED lights. At home, most of us have grown up with a warm, yellow glow from tungsten halogen incandescents. These bulbs deliver a so-called colour temperature of around 2,700K – in contrast, a candle is 1,900K and a sunset is around 2,000K – and people genuinely feel more comfortable under these warmer colours.

Now, switch on the LED.

Almost all white lighting LEDs are based on a blue-emitting die with a yellow phosphor on top to convert some of the blue light to broadband amber, giving an overall result of white light. Generally, the more phosphor you use on a white light LED, the warmer your white light, but the greater your emission losses and the lower your efficiency.

Thankfully, this has become less of an issue over time as the basic chip efficiencies have improved, making it more cost-effective to modify that cool blue raw light to the warmer light much preferred in the home. Indeed, top-of-the-range LEDs are now available at 2,700K and 3,000K, closely replicating the more yellow glow of halogen tungsten and fluorescent light sources.

Importantly, converting light in an LED could be more cost-effective than doing the same in the widely-used fluorescent lamp, the LED light's key competitor. As Macrae highlights, in the same way that a yellow phosphor is used to modify the blue LED light, most fluorescent bulbs emit ultraviolet light and use a white phosphor to convert this high frequency blue light into white light.

"LED light sources are smaller [than fluorescent alternatives] so you have less phosphor per unit of light. This means you can afford to put a little bit more expensive phosphor in as there is so little of it," he explains.

Colour rendering

But, while a warm glow can make for a happy home, what about the workplace? This is where colour rendering becomes more of an issue.

Colour rendering relates to the way objects appear to somebody, under a given light source. It is measured via the colour rendering index (CRI), a quantitative measure of the ability of a light source to reproduce the colours of various objects faithfully in comparison with an ideal or natural light source.

A low CRI indicates that objects may appear unnatural under the light source, while a light with a high CRI rating will allow an object's colours to appear more natural. The ability of an artificial light to meaningfully show, say, blood in a hospital setting, or to light up beef on a supermarket shelf in an attractive way, is crucial.

Today's LED lights typically have a CRI on a par with that of a fluorescent light fitting – around 85 – while the CRI of a tungsten halogen is 100. However, this original colour-rendering scale was developed in the 1970s to measure phosphor-based light sources, and does not necessarily provide an accurate reflection of an LED's colour quality.

LED manufacturers could reproduce more relevant CRI figures for the interested customer but will not specify them. Instead, spectra of a product's colour characteristics are published, leaving the buyer to make his or her own evaluations and calculations. Thankfully, this will soon change.

The CRI index is currently being revised by the International Commission on Illumination (CIE) to take into account new light sources including the white LED. "We now know a lot more than we did when this scale was developed. We have new light sources, we view from different angles and different dimming levels so this rendering scale is not longer ideal," explains Macrae. "We need to change the scale so it includes more vivid colours and less of the skin tones – we'll have the solution in about a year or so." >

< Colour aside, what about lifetime and costs? Right now, LED bulbs come with advertised lifetimes of 25,000 hours while the compact fluorescent bulb is meant to last 10,000 hours and the lowly incandescent halogen some 1,000 hours. However, according to Simpson, LEDs can last 50,000 to 60,000 hours, that's between 15-60 years, depending on how the product is used. As such, Philips is careful not to put life into a product where it isn't needed.

"For example, we design domestic products for 25 years," he says. "But you have to ask yourself, how long do I want this in my home? If I bought one of these products, I'm going to be leaving it in my will to my children."

Longevity of LEDs

Temperature is a real killer for an LED's lifetime, although clever cooling techniques counter this. Recent LED lightbulbs, packed full of LEDs, come with some sophisticated passive cooling fins to divert heat away from the bulbs. Meanwhile, other fittings are equipped with the same fans or syn-jets used in laptops, which are rated to nearly 100,000 hours and could possibly outlive the LEDs.

And then there's the thorny issue of cost. With prices up to £25 per bulb, the received wisdom that LED lighting is expensive seems well deserved. However, rising electricity prices and falling LED costs could see the technology finally making financial sense. Factor in the long lifetimes and the fact that a typical 35W halogen replacement LED could use as little as 4W, much less than the 10W compact fluorescent equivalent; then the cost case for the LED becomes much stronger.

But despite these gains, for the present the LED still might make less sense in large-scale commercial applications. "The LED hasn't broken the cost of efficiency barrier yet," asserts Macrae. "A fluorescent fitting is cheaper and not particularly inefficient, you don't want to recycle your building stock all the time."

And, although Simpson asserts the £15 LED lamp will pay for itself in two years, he admits industry is still waiting for prices to come down while watching the performance go up. "Like all semiconductor technologies, the price is going to continually come down and performance will rise. At a chip level we are currently at 150 lumens per watt, but by end of this decade, that figure will have gone up to 250L/W."

In fact, time seems to be the answer for just about every LED light issue. Despite the clear discrepancies on energy efficiency and savings, colour quality and rendering as well as cost issues, most in the industry agree that the LED is the light of the future.

An LED revolution

Philips Lighting's Simpson is incredibly positive: "In 2003, 6 per cent of our sales were in LED technology and by 2020 we see 75 per cent. You start off saying you wouldn't ever see LEDs in this application and then six months later you say yes, yes, yes. LEDs are going to encompass almost every lighting application you can probably think of."

Not as upbeat, but still positive, Robinson also points to the ongoing increases in luminance lumen per watt. "I am certain this will match that of the latest fluorescent in another four to five years so if you intend to have lighting installed for 20 years, wait five years and you might find the fifteen years you've got left of your savings is more than jumping in now," he says.

But, perhaps surprisingly, Macrae expresses some reservations. While he fully expects the industry to move towards LEDs, he believes demand for other light sources is not going to disappear.

"I know of fluorescent lamps that offer a similar sort of lifetime to LEDs and are more efficient than LEDs," he points out. "And importantly, if I'm not cash rich, can I really afford to replace fluorescent lighting that might still have another 20 years' worth of life?" ✻

COLOUR RENDERING INDEX

22	high pressure sodium lighting	street lighting
62	common 4ft flourescent tube	office
80-85	compact flourescent lighting (warm white)	residential
85	premium 4ft flourescent tube	retail
80-90	solid state LED lighting	residential
95	incandescent lightbulb	residential

Lights with CRIs of 80 or higher are generally considered to have a high CRI. CRI values should only be compared when the light sources being compared have similar colour temperature ratings.

ORGANIC LIGHTING

BRIGHTER FUTURES?

Iain Macrae, president of the Society of Light and Lighting, asserts the organic LED is where the real action is. As he says: "LEDs will change the market but organic LEDs will change the way we light spaces completely."

The OLED is made by placing a series of organic thin films between two conductors. When electrical current is applied, a bright light is emitted. OLEDs can be printed on to any suitable substrate, including plastic, giving way to flexible organic light-emitting diodes and other applications such as roll-up displays and lights embedded in fabrics, clothing, even wallpaper.

The technology is already used in the displays of Motorola and Samsung colour mobile phones, as well as a host of other mobile devices. What's more, Philips Lighting, Germany-based Novaled and US-based Universal Display Corporation have developed OLED lamps. Indeed, as Macrae points out, OLEDs suit soft lighting and says: "If in my office I didn't want to put luminaires in the ceiling, I could instead put wallpaper or light panels on the wall."

However, the cost of OLED lights must first come down if the technology is to light up the mainstream; will this happen? Macrae believes so: "Efficiency and quality must also go up, and this [development] will cost millions. But it will happen in about five years' time."

LIGHT MEASUREMENTS

KNOW YOUR LUMENS

Lightbulb efficiency is measured in lumens per watt; the amount of light produced for each watt of electricity consumed. Put simply, more lumens per watt means more light for your money.

The most common energy-efficient lightbulbs include energy-saving or halogen incandescents, compact fluorescent lamps (CFLs), curly versions of the long tube fluorescent lights, and LEDs. Today's white light LED bulb produces around 150 lumens per watt; this figure is predicted to increase to 250 lumens per watt in the next decade. In comparison, the CFL produces 60 to 80 lumens per watt while the halogen incandescent produces around 16 lumens per watt.

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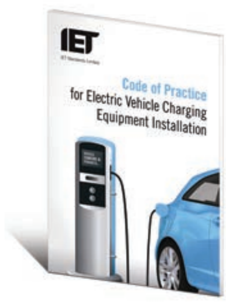

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The Institution prepares regulations for the safety of electrical installations for buildings, the IET Wiring Regulations (BS 7671), which has now become the standard for the UK and many other countries. It has also prepared the Code of Practice for Installation of Electrical and Electronic Equipment In Ships (BS 8450) and recommends, internationally, the requirements for Mobile and Fixed Offshore Installations. The Institution provides guidance on the application of BS 7671 through publications focused on the various activities from design of the installation through to final test and certification with further guidance for maintenance. This includes a series of eight Guidance Notes, two Codes of Practice and model forms for use in wiring installations.

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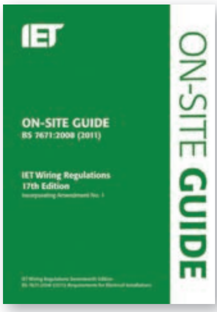

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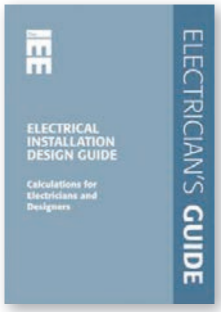

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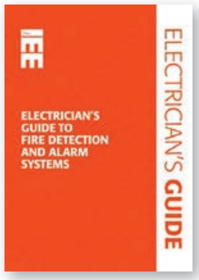

This is one of a number of publications prepared by the IET to provide guidance on electrical installations in buildings. This publication is concerned with fire detection and fire alarm systems and must be read in conjunction with the legislation, Approved Document B and the British Standards, in particular BS 5839-1 and 5839-6.

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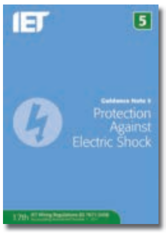

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CHARGE YOUR ENGINES

The electric vehicle market is gaining strength thanks to careful consideration of the future charging-point infrastructure.

By Anne Harris

Will the charging infrastructure be in place for UK EVs?

GETTY IMAGES

IN AMERICA, the Obama administration has set a goal of one million electric cars on the road by 2015 to reduce air pollution and dependence on fossil fuels. In the UK, the government has similarly ambitious targets, but all of this is dependent on public confidence that the charging infrastructure will be in place.

Although the vast majority of owners will charge their vehicles at home there is a need for a safety net of roadside charging options required for top-ups, or 'grazing' as it is termed within the industry.

In the UK the Plugged-In Places programme has made £30m available to match-fund eight pilot projects installing and trialling recharging infrastructure in the UK. This will support the Carbon Plan commitment to install 8,500 chargepoints.

In its strategy document, the UK government expects to see tens of thousands of plug-in vehicles on the roads by 2015, with manufacturers bringing increasing numbers of models to market. In the period from 2015 to 2020, it is expected that the number of plug-in vehicles will accelerate as costs reduce and vehicle manufacturers bring forward a wider range of models to meet their stringent targets under the European New Car CO_2 Regulation.

The rate at which the UK plug-in vehicle market develops will be determined by a range of factors including consumer acceptance and oil prices, which are difficult to predict. Independent forecasts suggest that hundreds of thousands of plug-in vehicles could be on the road by 2020. The government has accepted that it needs to be equipped to deal with this growth but it also needs to be prepared to accommodate an even more rapid rate of growth should this occur.

The recharging infrastructure

The approach is not to mandate a chargepoint on every corner as this is uneconomic and unnecessary to support market growth. For plug-in vehicles to appeal to and be a viable >

The network of public charging posts is growing rapidly, intended for 'grazing' or topping up

solution for consumers, the recharging infrastructure needs to be targeted, convenient and safe.

"We want to see the majority of recharging taking place at home, at night, after the peak in electricity demand," the UK government charging strategy says. "Home recharging should be supported by the workplace, with a targeted amount of public infrastructure where it will be most used, allowing people to make the journeys they want.

"After home recharging, we want to see workplaces providing recharging opportunities, both for fleet vehicles and employees for whom recharging at home is not practical or sufficient."

Given that the majority of recharging is likely to be done at home and at work, an extensive public recharging infrastructure would be uneconomic. "We want public infrastructure to be targeted at key destinations, where consumers need it, such as supermarkets, retail centres and car parks, with a focused amount of on-street infrastructure, particularly for residents without off-street parking," the document adds.

"Although central and local government is currently playing a key role in establishing the early public infrastructure, in the longer term a commercial market needs to develop. Public infrastructure needs to be easy to locate and easy to access, to give the public the assurance that they need to use the full range of their vehicles and to support the commercial case for public charging."

Public charging points

In a study undertaken by Elektromotive, a provider of recharging solutions for electric vehicles, two-thirds of motorists would be more likely to consider the purchase of an electric car if charging posts were readily available at roadsides and in car parks across the UK.

The current coalition government plans to expand existing EV charging infrastructures by installing charging stations in areas where people are most likely to plug in for a reasonably long period of time, in public car parks and on the roadside in focused areas.

"With over 2,000 of its charging stations already installed worldwide for public and private use, Elektromotive is highly respected in the industry and plays a major role in advising government, local councils, car manufacturers and energy suppliers on the best solutions to providing public charging infrastructures," Calvey Taylor-Haw, managing director of Elektromotive says.

"We are also ranked number one in Europe and third in the world for recharging post-manufacture in a 2011 study by market analysts Pike Research."

Based in Brighton, the firm has installed charging stations across the UK as part of various government and private-led schemes, including the Brighton and Hove City Council's EV Charging Point scheme and CABLED, a scheme run by the Transport Strategy Board and Advantage in the West Midlands. Elektromotive has also installed 200 charging stations across Ireland as part of the 'e-cars' initiative launched by the Electricity Supply Board (ESB).

"We have developed an extensive range of charging stations for use by passenger cars, public service vehicles and commercial vehicles," Taylor-Haw adds. "We were the first company to install charging stations in the UK, beginning with the Elektrobay in Westminster, London, in 2006. There are now nearly 900 Elektromotive products installed in various locations across the country."

The Elektrobay is a safe, secure unit, with a simple, future-proof design. Last year the company was awarded a patent to protect the innovative design of the controller within a charging station. This controls the user's access and activation of the charging station via a personalised wireless key fob, and safely initiates the charging process when the secure, weatherproof door at the front of the unit is closed over the inserted plug.

A small colour screen and light at the top of the unit indicates when charging is in progress. With a power output of 240V AC and 13 to 32A, they are fully compliant to BS.7671:2008 and BS EN 61851 Mode 1, 2 and 3 charging (dependent on model) in the UK. It is also compatible with all fully-electric and plug-in electric hybrid vehicles.

The range has now been extended to include a twin-head Elektrobay. Able to charge two vehicles at once, this will reduce the amount of street furniture required.

"There's been a lot of scepticism about EVs, and now is the time to trumpet the message that EV drivers haven't been affected by spiralling fuel costs or the recent fuel crisis," Erik Fairbairn, CEO of EV charging company POD Point, says. "The lifetime costs of running a petrol or diesel car continue to escalate, and when you can charge your car for under £1.50, the £80-a-tank cost doesn't make financial sense.

"The public charging infrastructure for electric vehicles is being rapidly installed in car parks, railway stations and designated on-street parking bays. There is also a growing network of rapid chargers at motorway service stations."

Charging time

One concern that many early adopters have expressed is the amount of time that it takes to charge their vehicles. With battery technology continuously improving, some of the latest production EVs – such as the Nissan Leaf and Mitsubishi i-MiEV – can now take a much higher voltage, thus reducing their charging time. With this in mind, Elektromotive launched the DC-DC 50KV Rapid Charger, compliant with the CHAdeMO protocol, which can charge a compatible EV to 80 per cent of its capacity in just 20 minutes. The Rapid Charger is currently being rolled out in car parks on main roads and conurbations where they will be of most use.

The network of public charging posts is growing rapidly. Public charge posts are intended for 'grazing' or topping up, and a rule of thumb is: 10 miles/hour of charge on a 13A socket; 15 miles/hour of charge on a 16A socket; 30 miles/hour of charge on a 32A socket.

POD Point already has 424 active bays (two bays in each post) in the UK, with over 70 more waiting to go in the ground.

"It is already possible for EV motorists to drive from coast to coast in the UK. The biggest challenge is not the distance between charge points, but locating the charge points while en route. POD Point is working with the Office for Low Emission Vehicles to produce the National Chargepoint Registry with an interactive map to show the location and availability of charge points and enable developers of apps, satnavs and websites to create platforms showing this," Fairbairn says.

At-home charging

While roadside charging is vital, the vast majority of charging will take place in the home. "Elektromotive has recently launched its Home Charger and has a new range of exciting chargers in development for the home and workplace. These feature innovative back-end management systems, demonstrating Elektromotive's ability to stay ahead of the technological challenges associated with EV charging," Taylor-Haw says.

"The number of public charging stations is set to increase since the International Electrotechnical Commission ended a long-standing debate over a plug and socket standard for charging stations in Europe. The decision to specify the Mode 3 62196 Mennekes-style plug and socket as the charging standard for all European EVs has boosted confidence in the industry."

CHARGING

RULES, REGULATIONS AND STANDARDS

While four different modes of electric vehicle (EV) charging have been established, the minefield of standardising one generic plug for public charging stations is still an ongoing saga. Modes 1, 2, 3 and 4 refer to the rate of charging of the EV, with the most basic level referred to as mode 1, a simple and slow AC charging method in the home. Mode 2 is also slow charging, introduced as a safer interim solution with in-cable protection, and as with mode 1 it must conform to standard BS 1363-2:1995. Mode 3, compliant with BS EN 62196-2, is predicted to be the most popular form of EV charging, used in public, work and household charging points, delivering both slow and fast charging within 10 hours using an EV socket. Mode 4 is the fastest, and the most expensive to equip and install of the four, delivering fast-charging DC charge converted from AC.

The IET has recently produced a code of practice for installing charging points, a specialist publication for electrical installers not aimed at the general public. While the IET believes that dedicated charging equipment is most appropriate for use with EVs, it is permitted to use an ordinary 13A plug to charge an EV if that type of cable is supplied with the vehicle.

The Code of Practice recommends that if intending to use a 13A plug and socket, the socket should be on a dedicated circuit so that in the event of a trip the whole house is not affected. This is similar to the usual advice for wiring showers and electric cookers, as they take a similar load.

In an effort to at least partially standardise the plug and socket for EV charging, the International Electrotechnical Commission has produced a standard comprising of two parts called the IEC 62196. Part 1 refers to plugs as specified in IEC 60309 for multiphase and industrial and power plugs and sockets which have been adapted for use in electric vehicle charging, while part 2 refers more specifically to plug types used during the active process of charging.

Three plug types that have been authorised by the IEC 62196-2 include Type 1, 2 and 3 as part of battery charging and ideal smart grid compatibility. Type 1 is a single phase vehicle coupler, favoured by the US electric vehicle market, and is displayed in Yazaki's round SAE J1772/2009 plug, featuring five pins: two AC wires, two single pins and a ground. Type 2 is single and three-phase vehicle coupler as shown in Menneke's VDE-AR-E 2623-2-2 plug specifications which has been accepted as standard by car makers across most of Europe, but has received criticism as being the most expensive. Type 3 is a plug proposed by Scame/EVPlug Alliance that is already in use in light electric vehicles and is the cheapest of the three.

Currently, each type's popularity is determined by regional preference of a particular mode of charging. For example, in the US and parts of Europe, including Italy, limited Mode 1 charging is used on grounds of safety, while Mode 3 is receiving a lot of interest for public charging points.

Mode 4 is the favoured type in Japan. But while the United States and Japan, for example, currently favour Type 1 connectors, various European countries favour Type 2 connectors and other international regulations mean Type 3 connectors could be required.

The IEC is currently in the process of developing a standard which will address mode 4 fast charging called the IEC 62196-3. It is unlikely that EV users will see one generic international connection any time soon, but many in the industry believe that at the very least the plug connecting directly into the charging station should be standardised, leaving the car side open to preference.

WiringFeature #44

GETTY, MK ELECTRIC

Socket protectors are widely available, but could they be doing more harm than good?

By Mark Coles

SOCKET PROTECTORS

SOCKET PROTECTORS are intended to stop foreign objects from being inserted into BS 1363, 13A socket-outlets. The socket protector usually takes the form of a dummy 13A plug and is inserted into the socket-outlet. The intention here is to prevent anything else being inserted into the socket-outlet, such as the fingers of children or lengths of metallic objects.

The safe system that is BS 1363

Accessories to BS 1363 are made to exacting requirements so that the plug perfectly fits the socket-outlet. When BS 1363 was defined in the 1940s the designers wanted to make sure that the socket-outlet was very safe. The standard requires that an interlocking shutter system stops random objects from being inserted into the socket-tubes and that all socket-outlets be tested to ensure that a pin has to be inserted a distance of 9.6mm into the socket before it makes contact with any live parts. The shutter system will operate and open to expose the line and neutral connections only when a plug is inserted. It is actioned by:

- **the earth pin of the plug, or**
- **both the line and neutral pins simultaneously, or**
- **all three pins; first the earth pin followed by both the line and neutral pins simultaneously.**

The shutter mechanism is shown in the diagram on page 30. An earth pin has been inserted into the socket on the left, the shutters which normally cover the socket tubes have opened. There is nothing inserted in the socket-outlet on the right, hence the shutters are closed. BS 1363, therefore, already incorporates a mechanism which stops intentional and unintentional direct contact with live parts.

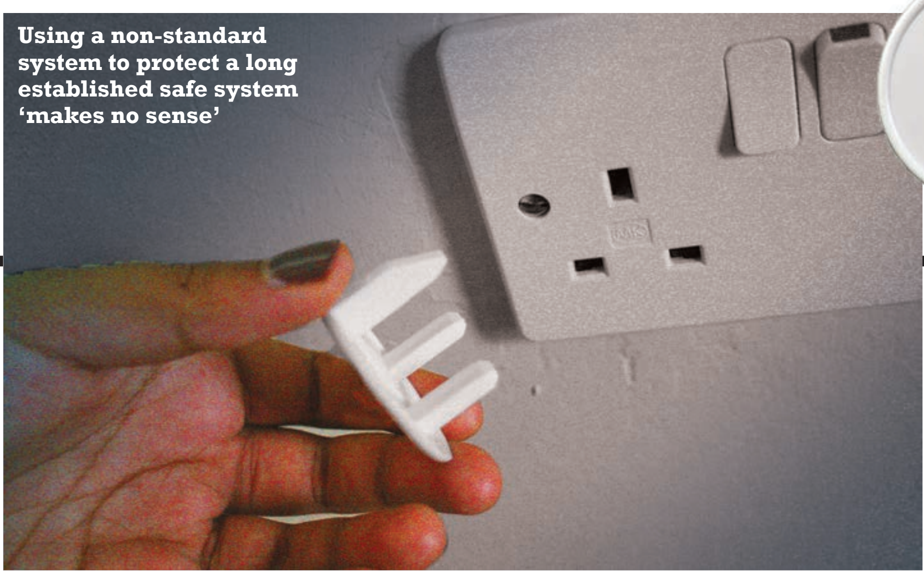
Dangers

The intended function of the socket protector sounds so simple, but the reality can be quite the opposite.

As there is no standard for socket protectors, products available on the market vary in terms of quality and dimension. The pins of socket protectors are rarely the same size as a plug; they are usually wider or narrower. Where the pins are wider than a 13A plug, the socket protector has the effect of widening the spring contact in the socket tube and, ultimately, results in permanent damage and poor contact with the socket-outlet leading to arcing in normal use.

Also, withdrawing an oversized socket protector is likely to be tricky as it is effectively wedged in. In such cases, forcing the protector out of the socket with whatever tools are to hand can damage the socket-outlet and lead to more danger. Where the pins of the socket protector are narrower than a 13A plug, the socket protector can be easily withdrawn from the socket-outlet.

Beyond the physical dimensions of the socket-protector, the next consideration is the material from which it is made. Should the material be brittle, the socket protector could snap during the withdrawal process, leaving a pin in the socket tube and other socket tubes exposed as the shutter mechanism has been defeated. Where the material is overly malleable, socket protectors can be inserted upside down, which will >



Using a non-standard system to protect a long established safe system 'makes no sense'

< operate the safety shutter mechanism and expose the live parts. Using a non-standard system to protect a long established safe system makes no sense.

What does BS 7671:2008(2011) require?

Regulation 553.1.100 states: "Every socket-outlet for household and similar use shall be of the shuttered type and, for an a.c. installation, shall preferably be of a type complying with BS 1363."

Socket-outlets in excess of 13A, e.g. industrial types to BS EN 60309-2, are available in current ratings of 16, 32, 63, 125A, but are not intended for household or similar use. Generally, these socket-outlets do not incorporate an integral shutter system.

Where did it all start?

During the Second World War, the government commissioned a number of reports which looked at how the country could proceed efficiently once war was over. Discussions on the 'Post-War Building Studies' were convened by the IEE (forerunner of the IET) and the committee was charged with the following:

1 To review existing information and practice concerning installations in buildings for:

a the supply of electricity for all purposes from the point of entry of the current at the property boundary to the point of its delivery to an appliance;

b electrical household appliances serving the single family dwelling; and

c all forms of electrically operated telecommunications.

2 To review proposals for improved electrical appliances for space heating, cooking, refrigeration, hot-water supply, dish washing, and clothes washing.

3 To make recommendations for practice in post-war building.

Post War Building Study No.11 'Electrical Installations' was published in 1944. Section 76 gave birth to the ring-final circuit:

"We recommend that small dwellings of the types considered should be wired with three separate circuits for lighting, cooking, and socket-outlets respectively, each controlled by a separate single-pole fuse. It is proposed that all socket-outlets should be supplied from a 'ring circuit' which, starting and ending at the fuse terminal at the consumer's supply control will pass through each room in turn. In the small dwellings under consideration it is considered permissible to connect up to 20 of the proposed standard socket-outlets on the ring circuit. At the consumer's supply control the ring circuit will be fused for 30 amperes, a current which is unlikely to be exceeded in the conditions of load diversity met with in small dwellings. At each outlet position on the ring circuit it will be necessary to provide a cartridge type fuse for local protection. With regard to the socket-outlet circuit, the recommendation to connect a number of standard socket-outlets on a ring circuit represents a departure from existing practice as laid down in the Wiring Regulations (Eleventh Edition)."

With ring-circuits rated at 30A and up to twenty socket-outlets connected to the circuit, it was therefore necessary to incorporate a fuse on the appliance side of the electrical system, this led to the development of British Standard 1363:1947 Fused Plugs and Shuttered Socket Outlets, introduced in 1947.

What does the government say?

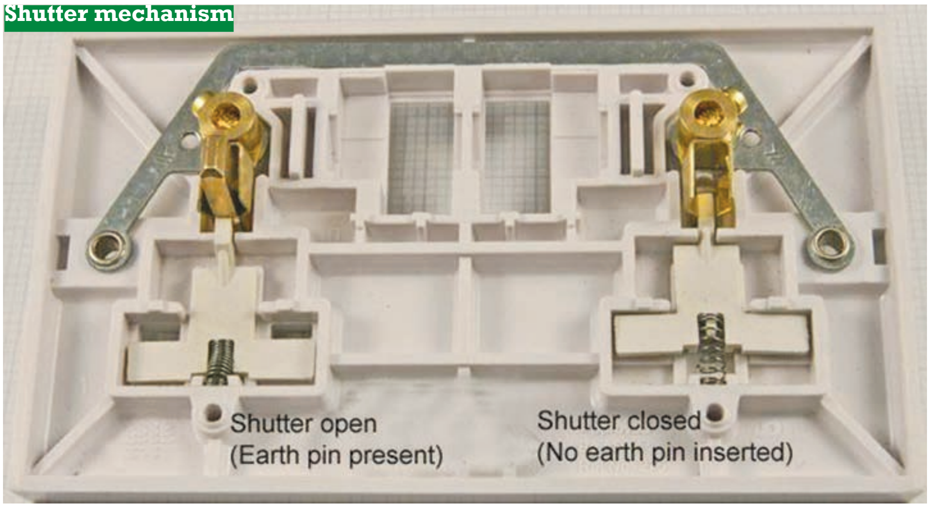
The government's advice on the use of socket protectors is posted under the 'Fire safety advice for parents and child carers' section of the Directgov website (www.direct.gov.uk/en/Parents/Yourchildshealthandsafety/Yourchildssafetyinthehome/DG_10038395). This states:

"It is very difficult for a child to get an electric shock by playing with a socket, so you shouldn't need to use socket covers. However, in some instances they may stop young children plugging in heaters or other appliances that could cause burns or start a fire. You should not rely on socket covers as they are not regulated for safety. It's much better to make sure appliances are safely put away."

Last word

Socket-outlets to BS 1363 are the safest in the world and have been since they were first designed in the 1940s. Socket protectors are not regulated for safety, therefore, using a non-standard system to protect a long established safe system is not sensible.

Shutter mechanism



Thanks to David Peacock (Fatally Flawed) and Malcolm Mullins (Honeywell)

Further information

BS 1363-2:1995 +A4 2012 13 A plugs, socket-outlets, adaptors and connection units — Part 2: Specification for 13 A switched and unswitched socket-outlets

The Plugs and Sockets etc. (Safety) Regulations 1994: www.legislation.gov.uk/uksi/1994/1768/contents/made

Wiring Matters Issue 18, Spring 2006, 'The origin of the BS 7671 Plug and socket outlet system': http://electrical.theiet.org/wiring-matters/18/plug-origin.cfm?type=pdf

Fatally Flawed: www.fatallyflawed.org.uk