Temporary Power Systems – an update

By: James Eade

The IET's *Guide to Temporary Power Systems* is undergoing a long-awaited update. Much has changed since the first edition in 2012, not just in respect of the British standards BS 7671 and BS 7909, but also with the temporary power industry in general. Perhaps the most significant progression has been in renewable energy; the revised guide has a section on battery storage which is increasingly common in events, construction and similar. While the guide has yet to go to public review, the current draft has seen a raft of changes and this article gives an overview of what the more significant ones are.

The use of transportable battery systems allows hybridization of generator packages which is important in the move to Stage V emissions-compliant diesel engines. Running such generators on low loads often results in unexpected shut-downs as the exhaust becomes blocked, so hybridizing a system with energy storage allows the generator to work hard for shorter durations and hence running more efficiently.

The updated guide looks at the considerations around energy storage capacities as well as how battery units can integrate into generation systems, such as working in a simple hybrid mode or as a mini-grid with other generators operating in a load-on-demand configuration for example.

On the subject of generators, generator control and operation has been updated and now includes guidance on parallel operation of sets, leading power factors and the stability of generator sets powering capacitive loads, such as switched-mode power supplies as commonly found in most modern equipment and lighting. The (often vexed) question over generator earthing – or lack of – has been significantly revised to take into account the previous work published in the IET's *Practitioner's Guide to Temporary Power.* Importantly, the requirements for effective electrodes are explained along with the typical failure modes experienced with temporary systems, demonstrating the relationship between the protection installed on the generator output and the value of the electrode resistance achieved on site.

Another chapter to receive a makeover is mobile and transportable units, which range from temporary site huts and office cabins through to high-end broadcast vehicles. In general, the requirements relating to equipment selection detailed in Part 717 of BS 7671 are quite straightforward, but the design is sometimes less so. There are diagrams in Part 717 which give examples of how the supply and earthing arrangements to a unit may be configured, but understanding the benefits and drawbacks of each can be a challenge. These are all explained in the revised chapter, in particular the benefits of transformer-based designs with respect to mitigating shock risks in the event of supply neutral (PEN) conductor failure where units are connected to the public distribution.

Protective earthing has been revised to provide more guidance on determining extraneous-conductive-parts and the appropriate requirements for protective bonding. In a similar vein, the need to join electrical environments is often necessary where multiple supplies are operating in proximity to each other. This has been considered in more detail (including fault current paths), building on the guidance in BS 7909.

Supply resilience is increasingly important in installations as well as with temporary systems. The section on uninterruptible power supplies has been updated and now includes information on the hazards associated with neutral switching on UPS inputs for example, as well as describing how inverters behave when faults occur on the output. Supply resilience in the event of emergencies is important for events where there may be large numbers of the public present. Systems may have to be kept operational for crowd control purposes and this is very important for outdoor events where the thunderstorms roll in. The guide has a completely revised section on management of the temporary systems when lightning is forecast, taking into account recent industry guidance on the subject.

While these are headline changes, there are of course a significant number of updates arising from the revisions to BS 7671 and BS 7909. The former has undergone a range of changes since the first edition of the book, with salient topics including cables in escape routes, the use of Arc Fault Detection Devices, Surge Protective Devices and the application of 30 mA RCDs on socket-outlets rated at 32 A or less. BS 7909:2023 has also seen a major revision, the last being in 2011. Many of the changes reflect those in BS 7671, whereas others relate to generator operation, earthing and renewables for example, which are explored in more detail in this guide.

While the underlying theme of the book is temporary power for events, the advice and guidance on temporary power generally from generators to cable selection and design methodologies will be useful and appropriate for many other sectors using temporary electrical systems.

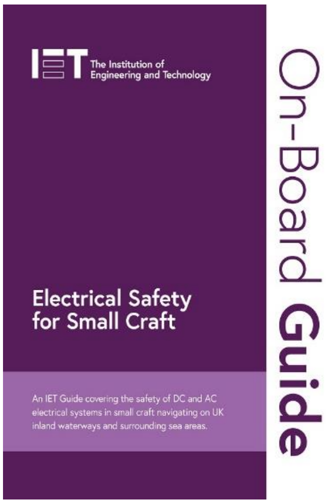
The draft for public comment will be available later this year and can be accessed here.

Polarity indication on boats – why it's important to get it right!

By: Graham Freeman BSc IEng

For those working in domains controlled by the requirements of BS 7671, the need to determine the polarity of a circuit is both acknowledged and well understood. In the marine electrical world, while the need to determine the polarity of on-board circuits is equally recognized, its implementation has additional factors that need to be taken into consideration.

The purpose of this article is two-fold: firstly, to explore an element of the world that exists on the other side of the supply interface defined in Section 709 of BS 7671 'Marinas and Similar Locations' and secondly, to announce the impending publication of a new IET publication: ***The On-Board Guide to Electrical Safety for Small Craft***.



To set the scene, it is necessary to provide some insight into the differences between the requirements for land and water-based electrical installations. From a BS 7671 perspective, the Section 709 'boundary' terminates at the BS EN 60309 fixed outlet connectors located on the power bollard/pillar found at many mooring locations (see Figure 1). Furthermore, Section 709 of BS 7671 also emphasises that electrical supplies in the marine environment attract an increased risk of electric shock due to the (obvious) presence of water, reduced body resistance, and an increased probability of body contact with earth potential.

Figure 1 Power bollard/pillar

By contrast, the Section 708 of BS 7671 'Electrical Installations in Caravans/Caravan Parks and Similar Locations' 'boundary' encompasses not only the caravan pitch socket-outlet(s) but also includes a definition of the assembly configuration of the cable which connects the caravan to the caravan pitch electrical supply socket-outlet.

It may come as a surprise to some that the **shore-power cable** that is used to connect the BS 7671-defined power bollard/pillar to a boat's **appliance inlet connector** is not defined in the same manner as Section 708. To illustrate this point, while marine electrical standard BS EN ISO 13297 *Small craft – Electrical systems – Alternating and direct current installations* does use the terms 'shore-power cable' and 'shore-power appliance inlet', it is left to the reader of this standard to form a mind-picture of the composition of a typical shore-power cable. Equally surprising is the fact that a shore-power cable is rarely supplied by the boat builder as it is regarded as an owner-supplied item in the same vein as mooring ropes!

Regardless of who supplies the craft's shore-power cable, ISO 13297 does require a statement on the safe use of such cables to be provided by the boat builder in the ISO 10240 mandated (boat) *Owner's Manual*; however, this too falls short on cable configuration detail and specific testing requirements.

By contrast, Clause 5 of IEC 60092 – 507 *Electrical installations in ships – Part 507 – Small Vessels*, provides a comprehensive oversight of shore connection arrangements and is recommended as the 'go-to' reference on this topic.

Faced with a poorly defined boat power electrical interface (from the ISO 13297 perspective), we now need to understand the role and function of polarity indicators fitted to small craft and how incorrect implementation can create issues that are not found in land-based installations. To avoid over-complication, the remainder of this article will only consider polarized AC supplies in metal-hulled craft.

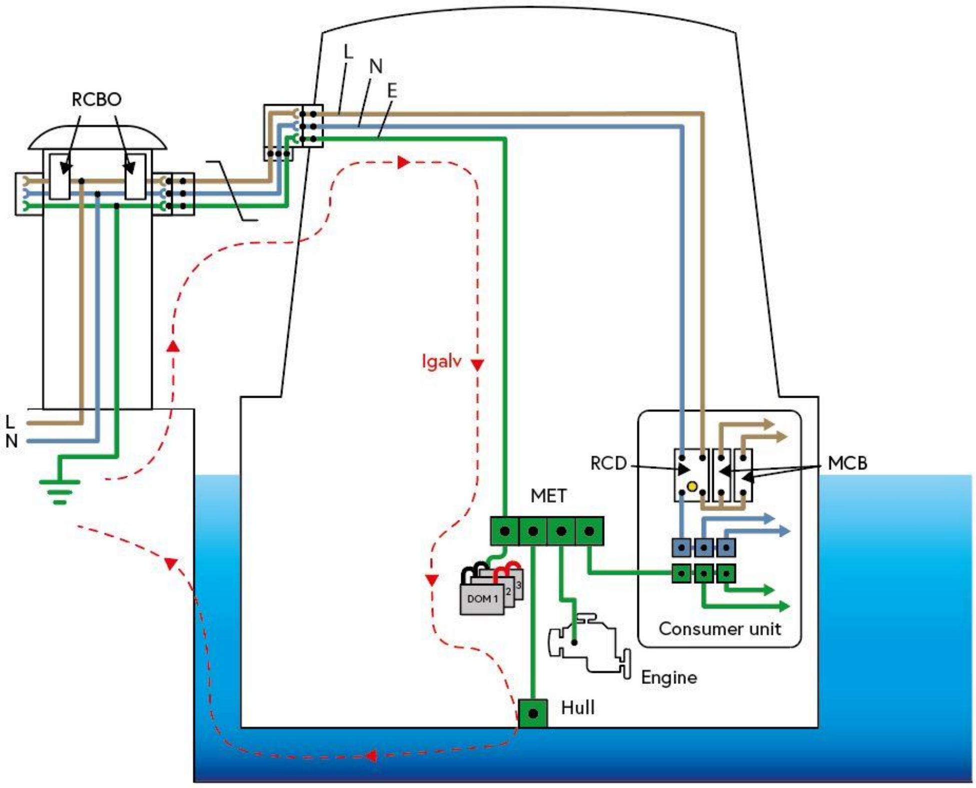
To ensure "proper operation of the electrical devices in the system", ISO 13297 not only requires that "the polarity of the system is maintained", but also requires "fitment of a reverse polarity indicator in shore-power systems that provides a continuous visible or audible signal that responds to reversal of the active (line) and neutral conductors". To provide a visual and/or audible reverse polarity indication, a 230 V neon indicator and/or 230 V buzzer is normally connected between the incoming supply neutral and protective conductors (PE), thereby providing a positive indication of L-N reversal.

While ISO 13297 provides no guidance on the location of any reverse polarity indicator, it should be noted that some suppliers of ready-made 230 V AC panel boards, have, (for reasons best known to themselves), decided to fit a 'polarity correct' indicator – see circled area of Figure 2. If you've already 'joined the dots', you'll have realized that such indicators need to be connected between the incoming supply line and PE conductors to function in the manner described on the caption and are therefore non-compliant to the requirements of both ISO 13297 and IEC 60092-507.

Figure 2 230 V AC panel board with a polarity indicator

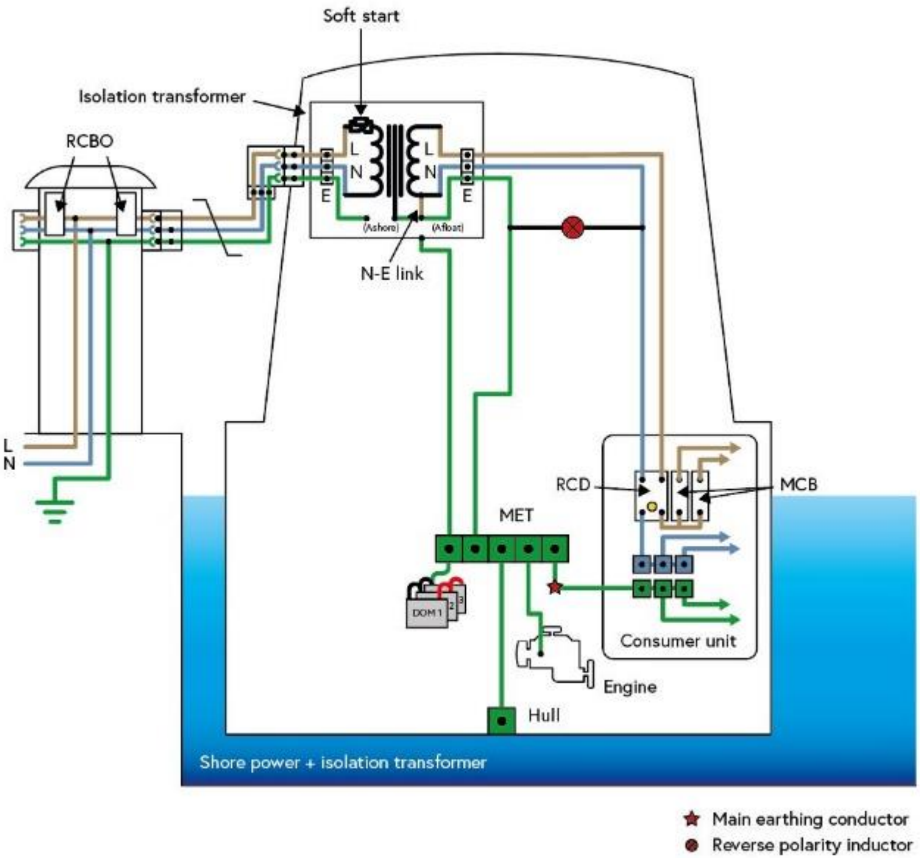
We now need to introduce a marine-environment-specific problem – galvanic corrosion. Although this phenomenon affects metal-hulled craft, its effect on GRP-hulled craft, while identical in outcome, is far less damaging. To illustrate the circumstances that can lead to the creation of a path for galvanic current (I_{galv}) to flow, consider a metal-hulled craft connected to a Section 709 of BS 7671-compliant 230 V AC shore-supply (Figure 3). The (I_{galv}) current path originates in the general mass of Earth which in turn is connected to the craft's main earthing terminal (MET) via the shore-power PE conductor. However, because the hull is an extraneous-conductive-part, a protective bonding conductor is required between the hull and the MET. In the manner illustrated, (I_{galv}) will then flow via the hull back to Earth via the surrounding water.

Figure 3 Diagram illustrating potential galvanic current flow when a craft is moored close to earthed metallic structures and powered from an AC shore-supply



Clearly, while some method needs to be introduced to break the (I_{galv}) current path, the method employed must also preserve automatic disconnection of supply (ADS) in the event of a fault. One of two methods is generally employed: firstly, a diode-based galvanic isolator can be inserted into the PE conductor, or alternatively, an on-board isolation transformer can be used to break the PE conductor path. However, to preserve the required ADS functionality, an N-E link ('local earth') will be required on the output of the transformer secondary (see Figure 4). Note that the illustrated configuration features an ISO 13297-compliant reverse polarity indicator.

Figure 4 AC shore-supply with an isolation transformer employed to galvanically isolate the craft's AC distribution system from the TN-S shore-supply



Now that we've introduced means to minimize the effects of galvanic corrosion attributable to the shore-power connection, we need to address the problem that arises when non-compliant polarity correct indicators are fitted - which is leakage current.

As previously mentioned, polarity correct indicators are connected between the line and PE conductors thereby providing a leakage path to Earth via the hull and the surrounding water. While this current will be small, its presence will accelerate erosion of any cathodic protection (anodes) fitted to the boat. To eliminate this problem, an appropriately rated momentary press switch can be fitted in line with the indicator.

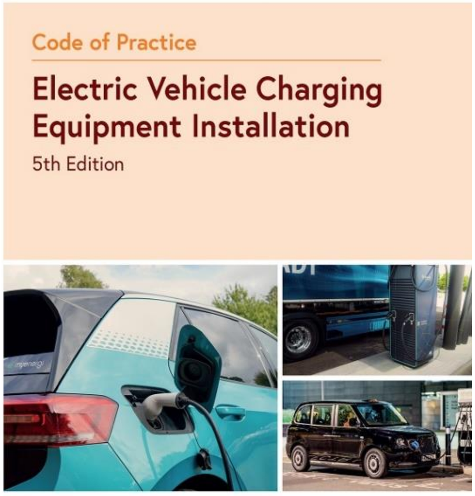
If you wish to dig deeper into the world that exists at the other end of a boat's shore-power cable, pre-order a copy of the soon-to-be published: *IET On-Board Guide to Electrical Safety for Small Craft*.

Fifth Edition of the IET Code of Practice for Electric Vehicle Charging Equipment Installation

By Graham Kenyon

There have been a number of changes in the EV charging installation sector since the publication of the Fourth Edition of the IET *Code of Practice for Electric Vehicle Charging Equipment Installation* in 2020, which have prompted calls from the industry for updates to the publication. The guidance has been updated and expanded primarily as a result of:

- introduction of new legislation;
- availability of new guidance on fire safety and accessibility of charging points;
- increased roll-out of Mode 4 (rapid charging) points;
- removal of indent (i) to Regulation 722.411.4.1 in BS 7671:2018+A2:2022;
- change of focus of related industry vocational qualifications; and
- completion of vehicle-to-grid (V2G) trials, along with innovations making vehicle-to-home (V2H) applications more likely.



The Fifth Edition of the IET *Code of Practice for Electric Vehicle Charging Equipment Installation* is now available. Technical Author Graham Kenyon provides some insight into what we can expect of the new publication.

The Electric Vehicles (Smart Charge Points) Regulations 2021

The Electric Vehicles (Smart Charge Points) Regulations 2021 came into force in Great Britain in June 2022, and apply to private charging points rated at not more than 50 kW, installed after 30 June 2022. The legislation requires charging points to include:

- inter-operable smart functionality to enable integration of the charging equipment to integrate with the smart grid for load curtailment (dropping maximum output of the charger) and demand side response services;
- pre-set default charging times for off-peak usage (with a suitable user-override);
- cyber-security; and
- minimum safety provisions.

Further guidance on the Regulations can be found on the Office for Product Safety and Standards website: https://www.gov.uk/guidance/regulations-electric-vehicle-smart-charge-points

Part S of the Building Regulations in England

Part S of the Building Regulations came into force in England on 15 June 2022 and relates to EV charging point provision associated with dwellings and residential buildings and certain non-residential premises. The legislation mandates charging equipment to be at least Mode 3, with a power capability of at least 7 kW, with a universal outlet, supplied by a dedicated circuit, and mandates the equipment to be installed according to BS 7671 and the IET *Code of Practice for Electric Vehicle Charging Equipment Installation*.

Installation of telecommunications and auxiliary cabling

One impact of the Electric Vehicles (Smart Charge Points) Regulations 2021 for installers is the increased requirement for communications interfaces and, where applicable, control and monitoring. As a result, guidance on communications and integration has been expanded in the Fifth Edition of the Code of Practice, and now includes guidance on telecommunications and auxiliary (control and monitoring) cabling installation according to BS 7671, BS 6701 and BS EN 50174 series. Cabling for Ethernet, ANSI/TIA/EIC-485-A (commonly known as 'RS 485') and control and monitoring auxiliary purposes are considered.

Guidance is provided on selection of appropriate cabling, and installation practices for telecommunications cabling inside and outside buildings.

Location and accessibility of charging points

The guidance on location and accessibility of charging points has been updated to take account of new standard PAS 1899:2022 *Electric vehicles - Accessible EV charging points - Specification* and the requirements of the Scotland Building Standards Division technical handbooks that came into force in June 2023.

Installers are also advised to consider RISCAuthority RC59 *Recommendations for fire safety when charging electric vehicles* when considering the location of charging points.

Vehicle as storage

Section 10 of the Code of Practice, which looks at vehicle as storage, has been updated to reflect guidance on the latest BS 7671 requirements for prosumer's electrical installations and includes guidance on V2H integration for installations operating in island mode, when the grid supply is disconnected.

Inspection and testing

Section 9 on inspection and testing has additional guidance for:

- earth electrode resistance measurement;
- RCD testing; and
- use of vehicle simulators for carrying out tests at socket-outlets or tethered cable vehicle connectors on the vehicle side of charging equipment.

The Code of Practice also provides advice on testing of RCD-DDs to BS IEC 62955. BS 7671 does not require tests of RDC-DDs to be conducted, however, tests could be carried out for fault-finding purposes, or functional testing if recommended by the manufacturer of the RDC-DD or electric vehicle charging equipment. Although, it should be noted that the test parameters in RCD test instruments or multifunction testers to BS EN IEC 61557 series *Electrical safety in low voltage distribution systems up to 1 000 V AC and 1 500 V DC. Equipment for testing, measuring or monitoring of protective measures* are not always suitable for RDC-DDs.

Installation of earth electrodes

Clearer guidance is provided for good practice in the installation of earth electrodes in accordance with BS 7671 and BS 7430.

Calculations for steel wire armoured (SWA) cables where the armour is used as the circuit protective conductor (cpc)

A new appendix has been included to help designers consider the reactance of steel wire armoured cables on the earth fault loop impedance calculations where the armour is used as a cpc (with or without an additional copper conductor in parallel). This can also be used by those carrying out inspection and testing, in cases where loop impedances are to be determined at least in part by calculation.

Appendix 4 to BS 7671 tells us that reactive effects need not be considered where the cross-sectional area (csa) of cables does not exceed 16 mm^2. However, where SWA cables are used, the csa of the armour usually exceeds 16 mm^2. For example, with BS 5467 cables, the gross csa of the armour exceeds 16 mm^2 for all:

- three-, four- and five-core multicore cables with conductor csa at least 1.5 mm^2; and
- two-core cables with conductor csa of at least 2.5 mm^2.

What is the effect of not taking cable reactance into account for SWA cables? As we can see from Table 1, (Z_1+Z_2) taking into account reactance is between 4 % and 9 % greater than (R_1+R_2), and this might be significant for long runs where overcurrent protective devices provide automatic disconnection of supply. In addition, with larger supplies required for commercial sites and Mode 4 (DC rapid charging) electric vehicle charging equipment installations, it may be necessary to take into account the reactance of the loop impedance at the feeder pillar or distribution board, which will have a further impact.

Table 1 Comparison of loop impedance contribution of SWA cables to BS 5467, where the armour is used as cpc, with and without consideration of reactance

Conductor csa (mm^2)	Loop impedance contribution per metre at 70 °C (mΩ/m)							
	2-core		3-core		4-core		5-core	
	(Z_1+Z_2)	(R_1+R_2)	(Z_1+Z_2)	(R_1+R_2)	(Z_1+Z_2)	(R_1+R_2)	(Z_1+Z_2)	(R_1+R_2)
1.5	28.3	27.0	27.3	26.2	26.4	25.3	25.6	24.6
2.5	20.8	19.7	19.9	18.9	19.2	18.3	18.1	17.2
4.0	16.2	15.2	15.6	14.7	14.7	13.9	13.9	13.1
6.0	13.1	12.3	12.7	11.9	9.50	8.96	8.96	8.47
10	10.3	9.55	7.59	7.10	7.19	6.73	6.78	6.36
16	6.37	5.91	6.10	5.67	5.57	5.18	4.35	4.08
25	5.19	4.79	3.98	3.69	3.71	3.45	3.31	3.08
35	3.61	3.32	3.47	3.20	3.20	2.96	2.80	2.59
50	3.17	2.91	2.91	2.67	2.24	2.06	1.97	1.81

NOTE: (Z_1+Z_2) is the loop impedance taking into account reactance. (R_1+R_2) is the loop impedance not taking into account reactance.

Depth of buried cables and height of overhead cables

With the exception of the Streetworks UK guidelines relating to cabling buried under the highway, there is currently no easy-use reference for the minimum depth of buried cables, and minimum height of overhead cables. It has been recognized that EV charging equipment is now starting to be installed in a variety of different types of premises, some having more onerous requirements. Appendix K to the Fifth Edition of the Code of Practice provides a ‘one-stop-shop’ for designers and installers to easily see how minimum depth and height requirements may change, when providing charging points in, say, agricultural premises or caravan sites.

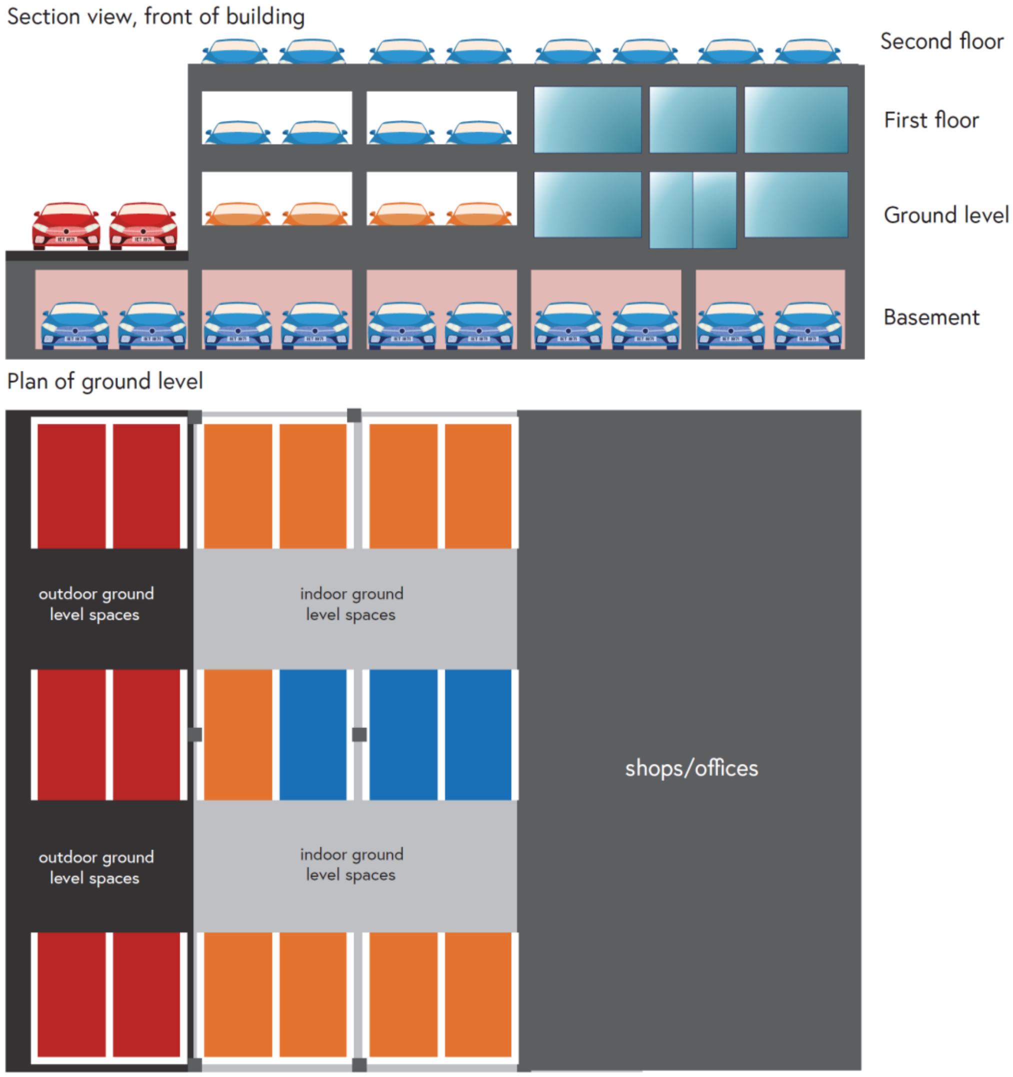
Other guidance for designers

For each of the use-case classifications (domestic, on-street, and commercial and industrial) there is updated guidance on determining adequacy of supply and maximum demand. The guidance takes into account load curtailment (where used), and also helps designers understand the difference between the maximum demand values required for:

- the maximum demand required by the electricity supplier (DNO);
- sizing switchgear assemblies and distribution arrangements; and
- selection of final circuit wiring systems and suitable conductor cross-sectional area.

There is also guidance on determining whether vehicles on charge are considered indoors or outdoors for the purposes of Regulation 722.411.4.1 in commercial and industrial applications. This is not always straightforward in buildings with parking on multiple levels (see Figure 1).

Figure 1 Examples of vehicle spaces considered to be indoors or outdoors for the purposes of Regulation 722.411.4.1 (from the 5th Edition of the IET *Code of Practice for Electric Vehicle Charging Equipment Installation*)



In all cases, vehicles and exposed-conductive-parts of equipment that are simultaneously-accessible should be connected to the same earthing system, as well as considering Regulation 722.411.4.1

Generally, charging outdoors for the purposes of Regulation 722.411.4.1.

Generally, charging indoors for the purposes of Regulation 722.411.4.1, unless the vehicle is accessible by someone standing on the ground outside the building.

Generally, charging outdoors for the purposes of Regulation 722.411.4.1 unless:
(a) the location of parking space, or use of barriers, prevents vehicle from being touched by a person standing outside the building; and
(b) tethered cable length or obstructions prevent connection to vehicle outdoors.

NOTE: The simplified examples above do not consider situations where ground levels outdoors change, or the levels of the building do not align with surrounding ground level. In such cases, vehicles on charge on multiple levels that can be touched by a person standing outside the building may need to be considered as 'charging outdoors'.

Conclusion
The Fifth Edition of the IET *Code of Practice for Electric Vehicle Charging Equipment Installation* contains a number of timely updates, so that industry can be kept up-to-speed with the rapidly changing landscape in this field which is of key importance to the UK Government's approach to reducing the UK's carbon emissions. The Fifth Edition includes updates to cover technological developments, industry practices, and legislative frameworks, since the previous edition.

About the author
Graham Kenyon is a Chartered Engineer, and Managing Director of consultancy G Kenyon Technology Ltd. Graham Chairs:

- the joint IET/BSI Committee JPEL/64, responsible for BS 7671;
- the IET Wiring Regulations Policy Committee; and
- the IET Committee developing the IET Standard for open-PEN disconnection devices (OPDDs), which will shortly be available for public consultation.

He is the technical author of a number of IET guidance publications including the IET *Code of Practice for EV Charging Equipment Installations*, the Second Edition of the IET *Code of Practice for Grid-Connected Solar PV Installations* (2022), and the latest editions of IET Guidance Notes 3, 5 and 6.

Latest developments in international standards for supplies for electric vehicle (EV) charging revisited

By: Geoff Cronshaw

Introduction
In this article, we revisit some of the international standards for electric vehicle (EV) charging and look at some of the latest developments.

The UK is actively involved in the development of international standards. It is worth noting at this stage, the relationship between, for example, the British standard (BS 7671) and the European and international standards for electrical installations. The IET Wiring Regulations (BS 7671) are based on European standards, which in turn are generally based on international standards. The International Electrotechnical Commission (IEC) is the oldest of the international standardization organisations. It was founded back in 1906 with the support of seven countries. The IEC is an international non-governmental organisation whose members are the National Electrotechnical Committees or standards bodies (like the British Standards Institution (BSI) in the UK).

Work on the first edition of IEC 60364-7-722 - *Supplies for electric vehicles*, was initiated back in 2009 (14 years ago) and the first edition was published in February 2015. This was developed to answer the needs of the EV market in terms of safety of supply of EV installations, reliability, and proper functioning of the supply.

Work on a second edition started in 2015 and was published in September 2018. This second edition is still current but under review to keep pace with the progress of EV charging.

The second edition includes a number of significant points worth noting.

Wireless power transfer
Most people involved in electrical installations for EV charging are familiar with conductive charging systems, where the EV is plugged into a charging point to charge the vehicle battery. However, IEC 60364-7-722 Edition 2 recognizes wireless power transfer (WPT) systems for EVs and requires compliance with the appropriate parts of the IEC 61980 series. These are new and emerging technologies.

(It is important to note that inductive charging is currently outside of the scope of Section 722 of the IET Wiring Regulations, BS 7671:2018+A2:2022).

BS EN IEC 61980 series is published in several parts. BS EN IEC 61980-1:2021 *Electric vehicle wireless power transfer (WPT) systems* was published on the 31 January 2021.

Part 1 covers general requirements for electric road vehicle (EV) WPT systems, including general background and definitions (e.g., efficiency, electrical safety, EMC, EMF). Part 1 applies to the supply device for charging electric road vehicles using wireless methods at standard supply voltages up to 1,000 V AC and up to 1,500 V DC.

In addition, Part 1 also applies to WPT equipment supplied from on-site storage systems.

Aspects covered include the characteristics and operating conditions of a supply device, communication between the EV device and the vehicle, and specific EMC requirements for a supply device.

Part 2 of BS EN IEC 61980 was published on 30 June 2023. This part of BS EN IEC 61980 addresses communication and activities of magnetic field wireless power transfer (MF-WPT) systems.

The requirements in this document are intended to be applied for MF-WPT systems according to IEC 61980-3 and ISO 19363 - *Electrically propelled road vehicles*.
Aspects covered include operational and functional characteristics of the MF-WPT communication system and related activities, and operational and functional characteristics of the positioning system.

Part 3 of BS EN IEC 61980 was published on the 28 February 2023 and covers specific requirements for magnetic field wireless power transfer systems.

This part of IEC 61980 applies to the off-board supply equipment for wireless power transfer via magnetic field (MF-WPT) to electric road vehicles for purposes of supplying electric energy to the rechargeable energy storage system (RESS) and/or other on-board electrical systems. The power transfer takes place while the EV is stationary.

Aspects covered include:
- electrical safety;
- characteristics and operating conditions;
- basic communication;
- requirements for positioning for power transfer; and
- specific EMC requirements.

EV operating as a source in parallel with other sources
The current standard (IEC 60364-7-722 Edition 2) recognizes the case where the EV may operate as a source in parallel with other sources and states that where EVs are intended to feedback energy to the electrical installations, the requirements of IEC 60364-8-2 *Prosumers LV Electrical Installations* apply. However, the standard does state that additional requirements for circuits intended for feeding back electricity from EVs are under consideration. Therefore, this is expected to be a future development.

(In the UK, Section 722 of the IET Wiring Regulations (BS 7671:2018+A2:2022) makes it clear that requirements for precautions on supply of the fixed installation by the EV are under consideration. Section 551 covers low-voltage generating sets. It is important to note that in the UK there are mandatory requirements concerning the parallel connection of generators with the supply network, and the Energy Networks Association (ENA) publishes Engineering Recommendations G98 and G99 concerning connection of generators.

Charging modes
IEC 60364-7-722 Edition 2 makes reference to IEC 61851 *Electric vehicle conductive charging system*. IEC 61851 describes the charging modes.
(Charging modes are described in Part 2 (definitions) of *the IET Wiring Regulations BS 7671:2018+A2:2022).*

Mode 1 charging: connection of the EV to the AC supply network utilizing standardized socket-outlets not exceeding 16 A and not exceeding 250 V AC single-phase or 480 V AC three-phase, at the supply side, and utilizing the power and protective earth conductors. IEC 61851 highlights restrictions at national level on the use of Mode 1.

Mode 2 charging: connection of the EV to the AC supply network utilizing standardized socket-outlets not exceeding 32 A and not exceeding 250 V AC single-phase or 480 V AC three-phase, at the supply side, and utilizing the power and protective earth conductors together with a control pilot function and system of personnel protection against electric shock (RCD) between the EV and the plug or as part of the in-cable control box.

IEC 61851 highlights the need for household and similar sockets and plugs for EV charging to be suitable.

Generally, Mode 2 is the minimal charging solution for single phase domestic socket-outlets. It usually provides charging currents of 10 A or less.

Mode 3 charging: connection of the EV to the AC supply network utilizing dedicated EV supply equipment where the control pilot function extends to control equipment in the electric vehicle supply equipment, permanently connected to the AC supply network.

IEC 62196-2 gives details of vehicle inlet and vehicle connector Type 1 and Type 2 and Type 3 for Mode 3 charging. A mechanical or electromechanical means must be provided to prevent intentional and unintentional disconnection under load of the vehicle connector and/or plug according to IEC 62196-1.

Mode 3 recognizes various levels of charging currents. A typical Type 2 Mode 3 charging point could be 32 A (7.2 kW).

Mode 4 charging: connection of the EV to the AC supply network utilizing an off-board charger where the control pilot function extends to equipment permanently connected to the AC supply.

A mechanical or electromechanical means must be provided to prevent intentional and unintentional disconnection under load of the vehicle connector and/or plug according to IEC 62196-1.

One of the advantages with Mode 4 charging is that it can provide fast high-power charging. When charging a vehicle from an AC output charge point, the charging power is often limited by the on-board battery charger of the EV. With (Mode 4) DC charging, DC power is provided directly to the battery system and is not limited by the on-board battery charger of the EV.

Therefore, Mode 4 charging appears to be suited for use at motorway services, shopping centres, and busy urban areas where a fast charge is required to minimize charging time.

Conclusion
This is only a brief overview and highlights some of the significant points in the current IEC standard. For more information, refer to IEC 60364-7-722 Edition 2.

Important: please note these are requirements at international level (world standards) which may or may not be incorporated in BS 7671 in the future.

Finally, it is worth noting that in the UK, the Building Regulations in England, Wales, Scotland or Northern Ireland have requirements for EV charging infrastructure depending on the location. For example, in England the government has introduced Approved Document S (Infrastructure for charging electric vehicles).