Wiring Matters

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Why have energy efficiency in electrical installations?

By: Cameron Steel

A background to Appendix 17.

In summer 2018, BS 7671:2018 (the 18th Edition of the UK's IET Wiring Regulations) included a new Appendix (17) concerning energy efficiency in electrical installations. The current proposals for Amendment 2 of BS 7671:2018 develop the initial provisions that have been derived from the international standard IEC 60364-8-1 *Low Voltage electrical installations – Part 8-1: Energy Efficiency*.

The UK building regulations provide a focus on reducing energy consumption. Most national and international legislative initiatives on energy efficiency focus on the design, construction, and commissioning of new buildings. It is now commonplace that the designs of new installations align with various internationally recognized accreditation schemes.

Relying solely on the implementation of new buildings that reduce energy consumption, to achieve national or international targets, is not enough. To really succeed in reaching global energy targets, energy efficiency measures should be applied to both existing buildings and to new building stock.

The replacement of the existing buildings with new stock is relatively low and is estimated to be around 2% to 5% per annum. Applying a new standard retrospectively to an existing building is always difficult and can be controversial, but IEC 60364-8-1 recognizes this and states that it is "… *in the refurbishment of existing buildings that significant overall improvements in energy efficiency can be achieved*."

Design hierarchy

Whether it is a new build or a refurbishment project, there is the need to achieve the lowest possible consumption of electrical energy. Appendix 17 of BS 7671 is an informative section so its contents are not mandatory, but there is clearly a moral imperative to ensure electrical installations do not waste energy. How does this affect the traditional role of the Wiring Regulations?

Within the built environment, the requirements for designing and maintaining safety in electrical installations are governed by national and international standards. International standards may be adopted as they are or might be adapted for local needs by national organizations.

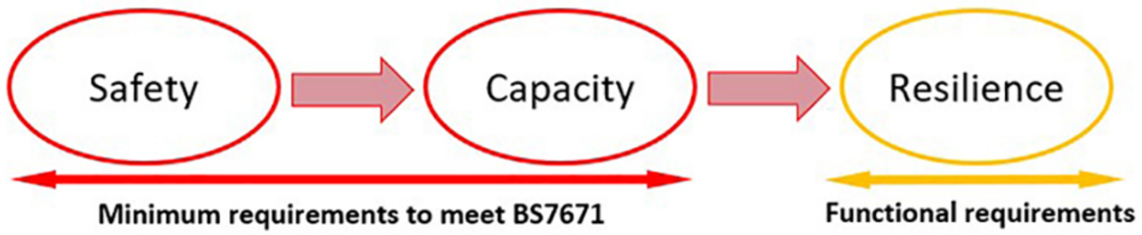
Historically the main two principles of BS 7671 Requirements for Electrical Installations (IET Wiring Regulations) have been safety and capacity. This ensures that an installation should:

- be safe enough to keep operators and users safe from the dangers of electric shock and allow satisfactory maintenance operations; and
- have sufficient design capacity for the existing needs of the installation and to prevent damage to the installation caused by the dangers of heat from overcurrent.

Meeting the requirements of these two basic principles has typically been all that is required for most domestic, commercial, industrial, and infrastructure installations.

Some installations, with safety-critical operations, will also consider resilience as an additional design principle. The requirement might be because of life safety risks, such as acute hospital care, or business continuity in data centres for example. The main purpose is to avoid single points of failure and to provide system continuity.

Embracing safety, capacity, and resilience, the traditional model of an electrical installation design hierarchy has typically been:



As the energy demands of our built environment rise, more burdens are placed on existing electrical distribution infrastructure that could be using quite old equipment and is already overstretched. This will only become more of an issue with the decarbonization of water and the adoption of electric vehicle charge points. This is not just an electrical distribution network issue, this is an issue that needs holistic solutions. We need to reduce energy consumption at the point of use, reduce losses in the distribution network and improve the quality and quantity of supply.

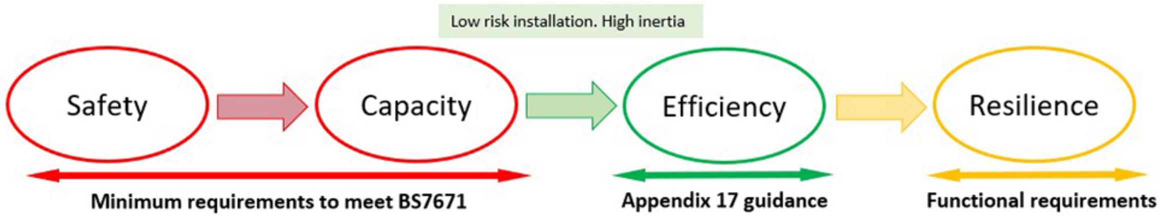
IEC 60364-8-1 considers design and maintenance from the context of reducing inefficiency in electrical installations, whilst still adhering to the original concepts of safety and operational control. Originally published in 2014, it was republished in 2019 and the draft Appendix 17 in the proposed Amendment 2 of BS 7671 addresses this document update.

The inclusion of energy efficiency will require a rethink on the hierarchy of design, but it is important to note that the priorities of safety and capacity will not alter.

A risk assessment approach is required and will vary from a low-risk installation to a high-risk installation. For installations with low operational risk, the need for energy efficiency may be considered more important when compared to the requirements of infrastructure resilience.

In low-risk installations, any critical loads may be small and supported by localized uninterruptible power supplies (UPS) facilities for specific equipment in a specific area.

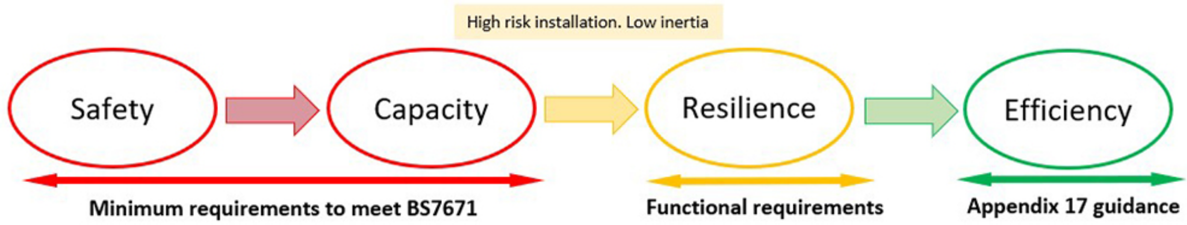
Other low-risk loads might not be badly affected by interruptions in supply, or load shedding activities, and can quickly resume normal service (known in IEC 60364-8-1 as high inertia loads). In this instance the traditional design hierarchy may change to this:



Electrical installations with a high operational risk may have a different approach, for example where there are greater risks to the critical healthcare of patients, or in financial institutions with major business continuity considerations.

In high-risk installations, critical loads will be significant, with large UPS facilities and backup generators to support an array of equipment across a large part of the installation. These types of loads will be badly affected by interruptions in power supplies, or load shedding activities, and cannot quickly recover (known in IEC 60364-8-1 as low inertia loads).

Interruptions in electrical supplies are always inconvenient. However, in high-risk installations, this could also lead to dangerous situations for hospital patients or loss of significant business in an international bank. Here the traditional design hierarchy will probably need to place much more emphasis on the principle of resilience and make energy efficiency a necessary but lower priority.



Whichever approach is ultimately adopted, there should still be a change of emphasis at the design stage to incorporate energy efficiency into electrical installation designs, and by default into operations as a prerequisite, not just as an aspiration. However, with the guidance offered, this does not need to be overly onerous or complicated. Indeed, many of the measures highlighted are common sense to aid efficient operations and others are already considered as part of a safety approach to electrical designs and installation.

The implications of energy efficiency on designs

Energy efficiency has not been addressed in an obvious way within previous editions of BS 7671, including the 2015 amendment of the 17th Edition.

Requirements for reducing volt drops on distribution and -circuit cables are primarily focussed on ensuring proper operation of equipment at the point of use. However, having the correct voltage at the point of use can also affect the operational efficiency of some electrical equipment.

Requirements on correct current carrying capacity reduces the risk of undersized cables and subsequent fire risks. However, having the correct sized cables is also a useful tool for addressing inefficiencies caused by harmonics of certain types of electrical equipment.

Within the Wiring Regulations, any discussion on controls and circuit switching has been about safe systems of work and functional operations. However, there has previously been no explicit mention of controls in the context of automatically reducing energy consumption. Sensors to control lighting have been become commonplace in recent years and used in conjunction with functional switching. It is these automatic switching and controls that are highlighted with the electrical energy efficiency standard.

Designing for power factor correction (PFC) has been considered previously, but usually just at the intake switchboard to improve load characteristics at the point of supply. The premise of energy efficiency is to reduce throughout the electrical distribution infrastructure, from the point of use to the point of supply. The designer should think about energy efficiency in a holistic way, through the whole installation. For instance, just focusing on power factor correction at the main switchboard may no longer be sufficient. Now other methods of power factor correction should be considered, including:

- small PFC units connected directly to large plant such as chillers
- use of more efficient equipment meaning less PFC is actually required, or
- small PFC directly connected to local switchboards.

Although not addressing energy efficiency, surge protection devices follow a similar integrated model and are increasingly being used throughout electrical installations. Using the surge protection model, localized PFC, and harmonic filters should be considered throughout the electrical distribution system to assist with energy efficiency. Such an approach will optimize the whole installation and potentially reduce oversizing cables.

Design factors

IEC 60364-8-1 considers various design and operational factors for energy efficiency in electrical installations. Each of these factors approach the energy efficiency question from a slightly different perspective to provide a holistic view.

- **Load energy profile (active and reactive energy)**

  This looks at the type of electrical loads and what measures can be put in place at the point of use to mitigate and reduce energy losses on the electrical distribution caused by equipment connected to it. By monitoring, measuring and analyzing energy consumption, patterns of typical use, and misuse, can be recognized so that action can be taken

- **Availability of local generation (PV, wind turbine, generator, etc.) and storage**

  This looks at the availability of on-site generation of electricity to reduce the demand of the installation on the wider grid. It will also include local electrical energy storage. Controls should be considered carefully to make best use of on-site generation or storage, especially at times of peak grid demand and higher prices.

- **Reduction of energy losses in the electrical installation**

  This looks at active measures such as power factor correction and harmonic filters and also passive measures to ensure cable infrastructure and other components are sized correctly to minimize losses. The proximity of the point of supply to the point of use should also be assessed, using the technique if applicable, to minimize losses on the distribution system by reducing distance between intake and load. The correct selection of energy efficient electrical appliances that are permanently connected to the installation is also important.

- **The arrangement of the circuits with regard to energy efficiency**

  This looks at how the circuits are grouped through zones, usages, or meshes. Requirements for zones focus on geography of circuits and loads, while usages deal with particular types of loads that are heavy users of electricity e.g. motors, air conditioning, or lighting. Meshes consider how the zones and usages integrate and how this is all monitored and controlled

- **The customer's power use distribution over time**

  This assesses which electrical loads are active at what times. Scheduling can be initiated to avoid capacity issues at the electrical intake and to avoid punitive costs for unnecessary energy consumption at peak times. Shifting the energy consumption of some loads to off-peak periods could be rewarded of cheaper tariffs at the time of use using contractual incentives from the electricity supplier. Load shedding may also be considered necessary.

- **The tariff structure offered by the supplier of the electrical energy**

  The roll-out of smart meters allow for the introduction of dynamic tariffs that vary throughout the day. Traditional tariffs can feel like they are one-size-fits-all and have higher costs. Newer entries to the electricity supply market, like Octopus Agile, offer half-hourly rates to the market allowing customers to plan their consumption through the whole 24-hour period. Loads like electric vehicles and electrified heating can be supported through off-peak hours when tariffs are significantly cheaper.

The case for energy efficiency in all electrical installations

Most legislative initiatives and associated benchmarking schemes on energy efficiency focus their outcomes primarily on new buildings. In order to improve, or promote, their environmental credentials, many newly built installations seek accreditation from international organizations such as BREEAM, LEED or similar benchmarks. These awards are driven during the design stage of new construction projects.

Refurbishment has not always had the attention or emphasis it needs. For refurbishment projects, similar benchmarks have not always been available. Changes in recent years to the UK Building Regulations, including Part L, which focuses on energy consumption, means that if a large enough part of the building is refurbished the other parts of the same refurbished building must also be considered for upgrade too – the idea of beneficial improvements.

Another driver for change in the UK is in the commercial rental sector. This means that commercial buildings must achieve minimum energy efficiency standards before they can be let.

An energy-efficient electrical installation has many potential benefits:

- It generally has less impact on the environment.
- It reduces energy losses overall and hence lowers energy costs.
- It has better controls and uses energy only when it is actually required and potentially at a lower (off-peak) tariff.

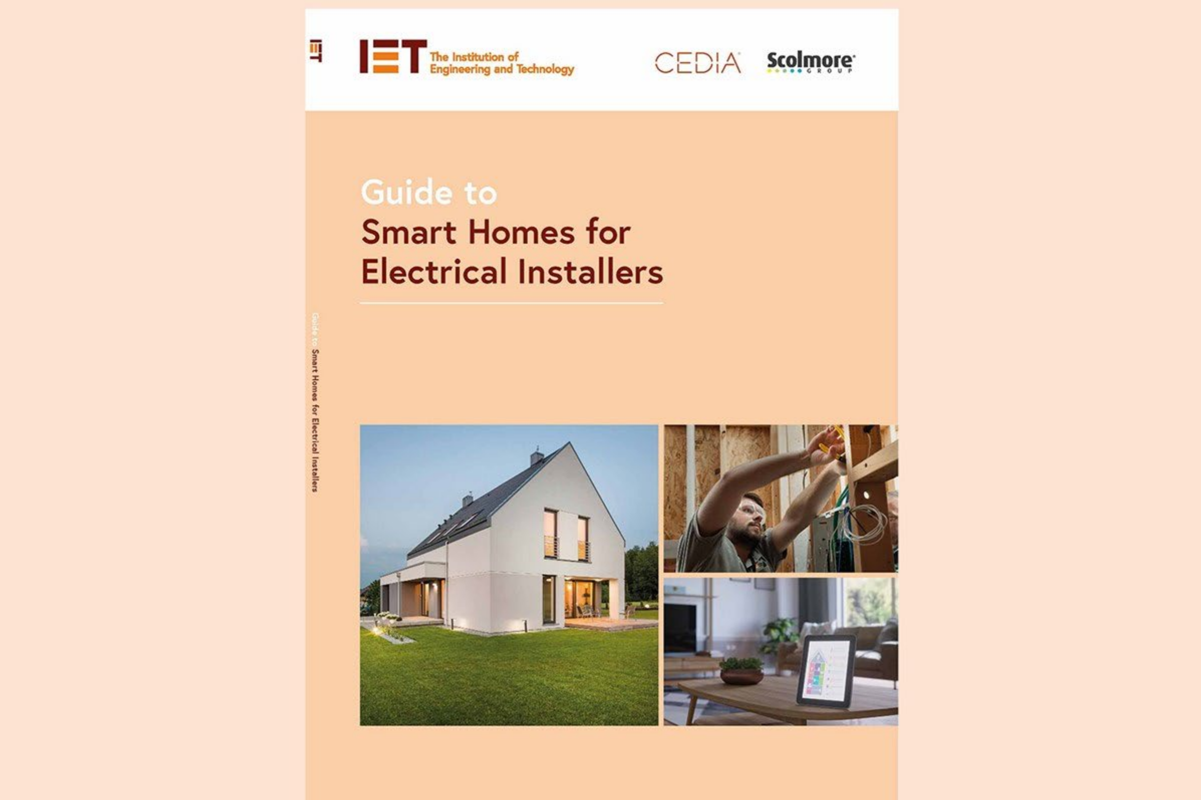
- It means less reactive maintenance throughout the electrical infrastructure by reducing the adverse effects of heat loss, and
- It optimizes the electrical system performance throughout its life cycle.

Conclusion

Safety and capacity are still the most important criteria for electrical installations covered by BS 7671. Resilience should always be considered especially on life safety systems.

However, energy efficiency is a necessity and can no longer be ignored as we move to a low-carbon future. The guidance within Appendix 17 and in IEC 60364-8-1 should underpin all electrical installations by design and by operation.

Designers and operators should be aware that there is now a duty of care to make their electrical installations as efficient as possible without reducing safety or compromising the needs of users or activities within the buildings. Design risk assessments of electrical energy consumption are likely to become as important within the built environment as health and safety or reducing single points of failure.



With great power comes great responsibility

By: Allan Burns BSc TMIET PGCE, Director of Telemental Ltd

'Smart' is undoubtedly the hot buzzword, both at the wholesalers and when considering options with clients.

Domestic and commercial customers are now very aware that there are a host of devices and equipment that can swap out the 'traditional' item and offer them greater functionality. These options are increasingly on a par in terms of price, room thermostats being a good example, where Internet of Things (IoT)/Wi-Fi versions are really not much more expensive than their older, physical-button relations.

However, an uncomfortable truth about 'smart' for electricians is that most manufacturers will design devices so that electricians are not needed whenever that is a safe option. This is simple economics as they will sell more units if the cost of ownership is lower. Online product reviews condense hundreds of hours of trial and error into summaries that can be read in minutes, so the electrician's product knowledge is trumped in most cases. QR codes and YouTube videos to simplify installation and setup will improve so devices with digital interfaces will become increasingly user-configurable.

So, should the humble electrician give up on the hope of being required or relevant anywhere outside of pulling cables or chopping out a back-box?

Answering this requires consideration of two very general factors of electrical installation; coverage and longevity.

In terms of coverage, in my experience as an installer, no other trade gets in as many places, with as many bits, making as many holes, and linking all those places as the electrician.

As to the longevity, the lifespan of an electrical installation is decades. Customers expect that they don't want the disruption of a rewire more than once in a generation. Let's say 30 years, that takes us to 2051.

So as the trade going everywhere and linking everything in a given building, you, the electricians are the best-placed people to cover off all the likely connectivity requirements of the building for the next 30 years. By 2051 we can expect a profound transition in how people and buildings interact with each other and the increasingly endangered environment.

How can an electrician not be relevant in that scenario?

How should electricians approach this responsibility?

Not every electrician will want to step into the role of 'future-readier'.

Some will already have grasped the crystal ball. For those thinking maybe they should but wondering how to shape it into something that works and can be invoiced, I offer three simple steps to get started:

Step 1

Notice trends, particularly those that take significant current.

Some examples:

EV charge points. They've been coming on slowly for 10 years - then all-of-a-sudden if you didn't put at least a 6mm cable from the origin into the garage or near the drive you're a lemon!

Battery energy storage is another slow burn. It is possible we will all end up using our cars as batteries but what if we don't, where would a static battery go and how would it be connected?

PV could become cheaper, easier and better incentivised, is a cable to a sunny surface justified?

Electricians don't just do power cables. Communication and bandwidth requirements are just going up and up. But so are concerns about screens and their effect on mental health. Is it possible wide-coverage Wi-Fi will become less popular in favour of wired outlets and low-power Wi-Fi? Do you need to specify CAT cables to allow for this?

DC power that we have seen expand as USB and USB-C is likely to increase in availability and capability as renewable DC and battery energy becomes better integrated. We could be seeing DC white goods in high street electrical retailers before the decade is out. Do some final circuits need to be earmarked for later adaptation to DC?

Step 2

Consider lifestyle.

No one is suggesting you need to become a behavioural scientist or interior designer but do bear in mind that there is an interplay between your installation and the building and between the building and the homeowners.

In addition to guidelines, like those found in the IET's *On-Site Guide,* which recommend minimum levels of sockets in different room types - take the time to find out how home dwellers live and use the space you are installing in and try to anticipate future requirements.

The term prosumer describes people who look to leverage their energy assets for financial benefit. Until recently it has been a bit niche but, for all we know, being a prosumer might become a necessity within 10 years. This being an example of a lifestyle change that might be thrust upon your client, a new build or rewire is an opportunity to work in the capability to prosume.

Importantly, consider how the client's lifestyle will change as they age. Putting it bluntly, the cost of residential care is a strong incentive to optimize the home so that owners can stay in it longer. Assistive living technology is a rapidly developing market. It is another digital trend that could have been listed in Step 1 above. The form and shape of solutions is highly fluid and will require research, but it is something electricians should explore and discuss with their clients.

Step 3

Take reasonable steps and adopt reasonable strategies, including:

Ducting

It is cheap and if a channel is open e.g. a trench, a wall, a floor that goes in a direction that might yield a benefit or possibility, put some ducting in it.

Nodes

Just because there is a duct does not mean pulling a cable through is going to be possible. Consider claiming nodes which break up 'pulls' and potentially create space for junctions and equipment in the future. At this point you are stepping into a mode that affects the work of others to a degree they might not be accustomed to (or like). Asking a chippie to create an access hatch where they planned to nail a bit of ply could be controversial, be prepared to explain benefits to other interested parties. The prospect of convincing others leads me on to my final recommendation.

Learn and inform

With great power comes great responsibility. The built environment's conversion to electrification and digitalization will continue to accelerate and electricians will be in the vanguard of that transition. Take the time and make the effort to become informed about how the way you structure your installation can enhance the user experience and minimize the environmental impact of the places you're designing for.

You don't need to have all the answers, but be ready to argue for that extra hatch, duct, cable or just cable cross-sectional area. The client, architect and other trades will have their own preferences and big picture, but you are the one who knows how to connect things up. If you are getting in every nook and cranny, make it count by making a better, more sustainable building for a better world.

Allan Burns BSc TMIET PGCE

Allan Burns is the Author of the *IET Guide to Smart Homes for Electrical Installers* where you can find more guidance on how to deep-design smart sustainable homes.

EICR Myths

By: Michael Peace CEng MIET

Answering some of the most common questions and dispelling the myths associated with the EICR.

Since the Electrical Safety Standards in the Private Rented Sector (England) Regulations 2020 came into force on 1 June 2020, the IET technical helpline has been inundated with calls related to the Electrical Installation Condition Report (EICR). This previous IET Wiring Matters article provides further information. In this article, we are going to answer some of the most common questions received and dispel some of the myths associated with the EICR.

What is an EICR?

An EICR is an electrical installation condition report, on the condition of an electrical installation. The process involves a combination of inspection and testing to determine if the electrical installation is safe for continued use. and on completion, a report is issued.

An EICR is carried out Regulation 651.1 of BS 7671:2018+A1:2020 states that:

'Where required, periodic inspection and testing of every electrical installation shall be carried out in accordance with Regulations 651.2 to 651.5 in order to determine, so far as is reasonably practicable, whether the installation is in a satisfactory condition for continued service.'

The EICR can be used to assist the duty holder in assessing the risk to determine the safety of the installation. The information in the report could be used to develop safety measures to mitigate the danger until remedial works can take place, such as isolation of an affected circuit.

Is an EICR retrospective?

We often get enquiries advising that an EICR has been carried out and the customer has been advised that their installation needs to comply with the latest edition of BS 7671, which is not the case.

The extract below is taken from the note by the HSE in BS 7671:2018+A1:2020:

'Existing installations may have been designed and installed to conform to the standards set by earlier editions of BS 7671 or the IEE Wiring Regulations. This does not mean that they will fail to achieve conformity with the relevant parts of the Electricity at Work Regulations 1989.'

Just because the installation does not fully comply with BS 7671:2018+A1:2020, does not necessarily mean it is unsafe, which will depend on the condition of the installation. The inspector must apply engineering judgment to determine if it is safe for continued use.

Who can carry out an EICR?

When commissioning an EICR, it is important to check that the person is competent to do so. It is recommended to use a registered competent person to carry out the inspection and testing. Further information can be found at the registered competent person scheme website.

A person carrying out an EICR is required to be competent. The term skilled person (electrically) is used in BS 7671:2018+A1:2020, defined as below:

'Skilled person (electrically). *Person who possesses, as appropriate to the nature of the electrical work to be undertaken, adequate education, training and practical skills, and who is able to perceive risks and avoid hazards that electricity can create.*
NOTE 1: *The term "(electrically)" is assumed to be present where the term 'skilled person' is used throughout BS 7671.*
NOTE 2: *Regulation 16 of the Electricity at Work Regulations 1989 requires persons to be competent to prevent danger and injury. The HSE publication HSR25 provides guidance on this.'*

It is clear to see from the definition that someone carrying out EICRs is required to have adequate education, training, and experience to do so. An inspection and testing qualification place is a good place to start, but it is also necessary that the inspector has the necessary experience.

Common mistakes observed on EICRs

Section D – Extent and limitations of inspection and testing

The description of the extent of the installation covered by the report is arguably one of the most important sections to complete as it describes what is being inspected and tested.

In order to establish the extent of the inspection and testing, a conversation with the person ordering the report will be required. The person ordering the report will not usually have knowledge of exactly what they need so it is important to understand their requirements and make clear exactly what has and, just as importantly, what has not been tested and inspected and agree this in writing before the work begins.

In some cases, it may be necessary to agree limitations to the report. This should be clearly noted in the agreed limitations section. It could be that the inspection and testing does not cover products such as fixed equipment connected to the installation, it is important this is made clear on the report.

Despite the best intentions of the person ordering the report and the inspector, it can sometimes be the case that on the day of the inspection, circumstances dictate that further limitations are applied to the inspection and testing. If this is the case, this must be recorded in the operational limitations section. The person ordering the report must be made aware of the implications of the limitations, it could be that it affects the inspector's ability to reach a conclusion to the report for certain aspects.

However, limitations should not be used as an excuse not to carry out the necessary inspection and testing. Statements such as, 'no access to high-level equipment' are not acceptable and the person ordering the report must be made aware of any implications of not inspecting certain parts of the installation.

Section E - Summary of the condition of the installation

This section is the opportunity for the inspector to describe the condition of the installation in layperson terms to the person ordering the report. It is common to see statements such as 'good', or 'needs new fuse box' inserted in this section which is not useful. Some would argue that there is not sufficient space on the form to provide the information. However, the forms are only models and additional pages can be used and appended to the report.

Depending on the extent of the installation, it is difficult to see how the condition of an electrical installation can be adequately described using the space already provided on the forms.

On completion of the inspection and testing the inspector will provide an overall assessment of the installation in terms of its suitability for use, this will either be satisfactory or unsatisfactory depending on the classification codes which have been attributed to any observations recorded on the report.

If the inspector has noted any C1 or C2 conditions, it should result in an unsatisfactory outcome of the report.

In some cases, the inspector may not be able to reach a conclusion and further investigation will be required. In which case the observation will be attributed with F/I. The classification of further investigation should not be used to locate the problem, it should only be used where it is reasonably expected to reveal a dangerous or potentially dangerous situation.

If further investigation is required, the person ordering the report should be advised that a potential safety issue has been discovered but due to the limitations of the EICR, a conclusion could not be reached and the issue should be investigated as soon as possible.

Section F - Recommendations

Any observations identified during inspection and testing should be recorded on the report. The observation should be a factual description of the problem, and not as commonly seen a proposal for the remedial works to rectify the issue.

If remedial works are necessary, this should be detailed on a separate quotation. It would be of great benefit to the person ordering the report if the observations were individually quoted to allow the person ordering the report to be able to determine what was required to make the installation safe for continued use.

The inspector is also required to recommend a date for further inspection and testing to be carried out. These dates are often assumed or taken from Table 3.2 of IET Guidance Note 3 Inspection & Testing.

However, it is important to remember that Table 3.2 is titled 'recommended initial frequencies of inspection of electrical installations.' The first important word is 'recommended', it is exactly that, a recommendation and **not** a legal requirement. It is also important to note that this is for initial frequencies for new installations. It is worth noting that for domestic rented accommodation and houses in multiple occupation, the recommended maximum period between each inspection and test is five years or change of occupancy, which is often overlooked.
The interval between each inspection and test will require an engineering judgment to be made based on the knowledge and experience of the inspector. The Electrical Safety Standards in the Private Rented Sector (England) Regulations 2020 states that an electrical test is required for a rented property at a maximum interval of five years, but this could be reduced by the inspector, but this would need to be justified.

If any observations are classified as 'danger present', the inspector should try and remove the danger where possible. The observation should be attributed with a C1 classification code and an electrical danger notification letter should be issued to the person ordering the report without delay. It would not be considered acceptable to provide the information on the report and issue it several days later. This is necessary to satisfy the Health & Safety at Work Act 1974 and the Electricity at Work Regulations 1989.

Attributing classification codes to observations

The best source of information available for guidance on attributing classification codes is Electrical Safety First Best Practice Guide 4, BPG 4 is an industry-wide agreed document, contributed to by many organisations including the IET.

Ultimately it is the inspector's engineering judgment to attribute the correct classification code, BPG 4 is a useful guide to provide a starting point for making that judgment. It is difficult to see how an inspector could deviate from this guidance without providing adequate justification.

Myths

A consumer unit made from combustible materials needs replacing

If a consumer unit is made from combustible material (e.g. plastic), BPG 4 recommends that the presence of a plastic consumer unit is worthy of a note, but does NOT warrant a classification code. If the consumer unit is located under a wooden staircase or within a sole route of escape from the premises, a C3 classification code is recommended.

Either way, this would not result in an unsatisfactory outcome.

A bathroom light needs to be replaced as it is not IP65 rated

The IET's On-Site Guide is a good source of information, minimum IP rating for a luminaire installed in zone 1 of a room containing a bath or shower is IPX4, protection against splashing water.

The minimum IP rating for electrical equipment installed in zone 1 of a location containing a bath or shower is IPX4.

A bathroom fan needs to be 12 V extra-low voltage

Again, the IET's On-Site Guide is an excellent source of information, Table 8.1 states that ventilation equipment installed in zone 1 of a bathroom is permitted to be 230 V, providing it is RCD protected and meets the minimum IP rating of IPX4.

230 V low voltage rated bathroom fans are permitted in zone 1 of the bathroom.

All circuits must be RCD protected

RCD protection is required for all socket outlets, a C3 classification code is recommended in BPG 4 where the socket-outlet is unlikely to be used for portable equipment outdoors.

A C3 classification code is recommended in BPG 4 for the absence of RCD protection for cables buried in walls at a depth of less than 50 mm, without mechanical protection.

BS 7671:2018 introduced requirements for additional protection for AC final circuits supplying luminaires within domestic (household) premises. If this is observed to be absent, BPG 4 recommends that a C3 classification code is attributed.

C3 classification codes do not result in an unsatisfactory outcome.

However, absence of RCD protection for a socket-outlet likely to be used for portable equipment for use outdoors or for circuits in a location containing a bath or shower would warrant a C2 classification code, which would result in an unsatisfactory outcome.

Rewireable fuses are no longer acceptable

Rewireable or semi-enclosed fuses to BS 3036 as they are referred to in BS 7671:2018+A1:2020, are indeed still permitted providing the appropriate correction factor (0.725) is used when determining the size of the conductor. In fact, Table 533.1 identifies the sizes of tinned wire for use in semi-enclosed fuses.

However, a 'fuse box' is unlikely to contain sufficient provisions for RCD protection where necessary and depending on the deficiencies observed, it may be more cost-effective to replace for a modern consumer unit.

Some 'fuse boxes' may contain an asbestos pad which effectively served as a flash guard. In the event that a fuse wire needs to be replaced, it is likely to release asbestos fibres, which would not be considered acceptable. For information on replacing an asbestos-containing fuse box, see HSE a33 datasheet. IET Wiring Matters article asbestos guidance for electricians provides general information on asbestos likely to be encountered by electricians.

TABLE 533.1 – Sizes of tinned copper wire for use in semi-enclosed fuses

Rated current of fuse element (A)	Nominal diameter of wire (mm)
3	0.15
5	0.2
10	0.35
15	0.5
20	0.6
25	0.75
30	0.85
45	1.25
60	1.53
80	1.8
100	2.0

The installation does not contain a fire alarm or emergency lighting system

Inspection of fire alarm and emergency lighting systems do not generally form part of an EICR. However, power supplies and wiring of emergency lighting systems will be part of the fixed wiring installation and should be included.

Fire alarm and emergency lighting systems are required to be inspected in accordance with BS 5839 *fire detection & alarm systems for buildings* and BS 5266 *Emergency lighting, code of practice for the emergency lighting of premises* respectively.

Whilst deficiencies observed on fire alarm and emergency lighting systems during the inspection may be worthy of a general note, a classification code should not be attributed.

Summary

An EICR is a factual report on the condition of an electrical installation and suitability for continued use.

The inspection and testing of an installation must only be carried out by (electrically) skilled persons with sufficient knowledge and understanding of electrical installations.

BPG 4 is an excellent guide to classification codes for common observations in domestic installations.

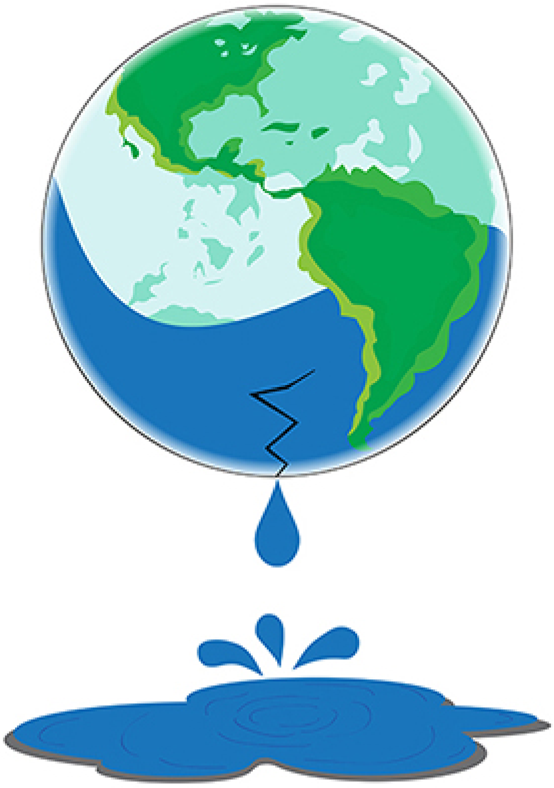
The EICR must be compiled in such a way that the person ordering the report can understand it. The condition of the installation should be accurately described to allow the person ordering the report to make an informed decision on the repairs to be carried out, based on the risk to the users of the installation.

BACK TO THE FORUM

Earth leakage

By: Michael Peace CEng MIET

How much is too much?



One question being asked in the IET Engineering Communities Forum is 'Earth Leakage Current – How much is too much?

This question is being asked more often due to the proliferation of electronic equipment.

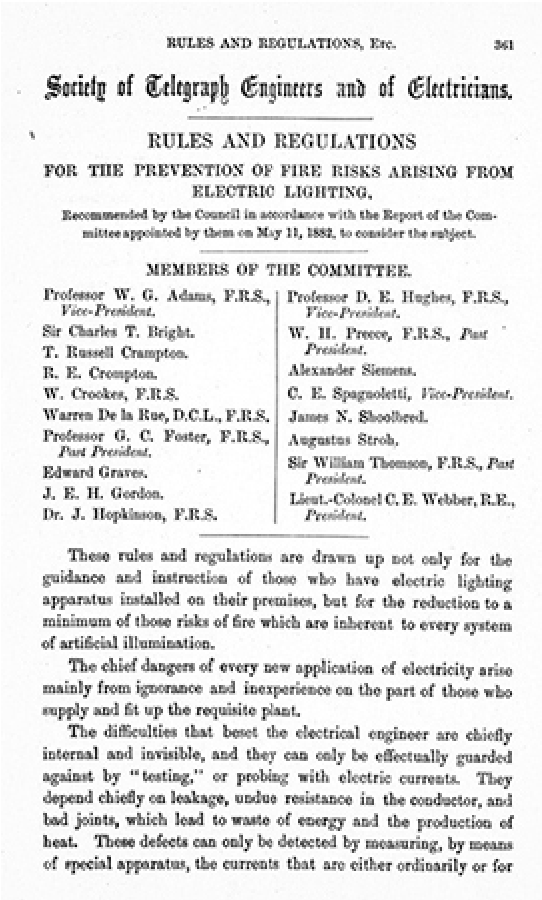
What is Earth leakage current?

Earth leakage current is not specifically defined in BS 7671:2018+A1:2020, it is referred to as protective conductor current. Protective conductor current is defined as an '*electric current appearing in a protective conductor, such as leakage current or electric current resulting from an insulation fault.*' Leakage current is also defined as *'electric current in an unwanted conductive path under normal operating conditions.'*

Earth leakage current can exist through an insulation fault in cables or equipment, or it can occur under normal operating conditions in electronic equipment which use capacitors for filtering purposes in power supplies which can cause leakage to Earth when functioning.

Hence this type of equipment requires a functional earth, which is different from a protective earth.

Figure 1



RULES AND REGULATIONS, Etc. 361

Society of Telegraph Engineers and of Electricians.

RULES AND REGULATIONS

FOR THE PREVENTION OF FIRE RISKS ARISING FROM ELECTRIC LIGHTING.

Recommended by the Council in accordance with the Report of the Committee appointed by them on May 11, 1882, to consider the subject.

MEMBERS OF THE COMMITTEE.

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These rules and regulations are drawn up not only for the guidance and instruction of those who have electric lighting apparatus installed on their premises, but for the reduction to a minimum of those risks of fire which are inherent to every system of artificial illumination.

The chief dangers of every new application of electricity arise mainly from ignorance and inexperience on the part of those who supply and fit up the requisite plant.

The difficulties that beset the electrical engineer are chiefly internal and invisible, and they can only be effectually guarded against by "testing," or probing with electric currents. They depend chiefly on leakage, undue resistance in the conductor, and bad joints, which lead to waste of energy and the production of heat. These defects can only be detected by measuring, by means of special apparatus, the currents that are either ordinarily or for

What are the effects of leakage current?

The extract in Figure 1 is taken from the First Edition of the IEE Wiring Regulations in 1882 and it can be seen that leakage current was a consideration even back then, although probably for different reasons. It could be said that the First Edition was more concerned with waste of energy and heat than electric shock.

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In 1882 unwanted tripping of RCDs would not have been an issue, today with most circuits requiring RCD protection for one reason or another, and the proliferation of appliances containing electronic equipment, unwanted tripping is a real issue.

How can Earth leakage/ protective conductor currents be measured?

One way of measuring earth leakage is to use a leakage current clamp ammeter. Leakage current clamp meters are similar to those used for measuring load current, but are more sensitive and therefore more accurate at measuring currents below 5 mA.

To determine the Earth leakage on the whole installation, place the clamp around the live conductors for the installation a shown in Figure 2 for single phase, or Figure 3 for three phase installations.

Figure 2

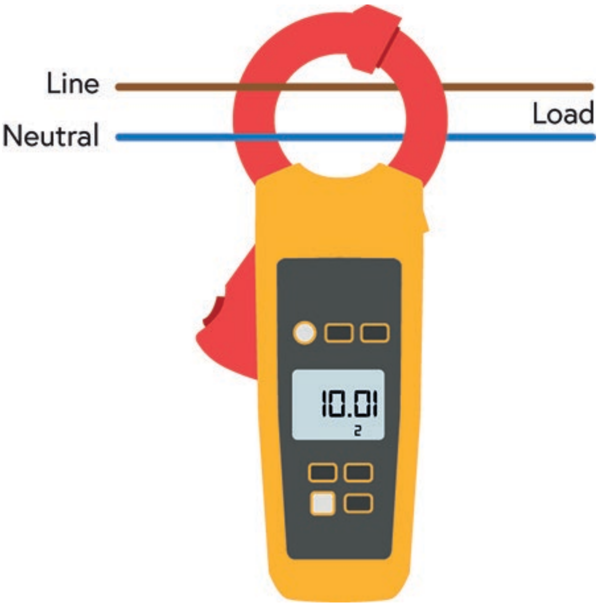
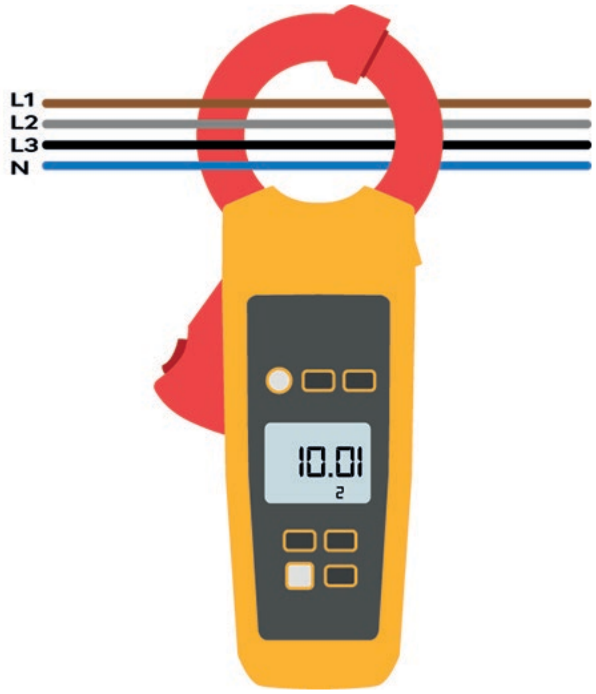


Figure 3

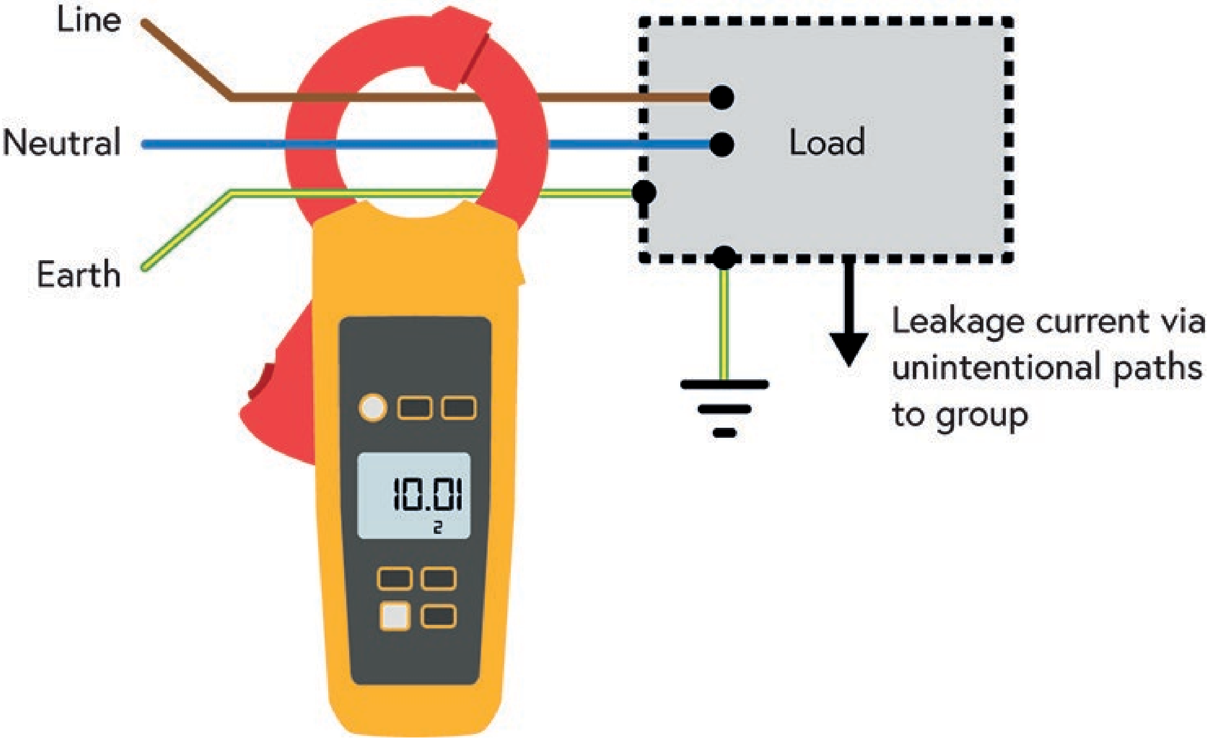


In the case of an installation that does not have any leakage current, the reading should be zero as the currents should cancel each other out, if any current is leaking to earth, the value will be displayed on the instrument. If leakage current is identified in the installation, it will be necessary to isolate and test individual circuits in order to identify those that are affected.

To determine if the Earth leakage current is within the installation or from the equipment, it is necessary to isolate current using equipment from the installation and use the clamp ammeter to test each individual item separately. Place the clamp around the live conductors for the installation a shown in Figure 2 for single phase, or Figure 3 for three phase installations

It could be that the leakage current is returning to Earth directly and not returning via the earthing conductor. To determine if any leakage current is returning via fortuitous connections with Earth, the clamp ammeter can be placed around the line, neutral and protective conductors as shown in Figure 4.

Figure 4



Insulation resistance vs insulation impedance

It is worth noting that taking a measurement of leakage current and using the value to carry out an ohms law calculation will provide the value of insulation impedance. The result will be different from the value of insulation resistance which is obtained from an isolated circuit using an insulation resistance tester. The reason being the insulation resistance tester applies a DC voltage test that does not take account of the capacitance of the circuit. It is the insulation impedance value which actually exists under operating conditions.

What about DC leakage current?

Measuring DC with a clamp meter is not as simple as measuring AC. At present, there are not any clamp ammeters which can measure DC leakage current to any degree of accuracy.

Residual DC leakage current can cause blinding to AC type RCDs, see IET Wiring Matters article Which RCD type? for further information.

What does BS 7671:2018+A1:2020 say about unwanted tripping?

Regulation 314.1 of BS 7671:2018+A1:2020 requires an installation to be divided into circuits, as necessary to, *'reduce the possibility of unwanted tripping of RCDs due to excessive protective conductor (PE) currents not due to a fault'.*

Regulation 531.3 of BS 7671:2018+A1:2020 provides the requirements for Residual current devices (RCDs). Regulation 531.3.2 states that residual current protective devices shall be selected and erected such as to limit the risk of unwanted tripping. Indent (ii) states that the accumulation of such currents downstream of the RCD shall be not more than 30 % of the rated residual operating current. So, assuming we are using an RCD with a rated operating current of 30 mA, the maximum leakage current is 9 mA.

Note 2 of Regulation 531.3.2 states that RCDs may operate at any value of residual current in excess of 50 % of the rated residual current. If unwanted tripping of an RCD protecting several circuits is experienced, it could be a cumulative effect of the leakage current of the protected circuits.

Regulation 543.7 recognizes earth leakage currents in excess of 3.5 mA as high protective conductor currents. Specific additional protective measures are required for circuits considered to have high protective conductor currents.

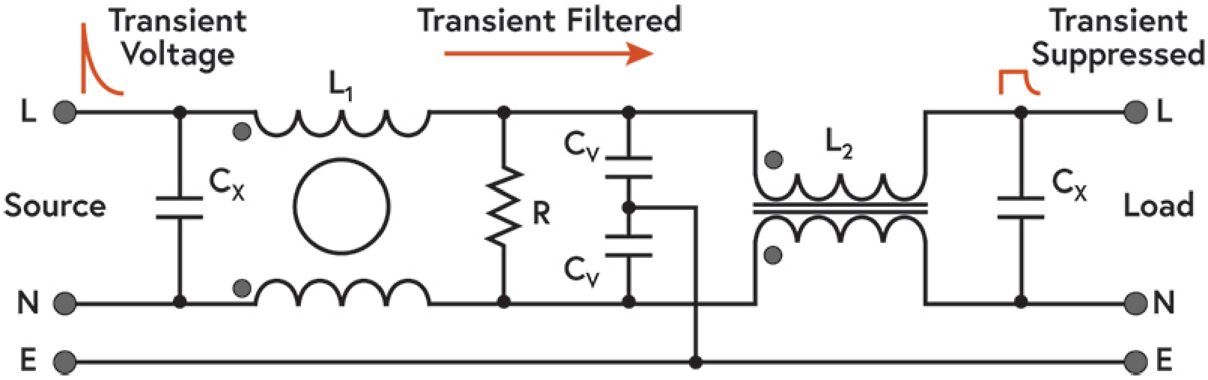
Other causes of unwanted tripping

In some cases, unwanted tripping could be caused by RCDs or RCBOs which are too sensitive, this can be determined with an RCD ramp test. An RCD with a residual operating current of 30 mA could trip anywhere between 15 mA and 30 mA, typically it will operate at 75 % of $I_{\Delta n}$.

How does current leakage occur within electronic equipment?

Leakage current in electronic circuits is typically from power supplies. This is due to the use of capacitors used to filter transients from the supply. Electrical transients are short bursts of energy with potential to damage electronic circuits. Figure 5 illustrates the filter capacitors connection to earth, which is the route for the leakage current.

Figure 5



What are typical equipment maximum earth leakage values?

BS EN 60335-1 provides the general safety requirements for household and similar electrical appliances. Maximum values of earth leakage for appliances are identified below, it is important to remember these are maximum values:

- For class II appliances and for parts of class II construction - 0.25 mA.
- For class 0, 0I and III appliances: 0.5 mA b for class I portable appliances -, 0.75 mA.
- For class I fixed motor-operated appliances - 3.5 mA.
- For class I fixed heating appliances - 0.75 mA or 0.75 mA/kW of rated power, with a maximum of 5 mA, whichever is the higher.

The amount of leakage current will vary according to the type of equipment. The IEC 60335 series of Standards provides requirements for different types of products:

- Fixed PC workstation - 2 mA
- Printer - 1 mA
- Photocopier - 1.5 mA
- Laptop - 0.5 mA (with EMC filter)
- Grills, toasters/portable cooking appliances - 0.75 mA (earthed metal)
- Fridges - 1.5 mA (class I)
- Dishwasher - 5 mA
- Hobs, ovens - 1 mA or 1 mA/kW of rated power
- Washing machine - 5 mA
- Tumble dryer – 5 mA
- Electric heat pumps - 10 mA (accessible to public)
- Floor heating - 0.75 mA or 0.75 mA/kW of rated power

Luminaires can also be a source of leakage current, BS EN 60598-1 provides the leakage current requirements for Luminaires:

- Continuous interference - 0.5 mA
- Class 0 and Class II -1 mA
- Portable, Class I - 1 mA
- Fixed, Class I up to 1 kVA of rated power, Increasing in steps of 1 mA/kVA up to a maximum of 5 mA

How much leakage current is too much?

To answer the question from the IET Engineering Communities forum, the amount of leakage current will depend on the arrangement of the electrical installation and the installed equipment. An acceptable level of leakage current can be determined by information from manufacturers of the equipment and protective devices. This information will allow final circuits to be arranged accordingly.

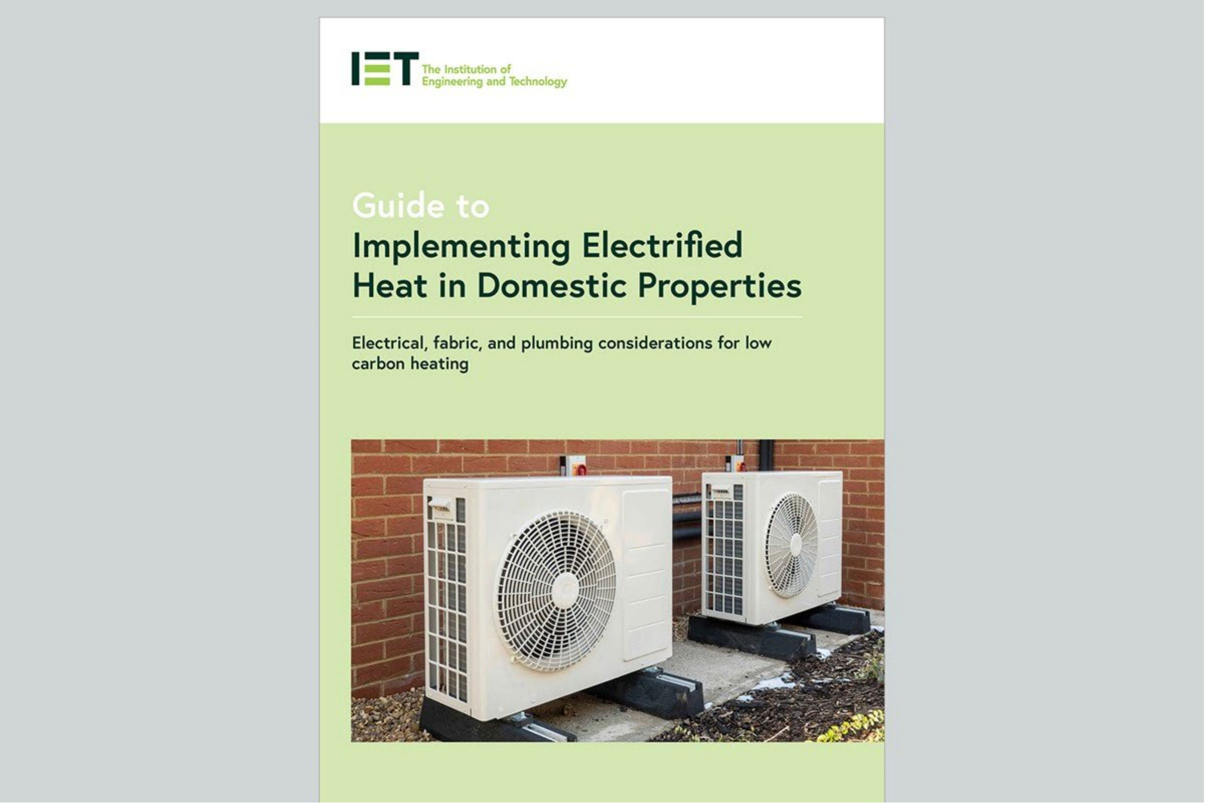
In order to prevent unwanted operation of earth leakage protective devices, the installation will need to be designed to take account of leakage currents. See this Schneider earth fault protection article for further information.

Summary

Installations incorporating electronic equipment are likely to have some level of leakage current. A leakage current clamp ammeter is a useful tool for identifying the source of protective conductor current within an electrical installation.

Different types of equipment have different levels of permissible leakage current according to the relevant standards. Manufacturers information should be used to determine an acceptable level of earth leakage current for the current using equipment. The installation should be designed to prevent unwanted operation of earth leakage protective devices due to the cumulative effects of leakage currents.

It is particularly important to maintain continuity of circuit protective conductors for circuits with protective conductor currents.



Draft for Public Comment for Guide to Implementing Electrified Heat in Domestic Properties

The IET Codes and Guidance team has recently released a draft Guide to Implementing Electrified Heat in Domestic Properties.

Prepared for all those involved in this sector, it focuses on all forms of electrified heat as well as other related approaches and technologies.

The draft will be available for review and comment until Friday, 21 May 2021.

Please visit the Draft for Public Comment web page to share your thoughts and feedback.

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You can even win a year's subscription to our Digital Wiring Regulations Silver Package, which will include all Amendment 2 to BS 7671:2018 content for the life of the subscription!

We're hoping to be back in the real world for the Elex shows later in the year, but until then, check out the showcase online.