# Derating grouped circuit-breakers within a consumer unit due to mutual thermal influences

By: Joe Cannon MSc IEng MIET

## 1. What are the requirements for derating grouped circuit-breakers within a consumer unit?

Circuit-breakers serving continuous loads from a consumer unit may require derating when grouped together. This is due to the thermal interaction between the circuit-breakers when serving continuous loads. In a similar manner to derating cables installed in a group, designers should apply derating factors to grouped circuit-breakers when continuously loaded.

It is the consumer unit manufacturers who will specify the derating factor, which is referred to as the rated diversity factor (RDF). The rated diversity factor is generally applied to thermal-magnetic circuit-breakers that are continuously loaded and that are placed adjacent to other circuit-breakers that are also continuously loaded. The rated diversity factor is applied to ensure that the heat emitted from the circuit-breaker stays within a tolerable value when under continuous load.

As the demand increases for electrical equipment that has a sustained load, such as electric vehicle charging points and heat pumps, it is crucial for designers to recognize the thermal impact these circuits can have. It is important to determine and apply the appropriate rated diversity factor to circuit-breakers in order to accommodate these loads effectively.

This article explores the concept of the rated diversity factor, highlighting its significance for designers, and provides guidance on its application to circuit-breakers within a consumer unit.

## 2. What is the rated diversity factor?

The rated diversity factor is defined in BS EN 61439-1:2011 as:

> *Per unit value of the rated current, assigned by the assembly manufacturer, to which outgoing circuits of an assembly can be continuously and simultaneously loaded taking into account the mutual thermal influences.*

The per unit value of the rated current can be more easily understood as a percentage value of the rated current. For instance, 1 represents 100 %, 0.5 represents 50 %, and so on. As an example, a per unit value of 0.5 applied to a rated current of 32 A would correspond to 16 A (32 A x 0.5 = 16 A).

**Note:** Multiplying the rated diversity factor by 100 will give the percentage value.

This article covers rated diversity factors in relation to outgoing circuits of consumer units, which are included in BS EN 61439-3:2012 and are referred to as ‘Distribution boards intended to be operated by ordinary persons...’. ‘Consumer unit’ is a UK term used to describe this type of assembly.

Consumer unit is defined in BS 7671:2018+A2:2022 as follows:

> ***Consumer unit (may also be known as a consumer control unit or electricity control unit)***
>
> *A particular type of distribution board intended for operation by ordinary persons, comprising a type-tested coordinated assembly for the control and distribution of electrical energy, incorporating manual means of double-pole isolation on the incoming circuits(s) and an assembly of one or more protective devices, signalling and other devices proven during the type-test of the assembly as suitable for such use.*

The rated diversity factor is assigned by the manufacturer of the consumer unit, which is then used by the designer when determining the size of the protective device. The manufacturer can assign the rated diversity factor to a consumer unit as a whole or may choose to specify it in relation to a group of circuits within the consumer unit.

### Complete assembly rating

When a whole assembly rating is assigned by a manufacturer, this is the manufacturer specifying the average permissible loading conditions of the outgoing circuits.

### Grouped circuit rating

When the rated diversity factor relates to a group of circuits, it is generally only applicable when the load of the circuit is continuous and has adjacent simultaneously loaded circuits.

## 3. What determines if a load is continuous or intermittent?

Rated diversity factors are generally only applicable to continuously and simultaneously loaded circuits. A continuous load is not defined in the BS EN 61439 series, although examples of what may be interpreted as continuous loads and what may be interpreted as intermittent loads are given below.

**Continuous load**

Continuous loads are not explicitly defined in the BS EN 61439 series, although the standard highlights the importance of being cautious with loads that remain energized for durations exceeding 30 minutes. Manufacturers' information varies, with some specifying a continuous rating for loads active for more than 30 minutes, while others indicate on-times exceeding 1 hour.

A circuit supplying a load with longer on-times than off-times may also be treated as a continuous load, as there may not be sufficient cooling time between on-periods. However, this is typically relevant only when the load current approaches the circuit-breaker's rating. An example of a continuous load is an electric vehicle charging point, where the continuous current may be sustained for several hours.

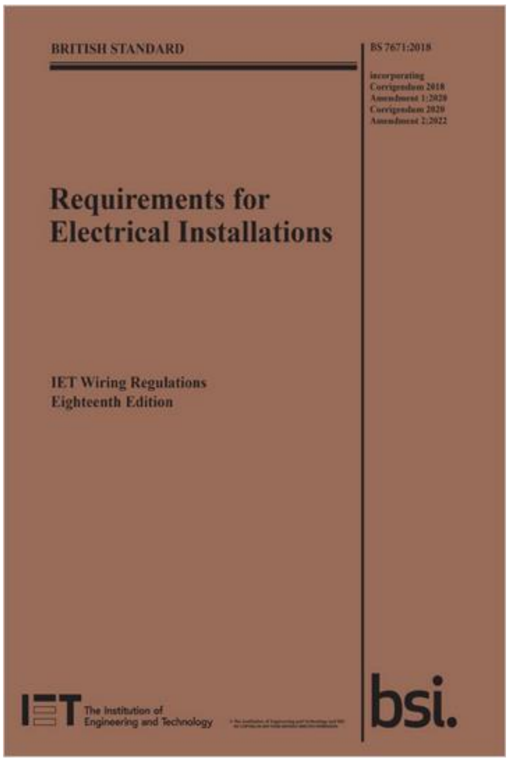
In summary, although the exact definition may vary, it is important to consider loads with extended on-times and their impact on thermal performance.

**Intermittent load**

Intermittent loads can be characterized as loads that are inactive for longer periods than they are active, typically with on-times shorter than 30 minutes. Kitchen appliances, such as washing machines operating in varying load cycles, and thermostatically controlled cooking equipment are examples of intermittent loads. These appliances go through cycles of operation where their on-time and load fluctuate, resulting in intermittent energy consumption patterns.

A calculation can be carried out to determine the root mean square (RMS) (average) current for an intermittent circuit, which can then be used to determine the rated diversity factor, although this is out of the scope of this article. For further reading see Annex E of BS EN 61439-1:2011.

**Figure 1** – IET Wiring Regulations, 18th Edition




## 4. Rated diversity factor and BS 7671 requirements

Within Part 5 of BS 7671:2018+A2:2022, it states the following regarding the current ratings of an assembly:

***536.4.202 Current ratings***

*The relevant design current shall not exceed the rated current of an assembly ($I_{nA}$) or rated current of a circuit ($I_{nc}$) of the associated assembly, having taken any applicable diversity/loading factors into account.*

*The terminology used to define the rating of an assembly concerning load/design current used in the BS EN 61439 series can be summarized as follows:*

- *The rated current of an assembly ($I_{nA}$) (A) is the maximum load current that it is designed to manage and distribute.*
- *The rated current of a circuit ($I_{nc}$) (A) is stated by the manufacturer, taking into consideration the rating of the devices within the circuits, their disposition and application.*

*The current rating(s) of an assembly circuit may be lower than the rated current(s) of the device(s) according to their respective device standard when installed in the assembly; therefore, the assembly manufacturer's ratings and instructions shall be taken into account.*

For compliance with BS 7671:2018+A2:2022, the designer shall consider the rated diversity factor when designing the installation's circuits.


## 5. Why have a rated diversity factor?

Consumer unit manufacturers perform temperature rise verification as per the requirements outlined in BS EN 61439-3:2012. This verification ensures that the consumer unit remains within acceptable temperature limits and does not overheat during operation. The circuits in an assembly, when continuously loaded and are placed adjacent to circuits that are simultaneously continuously loaded, have a mutual thermal influence. Generally, it wouldn't be economical for a manufacturer to rate the full assembly with all outgoing circuits rated at 100 %, as this isn't how circuits connected to consumer units are generally loaded. To address this, BS 61439-3:2012 provides guidance for manufacturers, which recognizes that circuits in practice are not continuously and simultaneously loaded. Specifying a rated diversity factor enables manufacturers to economically design a consumer unit.

The rated diversity factor enables manufacturers to design consumer units that account for the practical loading conditions of circuits, ensuring efficient and safe operation while maintaining cost-effectiveness.

## 6. Where to find the rated diversity factor of a consumer unit

Manufacturers of consumer units may apply a rated diversity factor derived from testing or may use the table below from BS EN 61439-3:2012, which states the assumed loading factor and is based on the number of outgoing circuits of the consumer unit. The assumed loading factor is the maximum permitted rated diversity factor to be applied by the user.

BS EN 61439-1:2011 states: “The rated diversity factor multiplied by the rated current of the circuits shall be equal to or higher than the assumed loading of the outgoing circuits”.

**Table 1 -** Based on assumed loading factors from BS EN 61439-3:2012 (Table 101)

| Number of outgoing circuits | Assumed loading factor |
|---|---|
| 2 and 3 | 0.8 |
| 4 and 5 | 0.7 |
| 6 to 9 inclusive | 0.6 |
| 10 and above | 0.5 |

It is the responsibility of the manufacturer of the consumer unit to agree with the user (designer) on the required rated diversity factor of their equipment. Installation instructions may take the place of an agreement. A selection of consumer unit installation instructions were downloaded from various websites. A summary of the assigned rated diversity factors is reported below. Where text accompanied the ratings, it has been included.

For accurate and up-to-date information, please refer to the instructions provided with a consumer unit.

**British General Fortress**

*Table 101 from BS EN 61439-3:2012 is used.*

***BG Note:*** *RDF only applies to continuously and simultaneously loading circuits. In principle, this means adjacent circuit-breakers having a load ‘on’ time exceeding 30 minutes, or where a load not exceeding 30 minutes has an ‘off’ time less than the ‘on’ time, will need to have the rating diversity factor applied as indicated. Table and ratings based on a continuous rating of 90A.*

**Contactum defender**

*Table 101 from BS EN 61439-3:2012 is used.*

**Fusebox F2 series**

*Adjacent thermal-magnetic MCBs should not be continuously loaded at their nominal rated currents when mounted in enclosures. We recommend a 60% derating factor is applied to the MCBs nominal rated current where it is intended to load the MCBs continuously.*

**Hager Design 30**

*Table 101 from BS EN 61439-3:2012 is used.*

***Note:*** *RDF only applies to continuously and simultaneously loaded circuits.*

*In principle, this means adjacent circuit-breakers having a load ‘on’ time exceeding 30 minutes, or where a load not exceeding 30 minutes has an ‘off’ time less than the ‘on’ time, will need to have the rated diversity factor applied as indicated.*

**Lewden QFS range**

*Table 101 from BS EN 61439-3:2012 is used.*
*Adjacent thermal magnetic MCBs/RCBOs should not be continuously loaded at their nominal rated currents when mounted in enclosures. We recommend a diversity factor (RDF) is applied to the MCB/RCBO nominal rated current where it is intended to load circuits continuously and simultaneously.*

**Live LHMC specification**

*Adjacent Thermal Magnetic MCBs should not be continuously loaded or approach their nominal rated currents when mounted in enclosures. It is recommended that a 60% diversity factor be applied to the MCBs nominal rated current where it is intended to load the MCB continuously.*

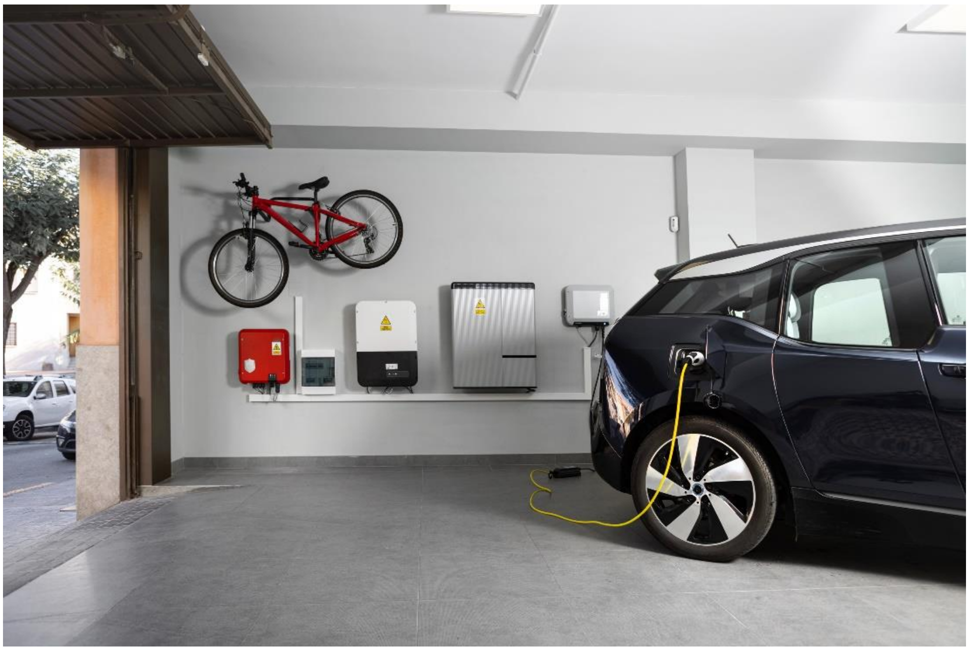
**MCG Industrial**

*Adjacent thermal-magnetic MCBs should not be continuously loaded or approaching their nominal rated current when mounted in the enclosure. Therefore, we recommended 60% diversity factor is applied to the MCBs nominal rated current where it is intended to load the MCBs continuously.*

**Wylex NM range**

*Adjacent thermal-magnetic MCBs should not be continuously loaded or approaching their nominal rated currents when mounted in enclosures. It is good engineering practice to apply generous derating factors or make provision for adequate free air between devices. In these situations, and in common with other manufacturers, we recommend a 60% diversity factor is applied to the MCB nominal rated current where it is intended to load the MCBs continuously (in excess of 1 hour).*

***Note:** Rated diversity factor (RDF) only applies to continuously and simultaneously loaded circuits.*



## 7. How the rated diversity factor is used by designers

When establishing the current rating of a circuit-breaker, designers must assess whether the inclusion of the rated diversity factor is necessary. If the designer identifies the presence of outgoing circuits that are continuously and concurrently loaded, they will proceed to determine the specific value of the rated diversity factor. The rated diversity factor is typically found within the manufacturer's installation instructions.

When the rated diversity factor is applied to the rated current of the circuit ($I_{nc}$), the value obtained is the grouped circuit rating ($I_{ng}$). The design current of the circuit ($I_b$) should be less than or equal to the grouped circuit rating ($I_{ng}$) ( $I_b \leq I_{ng}$).

$I_{ng}$ is defined in BS EN IEC 61439-1:2021[1] as "the rated current which a main circuit can carry considering the mutual thermal influences of the other circuits that are simultaneously loaded in the same section of the assembly".

**Worked example 1**

A heat pump with a continuous load current of 32 A is to be served by a consumer unit. The circuit-breaker serving the heat pump will be installed adjacent to circuit-breakers serving intermittent loads. From the manufacturer's instructions of the selected consumer unit, a rated diversity factor of 1 is declared for one continuously rated circuit. To determine the current to be used to size the circuit-breaker, the following calculation is carried out:

$$\text{Current to be used for circuit calculation} = \frac{I_b}{RDF}$$

$$\text{Current to be used for circuit calculation} = \frac{32\text{ A}}{1}$$

$$\text{Current to be used for circuit calculation} = 32\text{ A}$$

Where:
$I_b$ is the design current for the circuit
and
RDF is the declared rated diversity, or assumed loading factor, as determined by the consumer unit manufacturer.

From the worked example, the circuit-breaker will be rated at a minimum of 32 A. The rated diversity factor did not have an effect on the circuit's current rating. The cable's cross-sectional area will be based on a circuit-breaker rating of 32 A.

By following the requirements set out in Regulation 433.1.1 of BS 7671:2018+A2:2022, $I_b \leq I_n \leq I_z$, the cable's cross-sectional area will be based on a circuit-breaker rating of 32 A.

**Worked example 2**

A heat pump with a continuous load current of 32 A is to be served by a consumer unit. The circuit-breaker serving the heat pump will be installed with adjacent circuits to the left and right, serving an electric vehicle charging point and a solar PV system respectively. From the manufacturer's instructions of the selected consumer unit, a rated diversity factor of 0.6 is declared. To determine the current to be used to size the circuit-breaker, the following calculation is carried out:

$$\text{Current to be used for circuit calculation} = \frac{I_b}{RDF}$$

$$\text{Current to be used for circuit calculation} = \frac{32\text{ A}}{0.6}$$

$$\text{Current to be used for circuit calculation} = 53.3\text{ A}$$

Where:
$I_b$ is the design current for the circuit
and
RDF is the declared rated diversity, or assumed loading factor, as determined by the consumer unit manufacturer.

From the worked example, the circuit-breaker will be rated at a minimum of 53.3 A with the next standard size up of circuit-breaker being a 63 A device.

By following the requirements set out in Regulation 433.1.1 of BS 7671:2018+A2:2022, $I_b \leq I_n \leq I_z$, the cable's cross-sectional area will be based on a circuit-breaker rating of 63 A.

To verify the design from *worked example 2*, or alternatively to check an existing circuit for compliance, the grouped rating can be determined as follows:

$$I_{ng} = I_{nc} \text{ x RDF}$$

$$I_{ng} = 63 \text{ A x } 0.6$$

$$I_{ng} = 37.8 \text{ A}$$

Where:
$I_{nc}$ can be substituted for the rating of the protective device ($I_n$).

The design current of the circuit was 32 A, which is less than the determined grouped circuit rating of 37.8 A, therefore the design is compliant as $I_b \leq I_{ng}$.

The actual rated diversity factor for this circuit can be determined with the following calculation:

$$RDF = \frac{I_b}{I_{nc}}$$

$$RDF = \frac{32 \text{ A}}{63 \text{ A}}$$

$$RDF = 0.51$$

**Note:** The manufacturer of the heat pump may specify a maximum permissible circuit-breaker rating. This must be considered when designing a circuit and may be rated lower than the device that is determined when applying a rated diversity factor. Another consideration would be to ensure the terminal capacity of the load device is sufficient for the cable's cross-sectional area that is specified by the designer.


## 8. Why thermal-magnetic devices?

The rated diversity factor is to be assigned to thermal-magnetic devices and not devices such as switch disconnectors and residual current circuit-breakers (RCCBs). The principal workings of the thermal part of a thermal-magnetic device is that the current from the load heats a bi-metallic strip that releases and opens the circuit in the event of an overload. The heat in the bimetallic strip is proportional to the load of the circuit. In effect, each circuit-breaker is a resistive heater. The greater the number of circuit-breakers that are carrying continuous current, the greater the heating effect within the consumer unit. When a circuit-breaker’s rating is increased in ratio to its load, the lower the heating effect of the protective device.

**Note:** When the ambient temperature surrounding the circuit-breaker is above the value stated by the manufacturer, the circuit-breaker's sensitivity is increased and will require less current to operate.


## 9. How to avoid using the rated diversity factor

To avoid the need to apply the rated diversity factor to circuit-breakers, certain measures can be taken to enhance cooling. One approach is to strategically arrange the circuit-breakers to facilitate cooling. This can be accomplished by introducing blanks between circuit-breakers where they are continuously loaded. If there is sufficient room available in the location of the consumer unit, the consumer unit itself can be oversized, allowing for the installation of a greater number of blanks. Another method involves separating the continuously rated circuits that operate close to their circuit-breaker's capacity and situating them alongside circuits that either have a lighter load* or operate intermittently. By carefully planning the arrangement of circuits within the consumer unit during the design phase and breaking the conventional practice of grouping circuit-breakers based on their rating, it is possible to improve cooling efficiency. This strategic placement of circuits may eliminate the need for a rated diversity factor.

> *Circuits that experience continuous but light loads tend to have a low rated diversity factor. For instance, consider a lighting circuit in a domestic premises that carries a load of 1 A (equivalent to 230 W) and is protected by a 6 A circuit-breaker, resulting in a rated diversity factor of 0.17. Since this circuit is lightly loaded, it is possible to position the circuit-breaker serving this particular circuit adjacent to a circuit with a higher continuous load, eliminating the necessity for applying a rated diversity factor to the larger loaded circuit.

## 10. Adding a circuit to an existing consumer unit

When adding a new circuit, such as a heat pump, into an existing consumer unit that may already serve a continuous load, such as an electric vehicle charging point, the designer must reassess the loading of the consumer unit. This evaluation is necessary to ensure that any intended additions, which were not initially considered during the design phase, do not adversely affect the thermal performance of the existing consumer unit. By conducting this re-evaluation, the designer can ascertain if the proposed addition will place excessive thermal strain on the consumer unit [2].

Regulation 132.16 from BS 7671:2018+A2:2022 states:

> *No addition or alteration, temporary or permanent, shall be made to an existing installation, unless it has been ascertained that the rating and the condition of any existing equipment, including that of the distributor, will be adequate for the altered circumstances. Furthermore, the earthing and bonding arrangements, if necessary for the protective measure applied for the safety of the addition or alteration, shall be adequate.*

## 11. Conclusion

As the nature of loads connected to consumer units in domestic electrical systems are changing, the significance of the rated diversity factor is becoming more evident for designers. Traditional domestic loads were often intermittent or lightly loaded, however, designers now face the challenge of incorporating loads, such as electric vehicle charging points and heat pumps, into their designs.

To address the issue of the mutual heating effect of circuit-breakers, electrical designers have the option to position board blanks adjacent to circuits with continuous loads. They may also ensure that circuits that are continuously loaded at a current that is near their circuit-breakers' rating, are placed apart from each other within the consumer unit. In either case, designers must consider the rated diversity factor and be mindful of the thermal interaction between circuit-breakers. This consideration is also important when adding a new circuit to an existing consumer unit.

An additional point worth mentioning is the impact of solar photovoltaic (PV) installations on existing consumer units when they are directly connected. With the increasing popularity of solar PV generation, it is important to consider the heat generated within the consumer unit when directly connected to the PV system via a thermal-magnetic circuit-breaker.

Also, take note of 551.7.2 of BS 7671:2018+A2:2022 when connecting solar PV to a consumer unit.

**Notes/references:**

[1] BS EN IEC 61439-1:2021 supersedes BS EN 61439-1:2011, which is to be withdrawn on 21st of May 2024.
[2] BEAMA guide on coordination between design current of an installation and rated currents in panelboards, switchboards and motor control centres (BS EN 61439-2).

**Further Reading:**

1. BEAMA guide on coordination between design current of an installation and rated currents in panelboards, switchboards and motor control centres (BS EN 61439-2)

2. BEAMA consumer unit checklist
   https://www.beama.org.uk/resourceLibrary/beama-publishes-consumer-unit--safety-checklist.html

3. IET article on consumer units
   https://electrical.theiet.org/courses-resources-career/free-resources/consumer-guidance/consumer-units/

4. IET Wiring Matters article on thermal effects
   https://electrical.theiet.org/wiring-matters/years/2021/86-july-2021/back-to-the-forum-thermal-effects/

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# How voltage drop can affect EV charging point open PEN detection devices

By: Michael Peace CEng MIET MCIBSE

A final circuit for an electric vehicle charging point (EVCP) may seem like any other final circuit – it is only a socket-outlet after all. However, there are some additional considerations, especially when the installation of such equipment incorporates an open PEN detection device (OPDD). This article looks at how voltage drop can affect the operation of OPDDs included within EVCPs.

**Why is an EVCP different to any other final circuit?**

When EVCPs first arrived on the scene, they were nothing more than a socket-outlet. As technology has developed rapidly, EVCPs are now sophisticated equipment requiring connection to the internet and compliance with The Electric Vehicles (Smart Charge Points) Regulations 2021.

Not only has the technology become smarter, the requirements for safety have also evolved and the installation of OPDDs has become more common. The installation of an OPDD is often more desirable than installing earth electrodes. It is important that the designer of a final circuit for an EVCP, which features an OPDD, is aware of how they operate.

**What is an OPDD?**

An OPDD is a device intended to disconnect the live and protective conductors to the EVCP in the event of a broken PEN conductor on the public distribution network. The reason for disconnecting the protective conductor is that in the event of a broken PEN conductor on the public distribution network, the metallic body of the vehicle could become live.

OPDDs are available as a standalone device or can be incorporated in the EVCP. This article focuses on OPDDs which are built into EVCPs. Standalone devices are intended to be installed at the origin of the installation and measure the supply voltage, therefore it is not affected by voltage drop within the installation. The standalone devices may utilize different voltage parameters to those provided in indent (iv) of Regulation 722.411.4.1 of BS 7671:2018+A2:2022. The manufacturer of the OPDD is best placed to provide information on the voltage operating parameters of their equipment.

Many of the popular EVCPs incorporate some form of protection against open PEN faults. Regulation 722.411.4.1 of BS 7671:2018+A2:2022 provides several methods of operation for open PEN fault protection devices. The method of protection used for the EVCP is different depending on the manufacturer. Some manufacturers use a combination of several different methods to provide protection. This is covered in indent (v) of Regulation 722.411.4.1 of BS 7671:2018+A2:2022.

**How does an OPDD operate?**

One of the most popular methods of protection is provided by a device which monitors the utilization voltage at the EVCP. See indent (iv) of Regulation 722.411.4.1 of BS 7671:2018+A2:2022.

The utilization voltage is the voltage at the EVCP and not the supply voltage at the intake position. If the voltage is outside of the parameters stated (207 V – 253 V), the device must disconnect all live conductors and the protective conductor from the supply within 5 seconds.

**What is the nominal supply voltage in the UK?**

The supply voltage in the UK is 230 V (+10 %/-6 %). That means that the voltage could be as high as 253 V and more importantly, when it comes to voltage drop, the voltage could be as low as 216.2 V. This is set out in Regulation 27 of The Electricity Safety, Quality and Continuity Regulations 2002 (ESQCR).

The supply voltage will vary according to several factors such as cable length, transformer capacity, and also the demand on the network will be a major influence. When the load on the network is high, the voltage will be reduced and could, in some cases, be as low as 216.2 V but would still be within ESQCR parameters. The electrical designer must take account of this and consider the utilization voltage at the EVCP.

**What is the maximum permitted voltage drop in BS 7671?**

The requirements for voltage drop are that the product standard is consulted, Regulation 525.1 of BS 7671:2018+A2:2022 refers. There are recommended maximum values of voltage drop provided in Table 4Ab in Appendix 4, Section 6.4 of BS 7671:2018+A2:2022. These values are informative because the actual values of voltage drop depend on the requirements of the connected equipment.

For low-voltage installations supplied directly from a public low-voltage distribution system, the recommended maximum voltage drop between the origin and any load point for a load other than lighting, is 5 %. However, where a maximum voltage drop of 5 % has been factored into the design for a final circuit for an EVCP featuring open PEN protection, unwanted tripping of the device may be experienced.

For installations supplied from a private transformer, it is permissible to allow 8 % (18.4 V) voltage drop. This means that if the nominal voltage at the source is 225 V, the utilization voltage at the EVCP would be 207 V and would cause unwanted tripping of an OPDD.

**Figure 1** – Table 4Ab - Voltage drop from Appendix 4, Section 6.4 of BS 7671:2018+A2:2022

**TABLE 4Ab – Voltage drop**

| | Lighting | Other uses |
|---|---|---|
| (i) Low voltage installations supplied directly from a public low voltage distribution system | 3 % | 5 % |
| (ii) Low voltage installation supplied from private LV supply (*) | 6 % | 8 % |

(*) The voltage drop within each final circuit should not exceed the values given in (i).

Where the wiring systems of the installation are longer than 100 m, the voltage drops indicated above may be increased by 0.005 % per metre of the wiring system beyond 100 m, without this increase being greater than 0.5 %.

The voltage drop is determined from the demand of the current-using equipment, applying diversity factors where applicable, or from the value of the design current of the circuit.

**What is the maximum permitted voltage drop for an EVCP?**

Where an EVCP features a built-in OPDD, it is important to ensure the utilization voltage at the EVCP is not less than the tripping threshold of the OPDD, due to voltage drop of the cable to the EVCP.

If 5% voltage drop is applied to an EVCP, the user may experience unwanted tripping of the device. If the supply voltage at the installation is 216.2 V, taking into account a 5 % (11.5 V) voltage drop would mean the utilization voltage at the EVCP would be 204.7 V and trip the OPDD.

For an allowance of 4 % (9.2 V) voltage drop, the same problem exists because the utilization voltage at the EVCP would be 207 V, which is the lower trip threshold for an OPDD.

However, if 3 % (6.9 V) voltage drop is applied, the utilization voltage at the EVCP is 209.3 V exceeding the lower trip threshold of an OPDD as shown in Table 1 below.

**Table 1** – Voltage drop calculations

| | | | |
|---|---|---|---|
| **Supply voltage + 10%** | 253 V | | |
| **Supply voltage** | 230 V | | |
| **Supply voltage - 6%** | 216.2 V | | |
| **Voltage drop (%)** | 3 % | 4 % | 5 % |
| **Voltage drop (V)** | 6.9 V | 9.2 V | 11.5 V |
| **Supply voltage (– 6 %) – voltage drop = utilization voltage** | 216.2 V - 6.9 V = 209.3 V | 216.2 V - 9.2 V = 207 V | 216.2 V - 11.5 V = 204.7 V |
| **Lower trip threshold for open PEN device** | 207 V | | |

**What is the most appropriate table to use for XLPE cables?**

The cable of choice for the installation of EVCPs would usually be steel wired armoured (SWA) due to requirements for mechanical protection. A common mistake is to think that Table 4E4A and 4E4B should be used for thermosetting (XLPE) SWA cables. However, this table is for XLPE cables rated at 90 °C, and this temperature is not permitted at switchgear and accessories. Regulation 512.1.5 of BS 7671:2018+A2:2022 provides requirements regarding compatibility of equipment which limits the operating temperature to 70 °C.

It would probably be more appropriate to use Table 4D4A and 4D4B of BS 7671:2018+A2:2022 for thermoplastic cables as the conductor temperature is limited to 70 °C.

**What is the maximum circuit length for an EVCP?**

Taking the 3 % voltage drop into account, based on a 7 kW EVCP with a current rating of 32 A, according to Table 4D4B with an allowance of 3 % for voltage drop, the maximum circuit lengths are listed in Table 2 below and calculated based on the formula below.

$$Voltage\ drop = \frac{(mV/A/m)\ x\ Ib\ x\ Length}{1000}$$

**Table 2** – Maximum cable length with an allowance of 3 % voltage drop

| Voltage drop calculation<br>Table 4D4B – single-phase two-core (column 2) | | | | |
|---|---|---|---|---|
| **CSA (mm²)** | **Length (m)** | **$I_b$** | **mV/A/m** | **3 % VD** |
| 4 | 19 | 32 | 11 | 6.7 |
| 6 | 29 | 32 | 7.3 | 6.8 |
| 10 | 49 | 32 | 4.4 | 6.9 |
| 16 | 77 | 32 | 2.8 | 6.9 |

## Other design considerations

To overcome voltage drop issues, the designer may choose to select a larger CSA conductor. However, it is important to take account of the maximum conductor size for the terminals in the equipment.

Energy losses are an important factor when selecting the appropriate conductor size. A smaller conductor will mean more energy losses, and this can be significant when considering high power loads used over long periods of time.

## Summary

EVCPs that incorporate an OPDD require additional consideration with respect to voltage drop. It is important to consider the lower trip threshold of the OPDD.

Applying the maximum recommended voltage drop of 5 % for a final circuit to an EVCP circuit featuring open PEN protection might frustratingly result in unwanted tripping of the device.

Standalone OPDDs are not affected by voltage drop within the consumers installation. Manufacturers of OPDDs are best placed to provide guidance on voltage parameters for their equipment.

## Further reading

The IET has developed a standard for OPDDs for use in electric vehicle charging applications. There will be an opportunity to comment on the DPC later this year. The details will be announced on the IET website shortly.

For further information on PEN conductor faults, see the IET Wiring Matters Broken PEN article.

Further information on temperature ratings of cables can be found in the IET Wiring Maters article Thermoplastic (SWA) or Thermosetting (XLPE) SWA cable article.

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# Setting a new IET standard: Open Combined Protective and Neutral (PEN) Conductor Detection Devices (OPDDs) – OPDDs for Use in Electric Vehicle Charging Applications for Household and Similar Installations

The IET is delighted to announce this entirely new standard (also to be known as IET 01) which sets out the critical safety requirements for open PEN detection devices (OPDDs) for use in electric vehicle (EV) charging equipment and installations. This is a timely and necessary set of guidelines which aims to ensure that the highest safety considerations and requirements are met.

OPDDs provide, or initiate, electrical isolation in the event of a disconnected PEN conductor, or open PEN fault, in the distributor's equipment. An open PEN scenario occurs when the combined protective earth (PE) and neutral (N) conductor within a supply cable owned by the electrical distributor to an electrical installation becomes open-circuit, but the line conductor remains connected. The risk presented when an EV is charging can be extremely serious and may present a threat to life, both to the installer or operator and to household residents.

The standard maintains that OPDDs are intended to be installed and used in accordance with BS EN IEC 61851-1 and Section 722 of BS 7671:2018+A2:2022. OPDDs adhering to this standard may be stand-alone, or incorporated into other products or assemblies, such as EV supply equipment or switchgear and controlgear assemblies.

Coverage includes, but is not limited to:

- the classification, functionality, operation and testing of OPDDs;
- risk of and protection against electric shock;
- electrical safety requirements, such as degrees of protection;
- normative terms and definitions;
- values and ratings;
- marking and product information; and
- requirements for conformity with the relevant standards and related considerations.

The standard is primarily intended for use by companies manufacturing EV chargepoints but will also be beneficial to those involved in installation of domestic EV charging equipment and associated products, including, but not limited to, manufacturers, designers, installers, developers and operators. It will also be invaluable to architects, construction firms, facility and estate managers, and anyone investing in or responsible for the electrical safety of EV charging equipment and products.

Preparation of this document was entrusted to an IET formed technical committee, overseen by independent expert contributors, and developed in close collaboration with a cross-section of industry representatives and organizations. A list of organizations represented on this committee can be obtained on request to the IET.

A draft of this standard is currently being prepared for public comment and will be available at https://electrical.theiet.org/get-involved/consultations/. For additional information, contact Jon Newbury JonNewbury@theiet.org.

**Jon Newbury, Portfolio Development Manager for Technical Regulations, Codes and Guidance at the IET**

# Updating of the IET Exam Preparation series for electricians seeking appropriate electro-technical qualification

The IET is pleased to announce upcoming revisions to our popular and well-received books for learners and practitioners seeking additional qualifications, *Exam Preparation Requirements for Electrical Installations (2382)* and *Exam Preparation Initial and Periodic Electrical Inspection and Testing (2391)*, published by the IET and endorsed by City & Guilds. Those familiar with the Exam Preparation series will recall that they were first introduced with the 17$^{th}$ Edition of BS 7671. The new editions will be aligned with the latest and current update to the 18$^{th}$ Edition of the IET Wiring Regulations (BS 7671:2018+A2:2022).

It is important to remember that the Electricity at Work Regulations 1989 require persons involved in electrical work to be competent to do so. Technical knowledge of BS 7671 is essential as a measure of competency and must be obtained by all practitioners involved in electrical installation or maintenance work. Persons coming into the electrotechnical industry should obtain an appropriate and recognized level 3 qualification. Perhaps the most widely available being the City & Guilds 2330 Level 3 Certificate in Electro-Technical Technology (Electrical Installation) and the EAL Level 3 Diploma in Electrical Installation. Note that relevant qualifications may be pursued through a number of providers, such as City & Guilds, the EAL and others.

The IET Exam Preparation books are particularly suited as a study guide for those wishing to achieve competency and improve their knowledge of electrical installation, design, testing and supervision by undertaking the relevant City & Guilds Level 3 qualifications. They contain detailed information related to the qualifications, subject matter and ensuring conformity with BS 7671, with direct input from course assessors and senior engineers, as well as sample questions and worked-out model answers to enhance knowledge and understanding. While primarily a study guide, they also act as a useful tool to assist in learning and skills improvement for all those involved in roles within the electrotechnical industry.

**Exam Preparation Requirements for Electrical Installations (2382)**

This book is an essential practice aid for the examinations required to complete the City & Guilds qualification, Requirements for Electrical Installations (2382). The qualification itself ensures that the learner is up-to-date with the latest industry regulations on wiring and the safe use and operation of electrical equipment and systems, and is underpinned by the requirements of BS 7671.

All practising electricians must comply with the regulations for electrical work. The qualification is designed to provide those seeking progression in their career with the opportunity to develop the skills necessary to carry out job roles and responsibilities associated with the electro-technical industry.

**Exam Preparation Initial and Periodic Electrical Inspection and Testing (2391)**

This book is an essential practice aid for the examinations required to complete the City & Guilds qualification, Initial and Periodic Electrical Inspection and Testing (2391). This qualification helps to develop the knowledge and practical skills required to professionally carry out inspection and testing on electrical installations. Three pathways are offered depending on the type of inspection and testing required or previous qualifications gained by learners.

The three pathways for this qualification are:

1. Level 3 Award in Initial Verification of Electrical Installations (2391-50)
2. Level 3 Award in Periodic Inspection and Testing of Electrical Installations (2391-51)
3. Level 3 Award in Initial and Periodic Inspection and Testing of Electrical Installations (2391-52)

The qualification is suitable for practising electricians with existing specific qualifications who need to update their certification to meet the latest edition of the IET Wiring Regulations. Alternatively, it is appropriate for newly qualified electricians seeking, or required to gain, knowledge of this area in order to carry out their duties or progress their career.
Anyone seeking further information on City & Guilds or EAL courses should refer to them directly or visit their websites at www.cityandguilds.com and www.eal.org.uk.

The revised editions of the IET Exam Preparation books are expected to publish in September 2023. For additional information, contact Jon Newbury JonNewbury@theiet.org.

**Jon Newbury, Portfolio Development Manager for Technical Regulations, Codes and Guidance at the IET**

# Have your say! Drafts for public comment coming soon

A number of IET publications are currently in development, with their drafts for public comment becoming available towards the end of the summer.

These include:

- New publication, Open Combined Protective and Neutral (PEN) Conductor Detection Devices (OPDDs) – OPDDs for Use in Electric Vehicle Charging Applications for Household and Similar Installations.

- The 2nd Edition of Temporary Power Systems – A guide to the application of BS 7671 and BS 7909 for temporary events.

- The 3rd Edition of the Code of Practice for Electrical Energy Storage.

**Open Combined Protective and Neutral (PEN) Conductor Detection Devices (OPDDs) – OPDDs For Use in Electric Vehicle Charging Applications for Household and Similar Installations**

This new standard (also to be known as IET 01) includes definitions, requirements and tests for open PEN detection devices (OPDDs). The device provides, or initiates, electrical isolation in the event of a disconnected PEN conductor in the distributor's equipment – with specific requirements in relation to electric vehicle charging equipment and installations. OPDDs are intended to be installed and used in accordance with BS EN IEC 61851-1 and Section 722 of BS 7671:2018+A2:2022. OPDDs to this standard may be stand-alone, or incorporated into other products or assemblies, such as electric vehicle supply equipment or switchgear and controlgear assemblies.

The standard is primarily intended for use by companies manufacturing EV charge points but will also be beneficial to those involved in installation of domestic EV charging equipment and associated products, including, but not limited to, manufacturers, designers, installers, developers and operators. It will also be invaluable to architects, construction firms, facility and estate managers and anyone investing in or responsible for the electrical safety of EV charging equipment and products.

**Temporary Power Systems - A guide to the application of BS 7671 and BS 7909 for temporary events, 2nd Edition**

This updated book is the complete guide to designing, erecting and using temporary power systems for events and similar purposes.

It details the requirements and application of both the relevant parts of BS 7671:2023+A2:2022 IET Wiring Regulations and BS 7909:2023 Code of practice for temporary electrical systems for entertainment and related purposes.

Thorough guidance is given on the planning, design, verification and management of such systems, including references to current legislation as appropriate. It also considers the duties of those supplying equipment as well as venues that make available power supplies for temporary use.

While the focus and examples in the book are geared towards the entertainment and event industries, it addresses a host of topics which are invaluable to any who design, deploy or manage temporary electrical systems.

**Code of Practice for Electrical Energy Storage, 3rd Edition**

This updated Code of Practice is an excellent reference for practitioners on the safe, effective and competent application of electrical energy storage systems. It provides detailed information on the specification, design, installation, commissioning, operation and maintenance of an electrical energy storage system.

The 3rd Edition will also include:

- An update to the requirements for island mode isolators.
- Further guidance on fire safety and the location of batteries within an installation.
- Updates to schematics for domestic use.

Once available, all drafts for public comment will be accessible via the follow page of the IET website: https://electrical.theiet.org/get-involved/consultations/