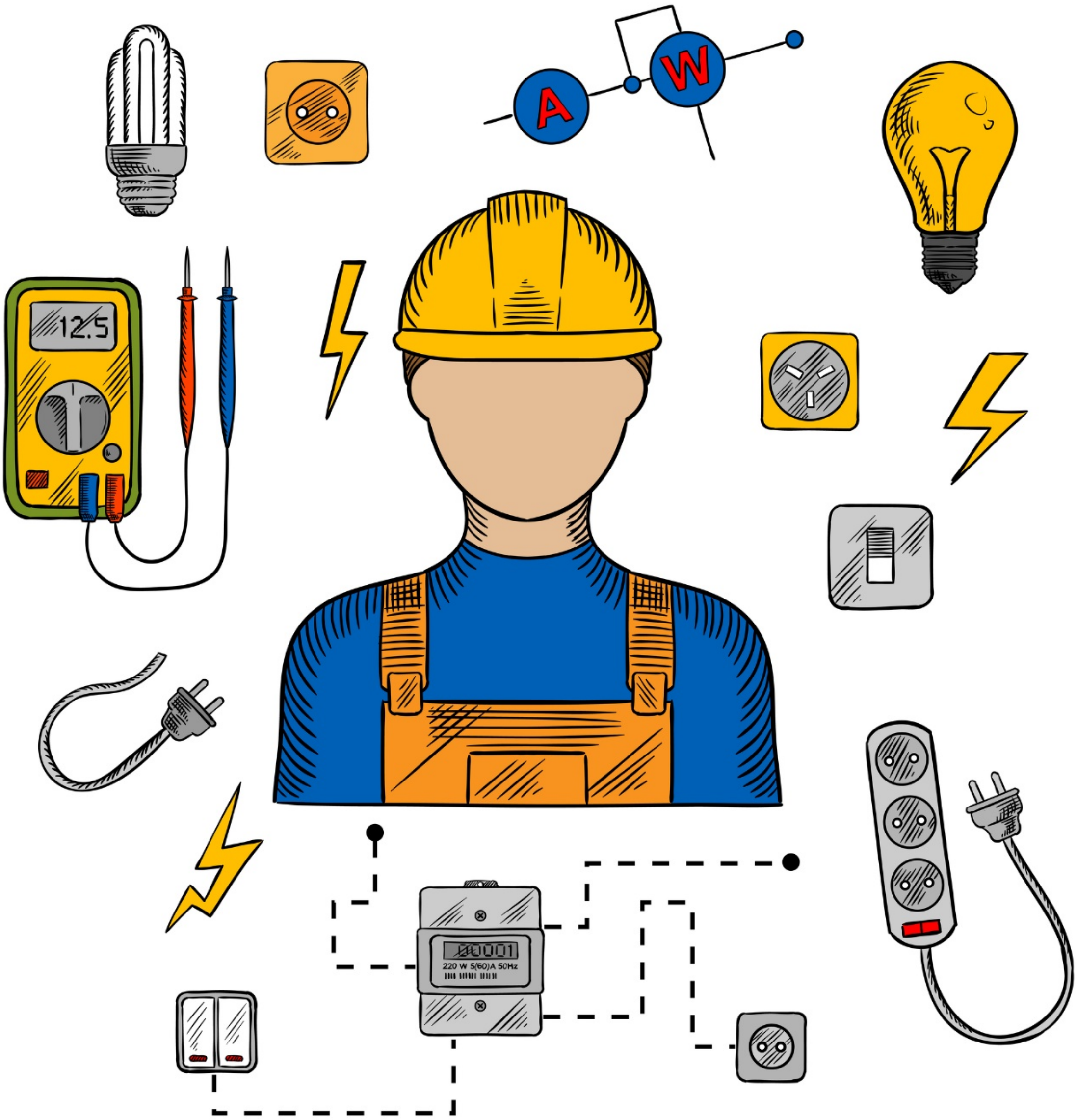


WIRING MATTERS

ISSUE 75 MAY 2019

Latest developments in International Standards for energy efficiency

By: **Geoff Cronshaw**

A new standard, IEC 60364-8-1 Edition 2, was published in February 2019. This replaces IEC 60364-8-1 Edition 1 published in 2014. In this article, we give a brief overview of some of the latest requirements at international level, which may or may not be incorporated in BS 7671 in the future. The new standard includes a number of changes including changes to the definitions and to the energy efficiency assessment for electrical installations. The worldwide need to reduce the consumption of energy means we have to consider how electrical installations can provide the required level of service and safety for the lowest electrical consumption. In order to make improvements we need to be able to measure the amount of electrical energy consumed and monitor and control energy effectively. Energy measurement is essential for energy management. Therefore, the design of the electrical distribution system needs to be carried out in such a way that will allow the metering and control of the various electrical loads in an installation. Also, in order to have an energy efficient installation, losses in equipment need to be as low as possible. All these aspects are taken into account in the new standard.

SIGNIFICANT CHANGES.

Energy efficiency assessment for electrical installations

A new section 4.2 has been introduced which requires the assessment of electrical installations in accordance with Annex B of the standard.

Method to assess the energy efficiency of an electrical installation.

The informative Annex B has been completely revised in the new standard. However the objective is still to provide an assessment of the energy efficiency of an electrical installation based on the relevant parameters influencing efficiency such as lighting, voltage drop, power factor correction, Motors and controls etc.

The method applies to both new and existing installations, in premises used for purposes including industrial, commercial, infrastructure and residential as the previous edition.

However, in this new edition the way in which the method is applied for residential premises differs in some ways from the way it is applied for other types of premises.

In this new the standard the energy efficiency of an electrical installation is rated into one of the following classes from the lower efficiency to the higher efficiency:

EE0,

EE1,

EE2,

EE3,

EE4, and

EE5.

The electrical installation efficiency class is determined by adding together all the points obtained from the tables corresponding to each parameter. There are separate sets of Tables for residential compared to industrial, commercial installations and infrastructure.

Where a parameter is not assessed, then 0 point is given for that parameter.

The total number of points is then compared with the number of points given in Table B.1 to determine the electrical installation efficiency class which ranges from EE0 to EE5.

Input from loads, sensors and forecasts

Section 8.3 of the new standard covering inputs from loads, sensors and forecasts has been revised. Requirements concerning the measurement of electrical parameters has been extended as this is key to energy efficiency.

<u>LIGHTING</u>

Lighting can represent a large percentage of energy consumption in buildings depending on the application. Solutions for lighting control could achieve significant savings on the electricity compared to a traditional installation (without automatic lighting controls).These systems should be flexible and designed for the comfort of the users. The solutions can range from very small and local controls such as occupancy sensors, up to sophisticated customised and centralised solutions that are part of complete building automation systems.

Lighting controls

Lighting controls for residential buildings are easy-to-install devices which are able to detect the presence of people and only switch on lights when required. Lighting controls eliminate wasted energy and save energy simply by switching lights off when not required. Lighting controls for commercial, public and industrial buildings are again easy-to-install devices that are able to automatically switch off lights when no occupants are detected or there are suitable levels of natural light.

When considering the design and installation of lighting controls there are a number of important points to consider. First, it is important to take into account the type of space, how it is used and the amount of daylight available. The type and use of space will determine the type of sensor and therefore the control used.

Safety is also an important consideration. The operation of lighting controls should not endanger the occupants of the building. This may happen if a sensor switches off all the lighting in a space without daylight. It is therefore important that lighting controls are designed correctly to ensure the safety of occupants and save energy.

Commissioning should be included as an essential part of the installation of lighting controls. Commissioning could include calibrating photoelectric controls, checking that occupancy sensors are working, and setting a suitable delay time for occupancy sensors.

<u>MOTOR CONTROL</u>

Electric motors are used in a wide variety of applications in commercial and industrial installations. These include motors driving fans for ventilation and air-conditioning systems, motors driving pumps for refrigeration and chilling applications and air compressors.

Pumps and fans probably represent one of the largest applications for motor-driven power. The use of variable-speed drives (VSD) to adjust the speed of the pump or fan to deliver the required flow, could result in energy savings.

<u>POWER-FACTOR CORRECTION</u>

A poor power-factor is undesirable for a number of reasons. Power-factor correction technology is used mainly on commercial and industrial installations to restore the power factor to as close to unity as is economically viable. Low power-factors can be caused by reactive power demand of inductive loads such as induction motors and fluorescent lights. A poor power-factor reduces the effective capacity of the electrical supply, since the more reactive power that is carried the less useful power can be carried, also causes losses at transformers, and can cause excessive voltage drops in the supply network and may reduce the life expectancy of electrical equipment.

For this reason electricity tariffs encourage the user to maintain a high power-factor (nearly unity) in their electrical installation by penalising a low power-factor. There are a number of ways in which power-factor correction can be provided. The most common way that this can be achieved is by the installation of power factor correction capacitors. These can be installed in bulk at the supply position or at the point of usage on motors, for example. Persons involved in this type of work are recommended to seek advice from specialists on the most economic system for a given installation.

RENEWABLE ENERGY

On site renewable energy sources do not of themselves increase the efficiency to the electrical installation but reduce the overall utility network losses as the consumption of the building from the utility is reduced.

There are a wide range of microgeneration technologies including: Solar photovoltaic (PV), wind turbines, Small scale hydro and Micro CHP (Combined heat and power). Microgeneration systems such as solar PV installations should always be carried out by a trained and experienced installer. For example, where the PV panels are roof-mounted the roof must be strong enough to take their weight, especially if the panel is placed on top of existing tiles. It is also important to note that there are mandatory requirements concerning the parallel connection of generators with the supply network.

CONCLUSION.

Please note this article is only a brief overview of some of the latest requirements at international level, which may or may not be incorporated in BS 7671 in the future. For more information refer to IEC 60364-8-1 Edition 2.

Note: It is important to consult the Building Regulations when designing electrical installations. The Building Regulations deal with energy conservation issues such as energy efficient lighting.

Mythbusters #4 Double insulated cables

By: **James Eade**

Following on from the last Mythbuster article on appliance testing in the workplace in Issue 74 (March 2019), a reader suggested looking at the confusion between protective measures for electric shock and the construction of flexible cables.

He noted that technicians often consider that:

- Meter tails are regarded as being double insulated; and
- Steel Wire Armoured (SWA) cables are regarded as having reinforced insulation.

Before looking at these, it is worth revisiting the principle of protective measures against electric shock. Generally electrical systems in common use comprise a protective measure consisting of basic protection and fault protection. Older readers may be more familiar with the old terms for these, namely direct contact and indirect contact respectively.

There are four common protective measures as given in Regulation 410.3.3 of BS 7671:2018:

1. Automatic disconnection of supply (Section 411);

2. Double or reinforced insulation (Section 412);

3. Electrical separation (Section 413); and

4. Extra-low voltage provided by SELV or PELV (Section 414).

All of the above have a requirement for basic protection, which is the primary line of defence against electric shock and is typically achieved by insulation over the live parts, such as the insulation around a conductor, or a barrier inside an enclosure. The requirements for basic protection are described in Section 416.

Fault protection is the second line of defence, preventing (or limiting the effects of) an electric shock in the event that the basic insulation fails. In the case of automatic disconnection, a fault to the earthed exposed-conductive-parts results in operation of a circuit-breaker, fuse or RCD, thereby disconnecting the circuit and protecting the user and the installation.

Double or reinforced insulation is another method of protection against electric shock, consisting of an extra layer of supplementary insulation over the basic insulation, or a single layer of special reinforced insulation directly over the live parts. The latter provides basic and fault protection in one application and is commonly found in power tools for example. Class II products complying with the requirements for double or reinforced insulation in electrical safety standards will be marked with the double insulated symbol. It is possible to erect an entire electrical installation using only double or reinforced insulation as the protective measure, with all equipment – as well as the installation of wiring and accessories – complying with Section 412. Such an installation must be subject to effective measures (such as supervision) to ensure that no changes could be made that would impair the safety of the installation, as may happen if electrical equipment with exposed-conductive-parts is introduced.

Electrical separation as per Section 413 is commonly achieved by using a source which may be an electronic power supply or an electromagnetic transformer that provides at least simple separation. Fault protection is achieved by separating the secondary side from Earth and other circuits, thereby preventing the user from getting an electric shock to Earth. Finally, the extra-low voltages described in Section 414 again require basic protection between live conductors, but shock protection is achieved by the low voltages in the installation, which should be provided from a source meeting certain safety requirements.

Are meter tails double insulated?

Technically no, because meter tails are not a protective measure in the installation designed to prevent the user from the risk of electric shock, like automatic disconnection, or electrical separation. More correctly such tails should be referred to as ‘insulated and sheathed’ cables, just as flat twin-and-earth or H07-RN-F flexible cables are.

However, it is evident that having two layers of insulation would appear to fulfil the requirements for both basic and fault protection, and this is noted in Regulation 412.2.4:

412.2.4 Wiring systems

412.2.4.1 Wiring systems installed in accordance with Chapter 52 are considered to meet the requirements of Regulation 412.2 if:

i. the rated voltage of the cable(s) is not less than the nominal voltage of the system and at least 300/500 V, and

ii. adequate mechanical protection of the basic insulation is provided by one or more of the following:

a. The non-metallic sheath of the cable

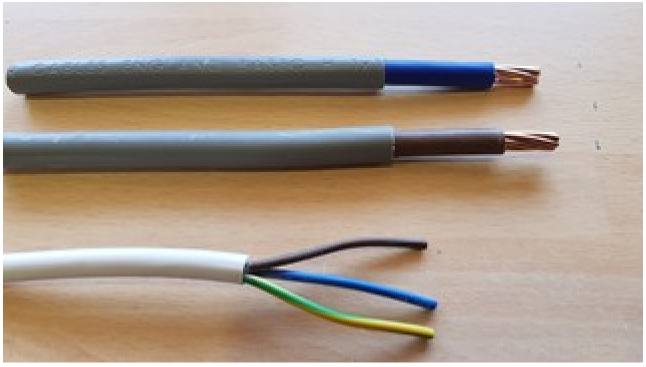
b. Non-metallic trunking or ducting complying with the BS EN 50085 series of standards, or non-metallic conduit complying with the BS EN 61386 series of standards.

So, for meter tails or other insulated and sheathed cables, the basic insulation over the conductor and the non-metallic sheath are deemed to comply with the requirements for both basic and fault protection in Regulation 412.2 and hence don’t need to be installed in containment (unless required for mechanical protection). What this also means is that removal of the outer sheath to enable the colour of the core to be identified outside of a wiring accessory (e.g. a meter or service block) should not be done, as the cable will have been reduced to having basic insulation only. The IET *On-Site Guide*has more information on meter tails in Section 2.2.3.

By the same rationale, an SWA cable does not have reinforced insulation. The wire armour is there for mechanical protection of the cable. Reinforced insulation is defined 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 homogeneous piece. It may comprise two or more layers which cannot be tested singly as supplementary or basic insulation.”

So, just because the cables meet the requirements for double insulation as a protective measure, it doesn’t mean that cables are double insulated products.



Insulated and sheathed cables such as these are not double insulated products

To Bond or not to Bond

By: **Michael Peace**

Following on from the Mythbusters article in Issue 73 (November 2018) of Wiring Matters, this article looks at the recent change of the wording in Regulation 411.3.1.2 of BS 7671:2018, and what can be done to determine if a conductive part meets the requirements of an extraneous-conductive-part as defined in BS 7671.

What requires protective equipotential bonding?

BS 7671:2018 Regulation 411.3.1.2 requires that;

"In each installation main protective bonding conductors complying with Chapter 54 shall connect to the main earthing terminal extraneous-conductive-parts including the following:

(i) Water installation pipes

(ii) Gas installation pipes

(iii) Other installation pipework and ducting

(iv) Central heating and air conditioning systems

(v) Exposed metallic structural parts of the building."

Connection of a lightning protection system to the protective equipotential bonding shall be made in accordance with BS EN 62305 and best determined by a lightning protection system designer.

It is important to remember that the above items are only examples of items which may require protective equipotential bonding and it must be verified if these parts actually meet the definition of an extraneous-conductive-part before deciding to connect to the main earthing terminal (MET).

Protective equipotential bonding is different from supplementary bonding. Supplementary bonding is the practice of connecting two conductive simultaneously accessible parts together to reduce the potential difference between the parts.

What is an extraneous conductive part?

The definition of an extraneous-conductive-part as defined within BS 7671:2018 is as follows:

"A conductive part liable to introduce a potential, generally Earth potential, and not forming part of the electrical installation."

It should be noted that the term extraneous-conductive-part is hyphenated, which means it is a single term which has a specific meaning. It can sometimes be difficult to determine if a part meets this requirement, therefore it is sometimes easier to break the definition down into three separate parts.

- A conductive part;
- Liable to introduce potential, generally earth potential; and
- Not forming part of the electrical installation.

The statement “Liable to introduce potential, generally Earth potential” is where it can sometimes be difficult to assess by visual inspection alone. Earth potential is generally assumed to be 0 volts introduced by the general mass of Earth more commonly known as the planet we stand on.

What has changed in the 18th Edition of the IET Wiring Regulations?

With a couple of minor changes in terms of wording there is bound to be some confusion, but what exactly has changed since the previous edition?

The first change has clarified that the PEN conductor CSA must be used when determining the CSA of a main protective bonding conductor on an installation with a PME earthing system. Table 54.8 should be used to determine the CSA of a main protective bonding conductor for PME systems.

In addition, the following statement has been added to Regulation 411.3.2.

“Metallic pipes entering the building having an insulating section at their point of entry need not be connected to the protective equipotential bonding.”

But what does this mean in practice?

Practically speaking, nothing has changed regarding this Regulation except for the addition of the above statement, but it will undoubtedly make people question whether protective bonding is required at all.

The definition of an extraneous-conductive-part can be found in Part 2 Definitions where it says, “*A conductive part liable to introduce a potential, generally Earth potential, and not forming part of the electrical installation”.*

So, the part has to be conductive, for example a metallic water pipe, and not part of the electrical installation and essentially able to introduce Earth potential. This would usually mean a conductive part going outside the building and touching the ground or going to another building. If this can be verified by visual inspection, the part does need main protective bonding.

If an installation pipe is constructed from a plastic type material such as medium density polyethene (MDPE) which is most commonly installed, it is unlikely to be considered an extraneous-conductive-part, but this must be verified.

Another cause of confusion is regarding the terminology of the pipework installation. Gas or water pipes entering the property are often referred to as “service pipes”, however it is important to distinguish the difference between service pipework and installation pipework. The gas regulations describe the service pipework as the pipe that comes in from the road to the meter. The pipe from the meter to the property is called the installation pipe. BS 7671:2018 regulations are with regards to the installation pipework and not the service pipework.

How to determine if a metallic part is an extraneous-conductive-part

It should be verified if parts are deemed to be extraneous-conductive-parts before there may be a requirement to connect them to the MET. The best way to determine whether a conductive part is likely to introduce Earth potential is visual inspection. If it is not possible to determine by visual inspection alone, then a measurement of resistance to Earth can be obtained to determine if the conductive part in question is to be considered an extraneous-conductive-part. Where the measured resistance value between the conductive part concerned and the MET of the installation exceeds the requirements calculated by the equation below, Figure 6.1 taken from IET Guidance Note 8 *Earthing and Bonding*, the conductive part concerned need not be considered an extraneous-conductive-part as defined in BS 7671:2018. However, the designer must consider the stability of the resistance of the conductive part throughout the lifetime of the installation.

$$R_{CP} > \left(\frac{U_0}{I_B}\right) - Z_T \qquad (6.1)$$

where:

R_{CP} is the measured resistance between the conductive part concerned and the MET of the installation (in ohms).

U_0 is the nominal voltage to Earth of the installation (in volts).

I_B is the value of current through the human body (or livestock) which should not be exceeded (in amperes).

Z_T is the total impedance of the human body or livestock (in ohms).

Once the test has been carried out and a value has been obtained, a calculation can be performed to determine if the resistance is low enough for the conductive part to be considered as an extraneous-conductive-part with respect to the safe level of current flow deemed acceptable to the designer.

The values of IB and ZT are taken from BS IEC 60479-1:2018 *Effects of current on human beings and livestock*. The type of current is 50/60 Hz alternating current.

Firstly, the designer must select a suitable value of ZT which will be different from person to person and is dependent on several factors including (but not limited to);

- The touch voltage
- The supply frequency
- The duration of the current flow
- The conditions of wetness of the skin and surface area in contact
- The general environment

Table 2 of BS IEC 60479-1:2018, indicates values of total body resistance for hand to hand in wet conditions.

For the purposes of this example, the value of ZT selected is 1000 Ω.

Secondly, the designer must select the acceptable value of IB;

- 0.5 mA – The threshold of perception
- 10 mA — The threshold of let-go; or
- 30 mA – a current which can cause effects such as the following, depending on the time which automatic disconnection occurs. Where automatic disconnection occurs within 300 ms (for example, by non-delay RCD with IΔn not exceeding 30 mA): Perception and involuntary muscular contractions, but usually no harmful electrical physiological effects. Longer disconnection time, up to 5 seconds: Involuntary muscular contractions, difficulty in breathing, reversible disturbances of heart function and immobilization, but usually no organic damage.

Looking at the examples below with various values of IB taken from IET Guidance Note 8, if the designer was to select 0.5 mA as a safe level of current through the human body and the measured resistance between the conductive part and the MET is above 459 kΩ, then it need not be considered an extraneous-conductive part, therefore would not require connecting to the main earthing terminal.

Using Equation (6.1) to illustrate the range of values of resistance R_{CP} for currents from 0.5 mA, 10 mA and 30 mA, we get Equations (6.2),(6.3) and (6.4), respectively:

$$R_{CP} > \left(\frac{U_0}{I_B}\right) - Z_{TL} = \left(\frac{230}{0.5 \times 10^{-3}}\right) - 1000 = 460\,000 - 1000 = 459\ \text{k}\Omega \qquad (6.2)$$

$$R_{CP} > \left(\frac{U_0}{I_B}\right) - Z_{TL} = \left(\frac{230}{10 \times 10^{-3}}\right) - 1000 = 23\,000 - 1000 = 22\ \text{k}\Omega \qquad (6.3)$$

$$R_{CP} > \left(\frac{U_0}{I_B}\right) - Z_{TL} = \left(\frac{230}{30 \times 10^{-3}}\right) - 1000 = 7667 - 1000 = 6.67\ \text{k}\Omega \qquad (6.4)$$

Testing and verification

A resistance test can be carried out between the conductive part in question and the MET. This is described in IET Guidance Note 8, Clause 6.1 and shown in Figure 1.0 below. The test needs to be carried out with a continuity tester with a voltage range of between 4 and 24 volts and with a test current of 200 mA. The test should be carried out between the MET and the conductive part in question.

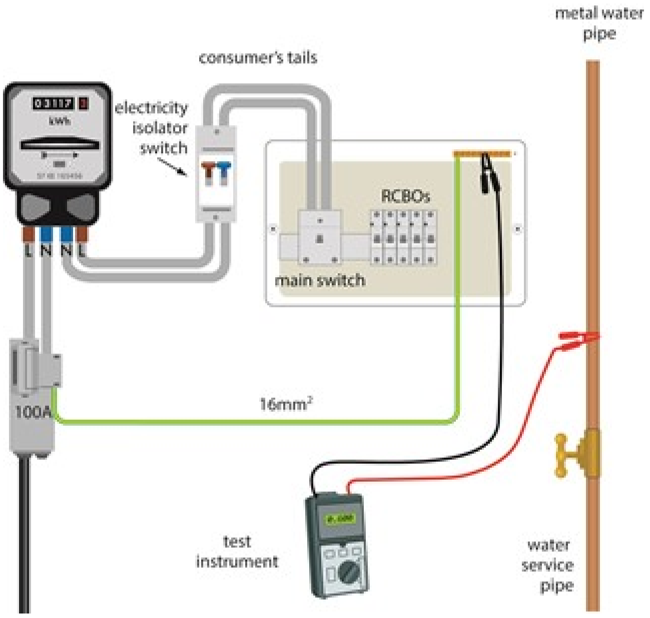


Figure 1

Hazards and problems

The first problem is that the test can only be carried out when the other installations, not forming part of the electrical installation, are complete which means it will not always be possible to determine until the later stages of a project.

Another problem would be that any class 1 electrical equipment connected to the pipework such as a boiler, motorised valve, or pump would create a conductive path to the MET which could indicate a low reading.

In most cases, for example at the design stage, the installation will not yet have been built. In which case, the designer will have to consider both scenarios with and without the protective bonding connected. The prudent option would be to install the protective bonding conductors at first-fix stage as it is likely to be more difficult and expensive to do at a later stage. It would also likely involve damage to the building fabric or be required to be installed surface mounted, which would not be desirable for most clients.

It is a common misconception that bonding such items won't cause any harm even if it is not required by BS 7671:2018 so a "better to be safe than sorry" attitude is taken. However, it is important to remember that by connecting to the main earthing terminal, in some circumstances, fault currents can be exported throughout the installation which would not be there if protective bonding had not been applied. This can cause an electric shock risk for persons outside of the installation in contact with the general mass of Earth and earthed equipment such as pipework, for example an outside tap or metal (class 1) electrical equipment.

Other considerations

It should be noted that even though the incoming service pipe may not be metallic or appear not to be in contact with Earth, there may be fortuitous connections with Earth throughout the installation which may or may not be apparent by visual inspection. For example, the incoming water pipe may enter the building in plastic pipe but in another part of the installation the metallic pipework could exit the building and enter the ground or be connected to earthed plant such as a metal pump, therefore introducing Earth potential. That is why it is important to ascertain where the extraneous-conductive-part enters or possibly exits the building.

If the designer chooses not to connect the metallic part in question to the MET, it would be prudent to label the conductor (if installed) at both ends to advise of the reason it has not been connected. This would ensure it is not inadvertently connected at a later stage. This should also be recorded on the electrical installation certificate.

The designer must also consider the stability of the resistance of the conductive parts over the lifetime of the installation, the resistance measurement will differ with temperature and humidity. For example, a measurement of resistance will change on a cold or damp day to that of a drier or warmer day.

Summary

To summarise, if any doubt exists following visual inspection, it could be determined by measurement and calculation if a part is deemed to be considered an extraneous-conductive-part before deciding whether to connect it to the main earthing terminal. Each installation is required to be assessed individually and a decision made, which will provide the greatest degree of safety, and the ultimate decision rests with the designer of the installation.

Sources of further information

The following publications will provide further information:

- BS 7671:2018;Requirements for Electrical Installations
- BS 7430:2011+A1:2015;Code of practice for protective earthing of installations
- IET Guidance Note 8 *Earthing and Bonding*
- BS IEC 60479-1:2018 *Effects of current on human beings and livestock.*

Crabtree: time to switch

Sponsored article from Crabtree

One hundred years ago John Ashworth Crabtree, the brand's founder and namesake, designed and patented a quick make and quick break switch. This innovation, which safely managed electric arcs that can occur in switching devices, was the beginning of the philosophy that became the culture of electrical safety for Crabtree.

Patenting his creation, John went into business for himself opening a factory in Walsall, a market town in the West Midlands.

Now, we're on the 18th Edition of the Wiring Regulations, but back when the 12th Edition of the wiring regulations was just being published in 1950, Crabtree had been operating for over 30 years.

Crabtree had launched during that time a number of innovations, including one still used today - British standard 13A twin sockets.

Now a staple in homes and businesses across the UK, British standard 13A twin sockets first introduced by Crabtree in 1947, one year after being awarded a Royal Warrant as supplier of electrical products to King George VI.

13A sockets might now seem ordinary. But they make our use of electricity safer. The secret to safety is the shutter system that makes BS sockets safer to use by protecting people from accessing live parts and by using switches that contain electric arcs within protective shields.

Sockets have changed over the years, through updates in decorative plates and the styles of the eras. The latest versions from Crabtree now combine recent innovations too, such as the multi shutter safety system, and full contact cable terminations, all combined with modern decorative features – while safety comes first, style certainly follows.

When Crabtree launched in 1919, it had a motto: “That which is built soundly endures well”. It was inscribed into the company plaque and rightly so.

Crabtree was built soundly enough to provide 100 years of electrical safety to its customers. And with a 100-year solid foundation what else can the brand do in the years to come?

For more information go to www.electrium.co.uk/crabtree