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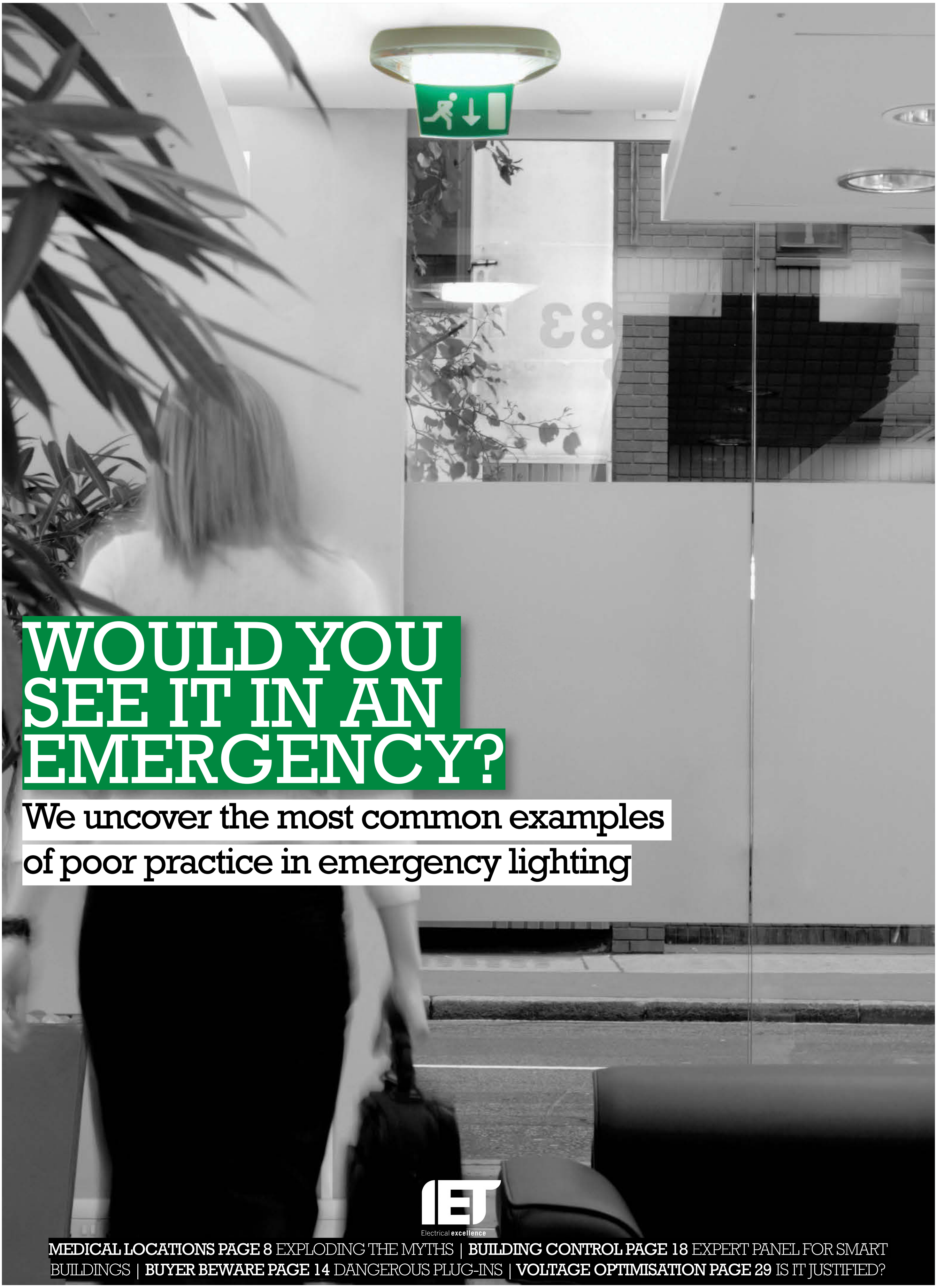

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Wiring Contents #47

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YOUR**LETTERS**

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SOCKET PROTECTORS – the last word

I would like to endorse and expand on the comments that David Peacock made in his letter in the Spring 2013 *Wiring Matters,* and to comment on Mr Madden's letter in the preceding issue which relate to the tragic death in 2009 of 20 month old Liam Boyle and the Fatal Accident Inquiry which followed.

I first raised the issue of the dangers of socket covers in the May 2008 issue of the IET's *Engineering and Technology Magazine*. It was partly as a result of this that Mr Peacock began his thorough investigation of the dangers of socket covers the findings of which can be seen at www.fatallyflawed.org.uk.

The Sheriff at the Inquiry specifically commented on the quality of Mr Madden's evidence, describing him as "a most impressive witness" Such comments are entirely consistent with my impressions of the professional engineers who work for the HSE.

The Determination of the Inquiry is well worth reading for anyone with an interest in safety, especially electrical safety, and is very reassuring in its thoroughness. At the Inquiry, Mr Madden proposed that The Crown should take into consideration the use of blanking covers as a preventative measure to stop young children plugging in dangerous items. The Sheriff found that, "I am not satisfied that the evidence led is sufficient for me to conclude that I can or should include that in any form in my determination."

I am most concerned that even an engineer of Mr Madden's ability and experience reiterates in his letter his opinion that socket covers can prevent young children plugging in appliances.

The FatallyFlawed research has unquestionably shown that very young children can easily remove all types of socket covers that are currently on sale to fit BS1363 sockets, often apparently more easily than adults can.

HSE promotes the irrefutable policy that the first action to ensure safety should always be to remove the hazard where possible and, only if this is not possible, to implement control measures. Where electrical appliances are concerned, the obvious measure is to remove the hazard by keeping appliances out of the reach of children in the same way that medicines, knives and household chemicals should be.

In Liam's case the Sheriff stated he "would not feel it right to prescribe" how the hazard, a mains cable with a 13A plug on one end and bare tails, could have been kept out of Liam's reach (www.shocked.org.uk). It would

appear from the Inquiry Determination that Liam's mother was as conscientious as any of us in looking after him and the main criticism the Sheriff made was that a more thorough tidy-up after a new oven was installed would have been a reasonable precaution. However, there were two people concerned with the installation and this led to each thinking the other had removed the cable from the house.

The Sheriff makes clear the limits of his responsibility, which specifically do not allow him to ascribe blame, and it may be because of legal limitations that he was unable to suggest the wise precautions of the kind which David Peacock advises should be taken whenever a mains lead is detached from an appliance. This should become part of the training, and second nature, to anyone working with mains plugs: make them safe immediately and keep them out reach of anyone vulnerable.

Even if socket covers had any value in inhibiting plugging in of appliances, there are none currently available that are effective in this respect and it is difficult to see how an effective design which does not incur a risk of damage to socket contacts could be devised. There are overall covers that can be locked in the closed position but these raise the danger that they can prevent appliances being unplugged if something should go wrong.

Having removed a socket cover, most types then make an ideal tool for a child to open the shutters, either by fitting them upside down or because the earth pin substitute is very easily broken off. Success in opening the shutters to reveal the often shiny contacts then encourages further investigation.

There is also considerable evidence that attempts to design socket covers that are significantly difficult to remove can damage the contacts of the sockets, especially when the cover is withdrawn.

If either of the live contacts is damaged there is a strong probability of overheating and fire when a high-power appliance is plugged in, but perhaps more worryingly earth contacts can also be damaged. It is very likely that many parents and householders do not fully appreciate the purpose of the earth connection and even more likely that a faulty earth contact would be unnoticed, except during formal testing, which might not happen until years after the children socket covers were intended to protect had outgrown their need.

From the findings of FatallyFlawed, there are good reasons why all current designs of socket covers should be withdrawn from sale. There is no justification at all for an uncontrolled device of questionable quality, indeterminate material and conforming to no standard should compromise the shuttering of a socket which is highly effective and designed and tested to exacting standards.

FatallyFlawed has found that safety advisory and enforcement agencies are generally reluctant to act on socket covers because of uncertainties over their field of responsibility and the scope of existing legislation. There is therefore a need for new or amended legislation.

If there is any justification for socket covers then they, and all other devices intended to be inserted into socket outlets, should be subject to rigorous and effective standards and legislation.

Peter M Munro

The correspondence on this important topic is now closed - Ed

A CALL TO AUTHORS

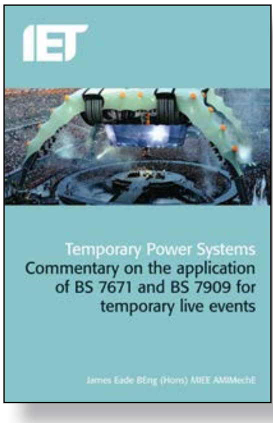
Wiring Matters welcomes contributions from anyone involved in electrical installation and safety. If you have something to say that you think could be of value and interest to your fellow professionals, then why not turn it into an article?

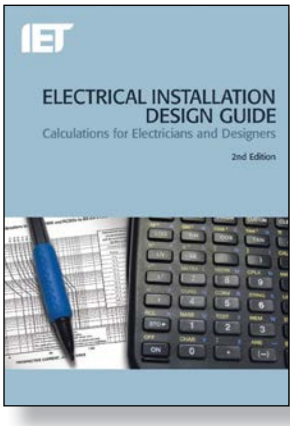
If you're new to article writing, it can be a daunting process, but we can offer lots of help and advice to would-be authors. This can cover advising on the suitability of topics, suggesting how an idea can be structured into a suitable article, and, if appropriate, detailed editing of copy to ensure a clear and readable end result. Articles are typically in the range 1,500 to 2,500 words.

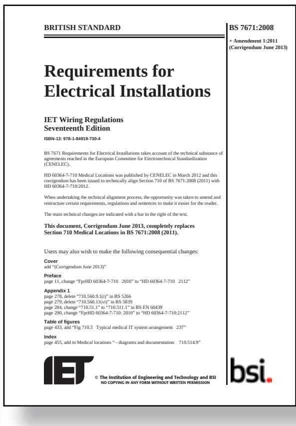
Along with articles we'd welcome opinion pieces – our 'guest editorial' – of around 700 words. Alternatively, you might just like to send a letter to the editor.

If you have any ideas you'd like to discuss, please contact the editor at wiringmatters.editor@theiet.org

IET launches three new publications







THE IET has launched three additions to its suite of publications: an all new guide to temporary power systems, a new edition of its top selling electrical installation design guide and a corrigendum to BS 7671:2008(2011).

Temporary Power Systems

Written by industry expert James Eade, 'Temporary Power Systems – Commentary on the application of BS 7671 and BS 7909 for Temporary Events', is the first book in the UK that deals exclusively with the application of the IET Wiring Regulations (BS 7671) to situations where the installation is not designed to be a permanent part of a building or environment. Such installations are referred to as TEDs (temporary electrical distributions) to draw a distinction from permanent installations. The duration of a TED may range from hours to months and uses specifically constructed reusable equipment. As required in BS 7671 for such situations, the book also explains and expands on the requirements of BS 7909 which is the code of practice for temporary electrical systems for entertainment and related purposes. While the content uses the event industry as a context, it is applicable to any situation where temporary power systems are used, except for construction sites using reduced low-voltage systems given in BS 7375.

The book takes the requirements of the IET Wiring Regulations and applies them in an event-based context. Until now there has been no guide or reference that effectively explains, for example, such issues as how to safely distribute a 400A three-phase supply around a muddy field; which sections of a festival stage or marquee could be considered an extraneous-conductive-part, or when disabling RCD protection may be appropriate.

The events industry has developed robust and flexible temporary distribution equipment to allow it to erect and dismantle systems rapidly. This principle is key to the type of systems covered in the book and accordingly the requirements of equipment testing methods and principles outlined in BS 7909 are explained in detail, as are the recommended types of distribution equipment. Other topics include generators, earthing principles and practices, circuit protection, testing of systems on-site, multiple sources of supply and general supply considerations including neutral loss, PME connections and load balancing.

The book is written in an accessible style with practical guidance and examples to illustrate and explain the requirements of not only the standards, but other industry related guidance such as the Association of British Theatre Technicians (ABTT) model conditions and the exhibition industry eGuide. It is undoubtedly the most comprehensive guide on the subject currently available and in the words of Mark White, chair of the Theatre Safety Committee and chair of the ABTT, "is an education for those who do not know and an aide-memoir for those that do."

Installation Design Guide

The 'Electrical Installation Design Guide – Calculations for Electricians and designs' has long been popular with electricians and designers, explaining basic calculations and providing clear guidance on those that are more challenging. This revision, the 2nd Edition of the guide, was prompted by changes made necessary by Amendment No 1 (2011) to BS 7671: 2008, the 17th Edition of the IET Wiring Regulations.

A notable addition to the new edition covers calculations for cables laid in the ground. Previously, basic calculations have used the clipped direct ratings or the manufacturer's ratings. This is no longer satisfactory as Appendix 4 of BS 7671:2008(2011) includes rating factors for ground temperature, soil thermal resistivity and depth of laying for inclusion in the various formulas. The new rating factors are used for grouping and voltage drop calculations.

Other important additions include changes to the minimum sizes of protective conductors for use with circuit breakers, an explanation of cable sizing in circuits that are not liable to overload, voltage drop calculations when the load current is less than the rating current – very useful on long cable runs, busbar trunking calculations and guidance on common problems associated with circuit breaker and lighting circuits.

Corrigendum to BS 7671:2008(2011)

BS 7671, Requirements for Electrical Installations, The IET Wiring Regulations 17th Edition, takes account of the technical requirements of Harmonised Documents (HD) as agreed by the European Committee for Electrotechnical Standardisation (CENELEC). HD 60364-7-710 Medical Locations was published by CENELEC in March 2012 and, in some cases, has differing technical requirements to those within BS 7671:2008 (2011).

JPEL/64, the UK national committee responsible for BS 7671, has therefore decided to issue a corrigendum to technically align Section 710 of BS 7671:2008 (2011) with HD 60364-7-710:2012. While undertaking the technical alignment process, the opportunity was taken to amend and restructure certain requirements, regulations and sentences to make it easier for the reader. The main technical changes have been indicated with a bar to the right of the text.

The document, BS 7671:2008 (2011) Corrigendum June 2013, will completely replace Section 710 Medical Locations in BS 7671:2008 (2011).

Securing your copy

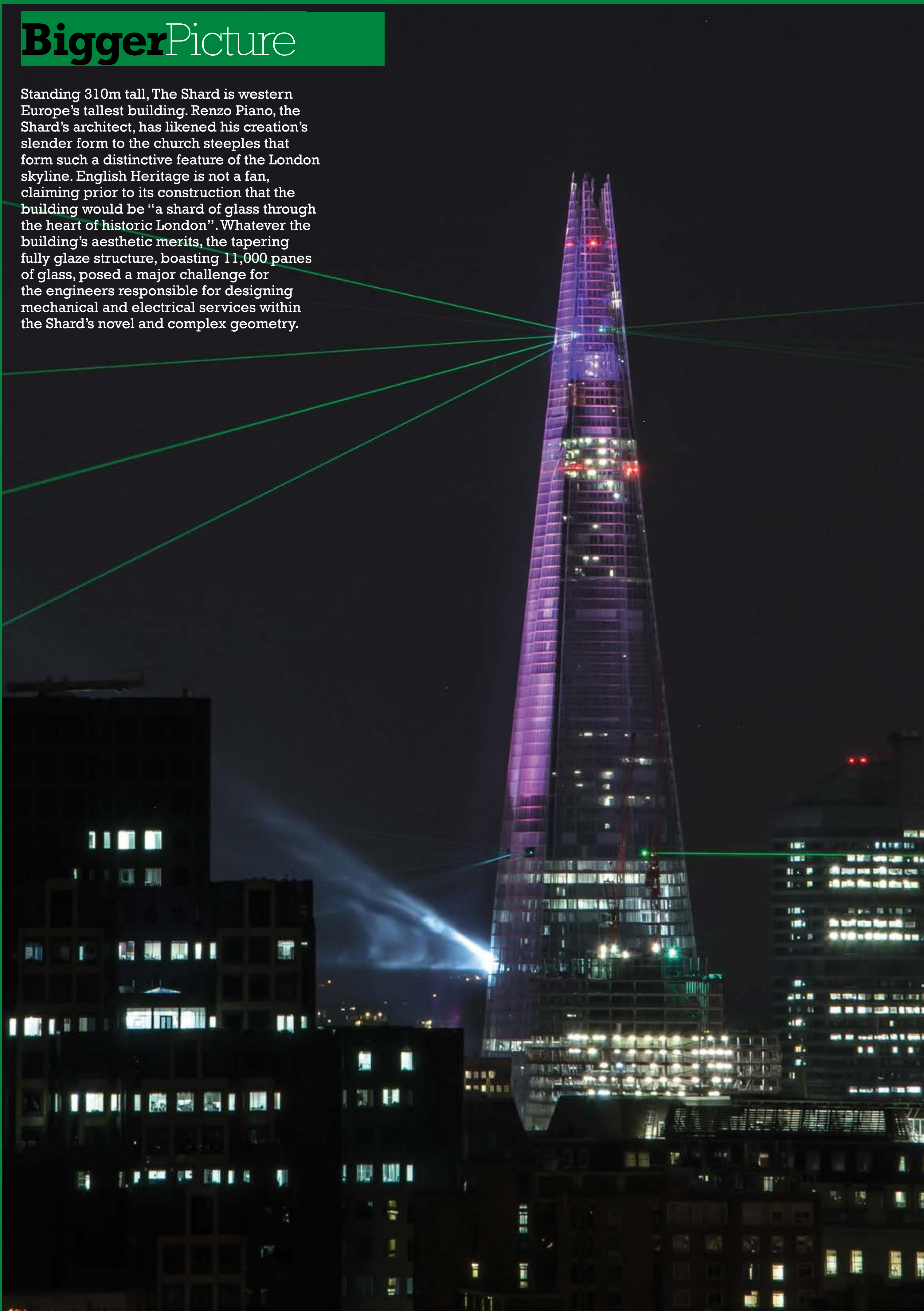
Temporary power systems: now available for pre-order. Get 15% off when ordered before publication (IET members 35% off): www.theiet.org/temp-power-wm

Installation design guide: available from the IET website at www.theiet.org/eidg-wm. (IET members receive 35% off the RRP of £35)

Corrigendum: free from the IET website at www.theiet.org/updates-wm

BiggerPicture

Standing 310m tall, The Shard is western Europe's tallest building. Renzo Piano, the Shard's architect, has likened his creation's slender form to the church steeples that form such a distinctive feature of the London skyline. English Heritage is not a fan, claiming prior to its construction that the building would be "a shard of glass through the heart of historic London". Whatever the building's aesthetic merits, the tapering fully glaze structure, boasting 11,000 panes of glass, posed a major challenge for the engineers responsible for designing mechanical and electrical services within the Shard's novel and complex geometry.



EXPLODING THE MYTHS OF MEDICAL LOCATIONS

We look at some of the common myths and misunderstandings surrounding touch voltages and the use of medical IT in group 2 locations.

By Paul Harris

ELECTRICAL installations in medical locations are the subject of numerous myths and misunderstandings within the electrical industry. In particular, there are widespread misunderstandings surrounding the use of medical IT systems – commonly known as Medical IPS (Medical Isolated Power Supply) systems. Along with with these common confusions, this article will examine three other important myth-attracting areas within medical locations: isolated pin earthing systems (known as MEIGaN or 'clean' earthing), touch voltages and the use of the human body model.

All of these misunderstandings can be attributed to the misapplication and misunderstanding of installation and equipment standards. With the passage of time, international standards for medical equipment and medical electrical installations have been developed and refined. These new standards have not been used in the UK to the level that they should, partly due to the availability of other guidance such as HTM 2007, which later became HTM 06-01, along with TRS 89, which was later developed into MEIGaN. The MEIGaN documentation was adopted virtually verbatim by equipment manufacturers and suppliers, and is embedded in the NHS psyche.

Medical IT systems

The 'medical IT system' refers to the specialist items of equipment, isolation transformers, insulation monitoring devices and alarms, which collectively provide isolated power supplies. One common misunderstanding among engineers and other stakeholders regarding the medical IT system is that the isolation/separation from earth provides a totally 'shock free' supply, and that this meets the 10μA discussed in Guidance Note 7 or the touch voltages contained in MEIGaN.

The primary purpose of the Medical IT system is to provide a robust electrical supply that will not fail on first fault to earth – that is L1 or L2 on the connected medical equipment shorting to earth. A secondary function is to reduce the risk from electric shock if either L1 or L2 is touched. This principle is simialr to the shaver socket in bathrooms. However, the arrangement is more sophisticated than the shaver socket as the medical IT system arrangement does not use electrical separation as the sole means of protection against electric shock.

In the event of a supply conductor being touched or shorted to earth, the medical IT system current is limited to a

Misunderstanding over electrical installations has become embedded in the industry psyche

safe value. This current is formed from the isolation transformer leakage (0.5mA maximum) and any current leakages picked up through cable capacitive coupling between the transformer and socket outlets; this is one reason why the interconnection cables between the IT system and socket outlets should not be too long.

This enhanced level of protection against electric shock is completely lost once a single fault to earth has occurred.

Use of an IT system has one other useful characteristic: it reduces the total earth leakage current of all the devices supplied by the IT system to that of the IT system itself (normally <0.5mA). For example, if 10 items are connected to the IT supply and each has an earth leakage current of 0.5mA, then we would expect the total earth current to be 5mA. In fact it will be only be a maximum of 0.5mA – the value from the IT system transformer (plus the leakage created by capacitive coupling of the interconnecting wires). Again, this leakage reduction is lost when a single fault to earth occurs on either the L1 or L2 supply lines.

Previous articles in *Wiring Matters* (issues 45 and 46) have shown that the national wiring standard BS7671: 2008 (2011), including the upcoming 2013 corrigendum, provides the UK with an electrical standard for medical locations. Because BS7671, along with the corrigendum, is based on internationally agreed standards, as opposed to UK-specific standards such MEIGaN, it contains few of the MEIGaN or similar stipulated procedures for earthing, or requirements for testing earth leakage or touch voltage.

Understanding the context

An understanding of the origins of other medical locations myths requires some background information on medical equipment and the BS EN 60601-1 standard.

The various leakage currents associated with medical electrical equipment are defined by the paths the currents take. There are three such leakage currents to consider.

Earth leakage current (Fig 1) is the current that normally flows in the earth conductor of an earthed piece of class I equipment (see panel 'The Three Classes'). No insulation is perfect, and there is always a certain amount of leakage, even if this is just a nominal level. The safety of the equipment can be checked by earth leakage testing on class I appliances.

The level of the earth leakage current depends on three factors: the voltage applied to the conductor, the resistance between the conductor and earth and the capacitive coupling between the conductor and earth.

From Fig 1 it is evident that, in the event of the loss of the protective earth, then all the current will flow through the person touching the conductive parts of the appliance.

Touch current (Fig 2) which is the same as enclosure leakage current in earlier versions of BSEN 60601, can be defined as the current that flows from the enclosure or parts thereof, excluding patient connections, to earth through a conductor other than the protective earth conductor.

Patient leakage current (Fig 3) is the current that flows through a patient connected to the particular applied part(s). Current can flow from the applied part(s) via the patient to earth as indicated in Fig 3. Alternatively, in the case of F type applied parts, patient leakage current can flow from an external source via the patient and the applied parts to earth, as indicated in Fig 4.

Patient auxiliary current (Fig 5) is defined as the current that normally flows between parts of the applied part through the patient, which is not intended to produce a physiological effect.

A flawed approach

There has been a flaw in previous approaches to medical locations design. It is well documented that within medical locations special measures are needed because patients will be undergoing procedures that weaken the body's natural defence against electric shock. This weakness can result from their condition, the drugs they are receiving or the simple fact that the protective membrane of the skin is breached. Many procedures within medical locations will involve the puncturing or cutting of the skin, resulting in a greatly increased susceptibility to electric shock.

The flaw in the design process has been to assume that the installation >

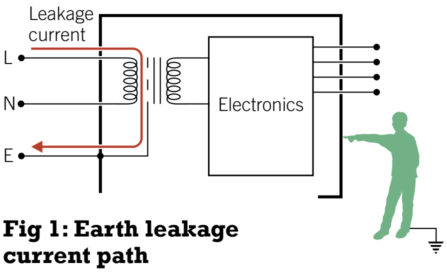


Fig 1: Earth leakage current path

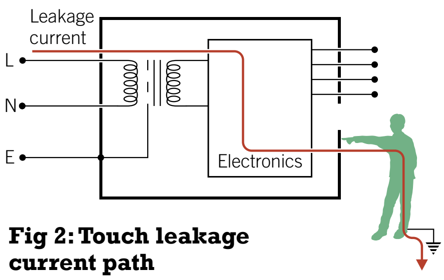


Fig 2: Touch leakage current path

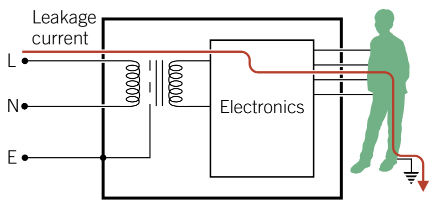


Fig 3: Patient leakage current path from equipment

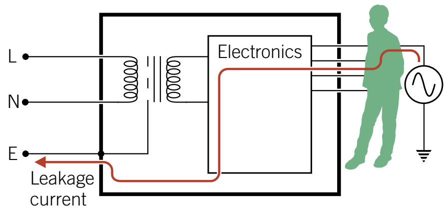


Fig 4: Patient leakage current path to equipment (F-Type parts only)

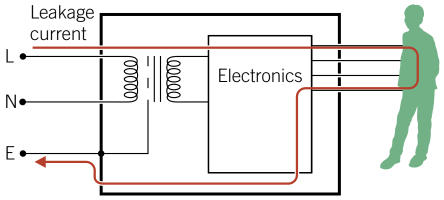


Fig 5: Patient auxiliary current path

is the applied part or the medical device itself. The process of treating a room or an installation of a medical location in this way is flawed as there are strict requirements and product standards for medical devices, which could not possibly apply to an installation.

To protect the patient, all electrical equipment and accessories used within the defined patient environment must comply with the medical device directive (93/42/EEC). This is normally achieved by conforming to the appropriate product standard, which in this case is the IEC 60601 series of standards.

These standards lay down the requirements for safety of the equipment and, in particular, the allowable currents that can flow into the patient in normal and fault conditions. The current limit depends on how the equipment is connected or applied to the body of the patient. These medical equipment interfaces to the body are defined in IEC 60601-1 (which is followed through nationally in BSEN 60601-1) into three types of connections, called applied parts:

- **B** **Body applied part**
- **BF** **Body floating applied part**
- **CF** **Cardiac floating applied part.**

B-type applied parts may or may not connect to earth, but they must ensure that the patient leakage current remains within the allowable limits. These parts are not intended to transfer energy either to or from the patient.

All F-type applied parts are isolated from other parts of the equipment, including earth. The allowable leakage limits are stricter for CF than BF parts. Table 1 shows the maximum permitted

FACT BOX

THE THREE CLASSES

Symbols seen on earthed equipment

Class I equipment has a protective earth, although not all equipment having an earth connection is necessarily Class I.

The earth conductor may be for functional purposes only, such as screening. Likewise, equipment finishes can cause confusion – a case that appears to be plastic does not necessarily indicate that the equipment is not Class I.

BS 7671 defines Class I equipment as: "Equipment in which protection against electric shock does not rely on basic insulation only, but which includes means of connection of exposed-conductive-parts, to a protective conductor in the fixed wiring of the installations (see BS61140)."

There is no agreed symbol in use to indicate that equipment is Class I. It is not mandatory to state on the equipment itself that it is Class I but the symbols shown above may be seen on medical electrical equipment adjacent to terminals.

Unlike other Class I equipment, medical electrical equipment should have fuses in both live and neutral conductors at the equipment end of the mains supply lead.

Class II equipment employs either double insulation or reinforced insulation as the method of protection against electric shock. In double insulated equipment the first layer of insulation affords the basic protection. If the basic protection fails then a supplementary, second layer, of insulation, preventing contact with live parts, provides protection.

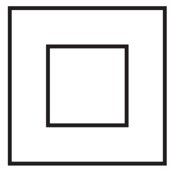
BS7671 defines Class II equipment as: "Equipment in which protection against electric shock does not rely on basic insulation only, but in which additional safety precautions such as supplementary insulation are provided, there being no provision for the connection of exposed metalwork of equipment to a protective conductor, and no reliance upon precautions to be taken in the fixed wring of the installation (see BS61140)."

Basic insulation is usually afforded by physical separation of live conductors from the equipment enclosure. This makes the basic insulation air. Supplementary insulation is provided by the enclosure material.

Reinforced insulation is defined in BS 7671 as: "Single insulation applied to live parts, which provides a degree of protection against electric shock equivalent to double insulation under the conditions specified in the relevant standard. The term 'single insulation' does not imply that the insulation must be one homogenous piece. It may comprise of two or more layers which cannot be tested singly as supplementary or basic insulation."

Class II medical electrical equipment should be fused at the equipment end of the supply lead in either phase conductor, or in both conductors if the equipment has a functional earth.

The symbol for Class II equipment is two concentric squares illustrating double insulation as shown below.



Symbol for Class II equipment

Class III equipment is defined by BS7671 as: "Equipment in which protection against electric shock replies relies on supply at SELV and in which voltages higher than those are not generated (see BS61140)."

In practice such equipment is either battery operated or supplied by a SELV transformer.

If battery-operated equipment is capable of being operated when connected to the mains (for example, for battery charging) then it must be safety tested as either Class I or Class II equipment. Similarly, equipment powered from a SELV transformer should be tested in conjunction with the transformer as Class I or Class II equipment as appropriate.

All medical electrical equipment that is capable of mains connection must be classified as class I or class II. Medical electrical equipment having no mains connection is simply referred to as 'internally powered'.

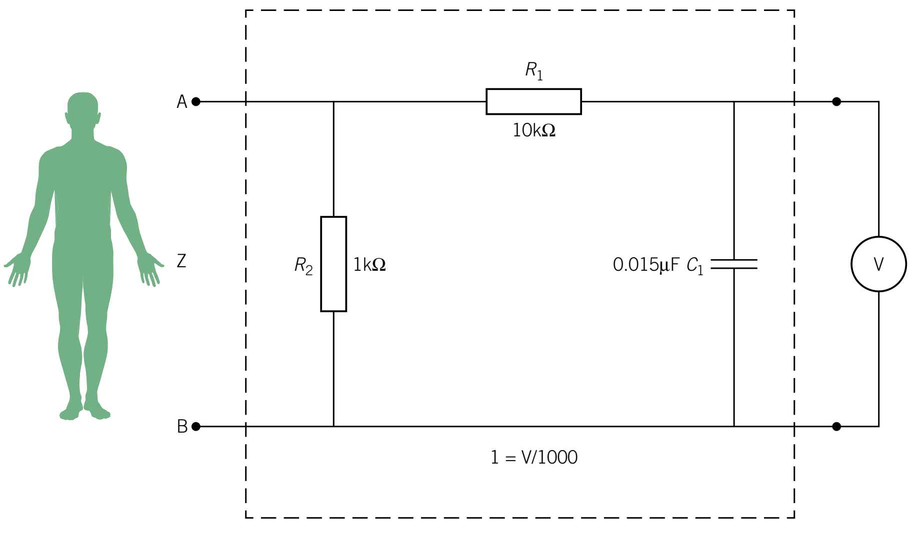


Fig 6: Human Body Model Equivalent Circuit

leakage currents that could flow in the patient for these applied parts.

As can be seen from Table 1 the values for B and BF are the same (excluding the F-type mains on applied parts values, which are not indicated in the table). Two other points are worth noting: the B & BF normal leakage limit is also the limit for touch leakage and the fault condition values generally correspond to the equipment or earth leakage limits. Touch leakage is defined as current flowing through an external path, other than the protective earth conductor, from any accessible parts, excluding patient connections, to earth or another part of the equipment.

Application of the human body model

One very important point to note is the method by which these leakage currents are measured using a human body model as shown in Fig 6.

In a normal environment the average equivalent resistance for a human being is about 2000Ω (2kΩ), but the average for a patient undergoing a medical procedure is deemed to be half this value, i.e. about 1kΩ. This is reflected in Fig 6, where R2 is 1kΩ, corresponding to the human body in a medical location.

A filter made up of R1 and C1 reflects the fact that the cells in a human body do not respond to electrical stimulus at higher frequencies (much above 100kHz) and therefore do not present a risk of electric shock (only a burns risk).

A key point is that if 100µA is flowing in R2 a voltage of 100mV will be read on the voltmeter, 10µA flowing will result in a reading of 10mV and so on. The touch voltages quoted in many references to medical locations have been derived from the 60601-1 leakage current limits for medical equipment. However, Guidance Note 7 and MEIGaN look at the initial voltage measurement without the use of the correct human body model (referred to as an IEC filter in MEIGaN).

Making the wrong measurements

It is quite easy to be confused by all of the documentation and values quoted. If you forget to apply the impact of the human body model (IEC Filter) on measurements taken, then you will lead yourself on to a route plagued with confusion and worrying readings. The problem arises because the commonly-used digital voltage meter (DVM) is characterised by a very high input impedance (10MΩ to 100MΩ) and, as such, provides no load to the circuit, leading to stray voltages being measured around the medical location. Many of these values will be of concern if they are taken out of context, causing installations to be declared unsafe.

Worrying voltage readings

For example, using a DVM to take a measurement on a class II double insulated device will inevitably result in a voltage measurement up to half the mains voltage. As can be seen in Fig 7, a totally innocent scenario can create a reading which is beyond the touch voltage described in BS7671. However, correct application of the human body model will not only fitter out any high-frequency interference it will also add a current component to the DVM values which assuming is only capacitive coupling or similar, will fall to a negligible value as can be seen in Fig 8.

Induced voltages

It also possible to measure seemingly high voltages on any conductive part that is isolated from earth, arising from the close proximity of strong fields from nearby AC or even RF (radio frequency) sources. These detected voltages will be significantly reduced (corrected) if the human body model is applied with a 1kΩ resistor in circuit. This will have the effect of filtering out high-frequency interference and passing current through a 1kΩ resistance. A similar effect (a reduction in the voltage measured by a DVM) will occur if the low-frequency current is measured used a sensitive ammeter in conjunction with a DVM, as the current flow through the ammeter will normally cause the voltage reading to collapse. >

Symbol	Applied part type	Definition/description	Normal Condition (NC)	Fault (SFC)
	**Type B Applied Part**	**TYPE B APPLIED PART** APPLIED PART complying with the specified requirements of the standard to provide protection against electric shock, particularly regarding allowable PATIENT LEAKAGE CURRENT and PATIENT AUXILIARY CURRENT	**100µA**	**500µA**
	**Type BF Applied Part**	**TYPE BF APPLIED PART** F-TYPE APPLIED PART complying with the specified requirements of this standard to provide a higher degree of protection against electric shock than that provided by TYPE B APPLIED PARTS	**100µA**	**500µA**
	**Type CF Applied Part**	**TYPE CF APPLIED PART** F-TYPE APPLIED PART complying with the specified requirements of this standard to provide a higher degree of protection against electric shock than that provided by TYPE BF APPLIED PARTS	**10µA**	**50µA**

Table 1: Applied Parts symbols and current leakage

What type of applied part is an electrical Installation?

There are many guidance documents both past and present that describe values of 10mV or 50mV in group 2 medical locations. These documents are in fact describing the leakage requirements of CF applied parts (10mV normal and 50mV SFC- (single fault condition)).

Reflecting on these details in the cold light of day we can see a piece of equipment that is intended to have connections that touch the heart would need to be classified as a CF applied part and be manufactured to meet the requirements of BSEN 60601-1.

It would also be tested to confirm its safety using IEC 62353. It is thus clear that only those items of equipment that conform to the 60601 series of standards can be tested to those stringent standards.

It is also clear that the electrical installation is not and can never be a BF or CF applied part, as it should never come into direct contact with the patient in that context.

The only part of an electrical installation that can ever come into contact with a patient is the earth (via a B type applied part such as a patient table).

Electrical installations in medical locations

Much criticism is raised by industry stakeholders who have been familiar with the MEIGaN documents. This criticism is normally aimed at the lack of particular tests with respect to protective conductor currents in EBBs ,which were formally known as ERBs in MEIGaN.

Certain tests such as partial dismantling of earthing systems are not called for by BS7671, as they can be dangerous and possibly in breach of the Electricity at Work Regulations 1989. Disconnection of earthing systems for live testing purposes should only be carried by suitably qualified and trained personnel, and even then should be avoided if at all possible.

BS 7671 is the national wiring standard which contains requirements for general installations and additional requirements for installation testing is contained in Section 710. Any attempt to include specialist equipment testing would be outside the scope of BS7671.

Medical appliance testing

The testing of the medical equipment is covered by the standard IEC 62353, and requires specialist test equipment and knowledge (including IEC or BS EN 60601). It is not appropriate or generally possible for non-specialists to perform such tests. This is reinforced by the specific exclusion of testing medical equipment within the IET code of practice on In-service inspection and testing of electrical equipment (4th edition).

Whether or not a designer chooses to use a 'clean earthing' approach or not, it is essential that he or she applies the principles of BS7671 and applies section 710 appropriately. 'Clean earthing' arrangements such as those described in MEIGaN are onerous and material/labour intensive and bring about limited or no added value to installations that are in accordance with BS7671. The correct use of EBBs and the other measures described in section 710 provides sufficient protection for the patient staff and visitor to a medical location.

This article has set out to demonstrate that the values discussed in MEIGaN and other guidance documents need to be considered for applied parts and medical devices in accordance with BSEN 60601 series of documents, and that the correct testing

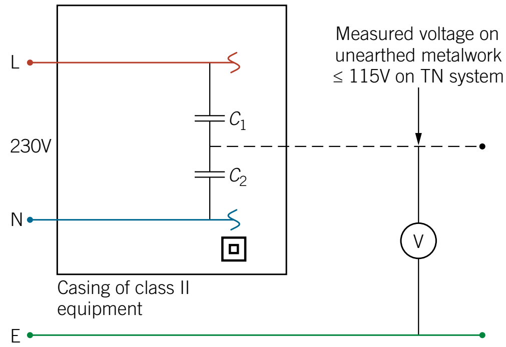


Fig 7: Superimposed voltage from Class 11 equipment on unearthed metalwork

techniques for installations is contained in Section 710 of BS7671.

Whilst the flow of leakage current through medical locations should not be ignored, it is important to remember the electrical installation should not be touching the heart or be inside the body cavity. It is medical equipment which is designed to touch or intrude into the body which is to be applied. This equipment is manufactured to comply with BS EN 60601 and is tested in accordance with IEC 62353. For this reason, when an electrical installation conforms to BS 7671:2008 (2011) and the requirements of section 710 are met, there should be no possibility of the touch leakage exceeding 100μA.

Paul Harris is an independent consultant for Harris Associates Ltd, Paul is one of a number of Medical Locations expert serving the wiring regulations committee JPEL 64.

Paul would like to thank Michael Bernard of Siemens Healthcare, who is also the representative for AXrEM. (Association of Healthcare Technology Providers for Imaging, Radiotherapy & Care) for his valued assistance in the production of this article.

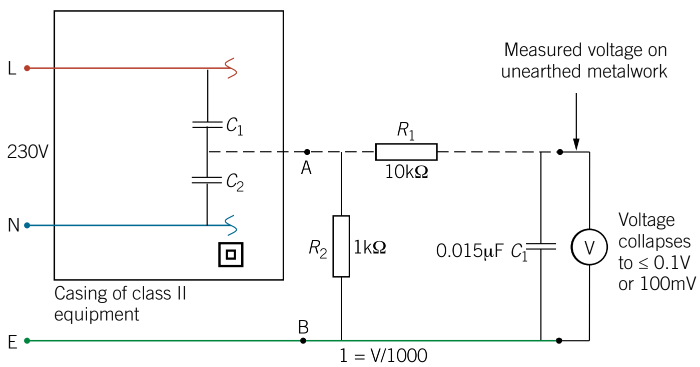


Fig 8: Voltage collapses as human body model is applied

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BUYER BEWARE

Many plugs and chargers – often obtained online – pose a serious risk to users.

By David Peacock

REBECCA POOL'S article in *Wiring Matters* issue 46 described the problems associated with fake electrical goods, concentrating mainly on products that are used for professional installation. If counterfeiters are able to profit from misleading skilled users, they clearly pose an even greater threat to consumers without specialist knowledge. One particular area of concern is the online trade in replacement cord sets, mobile device chargers, and travel adaptors. Sometimes the last two categories are combined with USB chargers to form so-called 'universal travel adaptors'.

Plugs

The Plugs and Sockets etc. (Safety) Regulations 1994 require that UK standard plugs must conform to BS 1363, be tested and approved by a notified body, and bear the approval marks and licence numbers for that approval. They also stipulate that domestic electrical appliances must be fitted with standard plugs. The main approval bodies are BSI (Kitemark), ASTA (Diamond Mark) and Nemko (N Mark). As BS 1363 is a national standard and the regulations are national in origin, CE marking should not be used on the products covered by the regulations. The use of a CE mark on a plug claiming to be made to BS 1363 is in itself a reliable indication of a counterfeit. The Plugs and Sockets Regulations, by requiring conformance to a specific standard with detailed specifications, make it very straightforward for trading standards officers to take action, They are relieved of the task of making a case as to why a product is dangerous – if it does not conform to the standard, it is illegal.

The key characteristics of an approved UK plug are that it must be fitted with a fuse to BS 1362, the pins are the correct size, the line and neutral pins (but never the earth pin) should have insulated sleeves, it must be impossible to touch live parts when in use, and be sufficiently robust to not come apart in normal use. In addition there are many tests to ensure that insulation, creepage, temperature rise under load and mechanical strength etc. conform to the standard.

Common problems with counterfeit UK power plugs and cord sets include:

- being fitted with counterfeit fuse – danger of explosion;
- a partially sleeved earth pin – will not provide reliable contact;
- incorrectly sized pins – poor contact and may damage socket;
- sub-standard flexible cords – danger of overheating and fire;
- plugs without any fuse, or with a fuse which is not connected.

Online dangers

Whilst sales of counterfeit plugs in traditional shops do occur, the main problem is with online stores such as eBay and Amazon Marketplace, both of which offer cord sets and appliances fitted with fake plugs. Sometimes these offers include photos of plugs which, to the trained eye, are obvious counterfeits. In other instances, there are photos of the genuine item, but the supplied product is fake. Another issue with Amazon Marketplace is the way that Amazon allows vendors to offer a product against an established listing, while supplying a product from a manufacturer different from the one given in the listing.

Customer product reviews are a good indicator of potentially suspect products. The following reviews for a cord set originally sold on Amazon Marketplace as a 'Cloverleaf Computer Power Lead by Volex', but now

Plugging in an appliance is an everyday task that can pose unexpected risks

withdrawn, gives a flavour of what to look out for:

"After only a couple of weeks' use, the cable started to burn and melted through."

"The cable started sparking then caught fire and burned a hole in the carpet."

"After two weeks it started to spark and strong burning smell came from it... exploded with a large bang and now has a small hole in the connector."

Similar reviews continued for over a year before the product was discontinued.

In 2011 PlugSafe – The Campaign for Plug Safety (www.PlugSafe.org.uk) – purchased a number of cables from this listing, from different suppliers, and only one of these was a genuine Volex. One supplier sent a 'King Coro' (a counterfeit of 'King Cord') which had all of the plug faults listed earlier. Other suppliers sent plugs with the fake 'guida' brand. It was simply a lottery.

One current (as of April 2013) example is the 'UK Longwell 1.5m Cloverleaf C5 Power Cable. Asta Approved and verified. By Volex' (Amazon ASIN B005JENBNK). The product illustrated (Fig 1) is from Longwell, and whilst the technical details list a 2m cable, the description states 1.5m. Of the eight reviewers, one confirms that he received a Volex cable, another says his was a Longwell, and a third had a Kitemark, indicating that it was neither Longwell or Volex as both carry ASTA, not BSI approvals. Two others are clear that their cable was neither Longwell or Volex, while the remaining three give no clue as to what they got. Clearly these reviews cannot be relied on as there is no way to tell which review relates to which supplier.

In support of the activities of the PlugSafe campaign I have made test purchases of many cord sets, adaptors and chargers, but I have also inadvertently bought fakes when making straightforward purchases. Last October I bought a replacement charger for my daughter's HP laptop. I chose one from Amazon Marketplace which was fulfilled from Amazon itself, believing that this would minimise the chances of buying a counterfeit. When it arrived the charger appeared genuine, but the cord set was an obvious fake. The plug supplied (Fig 2) was of the non-approved guida brand which bears a fictitious approval from the non-existent STGS, as well as a fake Kitemark. Unlike many guida plugs this one did not have a partially sleeved earth pin, but the fuse was a fake. When I informed HP about its product being sold with a fake cord set they asked to see the charger, kindly exchanging it for another. It turned out that the charger itself was also counterfeit.

With eBay the situation is a little different. There are no multi-supplier listings, but also no product reviews, so there is only the description

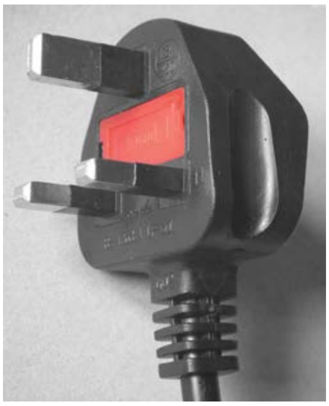


Fig 1 Illegal 'guida' brand plug with sleeved earth, purchased from Amazon.co.uk

to go on. Working with a local trading standards department, PlugSafe has initiated the removal of more than 1,200 eBay listings, which include illegal plugs. It would appear that eBay puts no effort into monitoring the legality of products offered on its site; it seems to act only on instructions from trading standards departments. The company does provide a means for consumers to report fakes, but there is no evidence that these reports are acted upon. An indication of the problem can be seen by comparing two pictures, from January 2012 and April 2013, taken from the same eBay listing of a disc docking station (Fig 3). The product has been reported to PlugSafe as being supplied with an illegal fuseless mains plug. The earlier image clearly shows the illegal plug. The current picture is the same except that a meaningless flash has been added to obscure the plug. Fig 4 shows another example of an illegal fuseless plug, similar to the plug in Fig 3.

Travel adaptors

Travel adaptors for use in the UK (for connecting to a BS1363 socket outlet) are within the scope of the Plugs and Sockets Regulations. BS 1363-3 is the standard applicable to adaptors intended to use with BS 1363 sockets and the dimensional requirements for the plug part of an adaptor are basically the same as for a normal plug. All adaptors must have shutters, and those that have more >

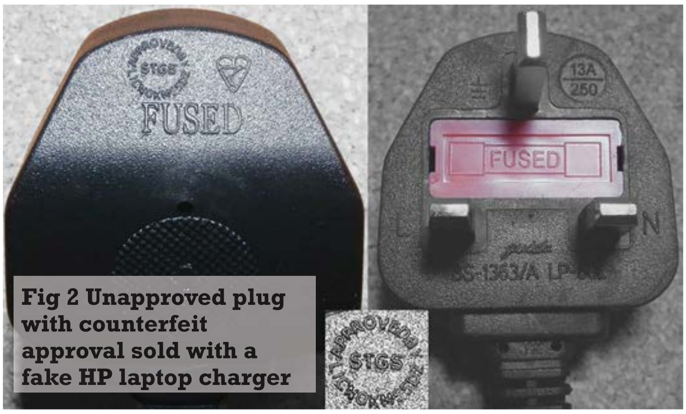


Fig 2 Unapproved plug with counterfeit approval sold with a fake HP laptop charger

Fig 3 How to hide an illegal plug. January 2012 picture (left) clearly shows an illegal fuseless plug – hidden by the meaningless 'HOT' flash in April 2013 (right)

than two BS 1363 sockets, or have non-BS 1363 sockets, must be provided with a fuse. Despite these clear regulatory requirements, there is a widely available group of so-called universal adaptors, made in China, but usually marked 'for export only' which are intended for use with BS 1363 sockets and accept UK, US, European and Australian plugs using a set of unshuttered contacts with no fuse (Fig 5). Often the plug part does not conform to the correct pin size, and invariably the pins are too close to the periphery. Sometimes there is no sleeving on the pins and sometimes the earth pin is only partially sleeved – both clear breeches of the regulations.

These potentially lethal devices are available from Amazon and eBay, often priced at less than £1, and typically posted direct from China. They have often featured on the EU RAPEX list of products withdrawn as dangerous. RAPEX is the EU rapid alert system that facilitates the rapid exchange of information between Member States on measures taken to prevent or restrict the marketing or use of products posing a serious risk to the health and safety of consumers. A weekly overview is published giving information on the product, the possible danger and the measures that were taken by the reporting country.

Another group of universal travel adaptors not only takes plugs of many different types, but also has a series of retractable pins intended to fit many different sockets (including UK sockets). The Plugs and Sockets Regulations exclude "any travel adaptor (that is to say an adaptor which enables a plug designed for use in the United Kingdom) to be connected to a socket used outside the United Kingdom."

It is unlikely that those who drafted those regulations conceived of adaptors with multiple sets of pins, so these devices fall somewhat between the cracks of the regulations, making it a little more complicated to deal with dangerous products. These products often incorporate a USB charger, which also puts them outside the Plugs and Sockets Regulations.

Some universal plug/universal socket adaptors are simply badly made, and show up on the RAPEX list for allowing, for example, a single plug pin to be inserted with the other live pin being exposed to touch, and/or inadequate isolation between the input and output circuits of the charger. Another common design fault is to have all the different plug pins connected in parallel, such that pins which are not inserted into the socket are accessible and have mains voltage on them. Such is the case with the models illustrated in Fig 6 and 7, which, despite featuring on the RAPEX list many times (not only the UK and Ireland but also Germany, Netherlands, Spain, Denmark and Malta) are still available through both Amazon and eBay.

The pins on universal plug adaptors normally consist of one set of UK pins with an ISOD (plastic earth pin) for shutter opening, a set of non-earthed Euro-plug pins, and a semi-rotating set of US/Australian/Chinese non-earthed flat pins. The socket usually accepts most two-pin and three-pin plugs. However, because there is no provision for connecting to earth they are in fact an effective (and illegal) earth isolation device.

This lack of earthing has been cited in RAPEX withdrawal notices in the UK, Germany, Netherlands, Hungary and the Czech Republic. There are many such unearthed universal adaptors still offered on both Amazon and eBay. The most common brand names are 'SKROSS', 'Design Go' and


Fig 4


Fig 5


Fig 8


Fig 6

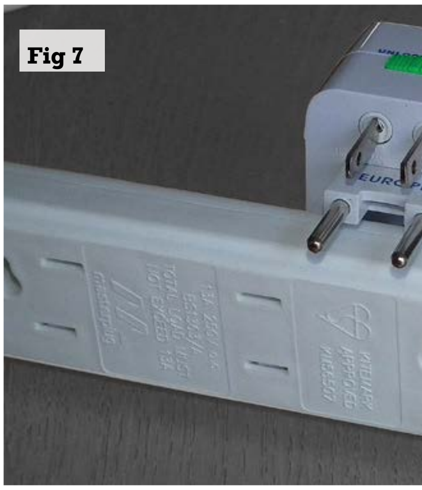


Fig 7

'FUJIFILM'; their products are offered widely on the Internet, and also in traditional stores such as B&Q, John Lewis, PC World, Currys and Boots. In addition to their unearthed adaptors, SKROSS also offer a universal adaptor with a full set of earthing pins. Why they also make an unsafe version is simply a mystery.

Chargers

In 2007, a seven-year-old boy was electrocuted by a fake Nintendo Game Boy charger, resulting in a major investigation by Buckinghamshire Trading Standards who found many unsafe game and phone plug-top chargers on the market, some costing as little as 99p. Typical problems include inadequate insulation between the input and output circuits, low-quality internal connections allowing wires to break loose, incorrectly sized pins, and inadequate marking. The last two faults can be identified by a visual inspection, but the others can only be uncovered by opening up the device.

Plug-top chargers are excluded from the Plugs and Sockets regulations, but subject to The Electrical Equipment (Safety) Regulations 1994, the relevant standards being BS EN 61558-1 and BS EN 60950-1. Although those standards are of a general nature, it would be normal for any safety evaluation to take into consideration BS 1363-1 as the reference for the plug pin dimensions, and this is what the Buckinghamshire tests did. The regulations also require that electrical products (excluding those covered by the Plugs and Sockets Regulations) should bear the CE mark and also "The manufacturer's brand name or trade mark should be clearly printed on the electrical equipment". Further details on the Buckinghamshire investigations can be obtained via a Google search on "What's in your socket?".

The situation uncovered by

Fig 4 Illegal fuesless plug - a Chinese plug with no provision for a fuse, and the pins set too close to the periphery

Fig 5 Fuseless, shutterless, travel adaptor

Fig 6 Two similar universal travel adaptors with multiple plugs, multi-socket and no earth, the design does not prevent deployment of all pins at the same time

Fig 7 Travel adaptor plugged into socket with live pins exposed to touch, the top (US) pins are spring loaded and can be deployed by releasing the green catch, even after plugging in the adaptor

Fig 8 A USB charger with pins illegally close to the periphery and no indication of the manufacturer

Buckinghamshire Trading Standards still pertains today.

The photograph of an illegal AC adaptor (Fig 8) clearly shows a product with no manufacturer's name or trademark, and with pins that are set far too close to the periphery (compare the width of the pins, 6.4mm, to the distance from the periphery, the minimum allowed is 9.5mm). The model shown was amongst those illustrated in the Buckinghamshire report, and currently [April 2013] can be found on eBay and Amazon. The Amazon offers are both described as being by Sumnique, a company that appears not to exist. The description of both versions claims that they are "Exclusively sold and distributed on Amazon by Sumnique" and yet that name appears nowhere in the list of 23 suppliers for one and 15 for the other. The product reviews for both Amazon versions include many references to "exploded", "blew up" and "burning". They also include a number of complaints about the dummy earth pin (ISOD) breaking off and remaining stuck in the socket (when this happens sockets are left in a dangerous condition because the broken earth pin holds open the protective shutters, making the live parts accessible to children). During a one-month period in 2012, PlugSafe initiated the removal of more than 3,000 eBay illegal charger listings by providing information to trading standards, but the problem keeps coming back.

Action required

What can be done to combat counterfeit online sales of cord-sets (whether sold separately or with appliances), unsafe chargers and travel adaptors? Following their charger investigation, Buckinghamshire Trading Standards called for major changes in the law, including:

- establishing a National Product Safety Agency – an independent single agency to protect the public's health and consumer interests, based on risk analysis, in relation to consumer goods;
- introducing a registration system – businesses manufacturing or supplying food for human consumption are required to register with their local authority so that due diligence processes can be assessed and compliance with food hygiene controls are in place. A similar system would enable local authorities and regulatory bodies to know where the businesses are selling electrical goods and advise/monitor if needed;
- introducing on-the-spot fines for non-compliant goods. A fine for obvious failures for certain breaches of product safety regulations would focus the mind of suppliers on their obligation to supply safe goods;
- improving consumer education – given the low levels of understanding about electrical safety there is a fundamental need to educate consumers of all ages.

My own proposals for augmenting the Buckinghamshire measures follow:

- as the law requires that all BS 1363 plugs are marked with the identity of the manufacturer or vendor, then that information should always be included in the description;
- Amazon should not permit offers for different products to be combined in the same listing;
- measures could be taken to require that there should always be a clear photograph of the plug showing the pins, the identification and the approval marks and licence numbers (with some designs this would require a photograph of both front and back);
- as an aid to consumer education, the major online suppliers should be required to make consumers aware of the importance of checking that plugs, adaptors and chargers received matched the pictures and descriptions of those offered. This should reduce the acceptance of counterfeit products, but it would be essential to insist that the suppliers picked up the cost of returns as the price is often less than the cost of normal postage to return them'
- online businesses should be prohibited from facilitating the direct shipping of mains-related electrical goods from outside the EU to UK consumers.

Electrical contractors and other professionals are well placed to assist in this area. In particular they can help educate consumers about the importance of safety, and alert all users to the dangers of counterfeit and substandard products, identifying them when found.

Finally, they can sign the government e-petition (started by electricians) calling for a strengthening of regulations http://tinyurl.com/plugpet. As professionals we need to do all we can to help eliminate these dangers.

David Peacock (david@plugsafe.org.uk) is a retired engineer and member of PlugSafe, a volunteer organisation working with other bodies to fight the threats to the safety of the BS 1363 system due to abuses, illegal counterfeits and substandard products. He is also one of the founders of FatallyFlawed, the campaign to raise awareness of the dangers associated with socket covers in the UK (www.plugsafe.org.uk)

BUILDING CONTROL: A SMARTER FUTURE

A new Voltimum expert panel will be supporting the drive to make buildings more intelligent.

By James Hunt

BUSCH & JAEGER & ABB, ALAMY

THE AUTOMATION of buildings has been accelerating over the past two decades. Initial efforts within the home were focused on bringing intelligent control to the operation of TV, home cinema, hi-fi systems, door access and other domestic equipment. The latest such products are increasingly supplied with the control and connectivity built in, so that such 'intelligence' has become almost a commodity item.

Today, the real advances are in providing intelligent control to buildings and their electrical/electronic equipment to make them more secure, save energy and control their climate to maximise occupant comfort and safety. Moreover, there are entry-level options that can be fitted with ease.

In Europe, the criteria for energy efficiency in buildings are detailed in EN 15232, which defines four energy efficiency classes, A to D, as the basis for evaluating the performance of building automation systems. In the UK, the Department of Energy & Climate Change has set four carbon budgets in law, as part of an initiative to achieve reductions in greenhouse gases of 80 per cent between 1990 and 2050 – set against a 2007 baseline.

The automation of buildings can help achieve such environmental aims, and, as a consequence, the technologies involved are becoming increasingly important and more widely used. They also represent excellent opportunities for electrical contractors and installers to gain new business, albeit with proper training.

Reflecting this growing importance, Voltimum UK and its partners involved in building intelligence have formed the 'Smart Homes and Automated Buildings Expert Panel'. Its members will meet regularly with the aim of bringing smart home and building automation

Modern building control systems are aimed a maximising security and comfort, while saving energy

issues and opportunities to both manufacturers and to Voltimum UK users. The Group will issue technical white papers about smart homes, intelligent buildings, and related equipment. It will provide webinars and seminars, and answer queries. The companies and organisations involved in the panel are: ABB, BEAMA, Eaton, Horstmann, Legrand and Schneider Electric, with other leading manufacturers and organisations expected to join shortly.

Building intelligence and communication

One of the key issues that has held back uptake of intelligent building technologies has been the need to install increasingly complex cabling and wiring, running from sensors and actuators to control and monitoring points. Such bulky and complicated wiring is expensive, difficult and time-consuming to install, and can even increase fire risks. Fortunately, this problem is now in the past, as the components of an intelligent building control system now communicate over a single bus cable using a common language or protocol.

The main languages for intelligent building applications are KNX, LonWorks and BACNet. In order to provide an idea about the importance of these protocols, taking KNX alone, over 170 internationally certified manufacturers are members of the KNX Association, while more than 22,000 qualified KNX partners plan, install and integrate KNX systems worldwide. As a result, thousands of buildings, ranging from private houses to airport complexes around the world, are equipped with more than 10 million KNX products.

There are other languages, however. Some are tailored to specific application areas, e.g. the widely adopted DALI (Digital Addressable Lighting Interface) protocol, along with EnOcean, Modbus, C-Bus, X10, Z-Wave and the open wireless protocol ZigBee, which is of growing importance.

Such 'open' languages interconnect all of the components in an electrical installation to form a network that can guarantee the transparency and utilisation of information across the system. All users can communicate via a single bus cable (or by wireless) so that all of the different functional subsystems can be integrated inside a building, or group of buildings, possibly within the local area network (LAN), into a potentially seamless solution.

Panel for smart home control, linking portable computers, mobiles and hand-held devices

Communication for connected devices and actuators in the system is implemented using data telegrams on the same bus cable. The sensors send commands, actuators 'listen' and then carry out defined functions (such as closing a window blind when a certain daylight level has been reached) as soon as they are addressed. Functions include group commands, logical sequences, control and regulation tasks.

Essentially, the bus (such as KNX) comprises a pair of twisted-pair wires that connect the devices. Over this cable, the data telegrams are transmitted, and the electronics of the bus devices are supplied with energy. Such systems can typically also be extended over Internet Protocol (IP) networks, and can also use radio frequency (RF) solutions – often known as 'wireless'. Note that linear, tree and star wiring configurations are usually possible, which provides high flexibility.

Schneider Electric has introduced a new concept: 'Wiser Homes'. The company maintains that, while smart homes are about technologies, Wiser Homes evolve around people. Wiser Home Control interlinks the electrical, multi-media and telecommunication worlds with a single solution – enabling homeowners to easily monitor, control and access their homes beyond physical boundaries any time, anywhere, on mobile phones, computers, door entry systems, web tablets etc., with the same intuitive graphic interface. Even so, most people will include all this under the umbrella of 'smart homes'.

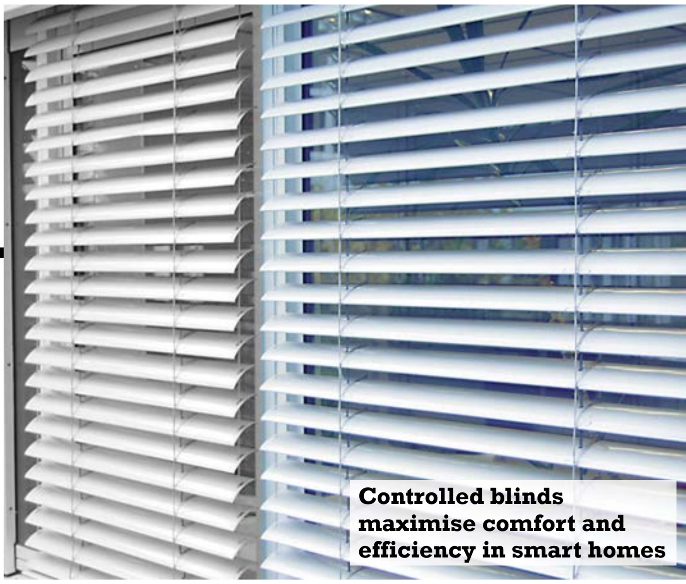
The devices and actuators

Intelligent building bus devices are typically the sensors or actuators that control building management system (BMS) equipment. Using one of the languages/protocols listed above, the bus devices can exchange information via twisted pair, radio frequency (RF), power line or IP/Ethernet media.

Interlinking via just one bus greatly reduces both design and installation time. The installation is also 'future-proofed' to an extent, because it can be readily modified to meet the requirements of new applications or extended range. Such systems are therefore well suited to buildings or groups of buildings, large or small.

Within the typical system, some or all sensors (such as buttons or motion detectors) are connected to the >

actuators (such as dimming and roller shutter actuators) via a data cable, rather than using directly wired switches etc., as in a conventional installation. The actuators then control the power circuit to the consumer.


Controlled blinds maximise comfort and efficiency in smart homes


Eaton's xComfort RF system is a wireless home automation system

The smart-meter roll-out

EU and UK-specific environmental mandates mean that smart meters are to be installed in most UK homes by 2019, and the UK government has ruled that the mass roll-out of these devices must start by 2014. According to a 2012 IMS Research (http://imsresearch.com) study, over the next five years more than £2.4bn will be spent in the UK on smart home energy management devices, ranging from smart meters to in-home devices that 'talk' to smart meters.

A smart meter, which will become an important component in all homes (and some other intelligent buildings), provides near real-time, direct two-way communication between electricity and gas meters and utility companies, using an Advanced Metering Infrastructure (AMI) network. This communications link will enable utilities to remotely measure how much electricity consumers are using, and send signals back to the meter. Importantly, from the smart-home perspective, smart meters will make it possible for intelligent appliances and other household devices to be turned on and off remotely, thereby saving energy.

Smart meters work in various ways, including an inbuilt SIM card to send the readings, while other suppliers are looking at long-range radio to transmit the energy usage data from the home by an open (protocol) standard to display, PC, router etc., and then (through a trusted gateway) to the grid/supplier – all using the consumer's Internet or other connections.

Consumers can benefit because they can see at any instant just how much energy they are using, making consumers much more energy conscious and encouraging energy efficiency. Some studies have shown that the introduction of smart meters can result in energy savings of around 10 per cent. There should also be far fewer disputes over billing. In addition, there will be the opportunity to collect information, for example prevailing weather conditions, which, linked to real-time energy-demand data, could be used to improve demand forecasts. Such improvements could reduce the need for 'spare' capacity within the supply system, further reducing overall costs.

Smart meters will also support variable electricity tariffs, such as 'dynamic pricing'. This will help convert the national grid to a smart grid, eliminating costly energy-demand peaks and troughs by varying prices according to demand, and changing the habits of household consumers. It will also reduce the need to operate the most expensive and least environmentally friendly power plants. Note that electric vehicle (EV) charge points will also become part of smart homes, some intelligent buildings and the smart grid.

The mass smart-meter roll-out will be expensive. Ofgem is reported to believe that this installation programme could cost £11bn or more, and some fear that the energy companies will simply add this to the cost of energy. The long-term benefits, however, should be huge.

And finally...

Clearly, there are fast-growing smart home and intelligent building business opportunities for electrical contractors and installers, although the inexperienced will inevitably have concerns about dipping their toes into a new, seemingly complex, pool. Getting the proper training will be crucial for many, but the reality is that such systems are not as difficult to understand, install and commission as people often think. The possibilities for significant new business are certainly there for enterprising installers.

Most equipment manufacturers offer training courses, for example ABB, which has provided free e-learning modules on the web. The list of topics is continuously updated.

Other organisations, such as the NICEIC, will soon be offering training courses on smart meters, and already provides training on automation, including wireless RF controls, plus EV charging systems. BEAMA can provide much up-to-the-minute information through its Smart Housing Association (www.beama.org.uk/en/other-associations/smart-housing.cfm), and the organisation has held presentations about home control networking, digital homes and smart metering.

There is plenty of information available online and elsewhere, and many organisations provide suitable training courses. Also go to the Smart Homes & Buildings Association (SH&BA) at www.shaba.eu.

This article is based upon its content provided by the newly formed Smart Homes & Building Automation Expert Panel www.voltimum.co.uk/smartbuildingexperts. Further articles and information on this topic can be found at www.voltimum.co.uk/smartbuildings .

James Hunt is the managing editor of the UK arm of the Voltimum electrical web portal

Correctly positioned exit signage is a key element in any emergency lighting scheme

SHEDDING LIGHT ON FIRE SAFETY

Fire safe assessments can reveal examples of poor practice in the provision of emergency lighting

By Ken Davis

ASK ANY GROUP of building owners for their assessment of the most important fire safety measure and you'll get a variety of answers. Some will identify the fire alarm, while others will maintain that escape routes or the fire exit signs should take precedence. I have even been assured that fire extinguishers should be top of the list as they can always be relied upon to extinguish a fire, making an evacuation unnecessary.

Whilst these different views offer the reassurance that some thought has been given to fire safety, as a fire safety consultant I would emphasise the need for a fire risk assessment to identify all relevant fire safety measures, and the importance of implementing these measures in priority order to ensure a balanced response to an outbreak of fire. For the majority of premises the elements of a basic fire safety package can be listed in the following order:

- a means of detecting a fire, often in the form of automatic detectors; >

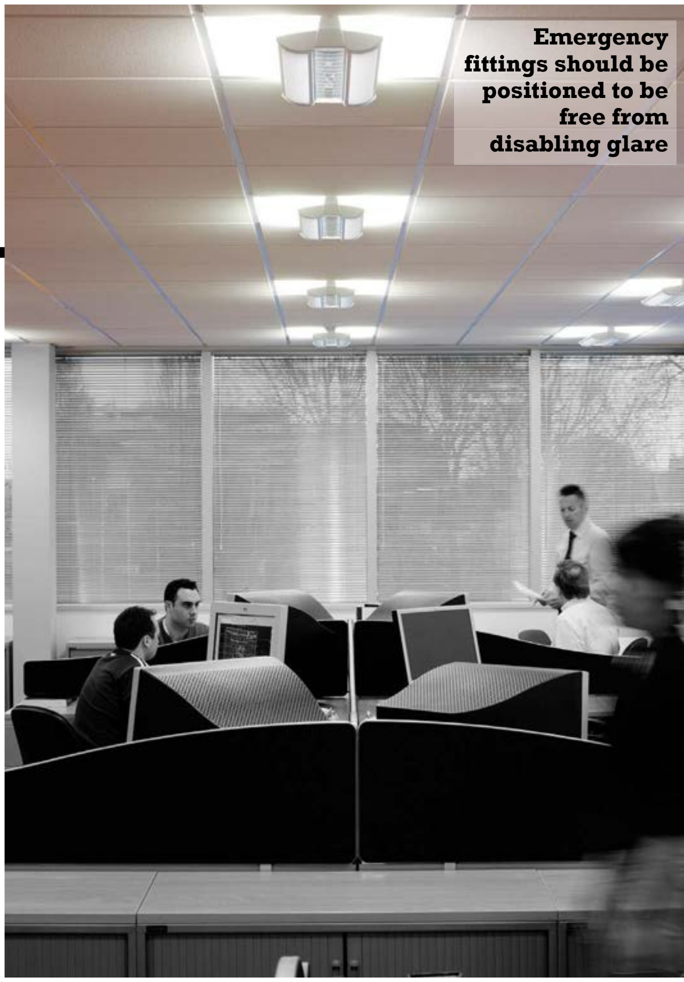
- a fire alarm to warn occupants of the outbreak;
- an emergency fire action plan designed to make sure occupants know what actions to take on hearing the alarm;
- escape routes and exits to permit occupants to evacuate in safety;
- signs to indicate exits;
- doors and partitions capable of preventing escape routes becoming smoke-logged before the premises have been evacuated;
- a procedure for taking a roll-call and summoning the fire and rescue service.

Emergency lighting is clearly an essential aspect of fire safety – providing sufficient illumination to assist detection of fire, assist occupants to locate essential equipment, illuminate signs and escape routes and assisting people to find the emergency assembly point. It's omitted from the list because it's a 'facilitator', underpinning all other safety measures, and, as such, can't be listed in order of importance.

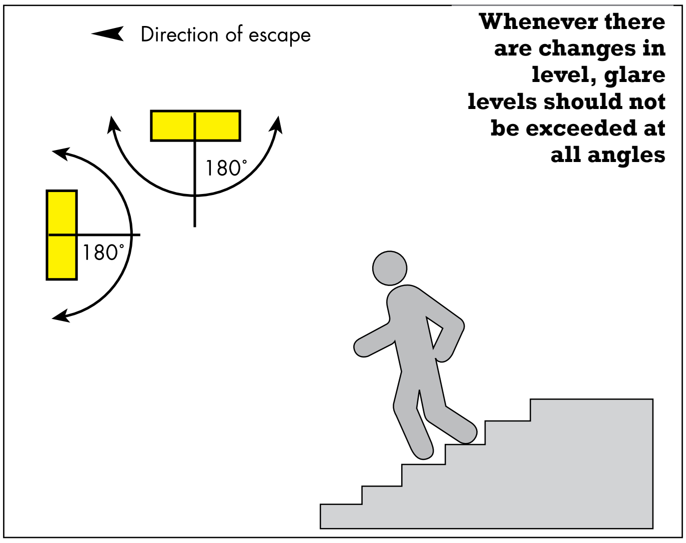
Assessment

When carrying out a fire risk assessment the assessor will consider all aspects of fire safety at the premises, including the way the premises are used, the methods of building construction, the number of occupants, the presence of vulnerable people, potential sources of ignition and the likelihood of a fire starting.

Where possible, the risk of an outbreak of fire should be reduced so far as reasonably practical, but the assessor will still need to ensure that if a fire does break out it will be quickly detected and the alarm raised. Very importantly, the assessor will need to be satisfied there are suitable escape routes and for these to have adequate illumination that can be relied upon should normal lighting fail.



Emergency fittings should be positioned to be free from disabling glare



Whenever there are changes in level, glare levels should not be exceeded at all angles

New buildings will require a fire risk assessment when they are occupied, and fire safety measures, including emergency lighting, should be planned carefully at the building design stage. From the outset there should be a clear understanding between all interested parties about the type of emergency lighting installation required and the extent of coverage. The emergency escape routes should be plotted on a plan, together with the location of fire safety equipment, safety signs and high-risk areas. For this to be carried out effectively there will first need to be a bringing-together of information to enable the emergency lighting designer to understand the layout of the premises and the location of fire safety equipment and fittings.

A fire-risk assessment on existing premises will often involve a close inspection of any emergency lighting already present and may result in recommendations for improvements. The fire risk assessor might identify a need for one or more additional luminaires and also specify where they should be installed. Where there are concerns about the general coverage of emergency lighting or the method of installation it is not uncommon for an assessor to simply recommend that a survey of emergency lighting be carried out by a competent person. Such a survey will frequently be accompanied by a recommendation for the system to be upgraded to the latest edition of BS 5266-1 which of course means that the competent person should be familiar with this standard.

Within existing premises, changes in layout or hours of use can often result in a fire risk assessment identifying a need for emergency lighting. For example, a revised layout might result in the loss of natural lighting in parts of a building, or the introduction of a night shift would mean a factory was occupied during the hours of darkness.

Requirements and regulations

The provision of emergency lighting for safety purposes is a well-established principle, and it is interesting to note that the 1934 'Manual of Safety Requirements in Theatres and Other Places of Entertainment' makes specific recommendations about safety lighting and the way it should be used in conjunction with the main lighting to ensure continuity of illumination. The manual goes on to specify requirements for the capacity of accumulators and the arrangements for evacuating the building if a lighting failure occurs.

Although this manual was not the first publication to identify the need for safety lighting, it has been hailed as the first comprehensive safety document for places of entertainment and it has more than passing similarities with today's fire safety guides.

Current UK recommendations for

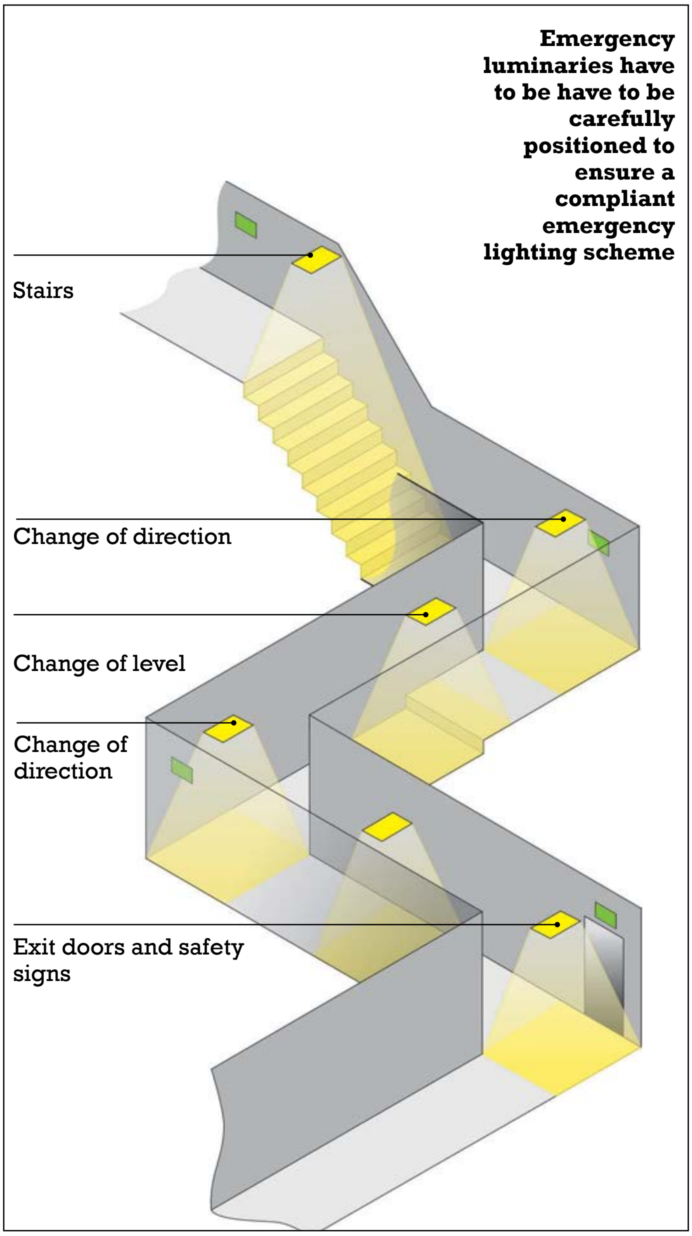
emergency lighting, known as emergency escape lighting where it is provided for fire safety purposes, stem primarily from national Building Regulations and fire safety legislation.

Guidance issued in support of Building Regulations and fire safety legislation direct us to a series of British and European standards dealing with emergency lighting. Whilst all of these documents have their own specific role, it is British Standard 5266-1: 2011 – 'Code of practice for the emergency escape lighting of premises' which applies to probably the majority of emergency lighting systems. This document will usually be quoted as the benchmark standard for emergency escape lighting in both new-build and existing premises.

Power supply

Emergency lighting is provided for use when the power supply to normal lighting fails, which means it must have a secondary power supply. This can be a central supply, such as an emergency generator or batteries, but more commonly will be in the form of self-contained units where the battery and charging equipment are contained within the luminaire itself. Emergency lighting is frequently combined with normal lighting in a single fitting.

Luminaires will often be of the non-maintained type, which comes into operation only when the electricity supply to individual units fails. This arrangement is suitable for probably the majority of premises, but where normal lighting may be dimmed or turned off altogether, as for example in cinemas and theatres, then it might be necessary to install maintained luminaires, in which emergency lamps are energised at all material times.



Positioning

The positioning of emergency lighting luminaires is very important to ensure occupants are able to locate essential equipment, identify the position of exit routes and to leave the premises in relative safety. In general, the emergency lighting designer should position luminaires to cover the following locations:

- staircases, high risks and extensive open areas such as large factory production floors and sports halls which occupants may have to cross to reach exit points;
- corridors, corridor intersections and changes in the direction of travel in corridors. Infill units may be required between these points to provide an adequate level of illuminance throughout the route;
- changes in footway level, such as ramps or one or more steps up or down within a corridor;
- doors intended to be used as escape routes, including storey exits and final exits;
- access rooms serving inner rooms;
- the area outside of final exits leading to a place of safety, which may include emergency assembly points. Reliance upon external borrowed light such as street lighting, is no longer recommended;
- signs that identify exit routes and also those signs providing other mandatory information;
- toilet facilities exceeding 8m^2 although closeted facilities having a smaller area may also require emergency lighting;
- facilities for use by disabled people which include accessible toilets and refuge points on escape routes. It is common for refuge points to be provided with communications facilities and it is important that emergency lighting is sufficient to enable call buttons to be easily used and instruction notices to be read;
- lift cars;
- plant rooms and switch rooms;
- fire extinguishers, fire alarm call points and emergency shut-off control locations;
- first aid equipment.

The above list is not exhaustive and a fire risk assessment may identify a need to vary the appropriate coverage.

Illuminance level

The selection of individual emergency lighting luminaires will be largely determined by the level of illuminance required, and this will vary with their location within the premises. As little as 0.5lx may be sufficient at floor level in a room exceeding 60m^2, whereas an escape corridor up to 2m in width should be provided with not less than 1.0lx. Panic bar devices, refuges and signs indicating exit routes should have a minimum illuminance level of 5.0lx. Higher levels of illuminance are recommended in kitchens, >

first-aid rooms, plant rooms and for fire alarm control and indicating equipment, where it is suggested that 15lx is appropriate. Care is required to avoid disabling glare when siting high-output luminaires, and it is recommended that such units are mounted at least 30° out of the direct line of site when viewing escape routes.

Duration

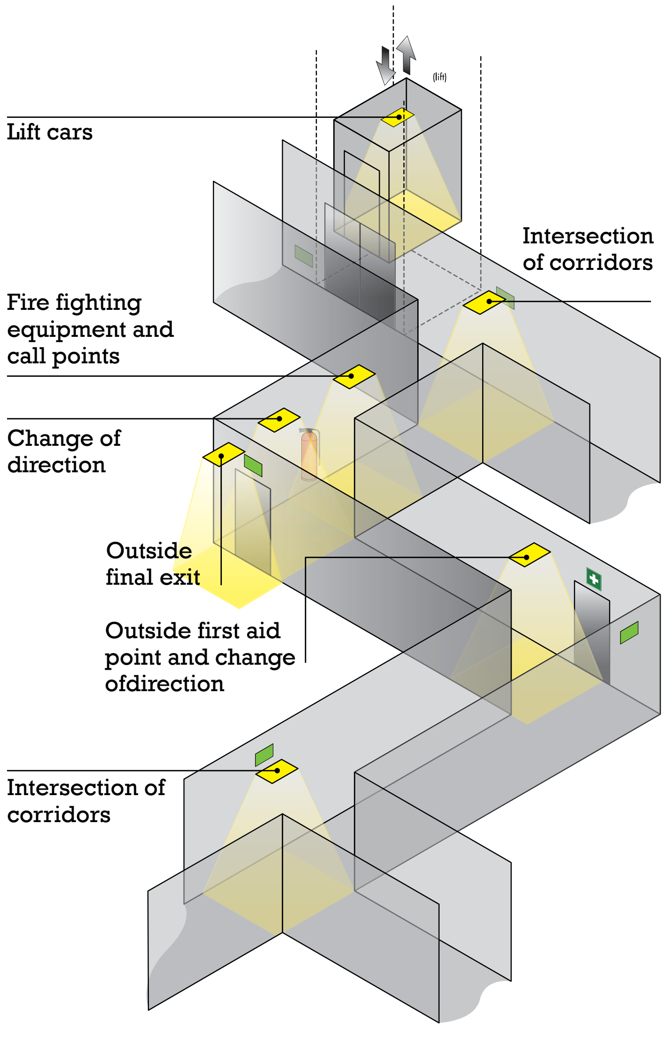
The operational duration of power supplies is an important factor when planning an emergency lighting system. Generally, a minimum duration of one hour will be adequate where the premises will be evacuated immediately on supply failure, and not reoccupied until full capacity has been restored to the batteries. A duration of one hour may also be suitable where people using the premises can be expected to be familiar with their layout, for example in the case of factories. Where sleeping accommodation is provided, or where occupants may be unfamiliar with the premises, then three hours' duration will normally be required.

The risk of lamp failure in individual luminaires presents the possibility that occupants will be in total darkness, but this threat can be minimised by ensuring that at least two individual luminaires, or internally illuminated exit signs, are visible from any location, although a single luminaire may be adequate in WC facilities.

Test facilities should be provided to enable failure of the normal supply to be simulated without interruption of the normal supply.

Concerns

Although the regulations and principles governing emergency lighting are well established, it is clear from my work as a fire safety consultant that emergency lighting



Emergency fittings must be installed at certain mandatory points

is the fire safety system that presents the greatest concern in the course of a typical fire risk assessment.

There are a number of typical situations that might arise, and there follows a summary of the most common.

Firstly, emergency lighting is frequently installed before the fire alarm has been fitted and before fire extinguishers requirements have been assessed, often leading to inadequate illumination of equipment.

Luminaires often appear to have been installed on escape routes in a haphazard manner and without regard for changes in direction of travel, changes in floor level or adequate illumination of landings, staircases and refuge points.

External escape routes are often not provided with emergency lighting or, where it has been installed, it does not afford continuity of illumination. This is often critical in the case of residential care homes where the nature of the residents necessitates temporarily keeping them secure at an external assembly point, perhaps at the side or rear of the premises. In these cases the fire risk assessment will usually identify a need for normal and emergency lighting on external exit routes leading to the assembly point, together with illumination of the assembly point itself.

Large rooms such as sports halls and school assembly halls are often provided with internally illuminated exit signs above exit doors but without any general emergency lighting coverage in the main body of the hall which brings into doubt whether the minimum illumination levels have been met. Low-output luminaires fitted on high ceilings may be ineffective at floor level

Twin-spotlight luminaires are often not adjusted to give the most benefit on escape routes.

High-output luminaires such as twin-spotlight units are mounted too low and result in disabling glare. A recent fire risk assessment found a twin-spotlight unit mounted at shoulder height at the base of an escape staircase with both lights directed up the staircase, directly at people descending.

An absence of test-switches leaving the user to switch off circuit breakers, or occasionally to pull fuses, in order to carry out monthly tests of emergency lighting.

Annual servicing and battery discharging being carried out too late in the day meaning that darkness may have fallen before adequate battery recharge has been achieved. This is critical in premises that are occupied 24 hours a day.

Non-maintained emergency luminaires are found to be installed entirely independently of normal lighting. This is probably the most common problem encountered with emergency lighting. Unless the power supply to the emergency lighting is taken from the circuit supplying the normal lighting, then a failure of the normal supply won't be detected by the emergency lighting and the emergency lighting won't operate when the normal supply fails. In one instance, 40 consecutive tests conducted on new emergency lighting systems revealed 38 that would not operate if the supply to the main lighting failed. In a separate incident involving a hotel fire, panic arose when the corridor lighting had failed and emergency lighting failed to operate because it had been installed on a dedicated circuit. These examples certainly suggest that the recommended standards for installation are not always fully understood.

Completion certificates and validation certificates


Exit routes must be clearly identified and always kept clear

are sometimes not supplied by the installer. The approach taken by fire risk assessors often varies with the requirements of the customer and may or may not include tests of fire safety systems such as emergency lighting. If the assessment is being carried out on an entirely new system the assessor may request to see a completion certificate as evidence that it has been designed and installed to a satisfactory standard. Where an existing system has been examined and judged to be suitable for ongoing use a validation certificate may be necessary. It is worrying to be told by an installer that he is reluctant to issue a certificate because he has never seen the applicable British and European standards for emergency lighting.

A need to refocus

Emergency lighting is a broad and complicated subject that requires specialist knowledge, but there are evidently grounds for believing that a refocus on standards of installation is warranted to ensure customers are receiving a service that will stand them in good stead should they be unfortunate enough to experience an outbreak of fire.

Where designers and installers have queries about emergency lighting recommendations arising from fire risk assessments, they are encouraged to discuss them with the person who carried out the assessment. However, it is important to stress that the designer is seen as the competent person in this field and technical decisions about the system are the designer's responsibility. It is worth emphasising that, under fire safety legislation, anybody involved in the supply of fire safety services can be held accountable in law for the quality of the products and services they provide, which includes the design and installation of emergency lighting.

The importance of emergency lighting for fire safety purposes should not be underestimated and it is only by careful planning and skilled installation that the potential dangers from lighting failure can be reduced to a satisfactory level. ✻

Ken Davis (ken.davis@churchesfire.com) is fire safety engineer, Churches Fire Security Ltd, and sits on the Fire Industry Association's Fire Risk Assessment Council and the Fire Risk Assessment Council's Professional Standards Working Group.

The images used in this article have been taken from the 'Emergency Lighting Design Guide', published by Thorn Lighting (www.thornlighting.co.uk/download/Em_Lighting_Design_Guide.pdf)

WiringBooks #47

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.

REQUIREMENTS FOR ELECTRICAL INSTALLATIONS

IET Wiring Regulations, 17th Edition (BS 7671:2008 incorporating Amendment Number 1:2011)

The Wiring Regulations are the national standard to which all domestic and industrial wiring must conform. Substantial changes have been incorporated in BS 7671:2008(2011) to align with European documents. Essential for all electricians, electrical contractors and their managers, installation designers, and students in further education and professional training.

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BS 7671:2008(2011)

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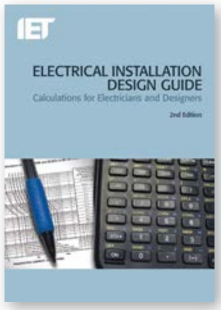

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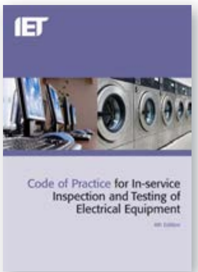

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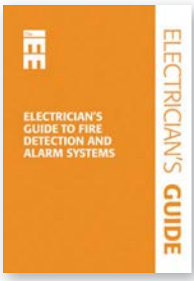

ELECTRICIAN'S GUIDE TO EMERGENCY LIGHTING

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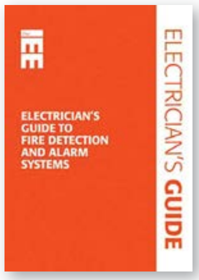

This is one of a number of publications prepared by the IET to provide guidance on electrical installations in buildings. This publication is concerned with fire detection and fire alarm systems and must be read in conjunction with the legislation, Approved Document B and the British Standards, in particular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

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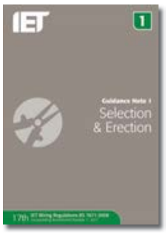

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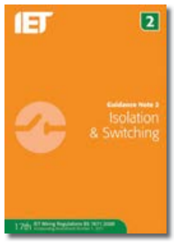

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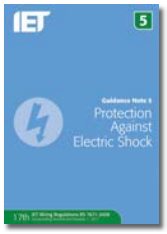

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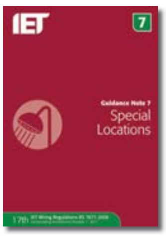

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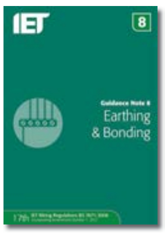

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VOLTAGE OPTIMISATION

Is the trend of using voltage optimisation in the home justified?

Despite having a national grid, regional variations in UK supply voltages provide an opportunity for energy savings

By James Hunt

VOLTAGE OPTIMISATION (VO) is a decades-old technology, offering potential benefits in terms of power savings, reliability and total cost of ownership. Well-established in the commercial sector, VO equipment is increasingly being promoted in the domestic market. The push to sell VO into the home, coupled with the increasing number of companies selling VO equipment, makes this a particularly good time to ask: does VO work?

The best answer is a qualified 'yes', but not for all types of load, nor for all applications. Properly applied VO can result in significant savings; applied incorrectly, it can be a waste of money.

If low-voltage (LV) electrical equipment is operating at higher than its designed voltage, losses occur, resulting in more energy being consumed than necessary. Many loads may also overheat. Certain electrical appliances and machines operate more efficiently when the supply voltage is regulated and stabilised. Yet supply voltages often vary considerably from place to place and from time to time.

Electricity supply companies in the UK provide an average incoming voltage to users of 242V, but it is not uncommon for 250V to be exceeded. Moreover, 242V is higher than that required for optimum use of plant and appliances, which is specified by the Electricity Safety, Quality and Continuity Regulations (ESQCR) and the IEC 60038 at 230V ±10% This is considered a suitable voltage to ensure correct operation, and all CE-marked electrical equipment should work safely within this range.

Reduce the voltage

This voltage mismatch can cost significant amounts of money, reduce equipment life and reliability, and needlessly add to CO_2 emissions. Avoiding the mismatch is the reason for choosing to use VO, which needs little or no maintenance or monitoring. VO units optimise the voltage for maximum appliance/equipment efficiency and some may filter out spikes and harmonics to provide a smoother power supply. This provides a good operating environment for electrical equipment and enables certain loads to use less electricity. For example, a 230V lamp (depending upon the lamp technology) run at 240V typically consumes 9 per cent more energy, yet has its expected lifetime reduced by around 45 per cent.

The claim is that VO can allow electrical equipment to operate at optimum efficiency, lowering energy bills, extending equipment life, reducing maintenance and cutting the carbon footprint. Installing VO technology should allow a significant reduction in energy bills when applied to sites with well-suited loads.

How VO works

The voltage reduction is achieved in two main ways:

Fixed ratio step-down transformer. Most buildings/sites run happily at around 220V phase-to-neutral, achieved using a fixed ratio step-down transformer having pre-determined tap settings. Alternatively, the voltage tap setting on the incoming transformer can be adjusted (if not shared) to reduce the supply overvoltage.

Businesses having their own dedicated LV transformer or substation effectively have VO already, and it is only necessary >

to re-adjust the ratio between incoming and outgoing voltages. Typical voltage reductions might be in the range 3 to 12 per cent, depending on the site.

The benefits of this basic, long-established technology include better energy consumption and longer equipment life. As it is relatively cheap to buy and simple to install, the return on investment (ROI) should be between one and five years, depending upon the application. However, the disadvantage is that any change in input voltage will result in a fixed percentage change on the output, resulting in a fluctuating output voltage that does not deliver the maximum potential energy savings.

Voltage regulator. This last difficulty can be avoided by using a voltage regulator (sometimes called a 'voltage stabiliser') on the incoming supply that controls the output to an adjustable set level, while each phase is independently controlled to balance the output voltages. This is important for improving motor efficiency. The elimination of fluctuating voltages should provide extra savings, so despite a voltage regulator costing more than a simple step-down transformer, this option is often preferred where the site voltage is erratic. It can reportedly provide energy savings of 10 to 35 per cent, depending upon who you talk to.

Some voltage regulators are ferroresonant-transformer (constant voltage) based, while others are essentially electronic. They work by continually comparing the incoming voltage to that needed to drive the loads. If the supply voltage is too high, a second wave is added anti-phase to subtract exactly the necessary voltage.

If the supply voltage changes with time, fixed ratio step-down transformers and voltage regulators will behave differently; the former will provide the output according to a fixed reduction, while the latter will correct to its setpoint voltage as long as the input is within range.

Installation

VO units are typically installed in series with the mains electrical supply to a building, but note that not all VO units service all downstream electrical equipment – some may be only connected to specific circuits. This is certainly the case in many domestic applications, where some circuits are isolated from certain VO units. Generally, with domestic installation, the VO unit will be installed alongside the consumer unit or fuse box, and it will regulate the voltage to the circuits where energy savings can best be made.

VO benefits with load type

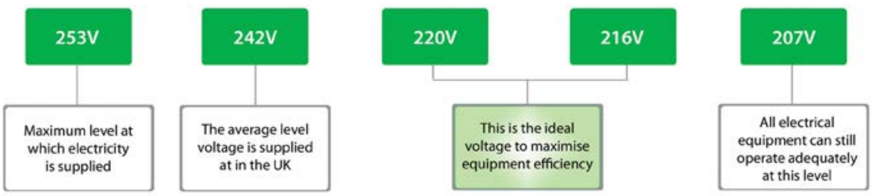
Can VO savings always be made? To quote the Carbon Trust: "prospective customers should understand the limitations as well as any potential benefits before investing in the technology." The Carbon Trust operated a very successful interest-free loan scheme for energy-saving projects a couple of years ago, and many organisations took the opportunity to install VO using this funding stream. All agreed projects had to be justified and independently verified by the Carbon Trust prior to funds being agreed.

Even so, while it is sometimes said that virtually all sites can benefit from reducing and controlling the voltage, some companies will not recommend VO for duties that offer only marginal potential savings. Unfortunately, the evidence is that VO is being promoted by some organisations as a panacea for every conceivable application; this is spoiling the market.

What are the electrical loads that matter? From a VO perspective, there are two main types: inductive and resistive. These react differently to VO, so typically benefit in different ways:

Inductive loads – Such loads include electric motors, which are often oversized so effectively operate under partial load. This reduces efficiency. Moreover, when running at 230V or over, internal losses can result in further reductions in efficiency. Such motor-driven equipment, like refrigerators, pumps and compressors, generally allows good savings with VO.

Using VO brings the following benefits for inductive loads: greater



Voltage variations and the scope for savings

Commissioning a commercial VO system from Marshall-Tufflex

Reigate & Banstead Borough Council is addressing its carbon management programme in a number of ways, including the installation of Marshall-Tufflex Energy Management Voltis VO units. The first of these, a 300A system, has been installed in Reigate Town Hall where it is returning electricity savings of 9-10 per cent. A second 300A unit is to be installed in the Harlequin Theatre, Redhill. The council is also considering a third installation into a leisure centre.

Environmental initiatives officer Raymond Dill: "We had looked at VO previously but were uncertain whether it worked. My view now is, don't hesitate to put VO in at the first stage of any carbon reduction programme. Other initiatives such as energy saving lighting may lessen the impact of VO, but by the time you have installed them you will have already made significant savings."

Other case study examples

VO technology has benefited a recording studio located in the countryside, where the unstable power supply put expensive equipment valued at over £200,000 at risk. This is using a VO unit by VO4HOME to help successfully balance the power supply and improve power quality. A similar unit by the company is being used to reduce the voltage to a flat in Fulham, where overvoltage was causing expensive appliances to shut down. One farmer too has benefited; his milling machine was rendered useless because of high voltages and spikes, but the VO unit has brought the required voltage stability to the farm.

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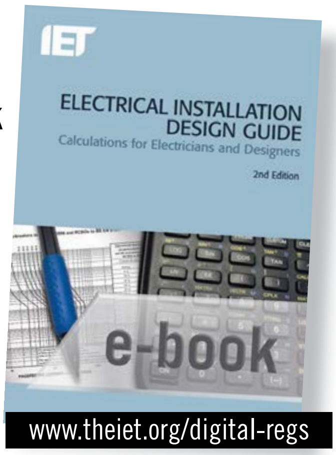

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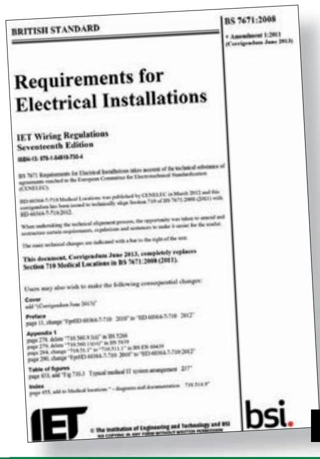
Corrigendum



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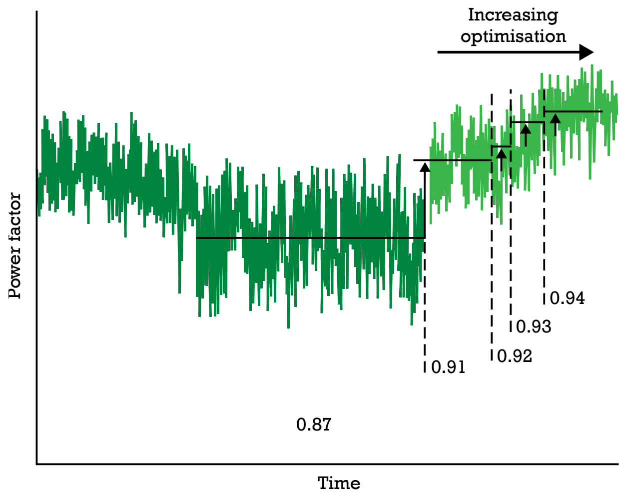

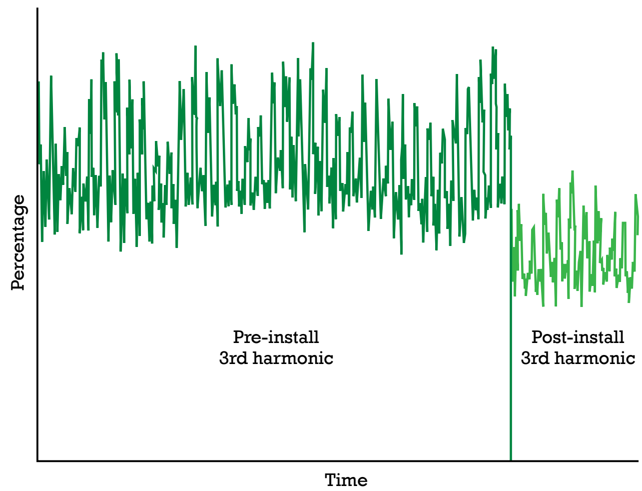

< efficiency; a better power factor; and a better motor working point on the magnetic hysteresis curve (which reduces internal losses). Note that VO will not make worthwhile savings powering motors driven by inverters and variable speed drives (VSDs) – increasingly the case for motors of any significant load.

A fluorescent lighting ballast is another inductive load. It is common for building owners and facilities managers to try to save money by removing older fluorescent lighting systems and replacing them with energy-efficient HF (electronic ballast) lighting or LED lighting systems. With the right control gear, such modern lighting can save large amounts of energy. Some say that VO cannot be successfully used with modern HF lighting and many LED lighting products. However, an EA Technology report (see panel 'VO and lighting', p34) indicates that dropping the voltage to 220V provides good savings on incandescent, fluorescent, CFL and certain LED lighting – even though in some cases light levels are reduced, but not always to a noticeable level. In reality, says VO provider Marshall-Tufflex, all that the VO is doing is bringing the light level down to what the fitting was designed to run at (220 to 230V preferred supply level in the EU under the CE mark).

The best potential for saving with lighting is with older incandescent, fluorescent or discharge lighting using conventional control gear, so elderly commercial and office buildings are likely to benefit most. However, before rushing to install VO, it's important to

Interior of powerPerfector Plus commercial VO equipment

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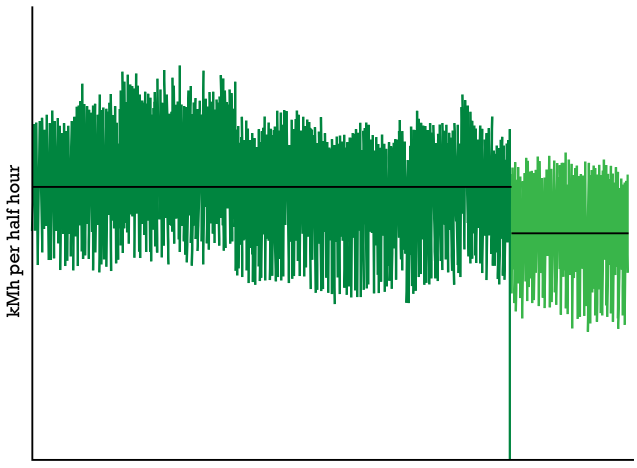


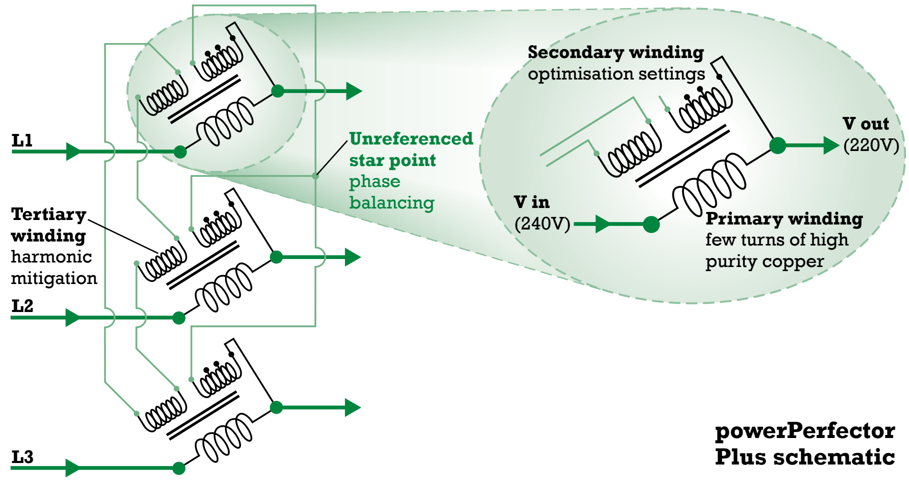
Voltage optimisation can improve power factor, reduce harmonics and save energy

determine whether switching to a more modern lighting solution might not be the more cost-effective option. Note that some VO units can filter out the high total harmonic distortion (THD) generated by HF lighting ballast and control gear, which is another consideration.

Resistive loads – This is Ohm's Law territory, with its simple linear relationship between voltage and power (Power = Voltage^2/Resistance). This is fundamentally important, as it suggests that if the voltage is reduced, the power taken will reduce as the square of the voltage. The result is a saving of energy. For an ideal, purely resistive load, dropping the voltage from 242V to 220V would give an energy saving just over 17 per cent. In the real world of non-ideal loads, savings of will be less than this – typically 11-13 per cent.

VO also helps resistive loads extend equipment life. For example, some lamps are resistive, so their energy consumption is improved and operating life extended using a stabilised voltage output. This can greatly reduce lighting maintenance and lamp replacement costs. Recent tests conducted by EA Technology even showed that savings of around 8 per cent could be made on certain LED lights by dropping the voltage to 220V – with only a 1 per cent loss in lumen output.

VO is not worthwhile for certain types of heating. An example is the humble electric kettle. Any voltage reduction >



powerPerfector Plus schematic

will require the kettle to be on for longer. The same is true for thermostatically-controlled space or water heating systems.

Other loads that cannot achieve a worthwhile VO energy saving include switch-mode power supplies, typically used to drive office and domestic electronic equipment. These use the same power as previously, but will draw a slightly greater current, resulting in slightly greater cable losses and possible circuit protection device tripping. With constant power devices having a wide input voltage range, reducing the voltage increases the current, so savings are negligible.

However, equipment life is usually extended, and it is claimed that this may make it cost-effective to install a VO unit, even where the loads themselves are not conducive to energy savings On any site, the higher the ratio of inductive loads to resistive loads, the larger the potential savings will be.

Does VO work domestically?

One study ('The Effects Of Voltage Variation on the Power Consumption and Running Cost of Domestic Appliances', GK Hood, School of Science and Engineering, University of Ballarat) has examined how voltage variation affects the power consumption and energy cost of a domestic household. Various inductive, resistive and electronic domestic appliances were subjected to normal voltage variations and their power and energy measured and analysed. The results indicated that that voltage variation from the consumer's point of view has minimal effect on the cost of electrical energy. This result, if correct, would tend to suggest that for consumer use, VO might not be justified purely for saving energy.

In short, VO equipment installed at home may save a relatively small amount of energy, but may also make lighting dimmer and the electric shower a little less hot – but this is highly dependent on many factors. For example, some types of lighting will not noticeably reduce light levels, and appliances such as fridges and freezers that are constantly on and use motors, can contribute good savings. Most domestic premises whose mains voltage is currently above 240V should save between 8 and 13 per cent (depending upon the user profile). The Energy Saving Trust provides interesting figures on the typical annual cost of household appliances, some of which can and do provide savings with VO.

Note that Marshall-Tufflex, which makes VO units for commercial and domestic use, does not support installing a domestic system if the incoming supply is lower than 230V, while a few companies do not support domestic applications at all.

However, Apollo Enviro says that older domestic buildings can certainly benefit from VO energy savings, and may even have a role to play in the Green Deal, the government's flagship energy efficiency scheme. The company believes that optimisation provides a much quicker payback period and greater percentage savings on energy consumption than solar PV. However, VO has not, so far, been included in the list of technologies approved for the Green Deal. Apollo Enviro is hopeful that it will be approved at some stage, and says that the resulting increased demand would reduce VO costs.

Site survey essential

Before choosing a VO unit, it is essential to carry out a technical site survey using instrumentation attached to the incoming supply. The electricity usage data gained should ideally be combined with previous electricity usage statistics gained over a number of months, and examined in terms of other relevant site information.

VO energy savings across any site can be estimated by summing all equipment that responds to voltage reductions and power quality improvements. A site survey must aggregate the potential VO energy savings from the mixture of loads, but loads that cannot benefit must be deducted from the total to provide a realistic estimation of potential energy savings. Finally, a comprehensive report and energy usage strategy should be provided to show any realistic cost savings, so that an accurate return on investment calculation to be made.

CHALLENGING MISCONCEPTIONS

VO AND LIGHTING

LEDs are revolutionising general lighting because they improve environmental footprints and provide more colourful and dynamic lighting with an extremely long life. However, orthodoxy has it that optimisers will not deliver power savings if installed in conjunction with LED arrays. Now, though, a new study by EA Technology ('Appliance Efficacy Study', August 2012, Robert Green, Rhys Roberts & Benedict Rowton) has examined the effect of VO on fluorescent, incandescent, CFL and LED lighting, and the results are challenging this established view. Researchers looked into the effects of supply voltage on LED light output and power use, looking specifically at 220V, 230V and 245V.

EA researchers concluded that data found for LEDs suggested that there is little variation in illuminance when varying voltage. The power consumption, however, is reduced, indicating that potentially a reduction in voltage would provide reduced power consumption without affecting the illuminance experienced by the user.

This study, says VO provider Marshall-Tufflex, could challenge the commonly held misconception that optimisation will reduce efficacy and performance, while delivering only very low savings with LED lighting.