WIRING MATTERS
SEPTEMBER 2018



The 18th Edition (BS 7671:2018) launch - revisited

This is the second of two articles on the launch of the 18th Edition (BS 7671:2018). The first article covered electric vehicle charging, surge protection, and arc fault detection. In this article, we focus on Section 708 (caravan/camping parks) and Section 721 (caravan and motor caravans) which were discussed in an article entitled 'The impact of the 18th Edition (BS 7671:2018)' in Issue 67 of Wiring Matters (published September 2017) when the 18th Edition was only at the draft stage. Here, we look at the actual requirements of the 18th Edition.

By Geoff Cronshaw

Section 708 caravan/camping parks

This particular requirement of 708 applies to the electrical installations in caravan/camping parks and similar locations providing connection points for supplying leisure accommodation vehicles (including caravans) and tents.

The scope of Section 708 has been extended to cover circuits intended to supply residential park homes in caravan parks, camping parks and similar locations. In addition changes have been made to socket outlet requirements, RCD protection, and external influences.

Protection against electric shock

General requirements

As you would expect the protective measures of obstacles; placing out of reach, in a non-conducting location and protection by earth-free local equipotential bonding are not permitted. These measures are contained in Sections 417 and 418 of BS 7671:2008 and are not for general application. The protective measures of section 417 provide basic protection only and are for application in installations controlled or supervised by skilled or instructed persons. The fault protective provisions of Section 418 are special and, again, subject to control and effective supervision by skilled or instructed persons.

Protective multiple earthing

As stated in Regulation 708.411.4 The Electricity Safety, Quality and Continuity Regulations 2002 (ESQCR) prohibit the connection of a PME earthing facility to any metalwork in a leisure accommodation vehicle (including a caravan).

This does not preclude the use of a PME earthing facility as the means of earthing for other purposes, such as to the installations of permanent buildings.

External influences
Any wiring system or equipment selected and installed must be suitable for its location and able to operate satisfactorily during its working life. Suitable protection must be provided, both during construction and for the completed installation. Regarding presence of solid foreign bodies, a minimum degree of protection of IP4X is now required. Regarding presence of water a minimum degree of protection of IPX4 is required.
Equipment must be protected against mechanical impact IK 08 (see BS EN 62262) and/or located to avoid damage by any reasonable foreseeable impact.

Caravan pitch socket-outlets
The requirements for socket outlets have been redrafted to prevent the socket contacts being live when accessible.
Regulation 708.55.1.1 requires that every socket-outlet or connector shall either comply with:

a) BS EN 60309-2 and shall be interlocked and classified to clause 6.1.5 of BS EN 60309-1:1999 to prevent the socket contacts being live when accessible; or

b) - be part of an interlocked self-contained product complying with BS EN 60309-4 and classified to clauses 6.1.101 and 6.1.102 of BS EN 60309-4:2006 to prevent the socket contacts being live when accessible.

The current rating is to be not less than 16 A but may be greater if required. At least one socket-outlet should be provided for each caravan pitch. Where socket-outlets are grouped in pitch supply equipment, there should be one socket-outlet for each pitch limited to a group of four.

Overcurrent protection
Every socket-outlet shall be individually protected by an overcurrent protective device, in accordance with the requirements of Chapter 43.
A fixed connection for a supply to a mobile home or residential park home shall be individually protected by an overcurrent protective device, in accordance with the requirements of Chapter 43.

Isolation
Regulation 708.537.2.1.1 now requires at least one means of isolation to be installed in each distribution enclosure. This device shall disconnect all live conductors.

RCD protection
Each socket-outlet must be protected individually by an RCD having a rated residual operating current not exceeding 30mA. The RCD must disconnect all live conductors including the neutral.

Requirements for RCD protection have been extended to cover supplies to residential park homes. A final circuit (from the metering point) intended for the

fixed connection for a supply to a mobile home or a residential park home shall be individually protected by an RCD having a rated residual operating current not exceeding 30 mA accessible to the consumer. Devices selected shall disconnect all live conductors.

PME
As mentioned previously, the ESQCR prohibit the connection of a PME earthing facility to any metalwork in a leisure accommodation vehicle (caravan). If the caravan supply is derived from a permanent building that is supplied by a PME system then the caravan supply will have to be part of a TT system having a separate connection to Earth independent from the PME earthing.

The separation of the earthing can be effected at the main distribution board. The IET's Guidance Note 7 publication *Special Locations* provides detailed information. This enables the exposed-conductive-parts connected to each system to be more readily identified and inspected periodically. An earth electrode for the TT system should be provided nearby and located so that the resistance areas of the PME supply earthing and earth electrode do not overlap.

Alternatively, the separation of the earthing can be made at the caravan pitch supply points. In this instance, earth electrodes will be required at these points.
Again, The IET's Guidance Note 7 provides detailed information.

Section 721 caravans and motor caravans

The particular requirements of 721 apply to the electrical installations of caravans and motor caravans at nominal voltages not exceeding 230/440 V AC or 48 V DC Note there are some exceptions.
This section contains a number of changes including requirements for electrical separation, RCDs, proximity to non-electrical services, and protective bonding conductors.

Protective equipotential bonding
Regulation 721.411.3.1.2 requires structural metallic parts that are accessible from within the caravan to be connected through main protective bonding conductors to the main earthing terminal within the caravan.
The requirements for connections of protective bonding conductors have been clarified. Regulation 721.544.1.1 states that the terminations of protective bonding conductors connecting the conductive structure of the unit shall be accessible and protected against corrosion.

Provision of RCDs
The requirements for RCD protection have also been redrafted.
Regulation 721.415.1 states that where protection by automatic disconnection of supply is used, a residual current device with a rated residual operating current not exceeding 30 mA, complying with BS EN 60947-2 (Annex B), BS EN 61008-1, BS EN

61009-1 or BS EN 62423 breaking all live conductors, shall be provided having the characteristics specified in 415.1.1.
Each supply inlet shall be directly connected to its associated RCD.
Please note this implies that there may not be any taps or junctions in this connection.

An RCD is a protective device used to automatically disconnect the electrical supply when an imbalance is detected between live conductors. In the case of a single-phase circuit, the device monitors the difference in currents between the line and neutral conductors. If a line to earth fault develops, a portion of the line conductor current will not return through the neutral conductor. The device monitors this difference, operates and disconnects the circuit when the residual current reaches a preset limit, the residual operating current (IΔn).

Proximity to non-electrical services
The requirements for proximity to non-electrical services have been redrafted. Regulation 721.528.2.1 requires that where cables have to run through a gas cylinder storage compartment, they shall pass through the compartment at a height of not less than 500 mm above the base of the cylinders and shall be protected against mechanical damage by installation within a conduit system complying with the appropriate part of the BS EN 61386 series or within a ducting system complying with the appropriate part of the BS EN 50085 series.

Switchgear and controlgear
The installation to the caravan should have a main disconnector, which will disconnect all the live conductors. This should be placed in a suitable position for ready operation within the caravan to isolate the supply. When a caravan only has one final circuit then the isolation can be afforded by the overcurrent protective device as long as it fulfils the requirements for isolation.

An indelible notice in the appropriate language(s) must be permanently fixed near the main isolation point inside the caravan to provide the user with instructions on connecting and disconnecting the supply (refer to Figure 721 of BS 7671).

The inlet to the caravan must be an appliance inlet complying with BS EN 60309-1. This should be installed not more than 1.8 m above ground level, in a readily accessible position, have a minimum degree of protection of IP44, and should not protrude significantly beyond the body of the caravan.

The connecting flexible cable
The means of connecting the caravan to the pitch socket-outlet should be provided with the caravan. This must have a plug at one end complying with BS EN 60309-2, a flexible cable with a continuous length of 25 m (±2 m). The connecting flexible cable must be in one length, without signs of damage, and not contain joints or other means to increase its length; and a connector if needed that is compatible with the appropriate appliance inlet. The cable should be to the harmonized code H05RN-F (BS EN 50525-2-21) or equivalent, include a protective conductor, have cores

coloured as required by Table 51 of BS 7671 and have a cross-sectional area as shown in Table 721.

Periodic inspection & testing

The purpose of periodic inspection and testing is to provide an engineering view on whether or not the installation is in a satisfactory condition where it can continue to be used safely. Periodic inspection and testing is necessary because all electrical installations deteriorate due to a number of factors such as damage, wear, tear, corrosion, excessive electrical loading, ageing and environmental influences. IET Guidance Note 3 gives the recommended initial frequencies for inspection of electrical installations for construction sites, caravan/camping parks, and in caravans.

Conclusion

It is important to be aware that this article (which is based on an article from Issue 67 of Wiring Matters) only gives a brief overview of requirements for electrical installations on caravan/camping parks, and in caravans. Refer to BS 7671:2018 for more information.

Earth fault loop impedance revision of ENA Engineering Recommendation P23

By Eur Ing Graham Kenyon CEng MIET TechIOSH

Introduction

The Energy Networks Association (ENA) recently published engineering recommendation (ER) P23/2:2018 *Guidance on Earth Fault Loop Impedance at Customers' Intake Supply Terminals*, which supersedes ENA ER P23/1:1991 *Consumers' earth fault protection for compliance with the IEE Wiring Regulations for Electrical Installations*. In this article, Graham Kenyon provides an overview of the changes and considers how designers should treat earth fault loop impedance (Z_e) in calculations for existing and, if required, new installations.

Industry has for many years been using the 'maximum values' of Z_e published in ENA ER P23/1 1991. The values of Z_e for supplies up to 100 A are shown in Table 1.

Table 1: Values of Z_e for 230 V single-phase TN and TT supplies not exceeding 100 A according to ENA ER P23/1:1991

Supply arrangement	Z_e
TN-C-S (Note 1)	0.35 Ω (Note 2)
TN-S	0.8 Ω (Note 2)
TT	21 Ω (Note 3)

Note 1: In ENA ER P23/1:1991, this value was quoted for both Protective Multiple Earthing (PME) and Protective Neutral Bonding (PNB) earthing arrangements. Higher values may apply where the consumer was supplied from small capacity pole-mounted transformers and/or long lengths of low voltage overhead line.

Note 2: The external earth fault-loop impedance for TT systems consists of the resistance of the neutral to earth plus the impedance of the transformer winding and line conductor, but does not include the resistance of the consumer's earth electrode.

The values in Table 1 have served as a reliable guide since their publication, although it has always been recognised that a small number of installations may fall outside these parameters, and represent an over-estimate (on the side of caution) for the majority of installations. They were never guaranteed for all installations, and for this reason, BS 7671 requires Z_e be validated (by measurement or another valid method) during verification.

The changes in ENA ER P23/2:2018

ENA ER P23/2:2018, contains a set of values based on PD IEC/TR 60725:2012 *Consideration of reference impedances and public supply network impedances for use in determining disturbance characteristics of electrical equipment having a rated current ≤ 75 A per phase*. The quoted values for existing supplies up to 100 A are shown in Table 2.

Table 2: Values of Z_e for existing 230 V single-phase supplies not exceeding 100 A according to EA ER P23/2:2018

Z_e	Comment
0.34 Ω (0.25+j0.23)	90% of premises will have an EFLI below this value.
0.64 Ω (0.46+j0.45)	98% of premises will have an EFLI below this value.
Over 0.64 Ω	2% of premises will have an EFLI above 0.64 Ω

Note 1: These are typical maximum values and the measured value of Z_e will change depending on the network configuration due to alterations, faults, maintenance and any embedded generation.

Note 2: Distribution network operators (DNOs) are under no obligation to design or maintain networks to provide a particular maximum value of Z_e. Many DNOs do, however, have their own internal quality and design standards, which often align with the Z_e values in Table 1.

Note 3: The values for new networks are available from the DNO.

Note 4: The typical maximum Z_e quoted in P23/1 was 0.8 Ω for a TN-S service with a capacity of up to 100 A.

What to use for calculations in installations with single phase supplies up to 100 A

The IET recommends that designers continue to use the values in Table 1 of this article, for public TN supplies up to 100 A, unless alternative recommendations are provided on enquiry with the DNO. It is recognised that this will now, as previously, provide an over-estimate for many installations, but this helps safeguard the design against future changes in transmission and distribution systems, and when embedded generation is added.

The IET also recommends using a calculation value for maximum prospective fault current of 16 kA for single phase supplies up to 100 A where the service cable exceeds 2 m in length, unless the DNO recommends an alternative value.

BS 7671:2018 requires that Z_e and I_{psc} are ascertained by measurement or another valid method during initial and periodic verification, to validate that disconnection times can be achieved for automatic disconnection of supply.

These recommendations will be reflected in the suite of IET guidance publications that accompany the 18th Edition of the IET Wiring Regulations, including:

- *The On-Site Guide* (IET Wiring Regulations 18th Edition)
- *Student's Guide to the IET Wiring Regulations*, 2nd Edition 2018
- Guidance Note 5: *Protection against electric shock*, 8th Edition 2018

- Guidance Note 6: *Protection against overcurrent*, 8th Edition 2018
- *Electrical Installation Design Guide*, 4th Edition 2018

Further information can be found in the relevant guidance publications.

Why is Z_e important for designers?

In design practice, the circuit length for a given cable cross-sectional area (csa) is limited by one of the following constraints:

1. The maximum Z_s for the circuit protective device used for fault protection to achieve disconnection times proscribed by Table 41.1 of BS 7671.
2. The adiabatic criterion in relation to protection against damage due to overcurrent faults in accordance with Regulations 434.5.2 and 543.1.3
3. Voltage drop.

The first of these constraints requires some consideration of Z_e., and the last relates to prospective fault current I_{psc}.

The earth fault loop impedance Z_s for a radial final circuit is given by:

$Z_S = Z_e + (R_1 + R_2)$, where

- $(R_1 + R_2) = L_S\, C_r(R_1^{"} + R_2^{"})$, and
  L_s is the maximum length of the radial circuit in m to achieve automatic disconnection in accordance with Table 41.1 of BS 7671, and

  $(R_1^{"} + R_2^{"})\ is$ the "volt-drop" resistance in mW/m of the cable from Appendix 4 of BS 7671.

- Z_s is the maximum earth fault loop impedance Z_{41} from the relevant Table 41.2, 41.3, 41.4, or, where Regulation 411.4.9 applies, Table 41.5.

Substituting these values, we see that for radial final circuits $L_S = \frac{Z_{41} - Z_e}{(R_1'' + R_2'')C_R}$.

Similarly, for ring final circuits, $L_S = \frac{4(Z_{41} - Z_e)}{(R_1'' + R_2'')C_R}$

> **Note:** See Section 2.6 of the IET's *Electrical Installation Design Guide* for a more in-depth discussion on these equations, and examples of how they are used.

With the exception of Z_e all of these values are available for the designer to adjust by selection, and using data from the relevant tables in BS 7671. We can see that, as Z_e increases, the maximum length of the circuit that will achieve the required disconnection time decreases.

The distribution system itself undergoes changes over time. There are two key issues that should be considered:

1. When some TN-S distribution systems are repaired, this must be done with combined neutral and earth (CNE) cable. In this case, additional earth electrodes are installed in the distribution system, and the distribution becomes, at least in part, TN-C-S. For this reason, it might be recommended to treat TN-S installations in the same manner as TN-C-S installations; however, they may still have a $Z_e > 0.35\ \Omega$
2. Other network changes may mean that values Z_e and prospective fault current I_{psc} measured at the time of the previous verification and validation have changed over time.

Importantly, Z_e may increase as the changes are made. It is therefore necessary to check Z_s for circuits during periodic verification, by measurement or another valid method.

Graham is Managing Director and Principal Consultant, G Kenyon Technology Ltd
Chair, IET Wiring Regulations Policy Committee Deputy Chair, JPEL/64 (IET Wiring Regulations) Sub-Committee D (Special locations and external influences)

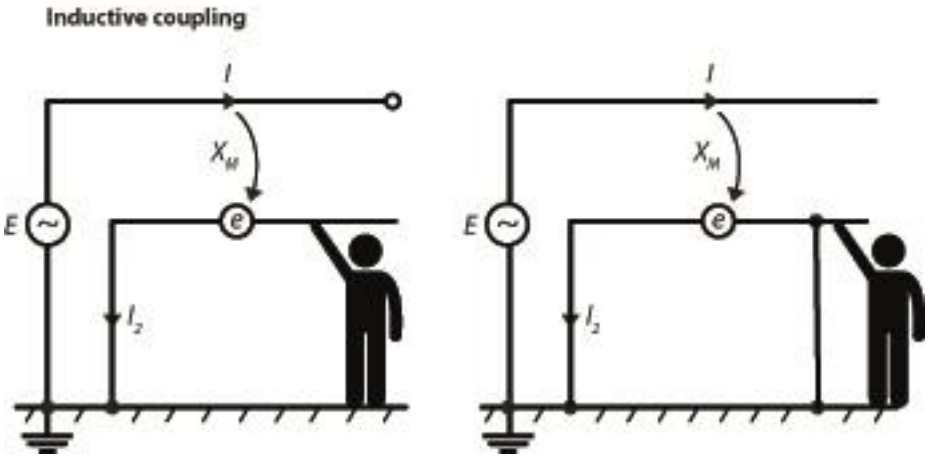
Impressed voltages

By Leon Markwell

Leon Markwell, Senior Engineer at the IET, provides us with information about impressed voltages, which relates to his forthcoming publication Guidance Note 2: Isolation & Switching, which is due for publication in Autumn 2018.

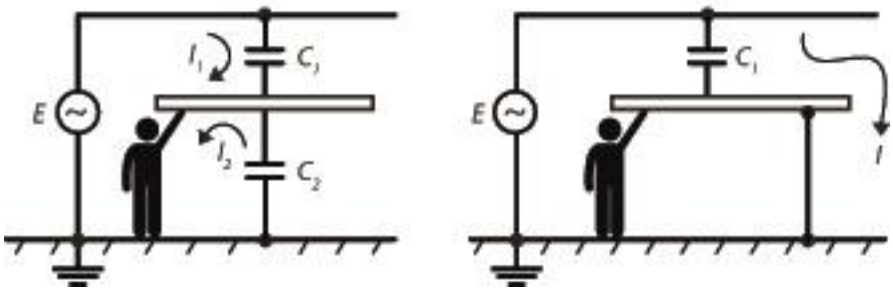
'Impressed voltages' are a general, catch-all term used to cover induced or capacitive voltages appearing on metalwork. The term relates to the existence of a voltage on an item of equipment, or metallic object, which is not directly connected to the energised power system, but which has arisen as a result of an electrical coupling or from a residual charge at the time of circuit de-energisation or testing. Some voltages can be quite high and a hazard and must be eliminated before contact is made with the metallic object. These voltages can be a significant safety hazard to be managed and controlled on a construction site. It is not the intent of this article to identify the possible sources of these voltages or provide any guidance as to their possible magnitude, but merely to remind duty holders that the possible production of such dangerous voltages must be considered.

Perhaps the most widely known are 'induced voltages', and general electrical theory shows that a changing current in a circuit can induce a voltage in another unconnected circuit, and the magnitude of this induced voltage depends on several factors including the relative disposition of the conductive parts of the circuit, their proximity and the current in the primary circuit.



A less well recognised effect is the possible capacitive coupling of two conductors to store charge between a live conductor (for example a HV overhead line) as well as allowing a current to flow when the other conductor forms a circuit, for examples someone touching metal scaffolding to allow a discharge to earth. Again the magnitude of this voltage depends on several factors including the relative disposition of the conductive parts of the circuit, their proximity and the voltage of the primary circuit.

Capacitive coupling



There can also be 'trapped charge' arising from residual charge left on the capacitance of an item of equipment – for example after insulation resistance testing a length of cable.

Generally normal low voltage systems are not an issue, but there are possibilities where high lv currents can be found, for example substations, railway systems, large industrial processes etc and in such cases impressed voltages may appear on metalwork such as scaffolding, disconnected or newly installed cables not yet connected etc. and local earthing may be required. Capacitive coupling can occur near HV overhead lines or HV rail tracks etc and significant and dangerous voltages have been recorded on roadside traffic barrier works near HV overhead lines. Again suitable earthing must be provided for the metalwork to discharge these voltages.

These voltages may arise on either permanent works or temporary works and the designer and construction management must recognise their possible existence and plan for their safe elimination during the works. Scaffolding can be adequately earthed, but other items, especially mobile plant or materials being moved around site may require careful earthing considerations. Current flow through the earth (usually fault current) will create a voltage difference between two points, which may be remote from the path of current flow. Should a person come into contact with these points a possible danger from electric shock may arise due to the difference in potential between the two points – this is known as step or touch potential. But a potential can also be transferred to another unexpected area through site metalwork, for example through a chain link fence.

When considering the protection provided by earthing it must be remembered that an earth rod driven into the ground has a finite resistance and does not constitute a solid connection to true earth. It must also be noted that the health and safety limits for exposure to electric and/or magnetic field strengths must not be exceeded.