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IET Code of Practice for Electric Vehicle Charging Equipment Installation, 4th Edition

By EUR ING Graham Kenyon CEng MIET, Managing Director, G Kenyon Technology Ltd, Chair IET Wiring Regulations Policy Committee, Chair JPEL/64 Sub-Committee D.

Introduction

The 4th edition of the IET *Code of Practice for Electric Vehicle Charging Equipment Installation* is now available.

There is a rapid pace of development in the electric vehicle (EV) sector. In addition to addressing Amendment 1 (2020) to BS 7671:2018 + A1:2020, the publication contains several important and informative updates, including:

- guidance on the selection and use of open-circuit protective earth and neutral (open PEN) detection devices for use in installations in which protective multiple earthing (PME) conditions apply;
- guidance for on-street installations (updated to cover a wide range of situations);
- a new approach to determining load unbalance in three-phase installations;
- guidance on the dangers associated with so-called ‘TT islands’, and safe separation distances below ground for TT earth electrodes from buried metalwork connected to other earthing systems; and
- extended guidance on smart integration and vehicle-to-grid.

This article provides some insight into these updates.

The Issue 79, March 2020 Wiring Matters article by Geoff Cronshaw provides an overview of the changes introduced in Amendment 1 (2020).

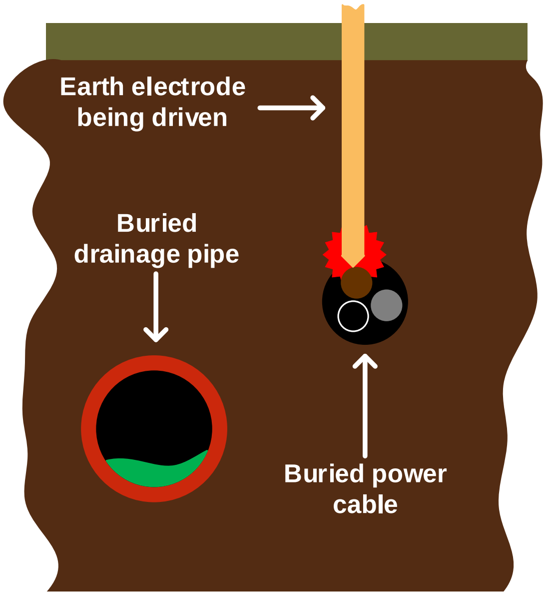
Emerging issues with ‘TT islands’

Since the publication of BS 7671:2018 *Requirements for Electrical Installations* (IET Wiring Regulations, 18th Edition), installers have increasingly adopted a TT earthing arrangement to comply with Regulation 722.411.4.1 of BS 7671. The installation practices for this approach have not always achieved an improvement in safety. The principal safety issues encountered when installing this type of system for charging points are:

(a) **simultaneous contact** between exposed-conductive-parts, such as the vehicle on charge (connected to the TT earthing system) and exposed metalwork connected to the PME earthing system, for example, building cladding, or exposed-conductive-parts of other outdoor equipment. Extensive guidance for this was included in previous editions of the IET *Code of Practice for Electric Vehicle Charging Equipment Installation*.

(b) **risk of striking buried services** when installing earth electrodes (**Figure 1**), especially when driving earth rods. It is not always possible to detect all such buried services and the alternative is excavation.

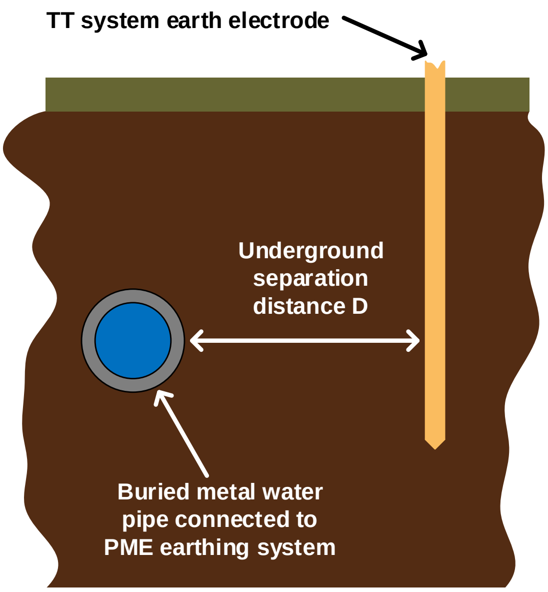
Figure 1: Risk of striking buried services when driving rods



(courtesy of G. Kenyon Technology Ltd)

(c) **separation below ground** between the TT earth electrode and buried metalwork connected to the PME earthing system (**Figure 2**). If the separation is not great enough, the EV charging equipment is effectively connected to the PME earthing system and no protection is offered.

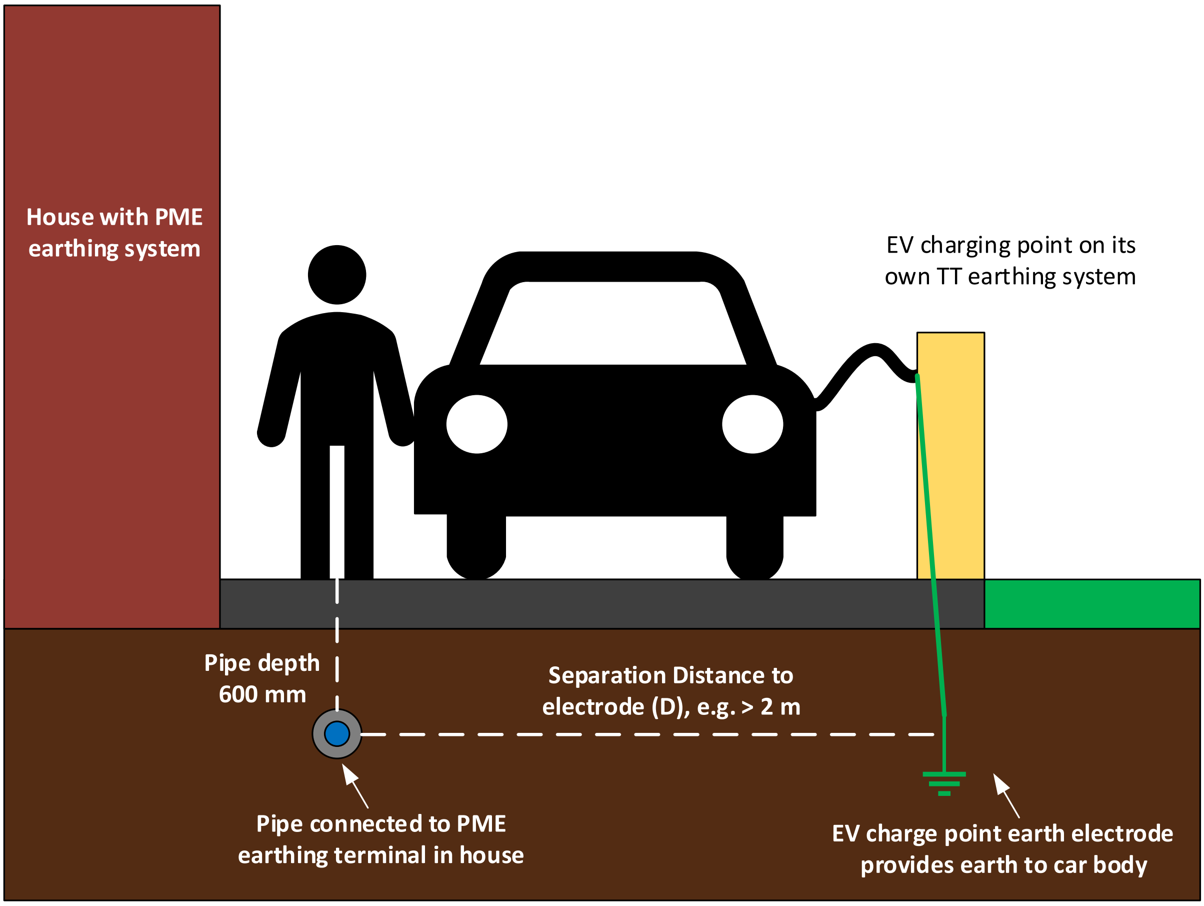
Figure 2: Separation from buried metalwork connected to PME earthing system



(courtesy of G. Kenyon Technology Ltd)

(d) **return of touch potential:** this may be caused by buried conductive parts connected to the PME earthing system affecting the potential of ground on which a person who may come into contact with the vehicle on charge is standing (**Figure 3**).

Figure 3: Possible return of touch potential in some conditions because of electrode separation and coincidentally located buried conductive parts connected to a PME earthing system



(courtesy of G. Kenyon Technology Ltd)

New guidance is included on these topics in Annex H to the Code of Practice. Table H1 provides recommended separation distances below ground for earth electrodes, although installers should be aware that some distribution network operators (DNOs) may require a greater separation distance.

Installers may have difficulty in establishing precisely what is buried in the vicinity of the intended earth electrode location. In certain situations, particularly smaller curtilage properties such as typical residential housing, addressing all of these constraints may not be practicable. Note 6 to Regulation 722.411.4.1 in Amendment No. 1 (2020) highlights this.

It is clear that different approaches are required, and the 4th edition of the IET Code of Practice has some guidance on alternatives.

Open PEN detection devices

One solution to the issues with separate TT earthing systems for EV charging equipment is the use of open PEN detection devices. These devices are relatively new and at present there are no product-specific standards. The 4th edition provides the guidance that installers need to select and install these new protective devices, in Section 5.3.5.

Regulation 722.411.4.1 (iii), (iv) and (v) of BS 7671 relate to the different technologies currently available for such devices.

Open PEN detection devices of the type described in Regulation 722.411.4.1 (iv) rely on a measurement of the line to neutral utilization voltage at the charging point. These devices are only suitable for installations with single-phase supplies and should not be used for single-phase charging equipment in a three-phase installation.

Open PEN detection devices that achieve the requirements of Regulation 722.411.4.1 (iii) currently adopt two approaches:

- monitoring of the voltage between the protective conductor of the charging point and a measurement earth electrode. In a similar manner to TT earth electrodes, the measurement earth electrode should be separated from buried metalwork connected to the PME earthing terminal, or a voltage will not be detected. Guidance is provided in the new Annex I to the Code of Practice, which recommends a minimum separation distance, and voltage trip threshold, for open PEN detection devices that use a measurement earth electrode. This type of device may be used in either single-phase or three-phase installations.

- monitoring of the voltage between the protective conductor or neutral at the charging point and a measurement point derived from the phase conductors of a three-phase supply. This type of device is only suitable for use in three-phase installations, but may be used to protect single-phase charging points in a three-phase installation, provided the device is fitted upstream in a three-phase part of the installation that supplies the single-phase charging point. No earth electrode is required.

Open PEN detection devices that do not operate in precisely the manner described in Regulation 722.411.4.1 (iii) or (iv) also exist. They may be used, according to Regulation 722.411.4.1 (v), provided that they offer at least the same level of safety.

An important feature of the wording in Regulations 722.411.4.1 (iii) and (iv) is that the devices shall not be capable of re-closing onto the hazardous conditions they are intended to detect . In order to provide equivalent safety, a device described in Regulation 722.411.4.1 (v) must also have the same feature.

Some types of open PEN detection device may have limitations when used in a prosumer’s electrical installation that is operating in island mode.

New guidance on balanced three-phase systems

Regulation 722.411.4.1 (i) of BS 7671 permits the direct connection of EV charging equipment to the PME earthing terminal in installations where the loading on the phases will be sufficiently well-balanced to prevent the PME earthing terminal rising above 70 V rms during open-circuit PEN conductor conditions.

In previous editions of the IET *Code of Practice for Electric Vehicle Charging Equipment Installation*, this approach was considered to be of limited practical use. However, further research in this area has helped uncover the limiting unbalance conditions, and the amount of imbalance required may be quite surprising.

A new approach developed by the author is published in Annex J of the IET Code of Practice. Lengthy calculations using the formulas in A722.1 and A722.2 of BS 7671 are no longer necessary. Knowing only the load currents of each of the three phases for the worst-case unbalance conditions, designers and installers can choose to use either:

- a rule of thumb, as per Annex J, item J4 (**Figure 4**); or
- for a more accurate approach, a look-up table, Annex J, Table J1, that uses the ratios of the load currents of each of the two most lightly loaded phases to the load current of the most heavily loaded phase.

Figure 4 Rule of thumb relating to 722.411.4.1 (i)
(see J4, Annex J, to the IET *Code of Practice for Electric Vehicle Charging Equipment Installation*, 4th Edition)

If the largest line current in the system is I_{LA}, the second largest is I_{LB} and the smallest line current is I_{LC}, then the PME earthing terminal for EV charging equipment can be used where either:

(a) $I_{LB} \geq 60\ \%\ I_{LA}$ and $I_{LC} \geq 40\ \%\ I_{LA}$

OR

(b) $I_{LB} \geq 50\ \%\ I_{LA}$ and $I_{LC} \geq 50\ \%\ I_{LA}$

Note: It is imperative that I_{LA}, I_{LB} and I_{LC} represent the worst-case unbalance conditions anticipated in the installation.

Vehicle as storage guidance

Section 10 of the IET Code of Practice discusses vehicle as storage. The guidance has been enhanced to discuss the relationship envisaged between a vehicle as storage and the grid. The guidance now includes special considerations for vehicle-to-grid services, and considers the vehicle as storage system as part of an integrated system with other microgeneration or local generation schemes.

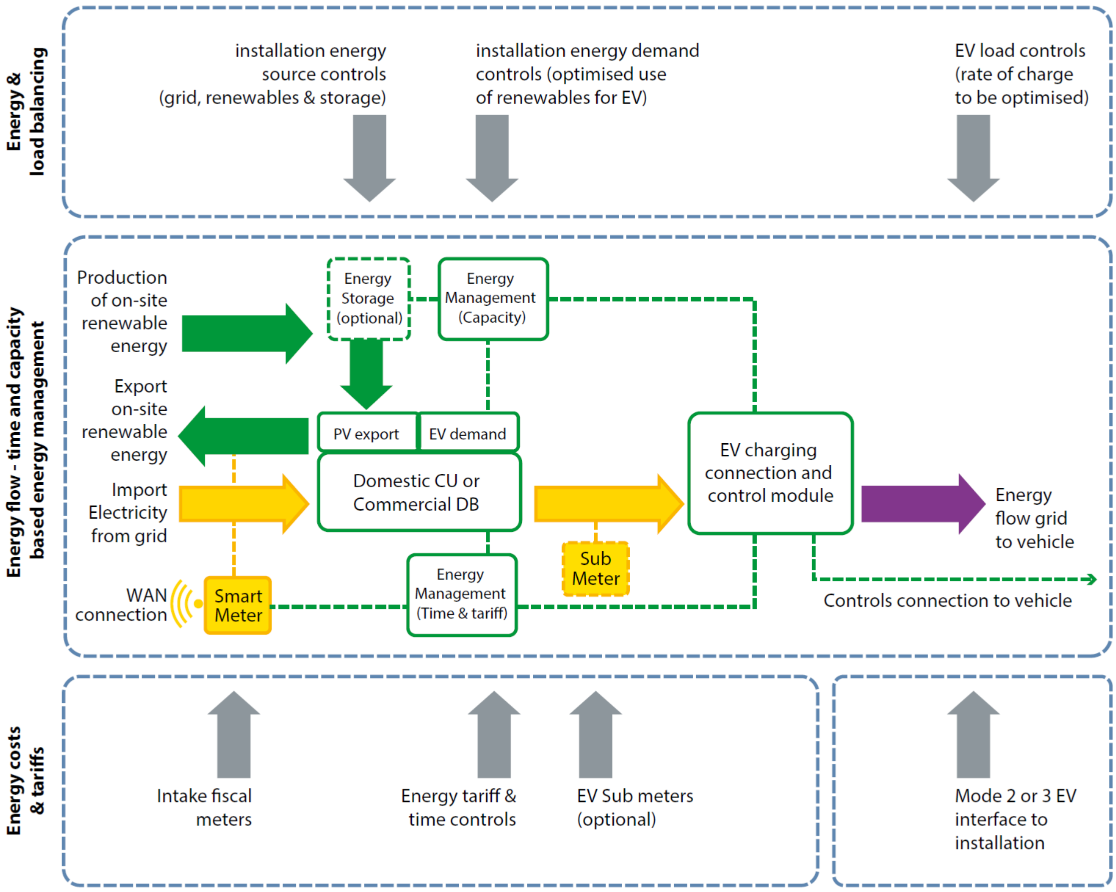
Earthing arrangements for vehicle as storage connected to PME installations are also discussed.

Smart integration guidance

Another area of EV technology that is set to become key for future energy strategies is integration with the smart grid. Building on the foundation guidance in the 3rd edition of the IET Code of Practice, Section 12 in the 4th edition now includes information flow diagrams of different smart control and integration use cases, with extended commentaries, covering:

- managed charging;
- demand-limited (load curtailment) charging;
- smart meter integration; and
- optimization for self-use of local renewable generation (**Figure 5**).

Figure 5 Integration representation: optimization for self-use of local renewable generation (updated for the IET by Cameron Steel)



Conclusion

IET *Code of Practice for Electric Vehicle Charging Equipment Installation*, 4th Edition makes extensive improvements to the guidance to cover new protection and control technologies that have emerged since the publication of the previous edition, in addition to supporting the latest installation safety requirements in BS 7671:2018+A1:2020.

The Code of Practice is available now from the IET bookshop.

BS 8629:2019 *Code of practice for the design, installation, commissioning and maintenance of evacuation alert systems for use by fire and rescue services in buildings containing flats*

By Michael Peace, Senior Engineer IET Technical Regulations

What is an evacuation alert system?

A new British Standard has been published that sets out the requirements for an Evacuation Alert System (EAS), for use by the Fire and Rescue Service (FRS). The standard is entitled '*Code of practice for the design, installation, commissioning and maintenance of evacuation alert systems for use by the fire and rescue services in buildings containing flats.'*

The purpose of an EAS is to assist the FRS with initiating an evacuation of part in the unlikely event it becomes necessary, the whole of the building, typically high-rise blocks of flats that, otherwise, have a stay put strategy.

The system comprises an evacuation alert control panel with indicating equipment (EACIE) located in a suitable low-risk location and sounders within each dwelling, with the system being under the control of the FRS.

How common are fires in blocks of flats?

Every day in England there are 20-30 fires that occur in blocks of flats. The fire is usually contained within the flat of origin and the need to evacuate is very rare. However, whilst fire spreading to other flats is not common, it can happen if the appropriate precautions are not in place, such as fire-stopping and adequate separation.

Why aren't people usually evacuated from high-rise buildings?

High-rise buildings present unique dangers with respect to simultaneous evacuation. Simultaneous evacuation can lead to large numbers of people trying to escape at once, possibly down a single staircase, with the group likely to consist of a mixture of young, elderly and infirm people. Such a situation is not desirable when the FRS may need to go up the staircase with heavy equipment. Directing people into smoke-filled areas, meaning that it would be safer for people to remain in their flats. It is for this reason that most high-rise buildings operate a design strategy that implements the ‘stay put’ policy. This policy has been proved to be effective over many years.

What is the ‘stay put’ policy?

The building design strategy for most high-rise buildings containing flats is to operate a ‘stay put’ policy. This is an established strategy whereby individual flats are designed with fire-rated compartmentation to ensure that fire cannot spread between flats, with occupants instructed to stay put unless they are instructed to evacuate by the FRS. This system generally works well, but there may be occasions when the FRS needs to change its plans and evacuate part or all of a building. At present, the only way to achieve this is to send firefighters to knock on residents’ doors – which may not always be possible.

Do I need to install an EAS?

Following the tragic events at Grenfell Tower, the Scottish Government formed an expert review panel to look at Scottish Building Regulations.

Following the review, the panel made a recommendation to the Scottish Government to amend the Domestic Technical Handbook (DTH), which was accepted. The new requirement states that all blocks of flats with a storey located at a height of more than 18 metres above ground level must incorporate a system to allow the FRS to initiate an evacuation signal within each flat.

The DTH was revised and published on 1st October 2019. It recommends that an EAS is installed to ensure compliance with mandatory Building Standard 2.14 *Fire and Rescue Service Facilities* under Scottish Building Regulations. This Standard requires that every building must be designed and constructed in such a way that facilities are provided to assist fire-fighting or rescue operations.

At present in England there is no requirement to install an EAS; however, there is nothing to prevent such a system being specified as part of the overall fire strategy for a building. The Grenfell Inquiry Phase 1 report recommends that such systems be installed in all new and existing blocks of flats. In addition, the Ministry of Housing, Communities and Local Government (MHCLG) carried out a public consultation on the requirement for such provision in all new high-rise blocks of flats.

It is worth contacting the FRS at the design stage of a project to discuss any possible benefits of installing an EAS. Following completion of the project, it is important to advise the FRS of the existence of such a system and allow them to familiarize themselves with its location and use.

Is an EAS different to a fire alarm system?

An EAS is different to a fire detection and alarm system (FDAS), as it is only intended to be used by the FRS and will probably never be used in a real evacuation. It is imperative to ensure that the system is maintained and is fully functioning. Whilst the EAS may never be used, it is likely to save lives if needed.

It is important to ensure that the design and layout of the control panel and indicating equipment is intuitive, consistent and easy to use for the FRS. The layout of the EACIE is required to be displayed in a vertical arrangement, to resemble the floor layout. To encourage the use of a dynamic thought process in the evacuation strategy, a conscious decision was made by the committee not to provide one single button to evacuate the whole building.

Careful consideration was also given as to whether to integrate the EAS system into existing fire alarm installations. However, the committee responsible for producing the standard, decided that integration would be inappropriate. This was for a number of reasons, including the fact that most blocks of flats do not feature communal fire alarm systems, as this is not a requirement of BS 5839-1, and therefore, the wiring would not already be in place or suitable. Non-integration also keeps the EAS independent and reduces the likelihood of failure. Another good reason for keeping the systems separate is that existing fire alarm maintenance companies would be unlikely to be familiar with the systems.

Another important consideration is the alarm sound. There are arguments for and against the use of voice alarms in this type of installation. Whilst voice alarms can sometimes be more effective than an alarm sounder, it must be borne in mind that 22 different languages were spoken by the residents of Grenfell Tower. The committee carefully considered the use of voice alarm systems, but it was decided that these would be inappropriate for an EAS. Evacuation alert devices or visual alarm devices (VADS) are used instead to alert occupants to the need to evacuate.

What are visual alarm devices?

Visual Alarm Devices or VADs, more commonly known as ‘flashing beacons,’ are used to alert people with hearing difficulties or for areas with a high ambient background noise. Devices installed after 1st January 2014 must comply with BS EN 54-23 under the Construction Products Regulation (CPR). This Standard ensures that devices have been tested to provide a minimum light output in relation to the size of the protected area. They are referred to as ‘visual evacuation alert devices’ within BS 8629:2019.

What type of wiring is required for an EAS?

The wiring for an EAS falls under the requirements of BS 7671:2018+A1:2020; Regulation 521.10.202 states that “wiring systems shall be supported such that they will not be liable to premature collapse in the event of a fire”. This means that cables must be installed with non-combustible supports.

Cables that are used for critical signal paths may be subjected to fire conditions and must remain operational for an adequate duration. It is for this reason that BS 8629:2019 requires enhanced cables, which have a survival time of 120 minutes when tested in accordance with BS EN 50200 or BS 8434-2.

The requirements of BS 8629:2019 for segregation align with those of BS 7671:2018+A1:2020, Regulation 560.7.1, which states that “except where the recommendations of other safety standards apply, circuits of safety services shall be independent of other circuits*"*. An explanatory note reads:

"This means that any electrical fault or any intervention or modification in one system must not affect the correct functioning of the other. This may necessitate separation by fire-resistant materials or different routes or enclosures."

BS 8629:2019 states that "the circuits of evacuation systems need to be segregated from the cables of other circuits to minimize any potential for other circuits to cause malfunction of the evacuation system*"*. Malfunction could be caused by several factors, such as breakdown of the cable insulation of other circuits and/or evacuation system circuits, a fire caused by a fault on another circuit, electromagnetic interference to any evacuation system circuit as a result of the proximity of another circuit, or damage resulting from the need for other circuits to be installed in, or removed from, ducts or trunking containing an evacuation system circuit.

Resilience

As with any critical safety service, resilience is essential to provide assurance of continuity of service. BS 8629:2019 requires that the system is designed in such a way to minimize multiple alarm zones failing simultaneously. Diverse and protected cable routes, and the quantity and size of the loops, are also design considerations intended to minimize this risk.

Power supply

The power supply for an EAS is required to conform to BS EN 54-4, which sets out the requirements for power supplies and battery charging. The batteries are required to be of sufficient capacity to maintain the system in operation for at least 72 hours, after which sufficient capacity should remain to provide an evacuation signal in all alarm zones for at least 30 minutes, unless the building is provided with an automatically started standby generator.

Security rating

As the EAS is designed to be operated by the FRS only, the correct security rating for the enclosure of the EAS is extremely important, to prevent unauthorized access. It would be undesirable for the system to fall into the wrong hands, as the building could then be evacuated simultaneously, posing a risk. It is for this reason that BS 8629:2019 requires the EACIE to be installed within a security-rated enclosure. The enclosure must be certified under Loss Prevention Standard (LPS) 1175 – one of many LPS standards published by the Loss Prevention Certification Board (LPCB).

LPS 1175 offers various categories of security rating, according to different attack duration times and tool kits. BS 8629 requires a minimum security rating of B5, which means that the enclosure can withstand an attack for five minutes with tool kit B. The enclosure will be accessible using a key with a restricted profile for use by the FRS only.

Summary

It is worth considering installing an EAS in buildings with specific risks. Consultation with the FRS is recommended to fully understand the benefits and requirements.

An EAS is an excellent way to alert residents to evacuate a building if required. Not only could it reduce evacuation time, but it could also prevent firefighters from having to knock on doors, further reducing risk.

It is important to note the difference between an EAS and a FDAS and to understand that the EAS is only intended to be operated by the FRS.

Other sources of useful information

- BS 7671:2018+A1:2020 The IET Wiring Regulations, *Requirements for Electrical Installations*
- BS EN 54-4:1998 *Fire detection and fire alarm systems, power supply equipment*
- BS EN 50200:2015 *Method of test for resistance to fire of unprotected small cables for use in emergency circuits*
- BS 8434-2:2003+A2:2009 *Methods of test for assessment of the fire integrity of electric cables. Test for unprotected small cables for use in emergency circuits*
- Loss Prevention Standard (LPS) 1175, Issue 8
- Building Standards Technical Handbook 2019: *Domestic buildings (DTH, Scotland)*

Socket-outlet protectors (updated Feb 2020)

By Mark Coles, Head of IET Technical Regulations

Figure 1: Image courtesy of MK (https://www.mkelectric.com/en-gb/Products/WD/logicplus/Pages/default.aspx)

Socket-outlet protectors are intended to stop foreign objects being inserted into socket-outlets. The socket-outlet protector usually takes the form of a dummy plug and is inserted into the socket-outlet. The intention is to prevent anything else being inserted into the socket-outlet, such as the fingers of children or lengths of metallic objects.

The safe system that is BS 1363

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

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

An earth-pin-operated shutter mechanism is shown in Figure 2.

Figure 2:

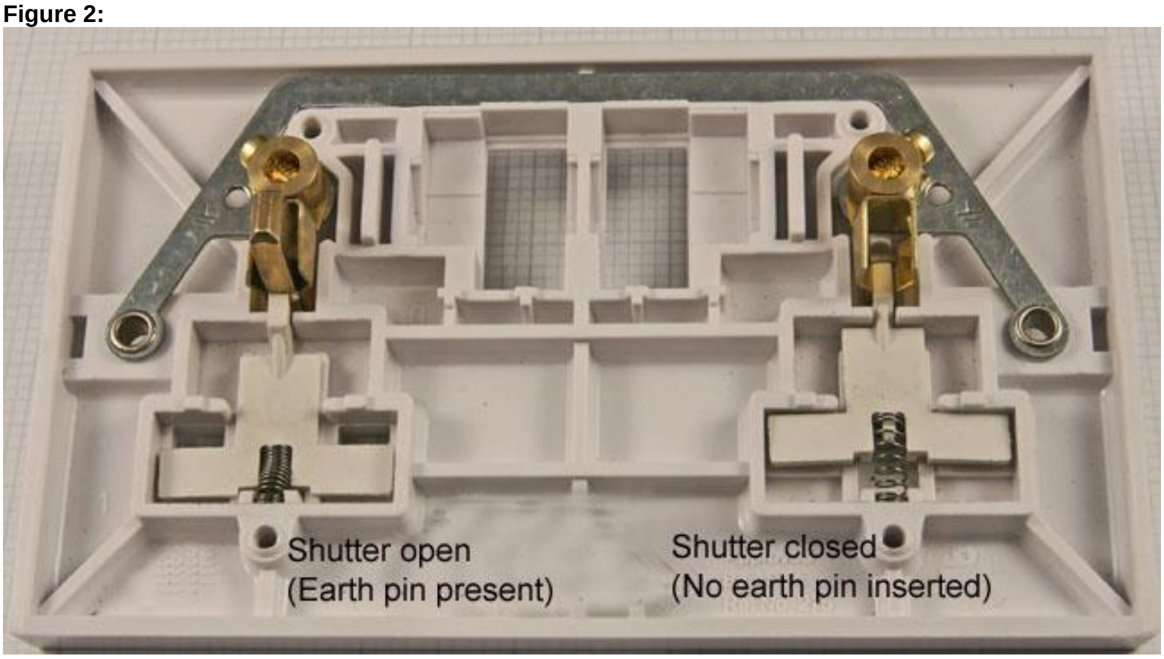


Image courtesy of Fatally Flawed

An earth pin has been inserted into the socket-outlet on the left, and the shutters that normally cover the socket-outlet contacts have opened. There is nothing inserted in the socket-outlet on the right, and hence the shutters are closed.

BS 1363 socket-outlets already incorporate a shutter mechanism that prevents intentional and unintentional direct contact with internal live parts.

Dangers

The intended function of the socket-outlet protector sounds simple – but the reality can be quite the opposite. There is no standard for socket protector design and performance and products available on the market can vary in terms of quality and dimension. The pins of socket-outlet protectors are rarely the same size as a 13A plug; they are usually wider or narrower.

Where the pins are wider than a 13A plug, the socket-outlet protector can widen and deform the spring contact in the socket-outlet, ultimately resulting in permanent damage and poor electrical contact with the socket-outlet. This may lead to potential arcing and overheating in normal use.

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

Further to the physical dimensions of the socket-outlet protector, the next consideration is the material from which it is made. If the material is too brittle, the socket-outlet protector might snap during its withdrawal operation, leaving a pin in the socket-outlet contact and thus exposing other socket-outlet contacts, as the shutter mechanism has been defeated. Where the material is overly malleable or too soft, socket-outlet protectors can be inserted upside down, which can operate the safety shutter mechanism and expose live parts; see Figures 3 and 4.

Figure 3:

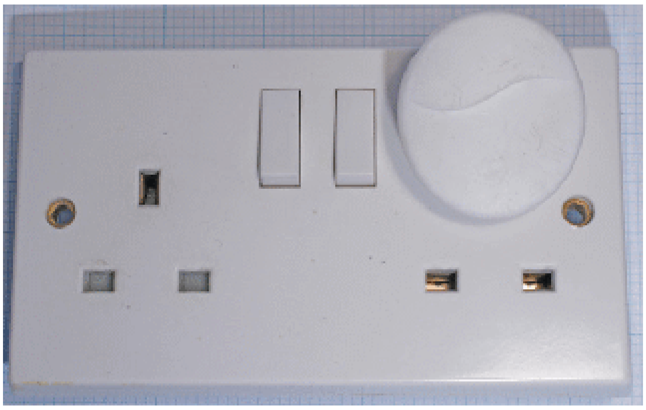


Image courtesy of Fatally Flawed

Figure 4:

Image courtesy of Fatally Flawed

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

<u>What does BS 7671:2018+A1:2020 require?</u>

Regulation 553.1.201 states: "Every socket-outlet for household and similar use shall be of the shuttered type and, for an AC installation, shall preferably be of a type complying with BS 1363."

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

<u>Where did it all start?</u>

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

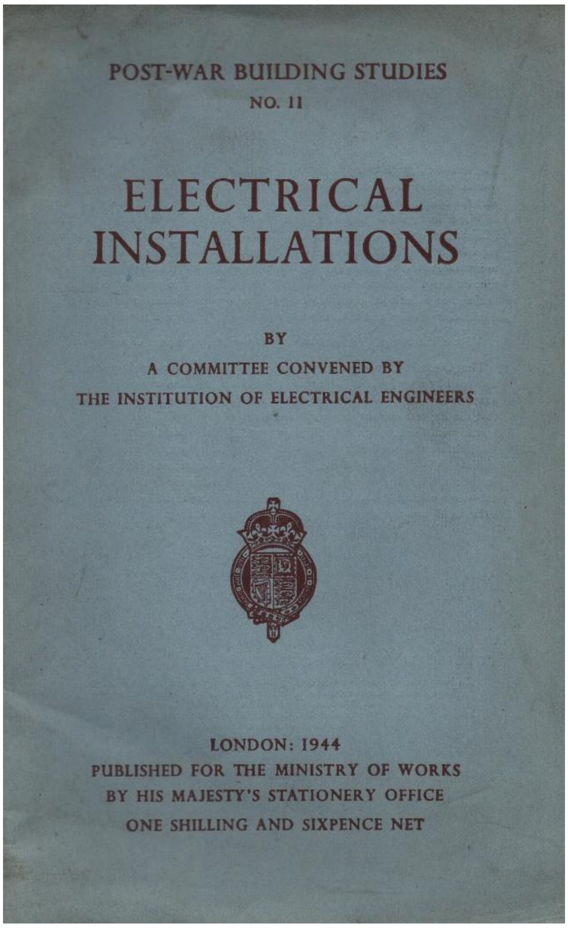
1 *To review existing information and practice concerning installations in buildings for:*

- a *the supply of electricity for all purposes from the point of entry of the current at the property boundary to the point of its delivery to an appliance;*
- b *electrical household appliances serving the single-family dwelling; and*
- c *all forms of electrically operated telecommunications.*

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

3 *To make recommendations for practice in post-war building (projects).*

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



“We recommend that small dwellings of the types considered should be wired with three separate circuits for lighting, cooking, and socket-outlets respectively, each controlled by a separate single-pole fuse. It is proposed that all socket-outlets should be supplied from a ‘ring circuit’ which, starting and ending at the fuse terminal at the consumer’s supply control will pass through each room in turn. In the small dwellings under consideration it is considered permissible to connect up to 20 of the proposed standard socket-outlets on the ring circuit. At the consumer’s supply control, the ring circuit will be fused for 30 amperes, a current which is unlikely to be exceeded in the conditions of load diversity met with in small dwellings. At each outlet position on the ring circuit it will be necessary to provide a cartridge type fuse for local protection.

With regard to the socket-outlet circuit, the recommendation to connect a number of standard socket-outlets on a ring circuit represents a departure from existing practice as laid down in the Wiring Regulations (Eleventh Edition).”

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

Last word

Socket-outlets to BS 1363 are the safest in the world and have been since they were first designed in the 1940s. Socket-outlet protectors are not regulated for safety: using a non-standard system to protect a long-established safe system is not sensible and can create potential electric shock and fire hazards.

Thanks

BEAMA: UK trade association for manufacturers and providers of energy infrastructure technologies and systems
Special thanks to David Peacock (Fatally Flawed) who, very sadly, passed away in November 2018.

Further information and reading

BS 1363-2:2016+A1:2018 *13 A plugs, socket-outlets, adaptors and connection units. Specification for 13 A switched and unswitched socket-outlets*

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

BEAMA: http://www.beama.org.uk/resourceLibrary/beama-position-paper-on-socket-outlet-covers.html

Fatally Flawed: www.fatallyflawed.org.uk

General Product Safety Directive: https://ec.europa.eu/info/general-product-safety-directive_en

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

BACK TO THE FORUM

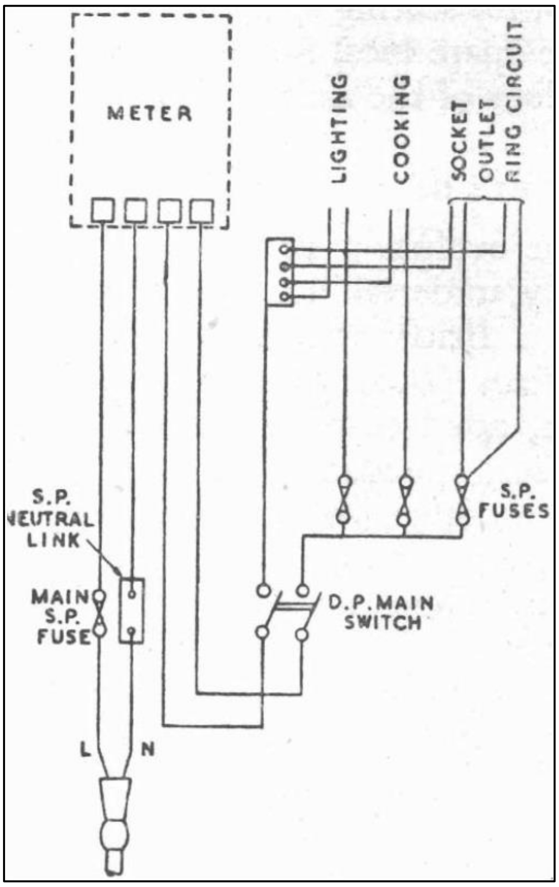
The IET online forum goes back many years. Previously called Fusetalk, it is an excellent source of electrical information for all, from end-users to electricians and designers. Some of the users of the forum have been participating for nearly twenty years and have a wealth of experience to share. If you have a question to ask, it has probably already been asked, and answered, on the IET forum.

As with all things, change is inevitable. The forum has transferred to a new platform called Engineering Communities. Despite the change of name, it is still the good old IET forum which we have come to love.

It has been decided to archive the old forum material. However, rather than letting all of those discussions gather dust, we have decided to create a new column in Wiring Matters looking at the 'hot topics'. In this new column, we will return to items previously discussed on the forum and, looking to the future, will aim to discuss some of the current forum topics (where possible, adding in some history).

The ring final circuit

Michael Peace, Senior Engineer IET Technical Regulations



Ring final circuits, more commonly and erroneously known as 'ring mains', have been debated since they were first installed. Like Marmite, you either love them or you hate them. Let's take a look at some of the considerations.

Ring final circuits originated in the UK, for historic reasons dating back to 1942 and the reconstruction effort following World War Two.

The Post-War Building Studies Committee No.11 was convened by the Council of the Institution of Electrical Engineers in June 1942. It was tasked with making recommendations to facilitate the building of the one million houses predicted to be required in the aftermath of the war.

In the face of shortages of materials, ring final circuits were conceived, to minimize the amount of copper required. The 13 A socket-outlet with fused plug top to protect appliance flexes was also introduced at this time. It was said that the ring final circuit typically required 30% less copper and could save up to 25% in cost. This allowed 15 A sockets to be installed in all rooms cost-effectively.

Not only do ring final circuits reduce the amount of copper required for cables to supply several sockets within the same area, but the size of the consumer unit required is also reduced. Back then, it was decided that a three-way fuse box would be sufficient for a small house, with a separate circuit for the lighting, cooker and socket-outlets.

The first appearance of ring final circuits in the IEE Wiring Regulations was in the 12^{th} Edition, published in 1950. Regulation 201 stated that a:

“final sub-circuit in the form of a ring both ends of which are brought into the terminal of a fuse having a rating not exceeding 30 Amperes may serve not more than ten socket-outlets of 13 Ampere rating.”

It followed on with the exemption: “provided that in a small houses or residential flats having a floor area not exceeding 1000 sq. ft. the number of socket-outlets served by such a ring circuit shall not be restricted”. This is where the 100 m^2 rule of thumb comes from, which is still used in guidance today (see IET Guidance Note 1 *Selection & Erection*, Appendix C).

It was considered that a 30 A ring final circuit could supply a kettle and two electric heaters, which was sufficient for the householder. The minimum cable size required was 0.0045 sq. in., more commonly known as 7/.029 in. This is equivalent to 2.9 mm^2, so the nearest metric conductor size would be 2.5 mm^2.

Table C (below) is taken from the Thirteenth Edition of the IEE Wiring regulations, it indicates the maximum permissible number of socket outlets, for the various types of circuits.

TABLE C

Use of fused plugs and socket-outlets

(with provision for locally-fused fixed appliances)

	Special conditions, if any	Minimum size of stranded current-carrying conductor used throughout		Minimum size of current-carrying conductor of mineral-insulated cable used throughout, alternative to Cols. 2 and 3 (in^2)	Maximum permissible number of socket-outlets and fixed appliances, other than electric clocks fed through fused clock connectors, or electric shaver supply units complying with B.S.3052.	Maximum rating of fuse(s) or half maximum rating of instantaneous overload circuit-breaker, protecting the final sub-circuit (amp)
		Cross-sectional area (in^2)	Number and diameter (in) of wires			
	1	2	3	4	5	6
(*a*)	—	0·0045	7/·029	0·003	2	20
(*b*)	All socket-outlets in one room (of a house or flat) of less than 200 ft^2 floor area, and which is not a kitchen	0·0045	7/·029	0·003	3	20
c)	—	0·007	7/·036	0·0045	6	30
(*d*)	Ring circuit and spurs (if any) in industrial or other premises	0·0045	7/·029	0·003	10	30
(*e*)	Ring circuit and spurs (if any) in house or flat, on the basis of one ring circuit for every 1 000 ft^2 of floor area or part thereof, provided the socket-outlets are reasonably distributed among the ring circuits when there are more than one	0·0045	7/·029	0·003	Unlimited number	30

NOTE.—In industrial premises, a 30-ampere socket-outlet used in an extra-low-voltage circuit is regarded as equivalent, for loading purposes to two 13-ampere socket-outlets.

Circuits supplying socket-outlets should be designed according to their typical demand. Other than the kitchen, a modern dwelling is unlikely to have electrical equipment with a high power demand but will require several socket-outlets for convenience purposes. A radial circuit could therefore be considered appropriate.

Some say that the use of ring final circuits should stop, as they could be dangerous if any of the conductors became open circuit. Others argue that this is no different to a broken and undetected circuit protective conductor (CPC) on a radial circuit, and that this reinforces the need to carry out inspection and testing on a regular basis.

It could be argued that ring final circuits are in fact safer: if a CPC breaks, there will be another conductor connected to earth, but the reduced cross-sectional area (CSA) may not be sufficient to provide automatic disconnection within the required time.

It is true, however, that if ring final circuits are added to or altered incorrectly, a dangerous situation could occur with regard to overloaded cables. Other issues with ring final circuits include cross-connections between two different final circuits, resulting in two devices being required to isolate the circuit and increased disconnection times.

Summary

In summary, ring final circuits can be a cost-effective way of providing socket-outlet circuits and, like any other installation, are safe if designed, installed and maintained properly. However, continuity testing of ring final circuits can be time-consuming and requires the electrical supply to be isolated during testing, involving downtime. The installation of two radial circuits will take less time and use less cable than one ring final circuit, and this compensates for the additional protective device.

BS 7671:2018+A1:2020 permits both ring final and radial circuits to supply socket-outlets and each method should therefore be judged on its merits.