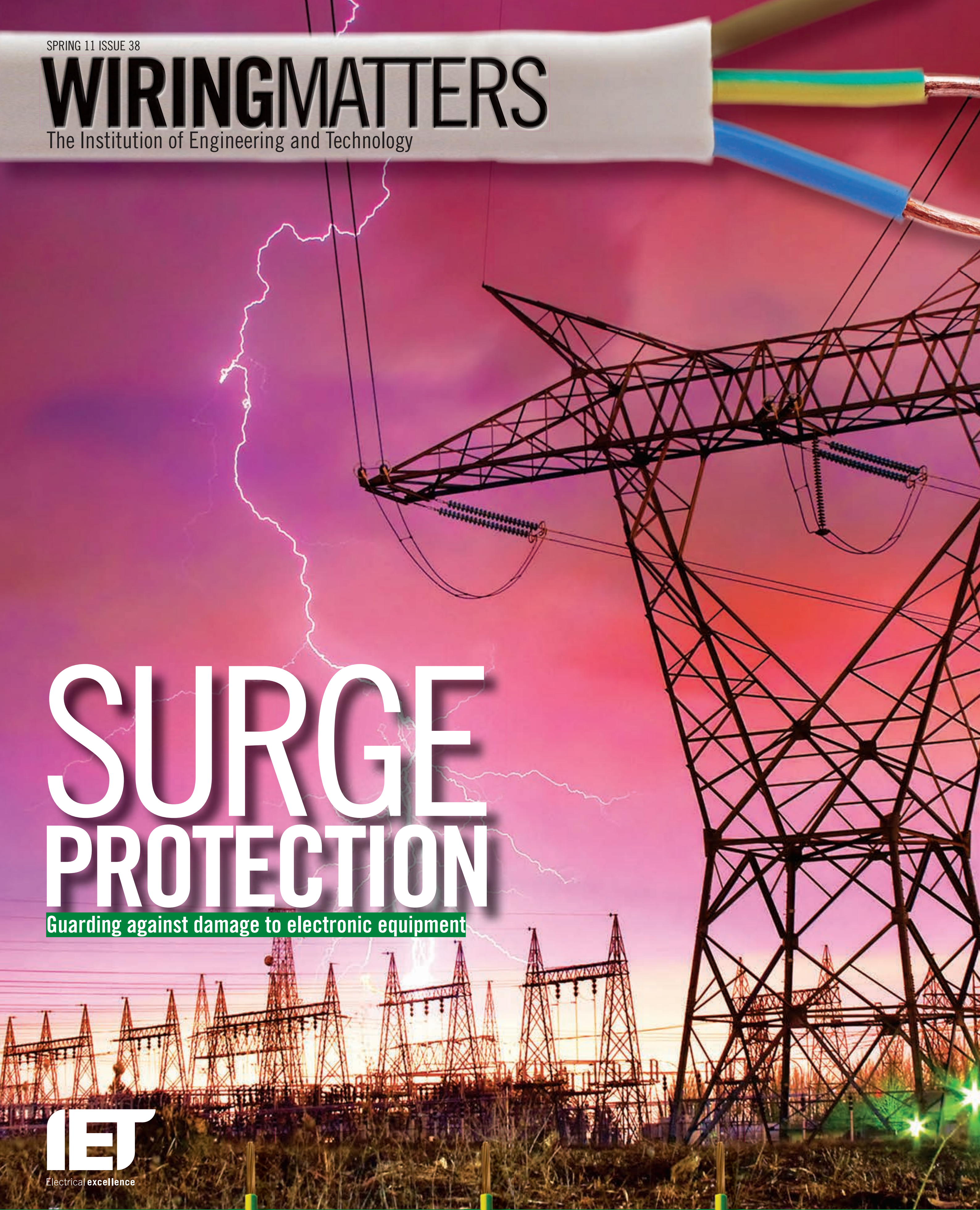
SPRING 11 ISSUE 38

WIRINGMATTERS

The Institution of Engineering and Technology



SURGE PROTECTION

Guarding against damage to electronic equipment

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Prefab wiring systems
Key aspects of BS 8488 and designers' responsibilities

PAT testing
We clear up some of the common causes of confusion

Medical locations
Details of a new section of BS 7671 to be introduced in July

Fuse standards
Changes to reflect developments of low-voltage fuse standards


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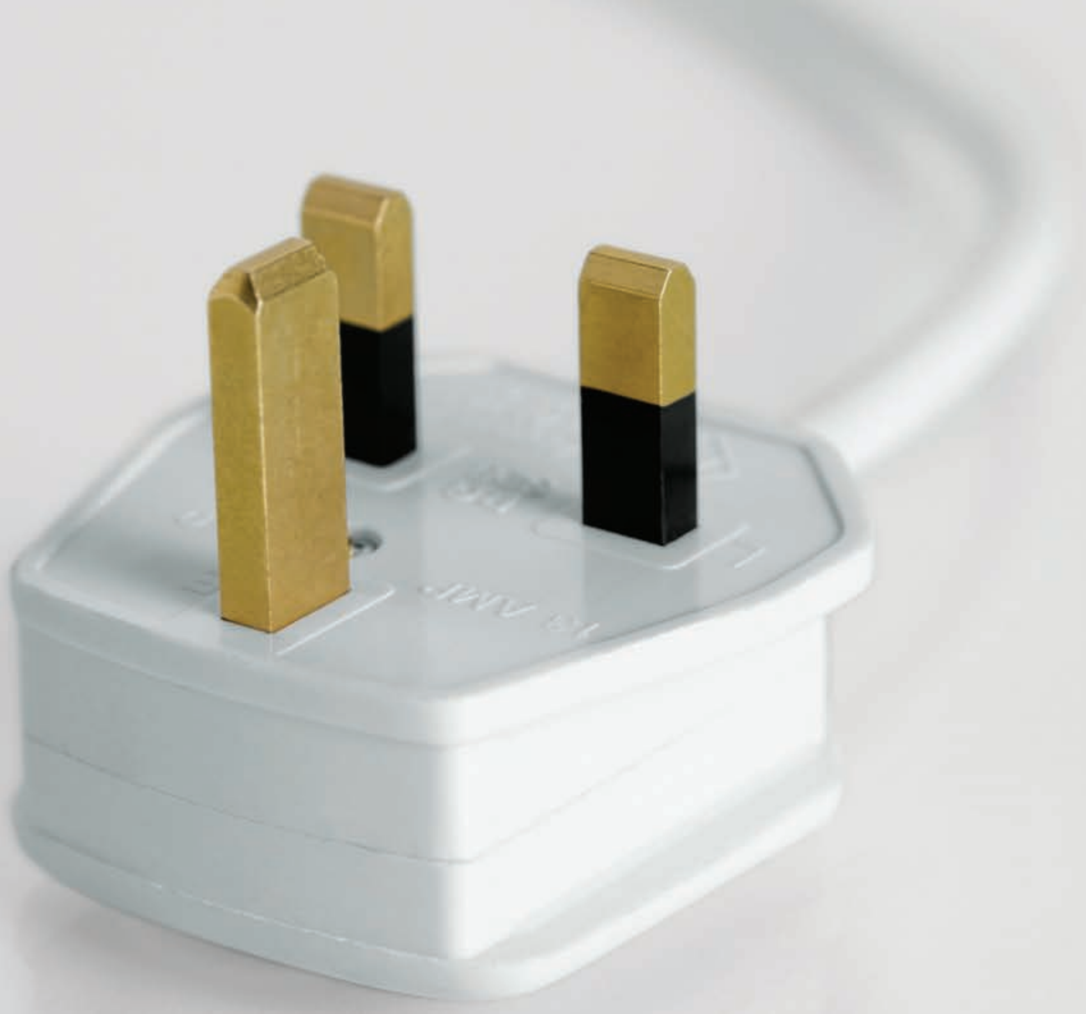
PAT Testing and the parameters affecting the frequency of testing

How frequencies of testing should be interpreted for in-service inspection and testing

By Richard Townsend



THERE IS A particularly common group of questions on the help-line, which centres on the requirement for consultants, contractors and customers to understand the frequencies of testing that should be carried out for in-service inspection and testing of electrical equipment, commonly known as portable appliance testing (PAT).

There seems to be much confusion as to why they should comply and how to comply, with a great deal of confusion linked to types of equipment and the environments they are used in and how this affects their testing regime.

The ‘Code of Practice for In-service Inspection and Testing of Electrical Equipment’ (3rd edition), produced by the IET, describes the tests required and offers guidance on the initial frequencies that should be applied. In some cases the help-line callers possess this document but struggle to understand what is meant or implied by requirements for and frequency of tests. ▶

'PAT testing' determines whether electrical equipment is safe to use

◀ The main objective for 'PAT testing' is to ascertain if electrical equipment that is in use, or likely to be, is fit and safe for continued use or if the equipment should be quarantined for repair/ maintenance or quarantined for correct disposal.

Legislation

The legislation relevant to electrical maintenance is:

- Health and Safety at Work etc. Act 1974
- Management of Health and Safety at Work Regulations 1999
- Provision and Use of Work Equipment Regulations 1998
- Electricity at Work Regulations 1989
- Workplace (Health, Safety and Welfare) Regulations 1992

For the purpose of this article we will be concerned with two of these.

- Electricity at Work Regulations 1989
- Provision and Use of Work Equipment Regulations 1998

The requirement for PAT testing and maintenance is to comply with the Electricity at Work Regulation 4 (2) which states that: "As may be necessary to prevent danger, all systems shall be maintained so as to prevent, so far as is reasonably practicable, such danger". It must also comply with Regulation 5 of the Provision and Use of Work Equipment Regulations 1998, which states that: "Every employer shall ensure that work equipment is maintained in an efficient state, in efficient working order and in good repair".

This means that any maintenance and frequencies of inspections and tests should be sufficient to prevent a dangerous occurrence, so far as is reasonably practicable.

The requirements of the Electricity at Work Regulations can be met by:

1. Performing in-service inspection and testing, which consist of three activities:
   i user checks
   ii formal visual inspections (without tests)
   iii combined inspections and tests
2. Performing maintenance or, if necessary, replacing the defective item of equipment (depending upon the results of the in-service inspection and testing), and
3. keeping up-to-date records that can be a means of showing compliance.

Information on the Electricity at Work Regulations can be found in the HSE publication 'The Memorandum of Guidance on the Electricity at Work Regulations 1989'.

When regular inspection and testing is carried out, this can form part of an ongoing maintenance programme, which in turn can be used by a competent person to determine the frequencies and level of inspections for the future on going programme.

It also allows the responsible person to monitor the ▶

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◀ condition of any equipment and in doing so the ongoing maintenance programme can be modified to ensure that equipment life expectancy can be achieved or safely extended.

Frequency of Testing

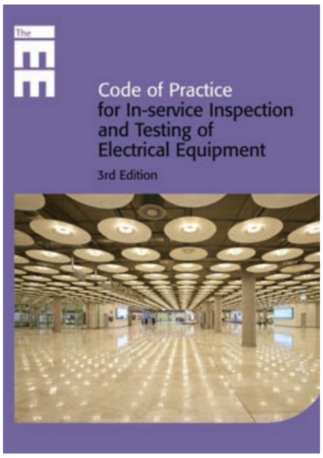
The code of practice for in-service inspection and test (COP), table 7.1 gives initial frequencies of inspections and tests. These “initial frequencies” are often taken out of context and used as absolute figures regardless of any analysis of an individual business requirement. This is a common and costly error of judgement and is made quite clear on page 36, item 7.4 of the same code of practice.

The table 7.1 in the COP should be used as a guide for the initial frequency of any inspection and tests. As soon as a history of regular testing, inspection and maintenance is produced or proved, the competent person responsible for the installation can determine whether the equipment test frequencies are acceptable and that sufficient protection is afforded to end users.

The frequencies that are used are based on general usage without any prior knowledge of the installation. Once a history of tests exists it may be acceptable to extend the frequencies beyond those used in Table 7.1. The level or time frame that the intervals can be extended is dependant on the competent persons technical judgement using the existing data, or history, with which to make an informed decision, which again, should be backed up with continual monitoring in order to confirm any decisions made.

It should be noted, however, that in certain circumstances that the frequencies may need to be reduced if the environment the equipment is operated in, is sufficiently harsh to degrade its safe working state, or it shows signs of requiring earlier maintenance periods due to breakdowns through damage or unreliability.

Consideration should be given to a piece of equipments position and accessibility will play a big part in its test frequencies, for example, if a television or monitor screen is wall mounted at high level and has little or no physical interaction with operators, it stands to reason that it’s frequency of test could be extended due to its inaccessibility and low risk of damage from user interaction.



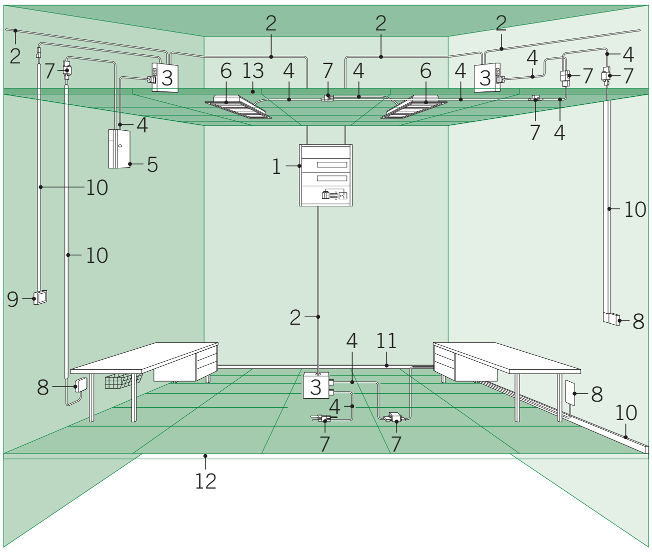
The Code of Practice describes the tests required and offers guidance on initial frequencies

Regular risk assessments remain key in all continuous monitoring PAT test plans and they should be re-visited regularly to prove their effectiveness. If this methodology is accepted and adhered to, the regular PAT testing programme can become a useful tool in product/asset reliability and effectiveness. This can only serve to reduce annual maintenance expenditure and ensure that the maximum life span of equipments can be achieved effectively and safely. ■

Specification of prefabricated wiring systems

Prefabricated wiring systems are an established alternative to conventional fixed wiring methods. They are often referred to in generic terms as ‘modular wiring’ or ‘plug-and-play’.

By Paul Sayer IEng MIET GCGI



Key

1 Distribution board
2 Mains cables (fixed installation)
3 Junction box
4 Factory wired cable set
5 Small distribution board
6 Lighting fixture
7 Distribution block
8 Socket-outlet for office desk
9 Switch
10 Pillar
11 Trunking/ducting
12 Suspended floor
13 Suspended ceiling

Fig 1 – Diagram of a typical prefabricated wiring system. Line diagram courtesy of BSI.

This article identifies key aspects of BS 8488 for the specification of prefabricated wiring systems and associated requirements in BS 7671 and highlights the responsibility on the designer to make the necessary electrical calculations.

When referring to this standard it is important to realise that its latest amendment is BS 8488:2009+A1:2010 Incorporating Corrigendum No 1. This latest amendment introduces requirements associated with electrical design calculations and BS 7671.

BS 8488 System safety standard

BS 8488 specifies safety requirements, together with associated tests, for prefabricated wiring systems that are within its scope. It includes systems that:

- incorporate installation couplers to BS EN 61535
- have a rated voltage up to and including 500 V a.c.
- are a permanent connection in fixed installations
- are intended to be installed by instructed or skilled persons, including the connection and disconnection of installation couplers

Application of the system

The standard provides a guide to use and applications, including those within suspended floors and ceilings. Fig 1 illustrates a typical prefabricated wiring system.

BS 8488 identifies that separate luminaires are a typical group of electrical equipment, which can easily be linked to a comprehensive lighting system by using a prefabricated wiring system (see fig 2).

Safety requirements and tests

Safety requirements and tests in BS 8488 include:

- provision for earthing

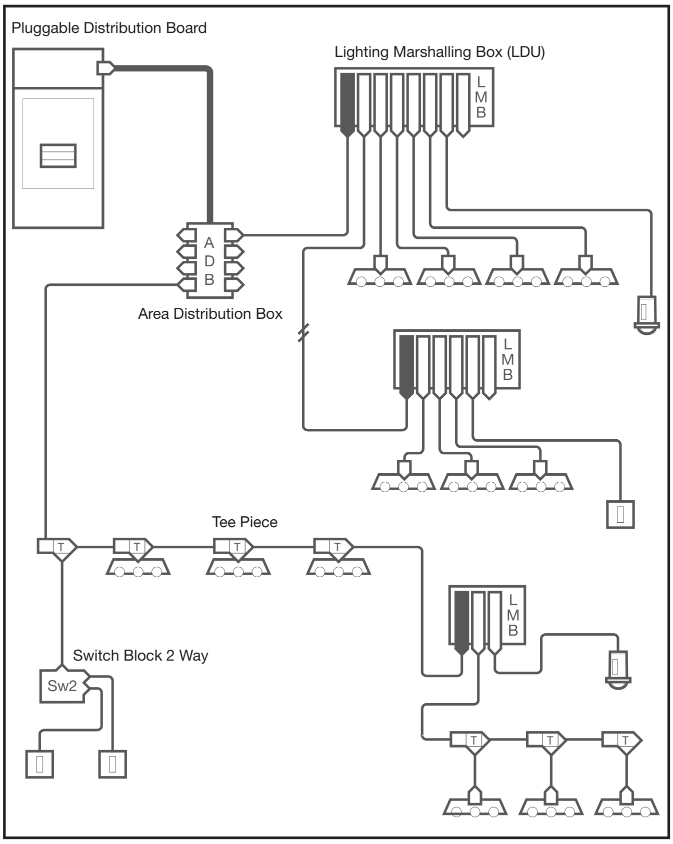


Fig 2 – Diagram of a typical prefabricated wiring system

- protection against electric shock
- resistance to solid objects, dust and moisture
- insulation resistance and electric strength
- clearances, and creepage distances
- resistance to heat, fire and tracking
- electrical connections
- routine tests during/after production

Rated current and wiring section conductor size

BS 8488 prescribes that the rated current shall be assigned according to a reference method defined by the manufacturer from BS 7671:2008, Table 4A2.

The rated current and cross-sectional area of the wiring section conductors, are determined on the following basis:

- the number of loaded cores defined by the manufacturer
- not being grouped with other wiring systems or cables
- not being in contact with thermal insulation
- the ambient temperature not exceeding 30°C
- the frequency of operating being not greater than 61Hz

Marking of wiring section rated current

BS 8488 requires that the rated current (A) and corresponding reference method from BS 7671:2008, Table 4A2 is distinctly and durably marked on each individual section (see fig 3, below).

System design to BS 7671 Additional documentation

BS 8488 requires the following details to be provided with each prefabricated wiring section, if they are necessary to ensure safe use and maintenance:

- instructions for safe use
- system design information, validating conformity with BS 7671*
- information required to facilitate inspection and testing for conformity with BS 7671*

*This information can be for the complete system and not provided with each wiring section.

It can be assumed that safe use includes protection against electric shock and adequate conductor current-carrying capacity. Therefore, it is likely that every BS 8488 system ▶

Fig 3 – Example of rated current marking on each individual section

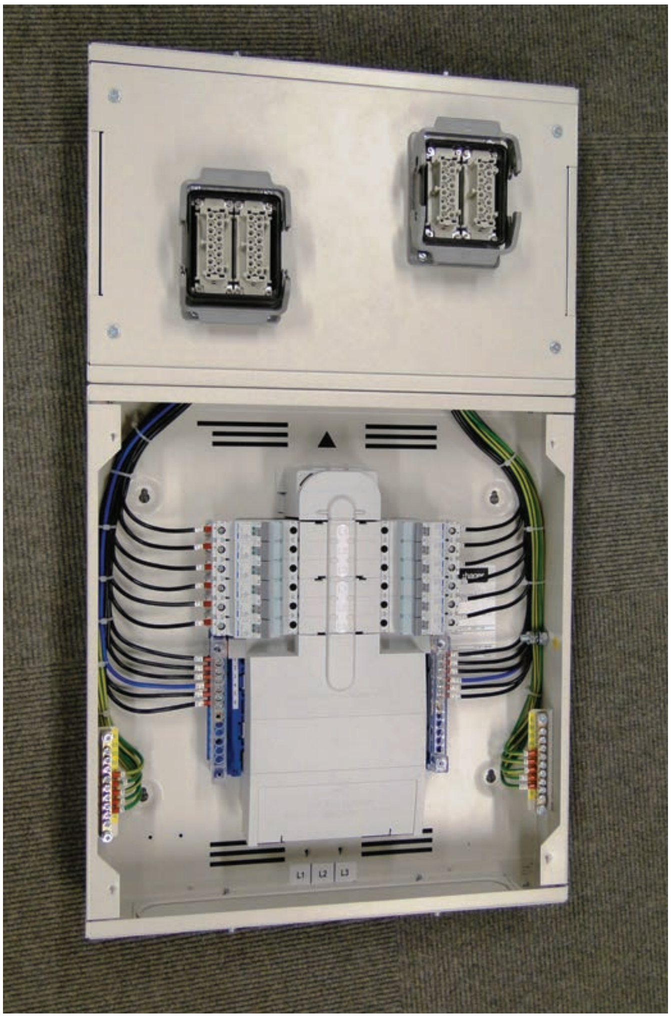


Fig 4 System distribution board to BS EN 60439-3 with distribution connectors to BS EN 61984

◀ will have been designed using basic calculations/circuit arrangements or dedicated calculation software and be provided with this design information.

BS 8488 states that the required current-carrying capacity of a system section should be determined by the system designer by applying rating factors for the specific installation conditions.

This current carrying capacity may be different from the rated current.

Design elements of the system

Design elements of the system, to be verified for compliance with BS 7671 may include:

- Cross-sectional area of live conductors
- Voltage drop
- Earth fault loop impedance for protection against electric shock (fault protection)
- Protective conductor cross-sectional area for protection against earth fault current
- Cross-sectional area of live conductors for protection against short circuit current

Connection to LV switchgear and controlgear assembly

A key requirement of BS 8488 specifies that a wiring system comprising a number of circuits connected to separate overcurrent protection shall originate from an LV switchgear and controlgear assembly complying with the relevant part of BS EN 60439, BS EN 61439 or BS EN 61534.

An appropriate standard for the system distribution board can be BS EN 60439-3, which is known as an MCB distribution board.

Where the LV switchgear and controlgear assembly contains the wiring system overcurrent protection, the connector to the assembly must conform to BS EN 61984 and the installation coupler shall conform to BS EN 61535 (see fig 4).

Through-connection arrangements

BS 8488 stipulates the applicable standards for the assembly containing couplers for the through-connection of circuits that emanate from separate overcurrent protection e.g. circuit-breakers.

One example of this arrangement is a multiple circuit distribution cable (known as a home run) originating from a distribution board and terminating at an assembly of couplers, known as an Area Distribution Box or ADB (see fig 5, below).

Depending upon the configuration of the assembly of couplers for through connection, BS 8488 requires conformity with BS 5733 or the relevant part of BS EN 60439, BS EN 61439 or BS EN 61534.

Circuit branching arrangements

Where a wiring system comprising a single circuit terminates at an assembly containing couplers intended for branching of the circuit, BS 8488 requires the assembly containing the couplers must comply as follows:

a. if it is not designated for the connection of luminaires, it must conform to BS EN 61535 and be classified as a distribution block

Fig 5 An assembly of couplers (known as an ADB) complying with BS EN 61439-2 connected to a multiple circuit distribution cable (known as a home run)

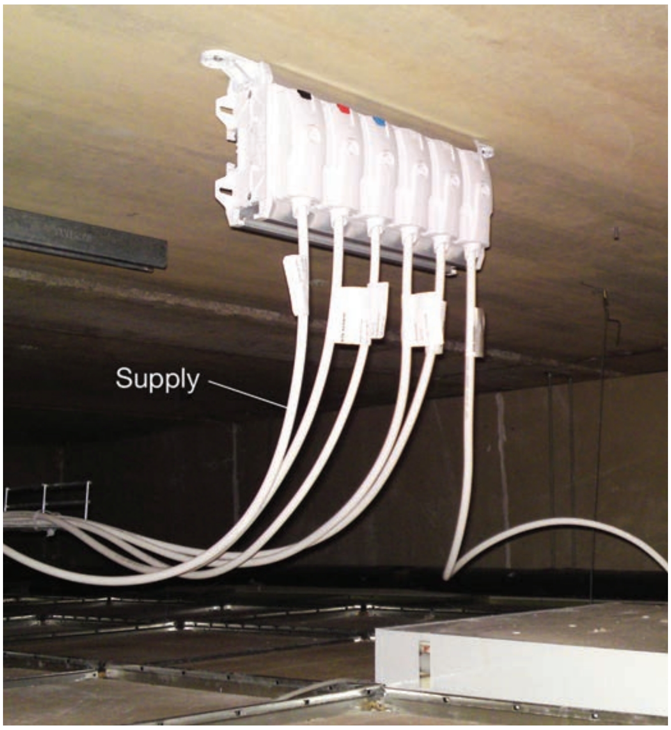


Fig 6 LDU complying with BS 5733:2010

b. if it is specifically designated for the connection of luminaires, it must conform to BS 5733 and be classified as a lighting distribution unit (LDU) as defined in BS 5733:2010 (see fig 6)

c. if it is not covered by (a) or (b), it must conform to BS 5733 or the relevant part of BS EN 60439, BS EN 61439 or BS EN 61534

Compatibility between different manufacturers

BS 8488 requires that prefabricated wiring systems use installation couplers that conform to BS EN 61535. Installation couplers are not required to be dimensionally compatible between different manufacturers. Therefore, the standard requires that a notice be marked on each section or in the manufacturer's instructions and/or literature, warning that prefabricated wiring systems manufactured to BS 8488 by different manufacturers might not be compatible nor safely interconnectable. Fig 7 illustrates one manufacturer's type of installation coupler used in a prefabricated wiring system.

Summary

BS 8488:2009+A1:2010 specifies the safety requirements, together with associated tests for prefabricated wiring systems. Three key requirements associated with BS 7671 are:

- Wiring sections must be marked with the rated current and corresponding reference method from BS 7671:2008, Table 4A
- System design information, validating conformity with BS 7671 shall be provided*
- Information required to facilitate inspection and testing for conformity with BS 7671 shall be provided*

*If they are necessary to ensure safe use and maintenance

If necessary, to ensure safe use and maintenance, BS 8488 requires information to be provided relating to system design and inspection and testing for conformity with BS 7671.

It can be assumed that safe use includes protection against electric shock and adequate conductor current-carrying capacity. Therefore, it is likely that every BS 8488 system will have been designed using basic calculations/circuit arrangements or dedicated calculation software and be provided with this design information.

Specifiers and installers have been keen to exploit the benefits of prefabricated wiring systems for a number of years. The development of BS 8488A1: 2010 now sets down the requirements for the design of pre fabricated wiring systems to conform with specific parts of BS 7671.

References and further reading

Standards referenced in this article can be purchased from the British Standards Institution (BSI) www.bsigroup.com.

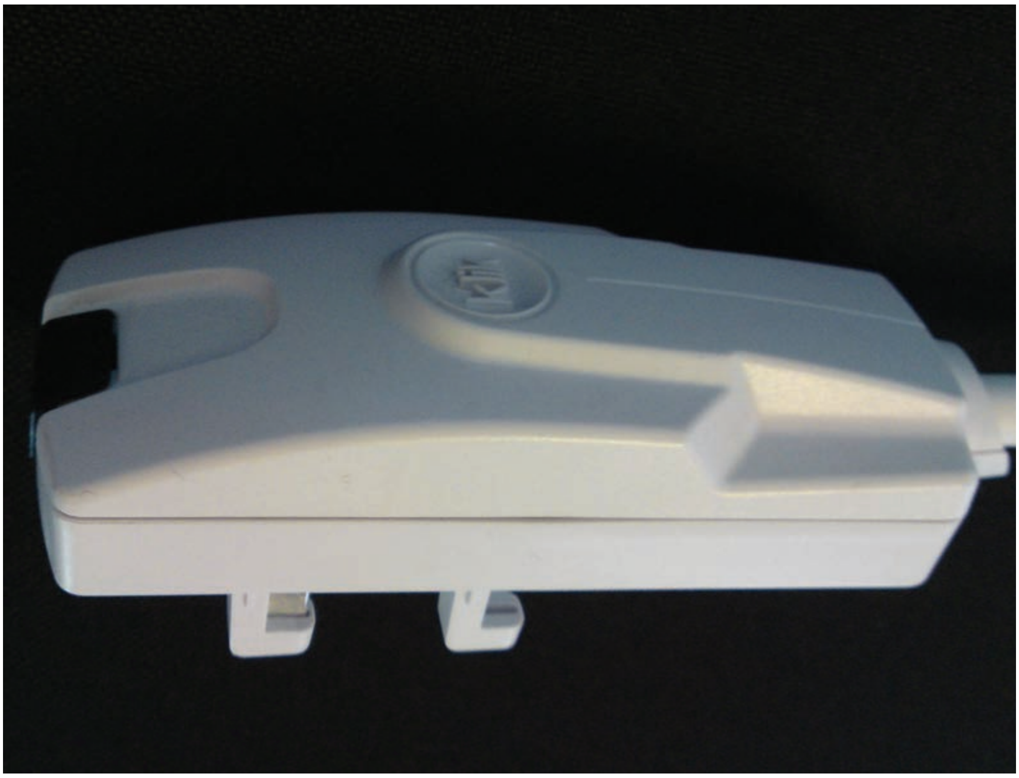


Fig 7 One manufacturer's type of installation coupler used in a prefabricated wiring system

Impact of Fuse Standard Developments on BS 7671:2008 (2011)

A previous edition of wiring Matters (summer 2010 Issue 35) discussed the developments of the low-voltage fuse standards that are currently referenced in BS 7671:2008. The first amendment BS 7671:2008 (2011), due for publication on 1 July will include a number of changes to reflect these developments, and this article will provide an overview for some of the changes.

By Paul Bicheno

Existing BS 7671:2008 Fuse Reference	BS 7671:2008 (2011) Amendment 1 Reference	Comment
BS 88-2.2	BS 88-2	This is a bolted type fuse that is recognised internationally as fuse system E
BS 88-6	BS 88-2	This is a clip in type fuse that is recognised internationally as fuse system G
BS 1361	BS 88-3	This is a cartridge type fuse that is recognised internationally as fuse system C

Table 1 – Summary of low-voltage fuse standard changes for first amendment

AS STATED in the previous issue (#35), the fuse standards BS 88-2.2 and BS 88-6 were withdrawn on 1 March 2010 and have now been replaced by BS 88-2:2010 and BS 1361 was also withdrawn on 1 March 2010 and has now been replaced by BS 88-3:2010. These updated BS standards reflect the developments of the IEC 60269 series and CENELEC EN 60269 series low-voltage fuse standards and include the specific fuse systems used in the UK.

Table 1 (above) summarises how this will affect the first amendment. Although the change appears simple, table 1 highlights that the existing BS 88-2.2 and BS 88-6 parts are now combined into the single BS 88-2 standard and the BS 1361 standard has been replaced by the BS 88-3 standard.

Engineers will need to appreciate the particular fuse standard part being referred to as the listed fuse systems will all have a 'BS 88' reference. It is also important to highlight that the first amendment has still not been finalised and is subject to editorial change; therefore this should be taken into account while reading this article, where the intention is to highlight key areas of change.

Part 2

Part 2 includes a section on symbols that are used in the Wiring Regulations. For fuses the symbols 'gG' and 'gM' are defined and currently align to the generic standard BS 88. However, due to the fuse standard changes, these now require specific reference to BS 88-2 to differentiate with BS 88-3 fuses.

Chapter 41

Regulation 411.4.6 plus its associated table 41.2 and Regulation 411.4.8 plus its associated table 41.4 currently both include values of maximum earth fault loop impedance (Zs) for commonly used ratings for fuse types BS 88-2.2, BS 88-6 and BS 1361. For tables 41.2 (a) and 41.4 (a) the fuse standard changes are likely to result in an updated title to clarify the types of fuse system, namely the bolted type E and the clip in type G as well as some updated values of Zs. The updated values of Zs are due to alignment to the time/current characteristics for the fuse types in BS 88-2 which are slightly different to those of BS 88-2.2 and BS 88-6.

For tables 41.2 (b) and 41.4 (b) the replacement of BS 1361 with BS 88-3 is likely to also result in an updated title to clarify the fuse type, namely the cartridge type C and updated values of Zs. However, ▶

EXEL fuse distribution board image courtesy of EATON Electric Ltd

◀ it should also be noted that certain nominal fuse ratings within the range given in BS 88-3 are also different to that of BS 1361 as shown in table 2. Lastly, Regulation group 411.8 Reduced low voltage systems has table 41.6 which includes values of Zs for BS 88-2.2 and BS 88-6 fuses. Therefore this will be updated to align with the characteristics given in BS 88-2.

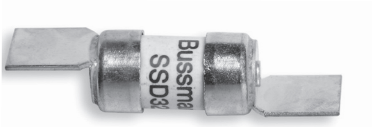
Chapter 43

Regulations 432.4, 433.1.2 and 433.1.5 currently include reference to BS 88.2-2, BS 88-6 and BS 1361. These now need to reflect the updated standards BS 88-2 and BS 88-3. In this instance an approach will be to provide a reference to 'BS 88 series' as this is an accepted method for referring to all parts of a standard and as such will include BS 88-2 fuse systems E and G and BS 88-3 fuse system C.

Chapter 53

Regulation 533.1 lists the recognised devices used for protection against overcurrent and includes BS 88.2-2, BS 88-6 and BS 1361. For consistency this will follow the same approach described previously for Chapter 43. Regulation 533.1.1.2 highlighted an amendment in the Draft for Public Comment (DPC) to include reference to BS 1361 fuses amongst other changes. However, this will now need to reference the replacement BS 88-3. Table 53.2, which will become Table 53.4 for amendment 1 due to the inclusion of Section 534 detailed in the DPC, includes ▶

BS 88-3 fuse system C



BS 88-2 fuse system G (clip in)

◄ an entry for BS 88 fuses. However, this again will need to refer to the BS 88 series to include the appropriate fuse types.

Appendix 1

Appendix 1 is normative and forms an essential place to check for the standards referenced in BS 7671:2008 and thus the first amendment. This will need to be updated to summarise the status of the various fuse standards already described and will be useful way of checking what updates have been implemented due to the cross referencing that is also included. To assist with understanding the impact of the fuse standard changes it is likely that entries to highlight that BS 88-2.2, BS 88-6 and BS 1361 have been withdrawn will be included.

Appendix 3

Appendix 3 currently includes figures (3.1, 3.3A, 3.3B) providing the time/current characteristic curves for BS 88.2-2, BS 88-6 and BS 1361 fuse ratings. The impact of the replacement standards BS 88-2 and BS 88-3 will be to align the associated characteristic data for these figures. It is worth highlighting that in the standards each nominal fuse rating includes a zone for the time/current characteristic, whereas in BS 7671:2008 a single curve representing the upper part of the zone is published to provide the most onerous values. To make this clearer the title of each associated table will be amended.

BS 1361 Fuse Ratings (Amps)	BS 88-3 Fuse Ratings (Amps)
5	5
15	16(1)
20	20
30	32(1)
45	45
60	63(1)
80	80
100	100
1: highlights different rating	

Table 2 – Comparison of BS 1361 and BS 88-3 fuse nominal ratings

As normally stated, for specific fuse data the manufacturer should be consulted.

Given that the replacement standards have different characteristics the cited figures will need updating to provide new values and curves where appropriate. For the replacement of BS 1361 with BS 88-3 it should again be noted (see table 2, above) that some of the nominal fuse ratings have a slightly different values.

For the replacement of BS 88-2.2 and BS 88-6 with BS 88-2 the alignment is likely to result in updated current values for some of the fuse ratings. Another useful point to highlight is the type G (clip in) fuses only have nominal values up to 125A. The values of current associated with the 0.4 and 5 Seconds disconnection times in these figures are used to generate the Zs values in tables 41.2 and 41.4, therefore the updated values for these figures has a direct impact on the tables. ■

Additional Information

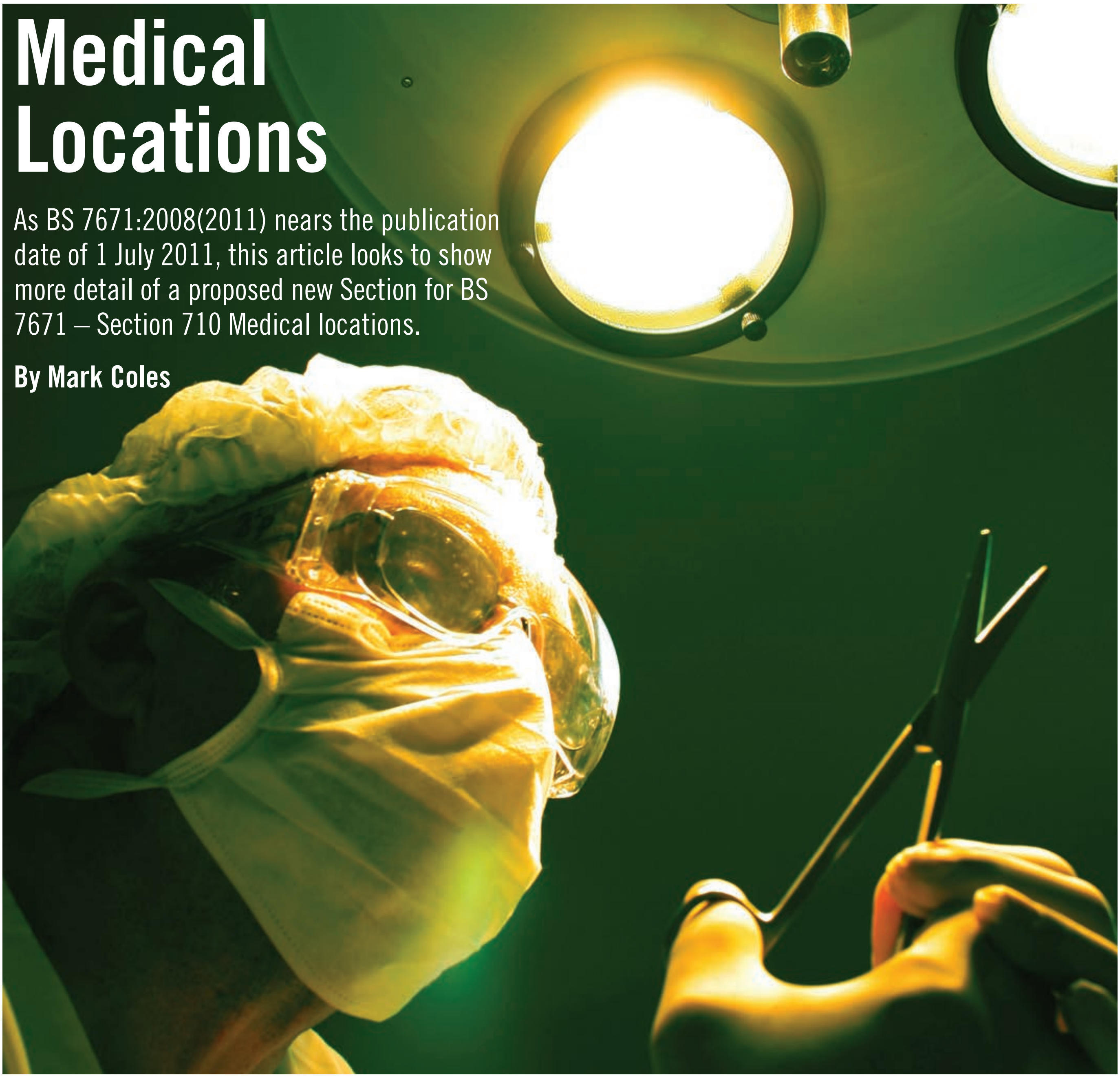
Subscription to 'British Standards Online' is a useful way of checking the status of Standards http://shop.bsigroup.com/en/Navigate-by/BSOL/

The British Electrotechnical & Allied Manufacturers Association (BEAMA) includes membership of fuse manufactures who can provide specific technical information on low-voltage fuse. The BEAMA website address is www.beama.org.uk

Fuse images courtesy of CooperBussman www.cooperbussman.com

Fuse distribution image courtesy of EATON Electric www.eaton.com

BS 88-2 fuse system E (bolted)



Medical Locations

As BS 7671:2008(2011) nears the publication date of 1 July 2011, this article looks to show more detail of a proposed new Section for BS 7671 – Section 710 Medical locations.

By Mark Coles

SECTION 710 has its origins in IEC 60264-7-710, the current and first edition being 2002. As with other areas of BS 7671 and the Treaty of Rome, the agreement is that the UK adopts the technical intent of European CENELEC Harmonised Documents. At present though, the HD has yet to be published but it is in the final stages of development.

Work on IEC 60364-7-710 began in 1988 and it has been a mammoth task to achieve standardisation across Europe in medical locations.

Scope of Section 710

The Scope of Section 710 is intended to cover areas such as hospitals, private clinics, medical and dental practices, healthcare centres, dedicated medical rooms in the workplace and veterinary clinics. There are, of course, many different types of medical procedure and the new section is arranged to reflect the electrical risks to patients and medical staff.

The risks in medical locations

The proposed new section is allocated a 'Seven' designation, i.e. included in Part 7 of BS 7671, which recognises the onerous nature of the procedures or task that will take place in these areas.

Often, when a medical or clinical procedure takes place, the skin may be broken and the patient could be bleeding. The natural protection of the human body against electric shock can be considerably reduced when certain clinical procedures are being performed on it. A patient may lose natural or involuntary reactions to voltages and currents as the skin resistance has been broken down or their defensive capacity has been reduced. During invasive operations, such as open-heart surgery, very small voltages (of the order of a few mv) can interfere with the heart's pumping action leading to ventricular fibrillation.

Designation of areas

Rather like other sections of BS 7671, such as bathrooms or swimming pools, where more onerous practices occur or the risk of electric shock increases, areas are grouped according to the expected risk.

Medical Locations are allocated a grouping signifier, as follows:

group 0
Medical location where no applied parts are intended to be used and where discontinuity (failure) of the supply cannot cause danger to life.

Examples of group 0 include consultant examination rooms or massage rooms.

group 1
Medical location where discontinuity of the electrical supply does not represent a threat to the safety of the patient and applied parts are intended to be used externally or invasively to any part of the body except where group 2 applies.


Fig 1 Medical trunking

group 2
Medical location where applied parts are intended to be used, where discontinuity (failure) of the supply can cause danger to life, in applications such as intracardiac procedures or vital treatments and operations.

It is important to be aware of the definition of an applied part:

Applied part
Part of medical electrical equipment that in normal use necessarily comes into physical contact with the patient to enable ME equipment or an ME system to perform its function.

Protection against electric shock
As medical locations of groups 1 and 2 have more onerous practices occurring within when compared to group 0, a 25 V a.c. or 60 V d.c. limit is imposed between exposed-conductive and/or extraneous-conductive-parts under fault conditions. Group 0 is a location where applied parts are not intended to be used and is less onerous, in terms of risk of electric shock, when compared to groups 1 and 2, therefore, the common rules of BS 7671 apply in group 0.

The reduced 25 V a.c. limit has been seen before in BS 7671, it was in the 16th Edition, Section 605 Agricultural and Horticultural premises. The requirement disappeared when the 17th Edition was published but now we see its reintroduction.

Further, in light of the reduced voltage limit, the disconnection times for 230 v Uo circuits in medical locations of group 1 and group 2 are also modified from the general rules, i.e. Parts 1 - 7: ▶

Fig 2 Services

◀ Note that with all Part 7 requirements, where an exception is not given, the requirements of the general rules apply, therefore, the disconnection times of Chapter 41 are applicable to group 0.

If disconnection cannot be achieved in the required time, BS 7671 requires other additional methods be utilised to protect those in the area.

Additional protection: IT system

In medical locations group 2, an IT system is to be used for final circuits supplying medical electrical equipment intended for life support systems, surgical applications and electrical equipment used in the patient environment.

An IT system, (I, Isolated; T, Terre), as the term describes, is isolated from earth, usually by means of an isolating transformer. During an important surgical operation, should an earth fault develop, the last thing anyone needs is for automatic disconnection to occur.

Therefore, in the event of a first fault, an insulation monitoring device will warn of the insulation failure, thus allowing the procedure to continue under the managed circumstances. Note that a short-circuit, or fault between line and neutral or line to line, will always disconnect upon presentation of a first fault. The insulation monitoring device (IMD) is to be in accordance with BS EN 61557-8:2007 and the device should alert of insulation failure when resistance has decreased to 50kΩ. If the response value is adjustable, the lowest possible setpoint value is to be ≥ 50 kΩ. A test device should be provided and the response and alarm-off time shall be ≤ 5 s.

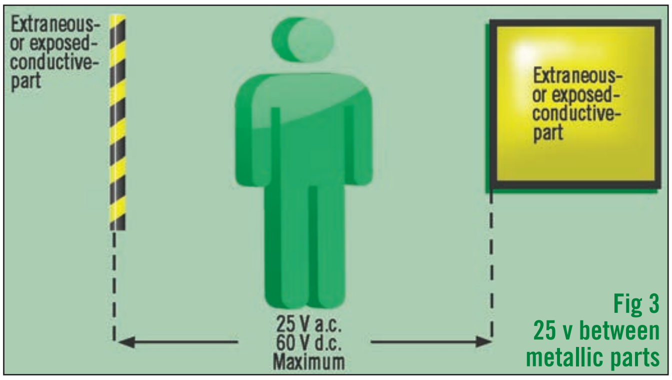


Fig 3
25 v between metallic parts

Additional protection: Supplementary equipotential bonding

In each medical location of group 1 and group 2, supplementary equipotential bonding should be installed between the following parts of the patient environment:

- protective conductors
- extraneous-conductive-parts
- screening against electrical interference fields, if installed
- connection to conductive floor grids, if installed
- metal screens of isolating transformers, via the shortest route to the earthing conductor

Supplementary bonding will limit any potential risk due to the effect of leakage currents appearing within the locations due to faults. Chapter 41 recognises that where

	a.c.	d.c.
TN	03.s	0.5s
TT	0.05s	0.1s

Table 1 - Disconnection times

disconnection will not occur in the required time, supplementary bonding can also be used to limit any voltages available within the locations.

Patient leakage current flowing through an earthed patient is normally greatest when the equipment's connection to the means of earthing is lost. A limit is set to the amount of leakage current which can flow in the patient circuit when the protective earth conductor is disconnected. Patient leakage currents of the order of 10 μA have a probability of 0.2% of causing ventricular fibrillation when applied through the heart.

In order to limit any potential rise due to the effect of leakage current, the voltage between the hard-wired system and the ERB (Earth Reference Bar) should not exceed 20 mV. A further voltage of 30 mV is allowed between the exposed conductive parts of the medical equipment and the supply cord (BS EN 60601-1).

This means that the maximum obtainable voltage between the exposed conductive parts of the medical equipment and the ERB should exceed not 50 mV. To limit potentials, the maximum resistance between the socket-outlet terminals, fixed equipment terminal or extraneous metalwork should be no greater than 0.2 Ω . ▶

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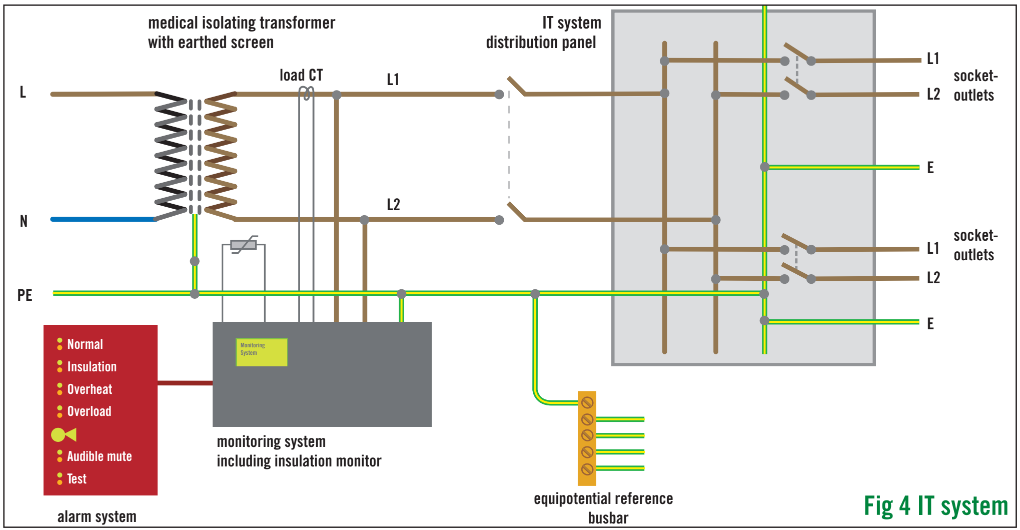

Fig 4 IT system

◀ To aid the reduction of electromagnetic interference, radial wiring methods are to be followed to avoid earth-loops, hence, supplementary bonding in medical location group 2 should consist of single conductors installed between the equipment and an equipotential reference bonding busbar, located in or near the medical location. The connections should be arranged so that they are accessible, labelled, visible and can be disconnected individually.

Safety lighting

It is likely that each emergency luminaire will incorporate its own battery to provide power when the electrical supply has failed. In addition to the requirements given in any lighting code, the necessary minimum illuminance shall be provided for the following:

group 1 – in each such room at least one luminaire shall be supplied from the power supply source for safety services

group 2 – minimum of 90% of the lighting shall be supplied from the power source for safety services.

The luminaires of the escape routes shall be arranged in alternate circuits.

Periodic inspection

In a step not usually taken by BS 7671, recommended periods are given for the periodic inspection of installations falling within the Scope of Section 710. Up to now BS 7671 has recommended that installations are periodically inspected in line with the requirements of the IET's Guidance Note 3 – Inspection and Testing. Therefore, in addition to the requirements of Chapter 62, the following procedures, appearing as a note, are recommended at the given intervals:

- Annually: Complete functional tests of the insulation monitoring devices (IMDs) associated with the medical IT system including insulation failure, transformer high temperature, overload, discontinuity and the acoustic/visual alarms linked to them.
- Every three years: Measurements of leakage current of the output circuit and of the enclosure of the medical IT transformers in no-load condition
- Annually: Measurements to verify that the resistance of the supplementary equipotential bonding is within limits.

Older installations

BS 7671 is the standard to follow when designing a new electrical installation or carrying out alterations and additions to an existing installation but the standard is not to be applied retrospectively.

There are many installations in medical locations in the UK that do not currently resemble the proposed requirements of BS 7671:2008(2011). Such installations will have been installed and maintained to the requirements of Healthcare Technical Memorandums (HTM). In time, the requirements of Section 710 of BS 7671 will be implemented in all medical areas as new building and refurbishment work takes place. ■

Thanks to: M. Al-Rafaie - Private Healthcare Consultant, Paul Harris - IHEE, Michael Bernard - AXrEM, Graeme Del - Cableflow International Ltd and Sean Hoban - WCH.

Further reading

IET Guidance Note 7 – Special Locations; IET Guidance Note 3 – Inspection and Testing; IEC 60364-7-710 – Requirements for special installations or locations – Medical Locations HTM 06-01 A and B

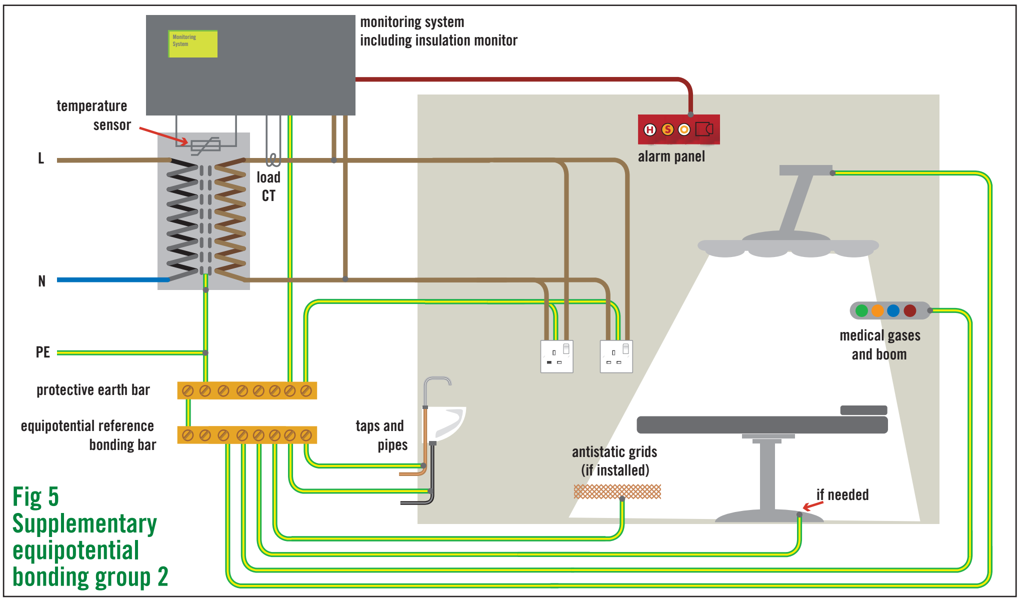

Fig 5 Supplementary equipotential bonding group 2

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Surge Protection

Why do we need it?

By Geoff Cronshaw

MORE AND MORE sensitive electronic equipment such as computers, electronic process controls, telecommunications systems and point-of-sale terminal equipment is in use as time goes by. Society is now heavily reliant on the continuous and efficient running of such systems. Electronic equipment today is much smaller and less energy from transients is required to damage this equipment.

Proposed new section 534

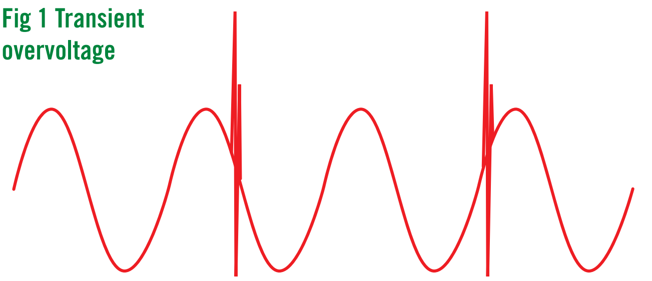
This is the second of two articles specifically on the proposed new Section 534 – Selection and erection of surge protection devices (SPDs) which is planned for inclusion in Amendment number 1 of BS 7671:2008. Note: The article is based on the draft for public comment and therefore the actual requirements may change.

In this article we take a closer look at transients compared with other forms of electrical disturbance, the different types of surge protection devices, and the selection and installation of surge protection devices.

Transient overvoltages

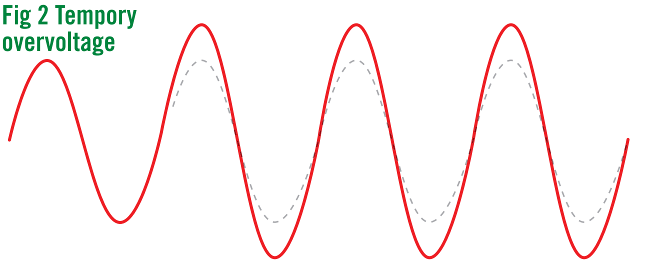
Both lightning strikes and electrical switching can inject what are called transient overvoltages into an installation. Transient voltages are usually only a few micro seconds in duration. However their peak value can reach 6kV. Normal electronic equipment cannot withstand this level of voltage. An example of a transient overvoltage is shown below.

Fig 1 Transient overvoltage



Other forms of electrical disturbance include temporary overvoltages, which are not transients and can last a few seconds but are usually at a much lower voltage. A temporary overvoltage is considered to be any voltage greater than the nominal voltage (Uo) plus 10%, see Fig 2. The permitted tolerance is +10%/-6% which gives a permitted voltage range of

Fig 2 Tempory overvoltage



216.2-253V. Temporary overvoltages are often caused by HV switching and fault clearing operations on the HV network.

In comparison, harmonics are a steady-state disturbance compared with short-term transient overvoltages. Harmonics are generally caused by non-linear loads such as switched mode power supplies of computers and discharge lighting see Fig 3. Regulations 523.6.1 and 523.6.3 of the 17th edition recognise the effect of triple harmonic currents in the neutral conductor and the need to take account of it. In electrical installations there is a particular problem in three-phase circuits.

The third and other triple harmonics combine in the neutral to give a neutral current that has a magnitude equal to the sum of the third harmonic content of each phase. The heating effect of this neutral current could raise the temperature of the cable above its rated value and damage the cable.

Power-cuts or blackouts as shown in Fig 4 are total breaks in the supply.

Switching events

As mentioned in a previous article, generally any switching operation, fault initiation or interruption in an electrical installation is followed by a transient phenomenon in which overvoltages can occur. The sudden change in the system can initiate damped oscillations with high frequencies (determined by the resonant frequencies of the network), until the system is stabilised to its new steady state. The magnitude of the switching overvoltages depends on several parameters, such as the type of circuit, the kind of switching operation (closing, opening, restriking), the loads and the protection device. In most cases, the maximum overvoltage is up to twice the amplitude of the system voltage but higher values can occur, especially when switching inductive loads.

Fig 3 Harmonics

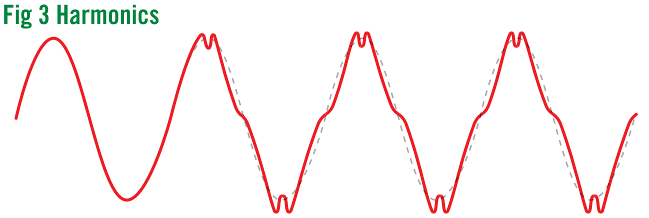
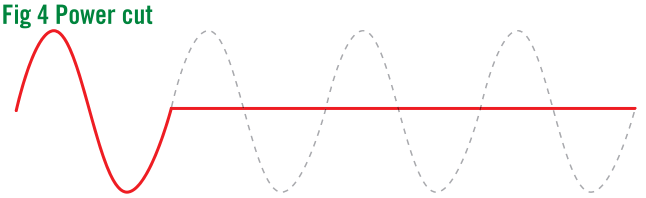


Fig 4 Power cut



Inductive circuits

The instantaneous voltage that appears across an inductor is given by

$$v = L\frac{di}{dt}$$

Where,

v = the instantaneous voltage across the inductor

L = the inductance in Henrys

$\frac{di}{dt}$ = instantaneous rate of current change expressed in units of amps per second.

Atmospheric events

The current contained within a lightning strike varies considerably with the atmospheric conditions. However it is understood that values of 200 kA are possible. Associated with this sudden discharge of current is a magnetic field that surrounds the lightning perpendicular to the direction of travel. Lightning can impress a voltage onto a low voltage power network in a number of different ways. Resistively, inductively or capacitively. A lightning strike direct to ground, overhead lines or building protection lattice will inject a huge amount of charge which flows, in the form of current, away from the point of injection. As it passes along its routes, potential differences are created and if the routes coincide with building structures or cabling then these voltages are seen within the installation. In addition the magnetic field associated with a lightning strike can induce a voltage in any metallic structure the magnetic flux cuts. Also, if a building is struck, it is the objective of the lightning rod and conductor tape to pass the current to ground to help protect the structure from physical damage. However the current flowing through the tape will generate its own magnetic field which can induce transients within the buildings cabling system.

As detailed within BS EN 62305 ‘Protection against lightning’, surges present a risk of dangerous sparking or flashover leading to possible fire and electric shock hazards. Surges also present risk of disruption, degradation and damage to electrical and electronic equipment leading to costly system downtime.

SPD operation.

The proposed new Section 534 contains requirements for the installation of SPDs to limit transient overvoltages where required by Section 443 of BS 7671:2008 or where otherwise specified by the designer.

An SPD is a device that is intended to limit transient over voltages and divert damaging surge current away from sensitive equipment. SPDs must have the necessary capability to deal with the current levels and durations involved in the surges to be expected at their point of installation. All SPDs are to comply with BS EN 61643. ▶

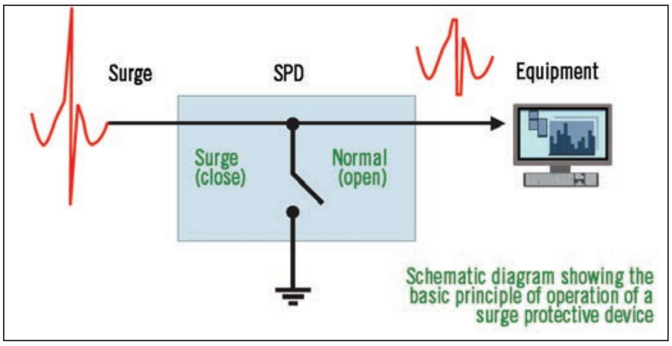


Fig 5 When an overvoltage is detected the SPD begins to conduct

◀ As mentioned in a previous article, SPDs can operate in one of two ways, based on the component technologies within them. One way is as a voltage switching device where under normal conditions, the device is an open circuit. However at a certain threshold voltage the SPD conducts and diverts the current through it. It has two states ON and OFF, hence the name of voltage switching. Spark gaps, gas discharge tubes, thyristors (silicon controlled rectifiers), and triacs are examples of voltage switching devices.

Another way is as a voltage limiting device. Voltage limiting type SPDs again present an open circuit under normal circuit conditions. When an over voltage is detected the device begins to conduct, dropping its resistance dramatically such that the overvoltage is limited and the surge current is diverted away from the protected equipment. Metal Oxide Varistors (MOVs) are a common example of voltage limiting devices. Advanced SPDs often utilise hybrid technologies combining voltage switching with voltage limiting components.

Selection of SPDs

All SPDs are to comply with BS EN 61643. Typically, Type 1 SPDs are used at the origin of the installation, Type 2 SPDs are used at distribution boards and Type 3 SPDs are used near terminal equipment. Combined Type SPDs are classified with more than one Type, e.g. Type 1+2, Type 2+3.

Standards such as BS EN 61643 series (components for low-voltage surge protective devices) define the characteristics of lightning and voltages to enable reliable and repeatable testing of SPDs (as well as lightning protection components). Although these waveforms may differ from actual transients, the standardised forms are based upon years of observation and measurement (and in some cases simulation). They provide a fair approximation of the real-world transient.

The most important aspect in selecting an SPD is its voltage limiting performance during the expected surge event – this parameter is the SPD's protection level Up, also known in industry as the SPD's let-through voltage. An SPD with a low limiting voltage or lower (hence better) protection level reduces the risk of flashover causing insulation breakdown and associated hazards (fire or electric shock) as well ensure adequate protection of the equipment.

It should also be noted that selecting an SPD with a lower value Up (compared to the equipment's damage threshold or withstand level UW) results in a lower stress to the equipment which may result not just in a lower probability of damage, but also a longer operating life. As such, the risk assessment within BS EN 62305 defines SPDs with low voltage protection levels Up as enhanced SPDs.

According to BS EN 62305, Type 1 enhanced SPDs should have a protection level Up (or let-through voltage) no more than 1600 V whilst Type 2 and Type 3 SPDs should have a protection level Up no more than 600 V when tested in accordance with BS EN 61643 series.

Given that transients can be present between all conductors or modes (for example line to earth, line to neutral and neutral to earth) it is important to ensure good protection level Up in all such modes.

Connection of SPDs

One important point to note is that in order to gain maximum protection the supply conductors of the SPD shall be kept as short as possible, to minimise additive inductive voltage drops across the conductors.

Section 534 contains a number of requirements for the Connection of SPDs depending on the type of supply and system earthing. Therefore, for example, Section 534 requires that SPDs at or near the origin of the installation (if there is a direct connection between the neutral conductor and the protective conductor at or near the origin) shall be connected between each line conductor and the protective conductor/ main earthing terminal which ever is the shorter distance.

SPD installation in conjunction with RCDs

Clause 534.2.6 of Section 534 is concerned with SPDs and their installation with respect to RCDs. It is ideal to install SPDs on the supply side of the RCD as this prevents the RCD from tripping during a surge event. Where this is not possible and SPDs are installed on the load side of an RCD transients could therefore trip the RCD. In this situation, 534 recommends the use of RCDs which are resistant to surge currents of up to 3 kA.

SPD status indication.

SPD status indication needs to be provided by a status indicator local to the SPD itself and/or remote, that the SPD no longer provides (or provides limited) overvoltage protection.

Further information

Important: this article is only intended as a brief summary of possible forthcoming requirements in BS 7671. Persons involved in this area should seek specialist advice. For further information on the installation of surge protective devices see HD 60364-5-534.

Conclusion

Section 534 is expected to be included in amendment number 1 of BS 7671:2008 depending on the decision of the National Wiring Regulations Committee (JPEL/64). The first amendment to BS 7671:2008 is expected to be issued on the 1st July 2011 and planned to come into effect on the 1st January 2012 subject to the decision of the National Committee.

Acknowledgements

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