

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

Draft for Public Comment (DPC)

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Technical Committee

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Preface

Electric vehicles have an important role to play in meeting air quality legislation and the UK's commitment to climate change targets. For these reasons, the UK government is actively supporting the switch to electric vehicles.

For many users, with the increase in battery size of electric vehicles, considerably more energy can be stored than the average daily commute requires. A large electric vehicle parking facility creates a major opportunity to provide battery storage capacity to the electricity system, mitigating the intermittence of renewable generation and network constraints. Other users need a larger range over which a vehicle can travel on a single charge, with a shorter time taken to recharge the vehicle. A greater range requires a larger battery pack, increasing the time taken to recharge the battery using a standard BS 1363 type socket-outlet. To address this issue, vehicle manufacturers have worked with the electrical industry to develop suitable solutions.

The solutions that have been developed involve dedicated electric vehicle charging equipment using dedicated socket-outlets, plugs and vehicle connectors. They also provide additional safety by requiring communication between the vehicle and the charging equipment before charging can commence. Two conductive charging solutions are now widely supported by the automotive industry:

- (a) AC charging using the vehicle on-board charger; and
- (b) DC charging using external chargers provided by the electric vehicle supply equipment (EVSE).

This Code of Practice has been amended to include the requirements of BS 7671:2018+[A2:2022](#)~~A1:2020~~ *Requirements for Electrical Installations*. Changes have been made to:, and includes:

(a) Section 5, contains including:

- (i) guidance on the selection and installation of open protective earthed-neutral (PEN) detection devices, according to the revised Regulation 722.411.4.1. This includes devices that operate when the voltage between the circuit protective conductor (cpc) and Earth exceeds 70 V rms, with or without a measurement earth electrode (722.411.4.1 (iii)), as well as devices for single-phase installations only that operate when the line to neutral voltage is outside certain limits (722.411.4.1 (iv)).

(ii) new guidance on the installation of telecommunications and auxiliary cabling.

(iii) revised guidance on provision of surge protective devices.

~~(e)(b) updated guidance on the selection and installation of residual current devices (RCDs) and residual DC current disconnecting devices (RDC-DDs), according to the revised Regulation 722.531.3.101. Chapter Section 10 (Vehicle as storage) and Chapter 12 (Integration and smart infrastructure) have been extensively updated, and include~~esing new content to assist designers and installers.

~~(d) Chapter 11 (Distribution network operator (DNO) notification) has been updated to reflect the latest notification process.~~

359 (c) new Annexes/Appendices have been included/revised, based on research conducted by
360 the author and members of the IET Wiring Regulations Policy Committee, as follows and
361 includes the following guidance:

362 (i) Appendix E/Appendix E contains updated guidance on the installation of equipment
363 for wireless power transfer via inductive charging (MF-WPT-MF), and a commentary
364 of standards and key safety issues;

365 (ii) Appendix F/Appendix F contains revised guidance on the required earth electrode
366 resistances to comply with Regulation 722.411.4.1 (ii);

367 (iii) Appendix G/Appendix G Annex H provides guidance on the transfer of potential
368 between buried conductors and earth electrodes in earthing systems for electric
369 vehicle (EV) charging points, which is important in the selection of a suitable location
370 for TT earth electrodes;

371 (iv) Appendix H/Appendix H Annex I provides guidance on the detection threshold
372 voltage, and location of a measurement earth electrode, for open PEN detection
373 devices described in Regulation 722.411.4.1 (iii); and

374 (v) a new Appendix I/Appendix I contains guidance for installation of earth electrodes;

375 (vi) Appendix J/Appendix J discusses supply, shock protection and earthing
376 arrangements for Mode 4 EVSE and has been revised to include details of
377 pantograph connectivity systems;

378 (vii) a new Appendix K/Appendix K provides latest guidance on the minimum depth of
379 buried cables, and minimum height of overhead suspended cables.

380 (iv) Annex J provides guidance on the use of protective multiple earthing (PME) earthing
381 terminals in three-phase systems that are sufficiently well-balanced according to
382 Regulation 722.411.4.1 (ii). A rule of thumb and look-up table are provided to avoid
383 lengthy calculations.

384 All guidance on indent (i) from Regulation 722.411.4.1 has been removed from this Edition,
385 as 722.411.4.1 (i) was deleted by BS 7671:2018+A2:2022.

1 Scope

This Code of Practice applies to the installation of dedicated conductive charging equipment for the charging of pure electric and plug-in hybrid electric road vehicles (PHEV), including extended range electric vehicles (E-REV).

The installation of wireless power transfer (WPT) charging equipment is not currently covered in this Code of Practice. This will be reviewed in future editions, once WPT technology has matured and more experience has been gained with its installation. Some guidance based on the information currently available is provided in [Appendix E](#)~~Appendix E~~[Annex F](#).

The Code of Practice covers the installation of dedicated electric vehicle charging equipment of the types described in Section 4 of the Code. It is not intended to cover socket-outlets provided for general power; references to socket-outlets in this Code are either to dedicated electric vehicle charging socket-outlets or to standard socket-outlets incorporated into dedicated electric vehicle charging equipment.

It covers the installation of both AC and DC charging equipment intended for plug-in electric vehicles (PEVs) complying with the BS EN 61851 series of standards. The term EV in this Code of Practice is intended to include the terms PEVs, plug-in vehicles (PiVs), full battery electric vehicles (BEVs), plug-in hybrid electric vehicles (PHEVs) and range-extended hybrid electric vehicles/extended-range hybrid electric vehicles (REHEVs/ERHEVs).

This edition of the Code of Practice:

- (a) discusses vehicles used for electrical energy storage (in conjunction with the IET *Code of Practice for Electrical Energy Storage Systems*) – see Section [1010](#); and
- (b) introduces integration with smart metering and control, automation and monitoring systems – see Section [1212](#).

It applies to the installation of conductive EV charging equipment in all locations where such equipment may be required, including:

- (a) domestic installations, such as installations in, or adjacent to, houses and their associated garages;
- (b) on-street installations; and
- (c) commercial and industrial installations, such as installations in, or adjacent to, business premises, [for example, e.g.](#) shops, offices, factories, etc., including public and private car parks, whether single-level or multi-storey, and filling stations.

Note~~NOTE~~: Standards for WPT installations are still under development. A commentary is included in [Appendix E](#)~~Appendix E~~[Annex F](#).

The objective of this Code of Practice is to provide guidance on the installation of EV charging equipment to assist the installer in ensuring that the final installation complies with the relevant requirements of BS 7671 (*The IET Wiring Regulations*, 18th Edition) and, where necessary, the Electricity Safety, Quality and Continuity Regulations (ESQCR) 2002 (as amended).

423 Whilst this Code of Practice addresses the technical aspects of EV charging equipment
424 installation, it does not specifically address the local authority planning regulations and/or
425 building regulations that may need to be considered when installing such equipment.

2 Overview of EV charging equipment

2.1 Introduction

Electric vehicle supply equipment (EVSE) is a key component in the roll-out of charging infrastructure for EVs using a conductive or wireless charging solution. [The majority of this Code of Practice is dedicated to conductive charging applications, which are the subject of particular installation requirements according to Section 722 of BS 7671. Wireless charging equipment should be installed considering the general rules of BS 7671 \(being outside the scope of Section 722 of BS 7671\) and this is discussed in Appendix E.](#)

2.2 Charging equipment for conductive charging (Modes 1, 2, 3 and 4 according to BS EN 61851 series)

2.2.1 Introduction

[Most Many general-use](#) EVs can charge from a conventional three-pin socket using the Mode 2 charging equipment often supplied with the vehicle. Increasingly, more sophisticated and digitally—managed EVSE is being deployed in the residential, business and public infrastructure context, providing charging management capabilities such as access control, configurable charging power and accountability for charging events.

EVSE for conductive charging ~~solutions supports~~ [solutions service](#) two principal charging options:

[1.](#) AC supply for the on-board vehicle charger; and

[2.](#) EVSE charger for DC supply to the vehicle battery.

There is a wide power range in EVSE, which may range from as low as 6 A to well over 100 A. This can create significant challenges, not just from an EVSE installation perspective, but also in terms of integration and management as part of the electricity supply system.

EVSE increasingly forms part of onsite generation and energy storage solutions, enabling the vehicle to act as a mobile energy storage device that can be charged as well as discharged via the charging infrastructure. This adds additional requirements to be considered as part of the EVSE installation design and its operational characteristics.

The BS EN IEC 61851/BS EN 61851 series of standards specifies the design and performance requirements for EV conductive charging equipment with which all equipment shall comply. Furthermore, EV charging equipment shall also comply with the Electromagnetic Compatibility Regulations 2016 and the Electrical Equipment (Safety) Regulations 2016, and ~~be CE-marked accordingly~~ [carry an appropriate regulatory mark \(see Appendix L\)](#).

BS 7671:2018+~~A1:2020~~[A2:2022](#) is the appropriate safety standard for electrical installation.

2.2 Charging equipment for Modes 1, 2, 3 and 4

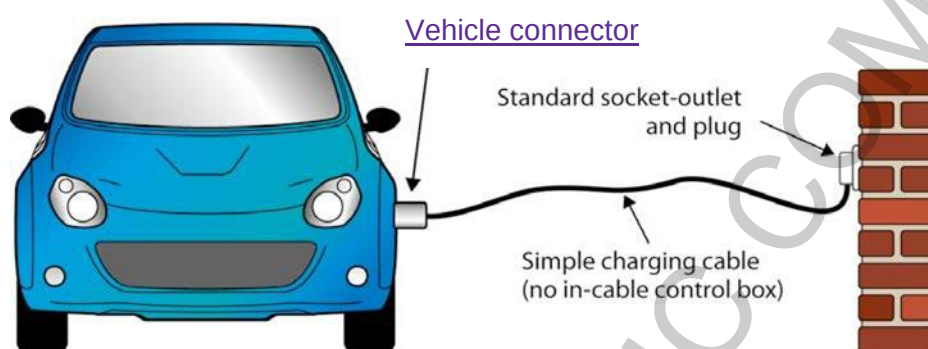
There are four commonly adopted charging methods [for conductive charging applications](#), called 'modes'. These are described ~~below~~ [in Sections 2.2.22-2.2 to 2.2.52-2.5 inclusive](#).

2.2.12.2.2 Mode 1 charging

In Mode 1 charging, connection of the EV to the AC supply network utilizes 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 (according to BS EN 61851-1). This can be seen in Figure 2.1.

NOTE: Mode 1 is no longer a mainstream charging technology.

Figure 2.1 Mode 1 charging



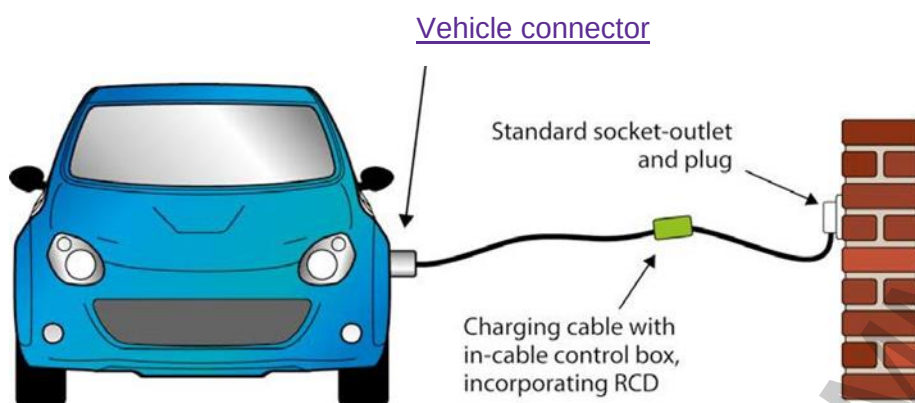
NOTE: BS 1363-1 plugs used on Mode 1 or Mode 2 charging cables should be marked 'BS 1363/EV'. BS 1363-2 socket-outlets installed as a charging point for Mode 1 or Mode 2 charging should be marked 'BS 1363/EV'.

2.2.22.2.3 Mode 2 charging

Mode 2 charging describes the minimal charging solution for single-phase domestic socket-outlets. It typically provides charging currents of 10 A or less where BS 1363-2 socket-outlets are used. In Mode 2 charging, connection of the EV to the AC supply network utilizes standardized socket-outlets (BS 1363-2 or single-phase or three-phase industrial socket-outlets to BS EN 60309 series) not exceeding 32 A and not exceeding 250 V AC single-phase or 480 V AC three-phase, at the supply side, and utilizes the power and protective earth conductors together with a control pilot function and system of personnel protection against electric shock (BS EN 62752) between the EV and the in-cable control box (ICCB). Refer to Figure 2.2.

NOTE: BS 1363-1 plugs used on Mode 1 or Mode 2 charging cables should be marked 'BS 1363/EV'. BS 1363-2 socket-outlets installed as a charging point for Mode 1 or Mode 2 charging should be marked 'BS 1363/EV'.

Figure 2.2 Mode 2 charging



2.2.32.2.4 Mode 3 charging

In Mode 3 charging, connection of the EV to the AC supply network utilizes dedicated EVSE where the control pilot function extends to control equipment in the EVSE, permanently connected to the AC supply network. The EVSE may be supplied from a three-phase AC supply and will often incorporate BS EN 62196-2 Type 2 [plugs-vehicle connectors](#) where tethered cables are not used ([see](#) [Refer to](#) Figures 2.3 and 2.4).

Figure 2.32.32.3 Mode 3 charging (dedicated [socket-vehicle connector](#) outlet)

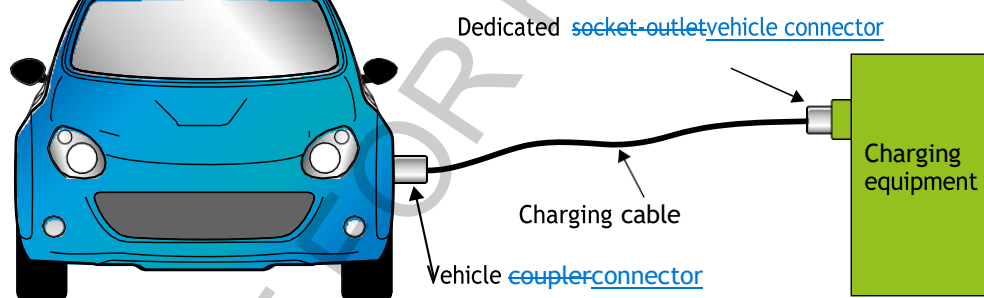
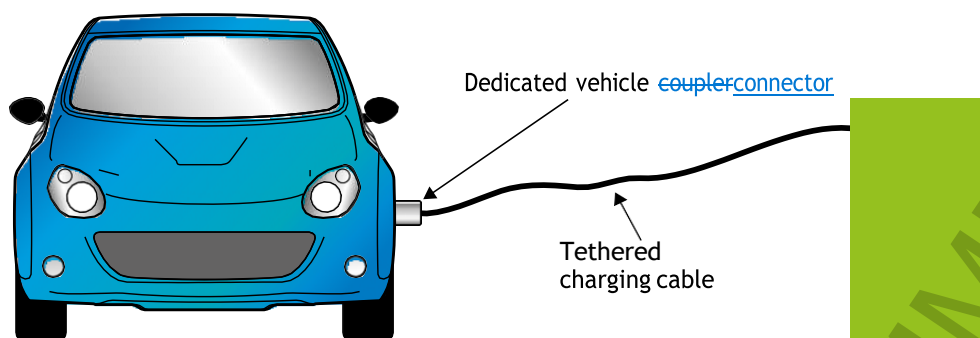
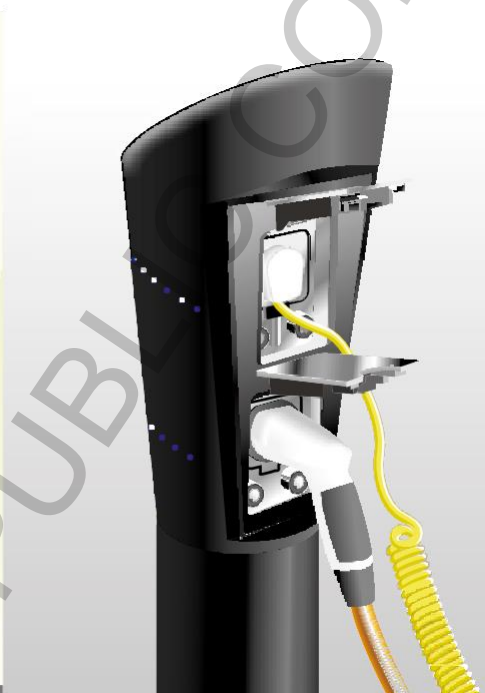


Figure 2.42.4 Mode 3 charging (tethered charging cable)



AC-charging equipment EVSE for Mode 3 charging tends to be either in the form of 'charging posts' or wall-mounted charging units, and comes in a variety of current ratings, both single-phase and three-phase for example, 13 A, 16 A and 32 A (s. Refer ee to Figure 2.5 Figure 2.5).

Figure 2.52.5 Typical AC charging equipment EVSE (Mode 3)



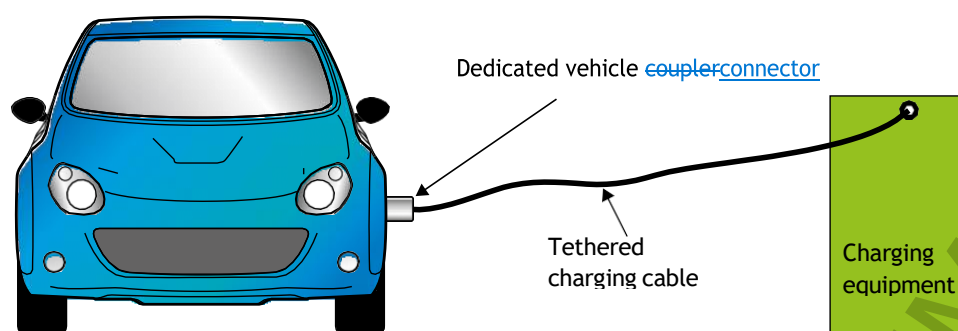
2.2.42.2.5 Mode 4 charging

In Mode 4 charging, ~~either single-phase or three-phase AC is converted to DC within the EVSE~~ output to the EV is DC. Conversion from single-phase or three-phase LV AC is typically carried out in the EVSE, although some larger power systems utilize DC from external power conversion equipment. The resulting DC is supplied to the EV via either:

- (a) a charging cable that is tethered to the EVSE; or
- (b) an automatic connecting device system.

~~The control pilot function extends to EVSE equipment permanently connected to the AC supply~~ fixed electrical installation (s-Refer to ~~see~~ Figure 2.6Figure 2.6).

Figure 2.62.62.6 Mode 4 charging



Due to its greater complexity, Mode 4 EVSE tends to be in the form of larger units that are usually designed to be wall- or floor-mounted. Refer to [Figure 2.7](#). For larger commercial and public service vehicle installations, an automatic connecting device (ACD) also termed 'pantograph' system may be used to connect the vehicle. Two types of ACD are covered in the draft standard BS EN 61851-23-1:

1. Case D: where the ACD is mounted on the EVSE, colloquially termed 'pantograph-down' system (see [Appendix A](#), [Figure A.7](#)); and
- 1.
2. Case E: where the ACD is mounted on the EV, colloquially termed 'pantograph-up' system (see [Appendix A](#), [Figure A.8](#)).

Figure 2.72.72.7 Typical Mode 4 DC charging equipment with tethered cable



Mode 4 EVSE to BS EN 61851-23 may often incorporate electrical separation, in which case the DC supply to the vehicle has an IT earthing arrangement. Appendix J~~Appendix J~~ Annex K provides a commentary on Mode 4 EVSE and associated earthing system arrangements to assist designers and installers.

2.3 Socket-outlets, connectors and cables (Regulation 722.55.101)

2.3.1 Modes 1 and 2

Each AC charging point shall incorporate:

- (a) one socket-outlet that complies with BS 1363-2 and where the manufacturer approves its suitability for EV charging use; or

NOTE 1: Socket-outlets conforming to BS 1363-2, and approved by the manufacturer for EV charging use, are marked 'BS 1363/EV' on the rear of the product.

- (b) one socket-outlet or connector that complies with ~~BS EN 60309~~ BS EN IEC 60309-2, which is interlocked and is classified in accordance with 6.1.5 of ~~BS EN 60309~~ BS EN IEC 60309-1 to prevent the socket contacts being live when accessible; or

NOTE 2: Regulation 722.55.101.0.201 of BS 7671:2018+A2:2022 refers to Clause 6.1.5 of BS EN 60309-1; however, BS EN 60309-1:1999+A2:2012 has since been superseded by BS EN IEC 60309-1:2022, and the respective Clause renumbered to 6.5.

- (c) one socket-outlet or connector that complies with ~~BS EN 60309~~ BS EN IEC 60309-2, is part of an interlocked self-contained product that complies with ~~BS EN 60309~~ BS EN IEC 60309-4 and is classified in accordance with 6.1.401-401 and 6.1.402 402 of BS EN IEC 60309-4 to prevent the socket contacts being live when accessible.

NOTE 3: Regulation 722.55.101.0.201 of BS 7671:2018+A2:2022 refers to Clauses 6.1.101 and 6.1.102 of BS EN 60309-4; however, BS EN 60309-4:2007+A1:2012 has since been superseded by BS EN IEC 60309-1:2022, and the respective Clauses renumbered to 6.1.401 and 6.1.402.

2.3.2 Mode 3

Each charging point shall incorporate:

- (a) one Type 1 vehicle connector that complies with BS EN 62196-2; or
(b) one Type 2 socket-outlet or vehicle connector that complies with BS EN 62196-2; or
(c) one Type 3 socket-outlet or vehicle connector that complies with BS EN 62196-2.

Note~~NOTE~~: Vehicle manufacturers' instructions should be followed when determining the type of ~~socket-outlet~~ vehicle connector to be installed. Where a socket-outlet or tethered cable with a vehicle connector is provided on EVSE, BS EN 62196 Type 2 is usually used in the UK for Mode 3 EVSE (female for socket-outlet, male on a tethered cable).

See Appendix A~~Appendix A~~ Annex A for descriptions and drawings of Types 1, 2 and 3 equipment.

In Mode 3, an electrical or mechanical system shall be provided to prevent the plugging/unplugging of the plug unless the supply has been switched off. Shuttered socket-outlets are

not required in Mode 3, as the electrical interlocking that is inherent in Mode 3 provides equivalent protection. The same equivalent protection is provided for vehicle connectors on charging equipment with tethered cables.

2.3.3 Mode 4

Charging equipment designed for Mode 4 charging will always be fitted with either:

(a) -a tethered charge cable that is equipped with a dedicated vehicle connector. An electrical or mechanical system shall be provided to prevent the plugging/unplugging of the vehicle connector unless switched off from the supply (Regulation 722.55.101.4); or

(b) Aan ACD for pantograph-down systems; or

(a)(c) -Aan ACD counterpart for the ACD of pantograph-up systems.

More detailed information on the charging socket-outlets, plugs, vehicle connectors, vehicle inlets, ~~and~~ charging cables and automatic coupler (pantograph) systems is given in Appendix A~~Appendix A~~Annex A. Automatic coupler systems are discussed further in Appendix J~~Appendix J~~.

2.3.4 Socket-outlet enclosures (Regulation 722.55.101.0.201.2)

BS 7671 requires that each socket-outlet shall be installed in a distribution board in accordance with Regulation 722.51 or in a box in accordance with BS 4662 or BS EN 60670-1 (for example, a flush- or surface-mounted socket-outlet box) and mounted in a fixed position. Portable socket-outlets are not permitted, but tethered vehicle connectors may be used.

2.4 Other variations in EV charging equipment design and specification

In addition to the types of EV charging equipment described above, further variations in the design and specification of such equipment can be found. Typical features are described in Sections 2.4.12.4.1 to 2.4.62.4.6 inclusive. Full details of such features and their operation are not covered by this Code of Practice, but can be found in the installation/operational instructions supplied with the charging equipment being installed.

2.4.1 Power supply

It is important to check that the electrical installation has the appropriate supply arrangement for the EVSE. Some EV charging equipment is designed to operate from a single-phase AC power supply, whereas other EV charging equipment may require a three-phase AC power supply.

2.4.2 Multiple socket-outlets

Does the EV charging equipment meet the needs of the vehicles that will use it? Some types of EV charging equipment provide multiple socket-outlets. These can either be multiple socket-outlets of the same type or different socket-outlet types to suit different modes of charging, such as one BS 1363-2:2016 socket-outlet for Mode 1 or Mode 2 charging and one BS EN 62196-2:2017 socket-outlet for Mode 3 charging.

2.4.3 Metering

Tariff metering must be provided where use of the charging point is billed on an energy usage basis. [The Alternative Fuels Infrastructure Regulations 2017 require metering to comply with the Measurement Instrument Regulations 2016.](#) ~~and~~ Tariff or non-tariff metering may be ~~required~~ used for energy management purposes, for example, where Part L2 of the Building Regulations apply.

Some types of EV charging equipment require a separate feeder pillar containing the energy meter, depending on their installation location. Other types of EV charging equipment have a built-in energy meter to measure, record and display the amount of electrical energy used.

2.4.4 Protective devices

Some types of EV charging equipment incorporate either a circuit-breaker and a separate residual ~~-~~current circuit-breaker (RCCB) or a residual current circuit-breaker with overcurrent protection (RCBO).

Simpler charging equipment such as home chargers may rely on such protection in the consumer or distribution unit that also protects the supply circuit to the charger.

BS 7671 explicitly allows the protection to be split between the charger and the consumer unit – such as DC fault protection in the charger and a Type A or Type F residual current device (RCD) in the consumer unit.

2.4.5 Security features

Is the EV charging equipment appropriate for the installation location in terms of security? Some types of EV charging equipment, especially those intended for installation in publicly accessible locations, incorporate security features to prevent unauthorized use of the equipment. For instance, the socket-outlet may be located behind a locked cover that can only be unlocked by a registered user presenting their individually authorized electronic key, presented via, for example, a radio frequency identification device (RFID) or a smartphone application (app).

2.4.6 Communications features

Does the EV charging equipment provide appropriate remote management, reporting, control and monitoring to meet the user's needs? Some types of EV charging equipment have built-in communications features that allow data on charge station utilization, energy usage and faults to be communicated to the owner/operator of the charging equipment. Such data may be communicated either through a wired connection, such as Ethernet, or through a wireless connection, such as wireless networking (WiFi) or a mobile network.

3 Arrangements prior to installation commencement

The following actions, where applicable, shall be undertaken by a competent person (the designer) prior to the commencement of the EV charging equipment installation.

NoteNOTE: In this sSection, the terms 'designer' and 'installer' are used to align with BS 7671. In some circumstances, the designer and the installer may be the same individual or organization.

3.1 Legislation specifically relating to charging equipment

3.1.1 The Electric Vehicles (Smart Charge Points) Regulations 2021

The Electric Vehicles (Smart Charge Points) Regulations 2021 came into force in June 2022.

NOTE: ~~t~~The Regulations do not apply to private charging points that are or were:

- (a) sold in Northern Ireland;
- (b) sold elsewhere in the UK before 30 June 2022;
- (c) solely intended for use outside Great Britain;
- (d) sold by individuals outside of the purposes of their trade, business, craft or profession (for example, second-hand sales made between private individuals);
- (e) cables with in-cable control boxes for Mode 2 charging;
- (f) EVSE with a rating of 50 kW or greater; or
- (g) intended for use as public charge points (but these may be subject to the requirements of the Alternative Fuels Infrastructure Regulations 2017).

The Regulations require EVSE sold for private charging of vehicles to meet certain equipment requirements, including:

- (a) smart functionality to enable the EVSE to integrate with the smart grid, and respond to smart signals to curtail or increase the maximum output the charging point can be controlled by the electricity supplier based on their needs;
- (b) pre-set default charging times for off-peak usage (with user over-ride);
- (c) demand side response services and a suitable user interface;

NOTE: Organizations can participate in demand side response if they are either a:

- (a) large industrial or ~~commercial~~commercial customer;
- (b) small to medium enterprise; or
- (c) aggregator.
- (d) electricity supplier interoperability to enable the EVSE to continue to work with smart infrastructure when the owner switches electricity supplier;
- (e) randomized delay functions for certain events (for example, start of charging, recommencement following supply failure etc.);
- (f) the ability for the EVSE to continue to be able to charge EV in the event of communications interruptions or failures;
- (g) functional safety requirements to prevent users from selecting unsafe states or operating modes;
- (h) logs of energy imported (and, for vehicle to grid (V2G)/vehicle to home (V2H) applications, exported), which must be available to the owner; and
- (i) cyber security to ETSI EN 303 645.

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

3.1.2 Part S of the Building Regulations

Part S of the Building Regulations came into force in England on 15 June 2022 and generally require:

- (a) new homes, including those created from a change of use, with associated vehicle parking, to have an EV charging point;
- (b) residential buildings undergoing major renovation works, with more than 10 parking spaces to have an EV charging point per dwelling with associated parking, and cable routes installed for all spaces without charging points; and
- (c) All non-residential buildings that are new, or undergoing major renovation, that have at least 10 parking spaces to have a minimum of one charging point installed, with cable routes installed for at least 20 % of the total number of spaces.

NOTE: If the building notice or initial notice was applied for prior to 15 June 2022, the project may proceed under the previous Building Regulations provided the building work commences prior to 15 June 2023.

There are circumstances, chiefly based on cost, where some of the above requirements need not be met. Further information can be found in Building Regulations Approved Document S 2021, published by the Department for Levelling Up, Housing and Communities.

Building Regulations Approved Document S states that charging points provided under the legislation should:

- (a) be a Mode 3 charging point complying with BS EN 61851;
- (b) be installed in accordance with BS 7671 and the IET Code of Practice for Electric Vehicle Charging Equipment Installation (this Code of Practice);
- (c) have a minimum nominal output rating of 7 kW and supplied by a designated circuit; and
- (d) be fitted with a 'universal socket'

NOTE: Approved Document S does not define 'universal socket', but in the UK a BS EN 61936-2 Type 2 ('Mennekes') female outlet would be considered 'universal'.

At the time of writing, EV charging requirements in Wales and Northern Ireland have not been announced, although it is anticipated that the Scottish Government will introduce secondary legislation revising the Building (Scotland) Regulations to have similar requirements to those in England.

3.13.2 Supply metering

Check whether the incoming supply is a metered supply and establish whether or not it is a landlord's supply.

3.1.13.2.1 Unmetered supply

If a public network supply is in use, for example, from a distribution network operator (DNO) or a building network operator (BNO) and it is suspected that this is unmetered, the client should be advised to contact the network operator (DNO or BNO) to arrange for a new connection.

3.1.23.2.2 Landlord's supply

If connection to a landlord's supply is being proposed, confirm that the landlord has given permission for such a connection. If this permission has not been given, discuss this with the client. If the landlord refuses connection to their supply, advise the client that it is necessary to contact the DNO or electricity supplier to arrange for a new connection.

3.23.3 Adequacy of supply

It is the responsibility of the designer to determine that the maximum demand of the existing supply will not be exceeded with the installation of the additional EV charging equipment.

The designer will first need to assess the capacity of the existing supply. If no records are available, then the designer should contact the DNO for advice, recognizing that they will not be able to determine the rating conclusively unless the supply fuse holder is withdrawn by the relevant DNO, which is likely to incur an additional cost.

Unless design information for an existing installation is available, the installer will need to determine the loads installed, taking diversity into consideration where appropriate. The following IET publications include content related to maximum demand and diversity for installations of varying complexity:

- (a) *Electrical Installation Design Guide: Calculations for Electricians and Designers*; and
- (b) *On-Site Guide*.

When considering the additional load to be used for the EV charging equipment, the rating of the equipment is used in assessing the additional load. For a larger installation with a series of EV charging equipment connecting points, the assumed maximum load will need to be the sum of all the EV charging equipment ratings, unless there is a load curtailment arrangement limiting the load to a particular value.

Any areas of concern identified whilst assessing the adequacy of the supply shall be discussed with the client. Potential solutions include the following:

(a) limiting the maximum current capacity of the charging equipment

This can be achieved by installing charging equipment with a lower capacity, for example 16 A instead of 32 A. Alternatively, the maximum current capacity of some types of EV charging equipment can be varied between pre-set levels. For information on whether the charging equipment incorporates this facility and details of how to vary the maximum capacity, refer to the installation/operational instructions supplied with the charging equipment being installed.

(b) implementing load management strategies

These could entail electrical, electronic, mechanical or behavioural means of restricting the simultaneous use of electrical equipment with high current demand.

It is also possible to utilize EVSE that implements automatic load curtailment, along with a suitable management system.

(c) **uprating the incoming power supply**

If this route is chosen, the client shall be advised that it is necessary to contact the DNO or electricity supplier to arrange for an uprating of the incoming power supply.

Even where the supply capacity at individual premises is not exceeded, clusters of connecting points at different premises can have impacts on the local distribution network (i.e. voltage levels and network capacity limits). Examples of planned installation projects with multiple connecting points could be:

- (a) as part of a housing refurbishment programme in the same road; or
- (b) as part of a new housing development.

3.33.4 Existing earthing arrangements

Check the existing earthing arrangement of the incoming power supply. This information is required to determine what type of earthing arrangement will need to be provided for the EV charging equipment (refer to Sections 55, 66, 77 and 88).

3.43.5 Simultaneous contact assessment

Where automatic disconnection of supply (ADS) is used to protect against electric shock, BS 7671 requires simultaneously-accessible exposed-conductive-parts to be connected to the same earthing system- (sSee Regulation 411.3.1.1).

A simultaneous contact assessment should therefore be carried out, if it is planned to provide either:

- (a) -Aa separate TT earthing arrangement for the EV charging equipment and the installation location is in the vicinity of an installation using a different earthing system, for example a network-provided earthing arrangement from a TN-C-S system,; and/or

NOTE: It is not possible to bond the TT earthing arrangement to the PME earthing system in this case, as the EV would then be connected to the PME earthing arrangement,

- (b) aAn additional supply from the DNO, or a new transformer, for the EV charging installation.

NOTE: It is not always possible to bond the earthing arrangements of two supplies, especially where they are derived from different HV transformers. See Regulation 542.1.3.3 of BS 7671.

- (c) An installation already has, or is being designed to have, more than one earthing arrangement. An example may be a domestic property with a PME or TN-S earthing arrangement for the house, and outbuildings with TT earthing arrangements.

early out an-The simultaneous contact assessment for-is to ascertain whether it is possible to make contact between the exposed-conductive-parts of the charging equipment-/vehicle being charged and any exposed-conductive-parts or extraneous-conductive-parts connected

to the other earthing system, as detailed in Sections [5.3.35-3.3](#), [6.46-4](#), [6.6.26-6.2](#), [7.37-3](#), and [8.28-2](#).

3.53.6 Mobile or wireless [network](#) coverage

If the EV charging equipment is intended to communicate wirelessly, assess the proposed installation location for available coverage. Any potential issues identified during this assessment shall be discussed with the client.

3.63.7 Charging equipment manufacturer's instructions and requirements

Review the specification and any installation instructions and/or requirements provided by the EV charging equipment manufacturer for the specific piece of equipment being installed. In particular, the installer should take note of:

- (a) whether the EV charging equipment is fitted with a circuit-breaker and a separate RCCB or an RCBO and the precise specification for any such devices. This information is required by the installer to determine the correct specification of any such devices that may be required for the installation (refer to Sections [5.65-6](#), [6.106-10](#), [7.5](#) [7.3.57-3.5](#) and [8.58-5](#)).
- (b) any particular installation requirements that are specific to the type of equipment being installed. This includes specific accreditation or training for the charging hardware required by the manufacturer to provide knowledge of commissioning and safety issues that should be taken into account in the installation design.

3.73.8 Planning permission

If planning permission is required for the EV charging equipment installation, ensure that this has been applied for and granted.

3.83.9 [Traffic Management Regulation](#) Order

For on-street, publicly available EV charging equipment installation, ensure that, where required, any necessary [Traffic Management Order \(TMO\)](#) [Traffic Regulation Order \(TRO\)](#) has been created and duly consulted on.

[Working on or near the highway requires contractors with appropriate training. Temporary TROs may be required for the duration of works on or near the highway.](#)

3.93.10 Agree installation details with client

Discuss and agree all details of the installation with the client, including:

- (a) the adequacy of the existing electrical installation; see Regulation 132.16 of BS 7671;
- (b) the location of the charging equipment itself;
- (c) the location of any necessary feeder pillar;
- (d) the location of any switches;

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- (e) the wiring system, including the routing of all cabling;
- (f) the location of any necessary earth electrode; and
- (g) where appropriate, the location of any circuit-breakers and RCCBs or RCBOs.

4 Physical installation requirements

4.1 Introduction

In addition to any installation instructions provided by the charging equipment manufacturer, the physical location and installation requirements covered by this ~~section~~ Section shall also be ~~followed~~ considered in the selection and erection of equipment.

Selecting equipment for installation may impact compliance with other requirements, some of which result from, or afford compliance with, legislation, or other parts of the contract and associated specifications. A good example is the selection of a make or model of EVSE that cannot be installed to meet mounting heights for socket-outlets, controls and displays (see Sections 4.5.2.14.5.2.1 and 4.5.34.5.3).

The question of whose responsibility it is to meet the physical installation requirements often arises, for example, where a client or designer determines a particular make and/or model of EVSE is used, and some of the physical requirements cannot be fulfilled by designers or installers. In reality, the answer to this question is often one of contract, and how the conflict arose.

4.14.2 Potentially explosive atmospheres

4.1.14.2.1 General

EV charging equipment shall not be installed in locations where a potentially explosive atmosphere exists, for example, where petrol vapour or other flammable/combustible gases may be present. Where charging equipment is to be installed in the vicinity of a potentially explosive atmosphere, the EV charging equipment must be located outside the defined hazardous zone and positioned such that any EV connected to the charging equipment will also be outside the hazardous zone.

Further guidance on planning and designing EVSE installations at fuel filling stations is available in the IET/APEA publication *Electric Vehicle Charging Installations at Filling stations*, which supplements this Code of Practice.

4.1.24.2.2 Fuel filling stations

The publication *'Design, construction, modification, maintenance and decommissioning of filling stations'* of the ~~Association for Petroleum and Explosive Administration (APEA)~~ and the Energy Institute (EI), also known in industry as the 'Blue Book', advises should be followed for electrical installations at fuel filling stations. To provide further guidance on planning and designing EVSE installations at fuel filling stations, a supplement to this Code of Practice, entitled *Electric Vehicle Charging Installations at Filling Stations – A supplement to the Code of Practice for Electric Vehicle Charging Equipment Installation* has been published by the IET in conjunction with the Association for Petroleum and Explosive Administration (APEA).

9.5.11 Electric Vehicle Charging Equipment

Where electric vehicle (EV) charging equipment is installed at filling stations reference shall be made to the latest edition of the IET *Code of Practice for Electric Vehicle Charging Equipment*.

The installation of EV charging equipment at filling stations shall comply with the following criteria:

- (h) The charger and vehicle when charging at the full extent of the charging cable must be outside of any hazardous area.
- (i) When calculating the capacity of the supply required (whether from the filling station supply or a separate Utility Company supply) the full load of all chargers (if more than one) must be allowed — no diversity may be applied.
- (j) BS 7671 Section 722 requires each charge point to be individually protected by a 30 mA RCD. Therefore, if more than one charge point is to be supplied RCD protection must be provided to achieve selectivity (time and sensitivity) with the 30 mA RCDs.
- (k) If a separate Utility Company supply is provided for the EV charger, the Utility Company supply cable must be routed across or round the filling station forecourt so that it does not pass under any hazardous area.
- (l) If a separate Utility Company supply is provided for the EV charger, it should have a TT earthing system which must be connected to the filling station TT earthing system. It is not acceptable for the EV Charger installation to be connected to an earthing system separate from that of the filling station.
- (m) Where a separate Utility Company supply is provided a prominent Warning label must be mounted on the supply cubicle to indicate that the charger is fed from this separate supply and is not controlled by the PFS main switch.
- (n) Whatever means is adopted to provide the supply to the charger, the supply must be interlocked with the PFS controls so that when the forecourt is closed for any reason, the supply to the charger is also switched off. Where the charging equipment is fed from a supply separate to that serving the filling station (see EN 50174-3), consideration should be given to providing a fibre optic cable link in order to avoid a copper link.
- (o) The EV charger supply must be controlled by the forecourt emergency switching system. Where the charging equipment is fed from a supply separate to that serving the filling station (see EN 50174-3), consideration should be given to providing a fibre optic cable link in order to avoid a copper link.

See also Section 4.10 of the publication '*Design, construction, modification, maintenance and decommissioning of filling stations*'.

9.5.2 Battery charging equipment

Battery charging equipment, other than that integral with the dispenser should not be installed or used within any hazardous area of the filling station. Where provision is made for charging batteries integral with electrically energised vehicles, the charging equipment should be located so that the cable connection to the vehicle is within the non-hazardous area when the cable is fully extended.

866 Where the fuel filling station supply is used, its maximum demand shall be re-evaluated
867 considering the load of charging equipment. As all chargers may be in use simultaneously,
868 unless a load curtailment arrangement is in place, the full load of all charging equipment is
869 generally considered.

Where EVSE is installed within the curtilage of the fuel filling station:

- (a) circuits supplying EVSE shall be controlled by the forecourt emergency switching system;
- (b) the EVSE must be interlocked with the filling station controls for lighting and signage, so that power is removed from EVSE when the forecourt is closed;
- (c) only TT earthing systems shall be used; and
- (d) only EVSE with tethered cabling shall be used ~~in the hazardous area of the filling station,~~ and both the EVSE and parking spaces shall be located so that ~~electric~~ they ~~vehicles~~ cannot be ~~used to~~ charged ~~vehicles~~ in the hazardous area.

Where a separate utility supply is used for EVSE:

- (a) ~~a prominent~~ a prominent label shall be provided on the EVSE to indicate that it is not controlled by the filling station main switch; and
- (b) see Section ~~5.1.25.1.2~~ of this Code of Practice with regard to simultaneously accessible extraneous- and exposed-conductive-parts and extraneous-conductive-parts of different electrical installations.

~~Note: If an existing filling station has a protective multiple earthing (PME) supply to forecourt equipment, that may not be compatible with either supplying EVSE, or bonding to a separate TT earth used for EVSE.~~

~~It is strongly recommended that contractors working in fuel filling station environments ensure their operatives are trained and qualified in accordance with the Petrol Retail Forecourt Contractors safety passport scheme.~~

4.24.3 Location of charging equipment relative to parking space

The EV charging equipment shall be installed in a position relative to the parking space that ensures that the distance between the charging equipment and the charge connection point on the vehicle, known as the vehicle inlet, is kept to a minimum. This requirement is intended to minimize trip hazards, prevent the charge cable from being strained and helps avoid the temptation to use extension leads which would exacerbate trip hazards.

The Equality Act 2010 applies; accordingly, BS 8300-1 and BS 8300-2, should be considered. Publicly accessible EV charging points should be installed such that they cater for the wide diversity of people who may use them, including wheel-chair users, people with mobility issues and parents with young children. PAS 1899 addresses design and installation considerations for publicly accessible charging points (see Section 4.5.34.5.3).

~~Note~~NOTE: The use of extension leads for EV charging is not permitted.

4.2.14.3.1 Charging equipment intended to be used for charging only one type of vehicle

For charging equipment intended to be used for charging only one type of vehicle, for example, an industrial installation used for charging a fleet of identical vehicles, the location of the charging equipment relative to the parking space shall be assessed using the relevant vehicle type.

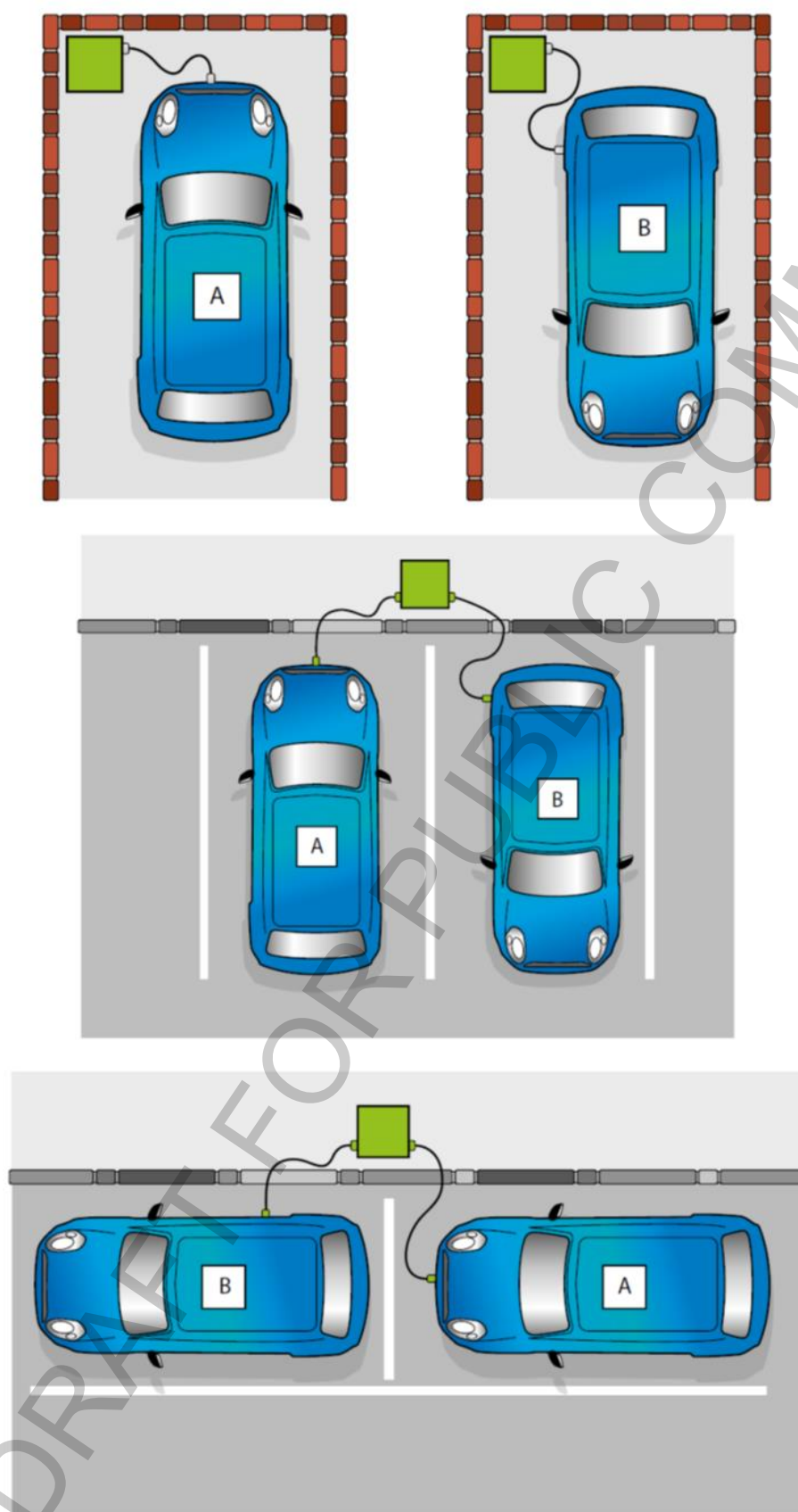
4.2.24.3.2 Charging equipment intended to be used for charging multiple types of vehicle

For charging equipment intended to be used for charging a variety of different vehicle types, or where the type of vehicle to be charged is unknown, compliance with the requirement specified in Section 4.34.3 is best achieved by installing the charging equipment at one corner of the parking space. This is because the position of the vehicle inlet on the vehicle is not currently standardized (some vehicles have their inlet on the front of the vehicle, some on the left-hand side of the vehicle and some on the right-hand side).

[Figure 4.1](#) on the following page demonstrates how placing the charging equipment at one corner of the parking space(s) can facilitate charging both a vehicle with its vehicle inlet on the front of the vehicle (labelled as A) and a vehicle with its vehicle inlet on the rear right-hand side of the vehicle (labelled as B).

919

Figure 4.14.14.1 Charging equipment location relative to the parking space



920

4.34.4 Protection against vehicle impact

The EV charging equipment shall be installed in a position to minimize the likelihood of vehicle impact damage, for example, to avoid the possibility of vehicles inadvertently driving into or reversing into the equipment.

Where it is foreseeable that the charging equipment could be damaged by vehicles, additional protective barriers must be installed (see [Figure 4.2](#)). Where EV charging equipment is associated with an accessible parking space, clear access should be provided for a wheelchair user to operate the equipment (see [PAS 1899](#) and [Section 4.5.34.5.3](#)), including ensuring that access to socket-outlets and controls is not impeded by bollards, as required by BS 8300-1.

Figure 4.24.24.2 Typical protection barriers



4.44.5 Location of controls and socket-outletsAccessibility and Part M of the Building Regulations

4.5.1 Introduction

This Section looks at the height requirements and accessibility of controls, socket-outlets, displays and other parts of the EVSE that are used by drivers charging electric vehicles. Procurement of EVSE and associated products shall take into account the relevant requirements in this Section to facilitate a compliant installation.

Installers, and those responsible for procuring EVSE are reminded that not all internationally-marketed products are designed to meet UK installation requirements discussed in this Section.

4.5.2 General requirements for charging points that are not required to be accessible charging points

4.5.2.1 Mounting heights

NOTE 1: See Section 4.5.34-5.3 for accessible charging points.

It is recommended that the All EV charging equipment should be installed such that:

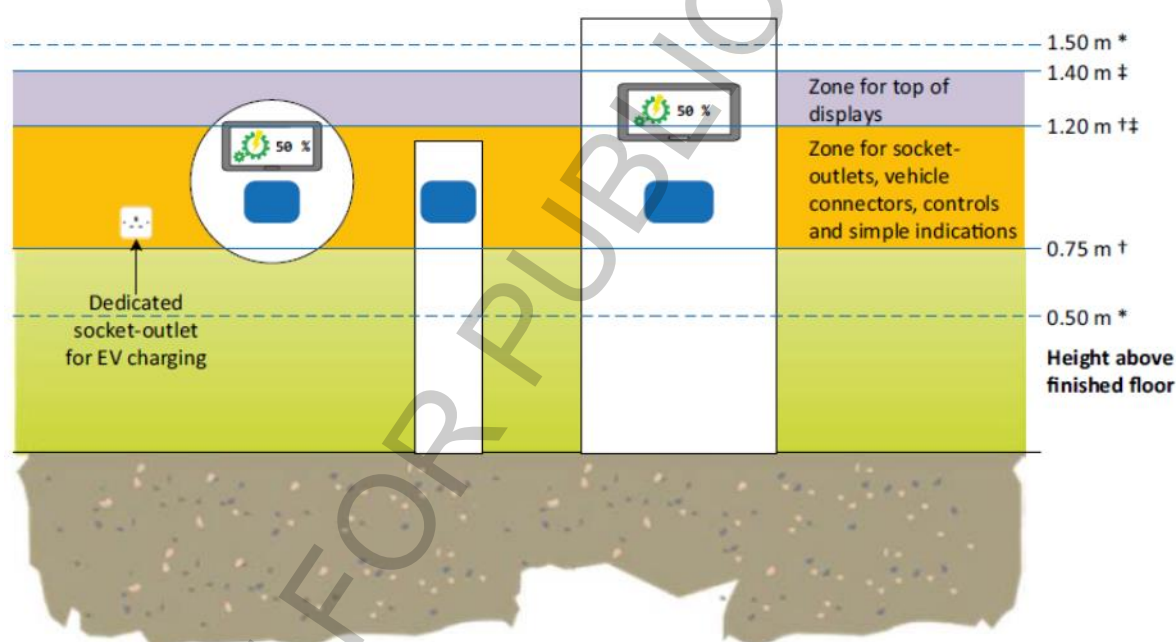
- (a) the main operating controls (including, where applicable, payment means) and any socket-outlets are between 0.75 m and 1.2 m above the ground; and
- (b) display screens are between 1.2 m and 1.4 m above the ground, viewable by a person standing or sitting.

NOTE 2: In (a) and (b) above, heights are stated as 'above the ground', which is intended to be above the ground on which the person is situated when using controls or viewing displays.

This is to avoid damage from vehicle bumpers and to ensure their accessibility in accordance with the British Standards for inclusive built environments, BS 8300-1 and BS 8300-2, (see Refer to Figure 4.3 Figure 4.3).

NOTE 3: Section 722 of BS 7671 no longer contains does not specify maximum and minimum heights. That does not mean it is considered safe to install socket-outlets and connectors outside the range recommended by BS 8300-1 and BS 8300-2.

Figure 4.34.34.3 Height of controls and socket-outlets



† Maximum and minimum recommended heights of socket-outlets and controls in BS 8300-1 and BS 8300-2.

‡ Maximum and minimum recommended heights of displays in BS 8300-1 and BS 8300-2.

* Maximum and minimum recommended heights for electrical safety specified in BS 7671 before Amendment 1:2020.

4.5.2.2 Avoidance of trip hazards

NOTE: See Section 4.5.34-5.3 for accessible charging points.

The EV charging equipment shall be installed in such a way as to avoid creating unnecessary trip hazards.

Any electrical wiring connecting the charging equipment to the mains supply shall be routed to avoid creating potential trip hazards, and suitably clipped or enclosed in containment.

Provision shall be made for the safe storage of any tethered charging cables when they are not in use.

4.5.2.3 Avoidance of unnecessary obstruction

NOTE: See Section 4.5.34.5.3 for accessible charging points.

The EV charging equipment shall not be installed in a position that causes an unnecessary obstruction to public or private footpaths, access passages, and so on.

4.5.3 Additional considerations for accessible public charging points

Accessible charging points shall be installed in accordance with PAS 1899:2022 *Electric vehicles -- Accessible EV charging points -- Specification*. The standard is aimed at improving accessibility of all charging points, and can be applied to charging points not in designated accessible bays.

Every EVSE installation should take accessibility requirements into consideration, in particular:

(a) ease of use of charging cables and vehicle connectors/socket-outlets, controls for starting and stopping of the charging session, and payment terminals;

(b) layout of EV parking spaces and charging bays to consider the use of mobility aids.

The spacing in front of the EVSE should be at least 1,200 mm with a reach distance for operating the charging point of no more than 220 mm.

EVSE with enhanced accessibility should be located close to amenities with accessibility requirements in the overall installation site context.

PAS 1899 specifies requirements for the provision of accessible public ~~chargepoints~~ ~~charge points~~ for EVs for all potential users, including disabled and older people. PAS 1899 provides requirements for the design and selection of accessible charging point equipment and charging point installation, that shall be considered in procurement of appropriate EVSE for accessible charging points.

For checklists of good practice guidance for the installation of public charging points with accessibility requirements refer to Annex E of PAS 1899.

Table 4.1 Enhanced requirements for height of charging point features for accessible charging points to PAS 1899

Charging point feature	Installed minimum height	Installed maximum height
Socket-outlet or fixed vehicle connector	800 mm	950 mm

<u>Tethered charging cable connector handle (when in holster, height to bottom of handle)</u>	<u>800 mm</u>	<u>950 mm</u>
<u>Display screen or other visual interface (for example, such as display screens touch-screens, indicator lamps)</u>	<u>Bottom of screen/interface</u> <u>800 mm</u>	<u>Top of screen/interface</u> <u>1,300 mm</u>
	<u>Bottom of interactive aspects</u> <u>800 mm</u>	<u>Top of interactive aspects</u> <u>1,200 mm</u>
<u>Payment terminal (bottom edge)</u>	<u>800 mm</u>	<u>1,000 mm</u>

Where possible, charging cables should be operational using a linear force-in-hand of less than 60 N for both upward force and lateral pull force.

Handrails can assist with cable connector grip. Handrails should be easy and comfortable to group with no sharp edges, whilst at the same time providing adequate resistance to prevent hand slippage.

When installed there shall be a minimum of 1,200 mm in front of access to accessible charging point components to enable access space for wheelchair users. Where EVSE is installed at footway level, and access is required from the carriageway, placement and orientation shall ensure usability allowing for obstacles and kerbs. It is important to assess distances of reach to access controls, payment terminals, and the like, where applicable.

4.54.6 Free space around the charging equipment

Once installed, and with any protective barriers in place, there must be sufficient space around the EV charging equipment to allow the full opening of any doors or covers provided for operational use, inspection or maintenance of the charging equipment. The installer shall refer to the installation or operational instructions supplied with the charging equipment being installed for details.

4.64.7 Ventilation and cooling

Once the EV charging equipment is installed, there must be sufficient space around it to allow for adequate ventilation and cooling of the equipment. This is particularly important for DC charging equipment incorporating rectifiers. The installer shall refer to the installation or operational instructions supplied with the charging equipment being installed for details.

4.7 Avoidance of trip hazards

~~The EV charging equipment shall be installed in such a way as to avoid creating unnecessary trip hazards.~~

~~Any electrical wiring connecting the charging equipment to the mains supply shall be routed to avoid creating potential trip hazards, and suitably clipped or enclosed in containment.~~

Provision shall be made for the safe storage of any tethered charging cables when they are not in use.

4.8 Avoidance of unnecessary obstruction

The EV charging equipment shall not be installed in a position that causes an unnecessary obstruction to public or private footpaths, access passages, and so on.

4.94.8 Labelling of BS 1363 socket-outlets

Any BS 1363 socket-outlets installed as dedicated EV charging socket-outlets, but which are not incorporated into dedicated EV charging equipment, shall be identified by a label of the type shown in [Figure 4.4](#)~~Figure 4.4~~. This label shall only be applied to socket-outlets that fully comply with all of the applicable requirements of this Code of Practice.

This labelling is to identify socket-outlets that are suitable for EV charging and, by default, those that may not be suitable.

Figure 4.4~~4.4~~ Label for socket-outlets suitable for EV charging



4.104.9 Lighting

Adequate lighting should be available to facilitate safe connection and use of the equipment, including:

- (a) the safe use of EVSE;
- (b) checking of vehicle connectors, plugs and socket-outlets for evidence of damage (for example, burning or blackening of contacts and contact tubes) prior to use;
- (c) the safe insertion and removal of vehicle connectors, plugs and socket-outlets; and
- (d) identification of trip hazards, including charging cables, around the EVSE or socket-outlet and the vehicle.

If the locations of the vehicle on charge and/or the EVSE do not have adequate lighting, it is strongly recommended that this is installed at the same time as the EVSE. Alternatively, it may be possible to install EVSE that has lighting included.

Except where safety would be compromised, appropriate energy-saving measures should be adopted to control the lighting, such as day/night and motion detection. Integration of lighting control with sensors and controls built into the EVSE could also be considered.

4.10 Fire safety

Electric vehicle charging installations should be addressed in line with a suitable fire risk assessment. Guidance on issues to consider is available in RISCAuthority RC59: Recommendations for fire safety when charging electric vehicles. See also Sections 6.166.16 and 8.118.11. There are premises with additional or different conditions that might need to be taken into account, such as fuel filling stations.

5 Electrical requirements – General

This ~~section~~ Section contains general requirements for the electrical installation supplying EV charging equipment and is applicable to all locations. For specific requirements applicable to domestic installations, refer to Section 66; for on-street installations, refer to Section 77 and for commercial and industrial installations, refer to Section 88.

5.1 General

5.1.1 BS EN 61851 compliance

The charging equipment shall comply with BS EN 61851 *Electric vehicle conductive charging system* including:

Part 1: *General requirements*

Part 21: *Electric vehicle requirements for conductive connection to an AC/DC supply* Part 22: *AC electric vehicle charging stations*

Part 23: *DC electric vehicle charging stations*

NOTE: Part 23: DC electric vehicle charging station with an automated connection device is currently being developed

Part 24: *Digital communication between a DC electric vehicle charging station and an electric vehicle for control of DC charging*

5.1.2 BS 7671 compliance

The charging equipment electrical installation shall comply with BS 7671 *Requirements for Electrical Installations*, including for conductive charging arrangements, the particular requirements of Section 722: Electric Vehicle Charging Installations.

Section 722 modifies or precludes some of the regulations in the general requirements of Parts 4 and 5 of the standard.

Since EV charging installations often supply equipment away from existing buildings, the following key requirements of BS 7671 in respect of protective earthing and bonding should be noted, regardless of what earthing arrangement is chosen for the charging installation:

- (a) Regulation 411.3.1.1 requires simultaneously accessible exposed-conductive-parts to be connected to the same earthing system. This applies whatever the earthing arrangement.
- (b) The requirements of Chapter 54 for earthing and bonding (including main bonding), in particular, in relation to extraneous-conductive-parts that may also be extraneous-conductive-parts of other earthing systems.
- (c) Regulation 542.1.3.3 in relation to protective conductors common to electrical installations with separate earthing arrangements. This may include screens or 'ground' conductors in communication and control cables.

5.2 Protection against electric shock

5.2.1 General requirements

The following protective measures shall not be used for EV charging installations:

- (a) obstacles and placing out of reach (Regulation 722.410.3.5); and
- (b) earth-free local equipotential bonding (Regulation 722.410.3.6).

5.2.2 TN-C systems

The final circuit supplying a charging point shall not include a PEN (combined neutral and protective) conductor. (See Regulation 722.312.2.1).

NoteNOTE: In Great Britain, Regulation 8(4) of the ESQCR 2002 prohibits the use of PEN conductors in consumers' installations.

5.2.3 TN-S systems

Unless it can be guaranteed by the relevant DNO that the TN-S supply system is TN-S back to the supply transformer and will not be converted to TN-C-S as part of any ongoing network upgrades, such installations shall be treated as TN-C-S systems (PME supply).

For EV charging equipment installations that are part of a guaranteed TN-S system, for example where the charging equipment is supplied from a TN-S installation supplied by its own private 11 kV transformer, the charging equipment may be connected to the existing earthing arrangements, whether the charging equipment is installed within a building or not. The installer must confirm that the earthing and bonding arrangements meet the current requirements of BS 7671 for TN-S systems, and that any non-compliances are rectified.

5.2.4 TN-C-S systems

Regulation 722.411.4.1 imposes particular requirements for EV charging installations where they are a part of a TN-C-S system and a PME earthing facility is used. The requirements are copied below as they are significant to the installation design.

722.411.4.1 A PME earthing facility shall not be used as the means of earthing for the protective conductor contact of a charging point located outdoors or that might reasonably be expected to be used to charge a vehicle located outdoors unless one of the following methods is used:

- (i) ~~Deleted by BS 7671:2018+A2:2022 The charging point forms part of a three-phase installation that also supplies loads other than for electric vehicle charging and, because of the characteristics of the load of the installation, the maximum voltage between the main earthing terminal of the installation and Earth in the event of an open-circuit fault in the PEN conductor of the low voltage network supplying the installation does not exceed 70 V rms.~~

NOTE 1: Annex 722, item A722.2 gives some information relating to (i).

NOTE 2: See also Regulation 641.5 when undertaking alterations and additions to an existing installation.

- (ii) The main earthing terminal of the installation is connected to an installation earth electrode by a protective conductor complying with Regulation 544.1.1. The resistance of the earth electrode to Earth shall be such that the maximum voltage between the main earthing terminal of the installation and Earth in the event of an open-circuit fault in the PEN conductor of the low voltage network supplying the installation does not exceed 70 V rms.

NOTE-3: Annex A722, item A722.3 gives guidance on determining the maximum resistance required for the earth electrode in (ii). [See Note 1.](#)

- (iii) Protection against electric shock is provided by a device which electrically disconnects the vehicle from the live conductors of the supply and from protective earth in accordance with Regulation 543.3.3.101(ii) within 5 s in the event of the voltage between the circuit protective conductor and Earth exceeding 70 V rms due to an open-circuit fault in the PEN conductor of the low voltage network. The device need not operate if the voltage exceeds 70 V rms for less than 4 s. The device shall provide isolation and be selected in accordance with Table 537.4. Closing or resetting of the device shall be possible only if the voltage between the circuit protective conductor and Earth does not exceed 70 V rms. Equivalent means of functionality could be included within the charging equipment. [See Note 1.](#)

NOTE-4: Annex 722, Item A722.34, gives guidance on (iii).

- (iv) Protection against electric shock ~~in a single-phase installation~~ is provided by a device which electrically disconnects the vehicle from the live conductors of the supply and from protective earth in accordance with Regulation 543.3.3.101(ii) within 5 s in the event of the utilisation voltage at the charging point, between the line and neutral conductors, being greater than 253 V rms or less than 207 V rms. The device shall provide isolation and be selected in accordance with Table 537.4. Equivalent means of functionality could be included within the charging equipment. Closing or resetting of the device shall be possible only if the voltage between line and neutral conductors is in the range 207 to 253 V rms. [See Note 1.](#)
- (v) Protection against electric shock is provided by the use of an alternative device to those in (iii) or (iv) which does not result in a lesser degree of safety than using (iii) or (iv). Equivalent means of functionality could be included within the charging equipment. The device (or means of functionality) shall operate by electrically disconnecting the vehicle from the live conductors of the supply and from protective earth in accordance with Regulation 543.3.3.101(ii). It shall provide isolation and be selected in accordance with Table 537.4. [See Note 1.](#)

NOTE 15: See Section 511. BS 7671 does not deal with the safety requirements for the construction of electrical equipment.

~~Where equipment to be used is not covered by a British or Harmonized Standard or is to be used outside the scope of its standard, it is the responsibility of the electrical installation designer or other person responsible for specifying the installation to establish that the manufacturer of the equipment has ensured that the equipment satisfies the safety objectives of the relevant Directive(s), as it will not benefit from a presumption of conformity afforded by the appropriate product standard.~~

Where equipment to be used is not covered by a British or Harmonized Standard, or where there is no British or Harmonized Standard for the functionality of a piece of equipment used, it is the responsibility of the electrical installation designer or other person responsible for specifying the installation to establish that:

~~(i)~~the equipment meets the requirements of the Electrical Equipment (Safety) Regulations 2016 (as amended), the Electromagnetic Compatibility Regulations 2016 (as amended) and other relevant legislation, and

(i)

~~(ii)~~~~(i)~~the equipment has either a CE, UKCA or UKNI mark and a Declaration of Conformity; where third-party approval is required, the equipment is marked appropriately.

The Declaration of Conformity is to be appended to the certification for initial verification.

Where the above is satisfied, it is not considered to be a departure from BS 7671:2018+A2:2022.

NOTE 2: See also Regulation 641.5 when undertaking an addition or alteration to an existing installation.

Where buried in the ground, a protective conductor connecting to an earth electrode for the purposes of (ii) or (iii) shall have a cross-sectional area not less than that stated in Table 54.1.

Protective conductors and exposed-conductive-parts downstream of a protective device provided for the purposes of (iii), (iv) and (v) shall have no connection to:

(a) 1—any protective conductors or exposed-conductive-parts of any circuit not protected by the same protective device; or

(b) 2—any extraneous-conductive-part.

NOTE 36: Creating a TT earthing system for charging equipment or the whole installation as an alternative to using a PME earthing facility with one of methods (i) to (v) above may not be an appropriate solution due to the inability to provide sufficient separation from buried metalwork connected to the supply PEN conductor.

The touch-voltage of 70 V rms in methods (ii) and (iii) of Regulation 722.411.4.1 is based on the proposed 71 V limit for 'both-hands-to-feet' touch-voltage, in water-wet conditions with medium contact area (12.5 cm²), in Table 2c of IEC TS 60479-5 *Effects of current on human beings and livestock – Part 5: Touch voltage threshold values for physiological effects*, Edition 1. The principle of operation of devices described in 722.411.4.1 (iii), (iv) and (v) is outlined in Section 5.3.55.3.5.

5.2.5 Street electrical fixtures

On-street installations are discussed in Section 77.

5.3 PME supply

5.3.1 Introduction

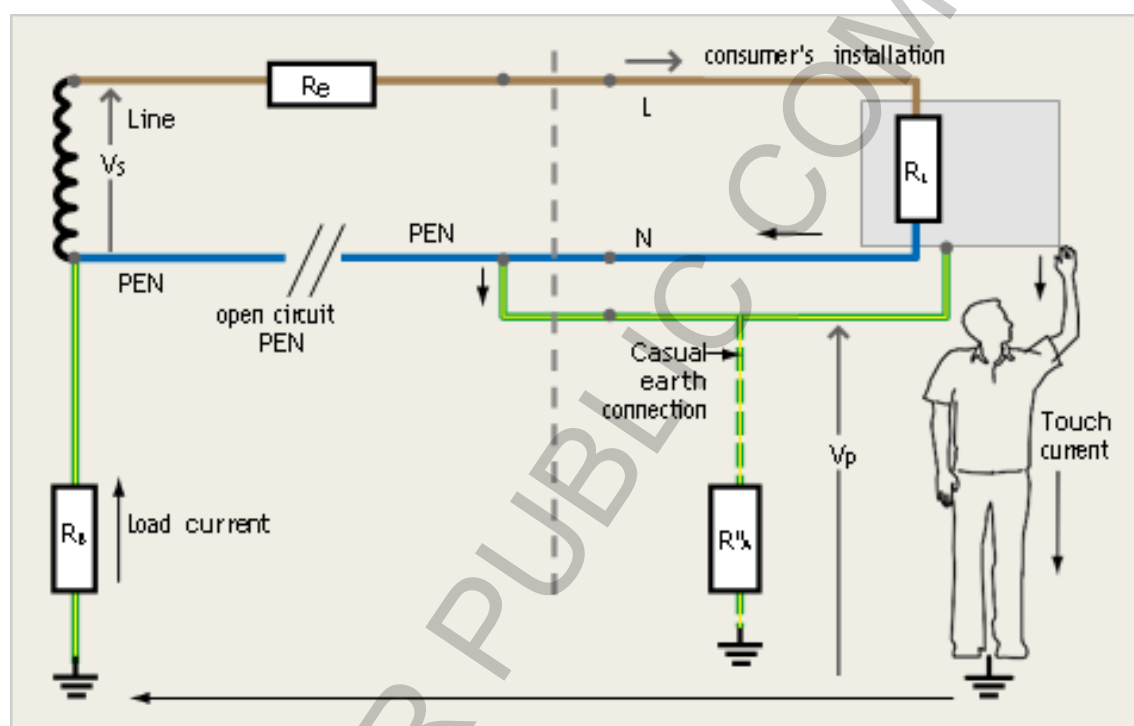
Most premises in the UK have a PME supply. This has proven to be a very reliable method of providing electrical installations with an earth connection. However, particular precautions are required for the earthing of installations and these are specified in BS 7671, in particular, in Chapter 54. In the event of an open-circuit fault to the neutral (PEN conductor) of a TN-C-S (PME) system:

- (a) all conductive-parts connected to the earthing system can rise to a dangerous voltage above earth potential;
- (b) load currents may return to the origin of the supply via the protective conductors of the installation, which can cause overheating of the earthing and bonding conductors.

This is illustrated in [Figure 5.1](#) ~~Figure 5.1~~.

The installation of an RCD will not provide any protection against these effects.

Figure 5.1 Schematic of a TN-C-S (PME) system with an open-circuit PEN conductor



To prevent anyone within the building being subjected to this voltage, protective equipotential bonding of all extraneous-conductive-parts is required by BS 7671. This may include as required by Regulation 411.3.2:

- (a) water installation pipes
- (b) gas installation pipes
- (c) other installation pipework and ducting;
- (d) central heating and air-conditioning systems; and
- (e) exposed metallic structural parts of the building.

The bonding conductors must be of sufficient cross-sectional area (csa) to carry the load current that would flow in the event of a fault in the electricity supply. The required cross-sectional areas are given in Table 54.8 of BS 7671, which is reproduced in [Table 5.1](#) ~~Table 5.1~~. The minimum csa is 10 mm².

Note NOTE 1: Local distributors' network conditions may require a larger conductor.

Note NOTE 2: The neutral of supply refers to the neutral of the supplier's feeder cable at the supplier's cut-out, and not the tails between the supplier's cut-out and meter, or from the meter to the consumer's equipment.

Table 5.1 Minimum csa of the main protective bonding conductor in relation to the neutral of the supply (from Table 54.8 BS 7671)

Copper equivalent csa of the supply conductor	Minimum equivalent* csa of the protective bonding conductor (mm ²)
35 mm ² or less	10 mm ²
over 35 mm ² up to 50 mm ²	16 mm ²
over 50 mm ² up to 95 mm ²	25 mm ²
over 95 mm ² up to 150 mm ²	35 mm ²
over 150 mm ²	50 mm ²
*The minimum copper equivalent csa is given by a copper bonding conductor of the tabulated csa or a bonding conductor of another metal affording equivalent conductance.	

This bonding will not protect people outside the building who are simultaneously in contact with conductive-parts connected to the PME earth (for example, an EV being charged) and true Earth (for example, metalwork in contact with the ground, but not connected to the main earthing terminal (MET) of the building).

5.3.2 Precautions to be taken for PME supplies

BS 7671 does not allow a PME earthing facility to be used to supply an electric vehicle charging point unless the requirements of Regulation 722.411.4.1 are met. These requirements are considered in Section 66 for dwellings, Section 77 for on-street installations and Section 88 for commercial and industrial installations.

Either a suitable protective device should be used (refer to Section 5.3.55.3.5) or, alternatively, provision should be made for protection against electric shock by measures that do not make use of the PME earth, including:

- (a) automatic disconnection using a TT system (refer to Section 5.3.35.3.3); or
- (b) use of an isolating transformer or other means to provide electrical separation (refer to Section 5.3.45.3.4).

5.3.3 Converting to a TT system

Converting some or all of the installation to a TT system requires an assessment of the existing earthing arrangements and some knowledge of the position of buried metalwork, earth electrodes, and other uninsulated conductors that will remain connected to the PME earthing system. Regulation 722.411.4.1 includes a note advising that creating a TT earthing system for charging equipment or the whole earthing system may not be an appropriate solution.

There are two options:

1. make the circuit that supplies the charging equipment part of a TT system.

Note NOTE 1: In cases where precautions must be taken to prevent simultaneous contact between those exposed-conductive-parts or extraneous-conductive-parts connected to the TT earthing system and exposed-conductive-parts or extraneous-conductive-parts connected to the TN-C-S (PME) earth of the main installation, a risk assessment is required – see [Annex Appendix B, C, or D or E](#) as relevant.

Note NOTE 2: In small curtilage properties, such as many dwellings, provision of a separate TT system for the charging point may not be possible, and/or may not improve safety. See Annex H.

2. convert the whole installation to a TT earthing system.

Note NOTE: These options should not be adopted where there would be simultaneous access to conductive parts of an adjacent installation that is connected to a PME earthing arrangement. Multiple earthing arrangements are not acceptable in a steel frame building, and consideration must be given to the effects of extraneous-conductive-parts such as incoming metallic gas/water pipes. A risk assessment is required – see [Annex Appendix B, C, or D or E](#) as relevant.

When assessing whether to adopt TT in an existing installation, consideration must also be given to the safety of installing earth electrodes, and the risk of striking underground services. For some installations, it may not be possible to provide suitable earth electrodes safely, without disruptive excavation.

When all of the above points are considered, converting part or all of some existing installations to TT may not be practicable.

5.3.3.1 Providing a TT earthing system for the charging equipment

Providing a dedicated TT earthing system for the charging equipment that is separated from the PME earthing system can help avoid problems associated with an open-circuit fault in the neutral (PEN conductor) of the supply, as the charging equipment would not be connected to the PME supply earth.

However, providing a dedicated TT earthing system for the charging equipment that is separated from the existing PME earthing system is only acceptable if all of the following conditions apply:

- (a) there is no possibility of simultaneous contact between exposed- and/or extraneous-conductive-parts of the TT earthing system and exposed- and/or extraneous-conductive-parts of the TN-C-S (PME) earthing system of the main installation or any other earthing system of any other nearby installation.
- (b) the earth electrode zone of the TT system must not overlap the zone of any buried metalwork connected to the earthing system of the main installation. If it does, the benefit of separating the earthing systems will be lost. See [Appendix GAppendix GAnnex H](#).
- (c) buried metalwork connected to the PME system does not unduly influence the potential of the ground on which someone will be standing, adjacent to a vehicle, in the event of a fault in the supply PEN conductor. It is particularly important to assess this in small curtilage properties, such as in many dwellings. See [Appendix GAppendix GAnnex H](#).

A risk assessment is required. Suggested risk assessment checklists are provided in [Annexes Appendices B to E](#), for dwellings, on-street installations, commercial and industrial installations and fuel-filling station installations.

The resistance of the earth electrode shall not exceed 200 Ω and one or more RCDs shall be provided to protect the EV charging equipment installation.

A notice must be fixed at suitable positions, including, but not limited to, the origin, the meter position if remote from the origin, and at the designated point of isolation for the EV charging equipment supply to advise any person carrying out work in the future that the EV charging equipment is connected to a separate TT earthing system. See the example in [Figure 5.2](#).

Figure 5.2 Example of warning notice for TT charging equipment installed in locations using a PME earth for other circuits, or where premises with PME supply is converted to TT

ELECTRIC VEHICLE CHARGING EQUIPMENT
TT system adopted for charging equipment circuit.
Do not connect to the PME earth

5.3.3.2 Converting the whole installation to a TT earthing system

Converting the whole installation to a TT earthing system avoids problems associated with an open-circuit fault in the neutral (PEN conductor) of the supply, as the complete installation is not to be connected to the PME earthing arrangement. Additionally, this will mean that the EV charging equipment (including the [connecting-charging](#) point) and the vehicle on charge need not be situated so as to prevent simultaneous contact between these items and exposed- or extraneous-conductive-parts of the main installation.

Conversion of a whole installation to a TT earthing system is not recommended where separation from the influence of the PME earthing system is not possible, for example:

- (a) in semi-detached or terraced housing where adjacent properties are supplied from a PME earthing system; and
- (b) in small commercial premises in a densely built-up area.

Even if the local earthing arrangements permit conversion of the whole installation to TT, it is often only practicable for smaller installations, such as dwellings, due to the extensive changes to protective devices that are usually necessary. Converting a larger installation to TT may present difficulties in co-ordinating RCD protection. Issues that can be introduced when converting PME systems to TT include the following:

- (a) ~~because~~ **Because** earth fault loop impedances increase, overcurrent protective devices cannot be relied upon alone to provide automatic disconnection in the event of an earth fault. Additional protection using RCD is therefore necessary.
- (b) ~~in~~ **In** the event of a fault to earth in a TT system, unless both the supply and installation earth electrode resistances are extremely low, most of the voltage due to earth fault current appears in the earth electrode resistances. Therefore, touch voltages between the general mass of earth and the installation protective earthing (including exposed-conductive-parts and extraneous-conductive- parts) may well be greater than with a TN system; however, touch voltages between exposed-conductive-parts, and between exposed-conductive-parts and extraneous-conductive-parts, may be much lower than with a TN system.

(c) ~~there~~ There is no longer a low impedance path to the general mass of earth, and between the supply neutral and the installation protective earth. This can affect electromagnetic compatibility, and make the electrical installation (and equipment within it) more susceptible to surges due to switching and of atmospheric origin. Electromagnetic compatibility and surge protection assessments may need to be reviewed.

A risk assessment must be carried out to consider the risks of simultaneous contact with conductive-parts connected to adjacent TN systems (if any). [Appendix G](#) ~~Appendix G~~ [Annex H](#) details the separation below ground between conductive parts connected to the TT earthing system and conductive parts connected to TN earthing systems.

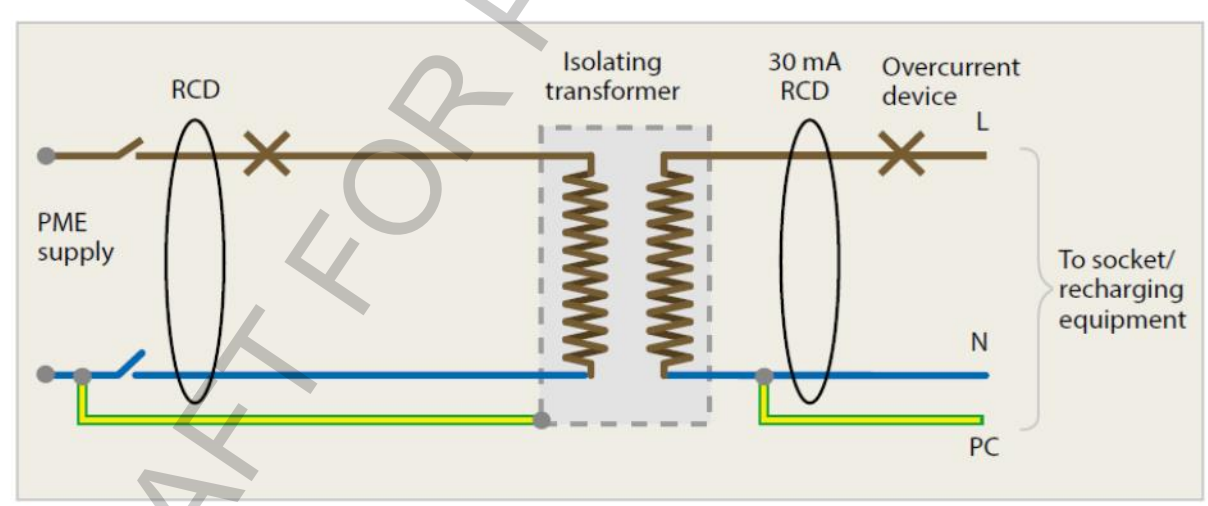
If a property is converted from PME to TT a notice ~~must~~ shall be fixed at the cut-out position to advise any person carrying out work that the PME earthing facility is not connected. ~~See the example in Figure 5.2~~ [Figure 5.2](#).

5.3.4 Electrical separation

Where electrical separation is used to provide protection against electric shock for the EV charging equipment circuit [of Mode 2 or Mode 3 charging points](#), all of the requirements of Section 413 of BS 7671 shall be met.

Electrical separation can be achieved by installing an isolating transformer in the EV charging equipment circuit. This approach avoids any problems associated with an open-circuit fault in the neutral (PEN conductor) of the supply, as the isolating transformer electrically separates the PME supply earth from the charging equipment, ~~see. An example is provided in Figure 5.3~~ [Figure 5.3](#).

Figure 5.3 ~~5.3.3~~ [Supply of Mode 3](#) charging equipment separated from the TN-C-S (PME) supply earth by a transformer



Note ~~NOTE~~ 1: A722.5 and Figure A722 of BS 7671 describe this arrangement as providing electrical separation.

Note ~~NOTE~~ 2: As the protective conductor labelled PC will be connected to the vehicle body, and perhaps other parts of the charging equipment, it is entirely feasible that PC may come into (accidental) contact with the general mass of Earth. It is therefore necessary to ensure that there is no possibility of simultaneous contact of persons between PC and the PME supply circuit protective conductor.

The fixed isolating transformer shall comply with BS EN 61558-2-4 and shall be installed such that the secondary circuit protective conductors are separated from the general installation earthing.

An overcurrent protective device and an RCD shall be installed in the [AC](#) secondary circuit.

Other arrangements for electrical separation are not precluded, so long as they are supported by the vehicle and charging equipment. See [also Appendix J](#) ~~Appendix J~~ ~~Annex K~~ regarding [electrical separation used in Mode 4 charging equipment](#) ~~EVSE~~.

5.3.5 Installing equipment that detects open-circuit PEN conductor faults

Installing equipment that detects open-circuit faults in the neutral (PEN conductor) and disconnects the supply, including the protective conductor, in the event of such faults, would address the problems associated with an open-circuit fault in the neutral (PEN conductor). However, although such devices are currently under development, at the time of writing of this Code of Practice, none are commercially available. If they are made available, these devices may be an appropriate solution for single-phase installations.

5.3.5.1 General

Installing equipment that detects open-circuit faults in the neutral (PEN conductor) and disconnects the supply, including the protective conductor, in the event of such faults, would address the problems associated with an open-circuit fault in the neutral (PEN conductor).

BS 7671 describes two different types of device in indents (iii) and (iv) to Regulation 722.411.4.1, and these are discussed in Sections [5.3.5.2](#) ~~5.3.5.2~~ and [5.3.5.3](#) ~~5.3.5.3~~, respectively. Both of the devices involve monitoring the voltage between specific points.

At the time of writing this Code of Practice, there are no specific product standards directly relating to such devices. To comply with Regulations 113.1, 511.1 and 511.2 of BS 7671, the installer should check that the manufacturer has compiled a suitable design and undertaken suitable type testing. Examples of standards that manufacturers may use are provided in [Table 5.2](#) ~~Table 5.2~~. This list is not considered to be exhaustive.

The voltage measurement threshold and timing parameters should not be adjustable by ordinary persons, and it is recommended that devices with factory-set parameters are used. The device may be reset manually, by local or remote control, or automatically but in all cases, resetting of the device shall not be possible if the hazardous condition remains.

Indent (v) to Regulation 722.411.4.1 permits the use of an open PEN detection device that does not result in a lesser degree of safety than either of the devices in indents (iii) or (iv). This provides an opportunity for manufacturers to offer innovative solutions; however, an installer should satisfy themselves that the devices conform to appropriate standards, and offer the required degree of safety in the particular installation conditions. For example, if the device is stated to have an equivalent degree of safety to that described in indent (iii), it may be used in three-phase or single-phase installations where this is stated in manufacturer's instructions. However, a device that is stated to have an equivalent degree of safety to that described in indent (iv) would be suitable for single-phase installations only.

Table 5.2 Examples of standards that manufacturers may use to demonstrate safety of devices providing protection in accordance with indents (iii) and (iv) of BS 7671 in the absence of a suitable product standard

Aspect of the device	Example of applicable standards
Voltage monitoring or sensing	Relevant parts of BS EN 60255, e.g. • BS EN 60255-1; • BS EN 60255-21-1; • BS EN 60255-21-2; • BS EN 60255-21-3; • BS EN 60255-26; • BS EN 60255-27; and • BS EN 60255-127.
Contactors or similar providing disconnection	See Table 537.4 of BS 7671

5.3.5.2 Open PEN conductor detection by voltage measurement between the cpc and Earth

When the voltage between the cpc supplying the vehicle and Earth exceeds 70 V rms, the protective device must disconnect live conductors to the charging point, that is line(s) and neutral, along with the protective conductor. The disconnection must occur within 5 ~~seconds~~ (s). The device shall only be resettable if the voltage between the cpc and Earth does not exceed 70 V rms.

The disconnection time of 5 s, whilst mirroring the disconnection time in Chapter 41 of BS 7671 for distribution circuits and large loads, in 230 V TN systems, may not always protect someone who is in contact with the vehicle at the moment the touch voltage due to the open PEN conductor rises above 70 V, for example, if touching the vehicle with both hands, with no shoes, in wet conditions. Manufacturers may choose to offer faster disconnection times for higher measured voltages, see Table A722 in BS 7671. Depending on the technology used, faster disconnection times may result in nuisance tripping of the device.

Earth is defined in BS 7671 as the “conductive mass of the Earth, whose electric potential at any point is conventionally taken as zero.”

In the event of a PEN conductor failure in a PME distribution system, the supplier’s PME earthing terminal is no longer Earth and accordingly, A722.4 in BS 7671 informs us that the device should not measure the voltage between the cpc at the charging point, and either the neutral conductor or the consumer’s MET. Instead, the voltage may be measured between:

- (a) the cpc at the charging point and a reference point derived from the line conductors of a three-phase system. An example is shown in ~~Figure 5.4~~ Figure 5.4a. This type of open PEN conductor protection device may only be used where there is a three-phase supply, as it is not possible to derive a reference point for voltage measurement in a single-phase system. Single-phase EVSE may be protected by this type of device in a three-phase system.

WARNING: If this type of open-PEN detection device has no further open-PEN protection means, it may not operate correctly if used in a PEI that is operating in island mode. (Ssee Section 5.3.5.55-3.5.5).

(b) the cpc at the charging point and a suitable measurement earth electrode (see [Appendix H](#) [Appendix H Annex I](#)). An example is shown in Figures 5.4b and 5.4c. This type of open PEN conductor protection device may be used for both single-phase and three-phase supplies.

Where a measurement earth electrode is used:

(a) the device manufacturer's instructions should be followed in relation to adequate separation of the earth electrode from buried metalwork connected to the PME earthing terminal, in relation to the tripping voltage of the device, which will necessarily be below 70 V (see Annex I).

(b) the conductor connecting the device to the measurement earth electrode should:

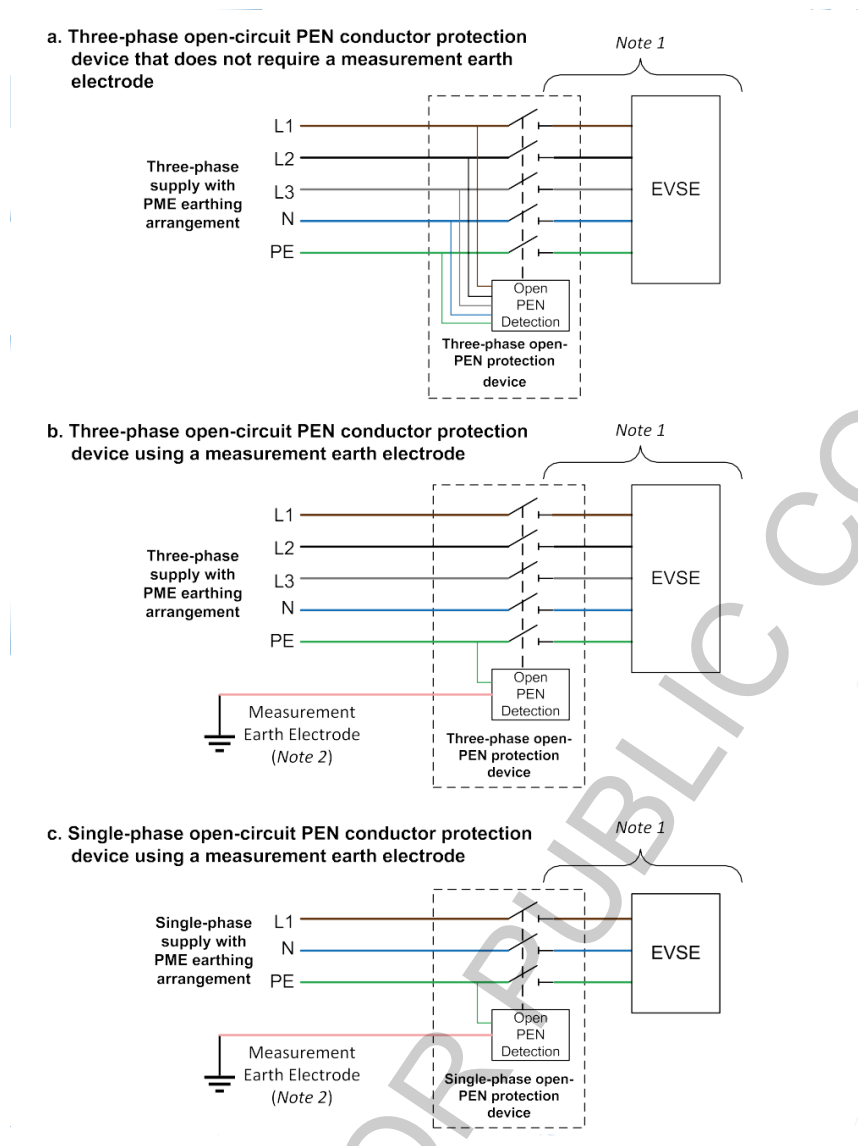
- (i) be suitably routed and protected to avoid damage; and
- (ii) be identified as a functional earthing conductor [using the colour pink](#). ~~Where colour is used to identify a functional earthing conductor, BS 7671 requires pink to be used from September 2020; cream or pink may be used before that date.~~

Equivalent means of functionality to that described in Regulation 722.411.4.1 (iii) may be included in the EVSE itself. Alternatively, a separate device may be installed upstream of the EVSE or charging point. To protect multiple charging points, a separate device may be installed at a consumer unit, final circuit distribution board or feeder pillar. In all cases, protective conductors downstream of disconnectors operated by the device shall have no further connection with earthing or bonding conductors or earth electrodes not protected by the same device (see Section [5.3.5.45.3.5.4](#)). A single detection device may protect more than one charging point.

Where the device requires regular checking to ensure its continued functionality, an instruction label or notice should be provided, or suitable information included in the handover documentation.

A device that uses a measurement earth electrode should ideally include automatic earth electrode integrity checking. Where this is not the case, regular tests for the integrity of the measurement earth electrode are strongly recommended, and suitable user instructions should be made available, stating the recommended period between tests.

Figure 5.45.45.4 Examples of open PEN conductor protection devices that measure the voltage between the cpc and Earth



Note-NOTE 1: Protective conductors and exposed-conductive-parts downstream of the open PEN protection device shall have no connection to earth electrodes, extraneous- conductive-parts or protective conductors/exposed-conductive-parts of any circuit not protected by the same device. See Section 5.3.5.45.3.5.4.

Note-NOTE 2: The measurement earth electrode shall be located at least 2 m from buried metalwork and be set to operate at a measured voltage of 40 V rms or less. Where it is not possible to achieve 2 m separation (for example, in some on-street applications or small-curtilage properties), a device using a measurement earth electrode cannot be used. See Annex I Appendix HAppendix H.

5.3.5.3 Open PEN conductor detection by voltage measurement between line and neutral at the charging point

Indent (iv) to Regulation 722.411.4.1 provides an alternative option for installations with single-phase supplies: a device that measures the voltage between line and neutral at the charging point, and provides disconnection when this is outside the utilization voltage range of 230 V $\pm$ 10 % (207-253 V). This utilization voltage range ~~is~~was stated in BS EN 61851-1:2011, which

is slightly more onerous than the utilization voltage range of +10/-11 % recommended for supplies provided in accordance with the ESQCR by the subsequent voltage drop in the consumer's installation stated in Table 4Ab (i) of BS 7671.

Note **NOTE 1:** As the utilization voltage at the charging point is measured, this device would be installed close to, or form part of, the EVSE.

Note **NOTE 2:** The supply voltage at the origin of the installation does not take into account voltage drop within the installation. The supply voltage must be in the range 216.2-253 V, as specified by the ESQCR. The utilization voltage takes into account voltage drop within the installation, and therefore the lower limit (in this case, 207 V) is less than the lower limit of the supply voltage.

The device must disconnect live conductors to the charging point, that is line(s) and neutral, along with the protective conductor. Equivalent means of functionality to that described in Regulation 722.411.4.1 (iv) may be included in the charging equipment (EVSE) itself. There is no requirement for a manual reset and therefore the device may automatically reset when the supply voltage is within the acceptable range of 230 V ± 10 %.

Note **NOTE 3:** If a discrete device is used, nuisance operation is to be expected, for example, when primary transformer taps change or during temporary voltage dips. Some vehicles may not resume charging automatically when the supply is reconnected: this may be unacceptable for some users.

In a prosumer's electrical installation, under some conditions grid-connected inverters may output voltages exceeding 253 V for some period. This is likely to cause unwanted operation of devices that measure line to neutral voltages. In addition, its use on EVSE for vehicle to grid (V2G)/vehicle to home (V2H) applications may prevent compliance with ENA Engineering Recommendations G98 or G99 as appropriate.

WARNING: a device that complies with Regulation 722.411.4.1 (iv), and has no further open-PEN protection means, may not operate correctly if used in a PEI that is operating in island mode., see-See Section 5.3.5.55.3.5.5.

This type of device detects most conditions that arise when there is a break in the PEN conductor in the distribution network. However, where the installation is supplied from a three-phase PME distribution network, which is usually the case, there are a small number of conditions in which the line to neutral voltage appears to be within the normal utilization voltage range, but the voltage on the PME earthing system has risen above 70 V rms.

Ans an option is available for three-phase installations that does not have these limitations (see Section 5.3.5.25.3.5.2); however, BS 7671 does not permit no longer says that a protective device as described in indent (iv) of Regulation 722.411.4.1 to may only be used to protect in single-phase charging equipment in three-phase installations. Equally, BS 7671 does not permit charging equipment containing equivalent functionality to that described in indent (iv) of Regulation 722.411.4.1 to be installed in installations with three-phase supplies.

Where this type of open PEN detection device is used, the designer should ensure that the voltage drop in the consumer's installation to the charging point is limited to 4 %.

Where the device requires regular checking to ensure its continued functionality, an instruction label or notice should be provided, or suitable information included in the handover documentation.

5.3.5.4 Limitations on supplementary equipotential bonding for equipment and circuits supplied by open PEN detection devices

The open PEN detection device disconnects all live conductors and the protective conductor. Protective conductors and exposed-conductive-parts downstream of the open PEN detection device shall not be earthed or bonded to any earthed metalwork or conductors forming part of the PME earthing system that are not protected by the same open PEN detection device. If such bonding were provided, it would defeat the protection provided by the open PEN detection device.

Installers should be extremely careful to avoid accidental (or fortuitous) earthing. This may occur, for example, when fixing or mounting metal-cased Class I EVSE to earthed metal components of outdoor equipment such as a feeder pillar or lamp post. In some circumstances, physical separation, or the use of insulating materials, may be required.

5.3.5.5 Open PEN detection devices and ~~presuming~~ prosumer's electrical installations in island mode

When a ~~presuming~~ prosumer's electrical installation operates in island mode, the MET remains connected to the distributor's means of earthing (where provided). Where open PEN detection devices are used, the vehicle must be electrically disconnected from the installation in island mode, unless the manufacturer of the open PEN detection device states that the device will continue to detect open PEN events in island mode. Usually, open PEN detection devices that use measurement earth electrodes will continue to operate safely in island mode, whereas other types are unlikely to continue to provide safe detection; however, some devices of all types may be affected when connected to certain types of self-commutating inverter.

5.4 General requirements for circuit design, cable selection and dimensions

5.4.1 BS 7671 Compliance

The electrical circuit for the EV charging equipment shall comply with the requirements of BS 7671 and shall include the following:

- (a) a suitably rated fuse or circuit-breaker (refer to Section 5.5);
- (b) a suitably rated RCD (refer to Section 5.6);
- (c) a suitable means of isolating the circuit (refer to Section 5.7.2); and
- (d) if necessary, an emergency switch in close proximity to the connecting point (refer to Section ~~5.7.15.7.1~~).

5.4.2 Separate circuit for each charging point (Regulations ~~722.533.101311~~ 722.531.3.101)

BS 7671 defines the charging point as, effectively the fixed socket-outlet, or for EVSE fixed vehicle connector, or tethered vehicle connector. EVSE may contain more than one charging point. A separate, dedicated final electrical circuit shall be provided for the Each EV charging equipment or connecting point is required to be protected individually by a single overcurrent protective device, and, for AC charging points, a single RCD of at least Type A, (see

[Section 5.65-6](#)). However, more than one piece of EV charging ~~equipment or connecting~~ point may be fed from the same [supply distribution](#) circuit, provided that the combined current demand of the ~~equipment connected EVSE~~ does not exceed the rating of the [supply distribution](#) circuit.

[Where both overcurrent and residual current protective devices complying with the requirements of Regulations 722.533.101 and 722.531.3.101 are included in the EVSE, the circuit supplying the EVSE could be considered as a distribution circuit.](#)

5.4.3 Cable selection

[5.4.3.1 General](#)

The cable type and csa for the EV charging equipment circuit shall be chosen to ensure compliance with the requirements for:

- (a) protection against electric shock (refer to [Section 5.55-5](#));
- (b) overcurrent protection (Chapter 43 of BS 7671); and
- (c) voltage drop (Section 525 of BS 7671).

When assessing the demand of installations, and distribution circuits supplying multiple EV charging points, load curtailment may be taken into consideration if it is provided (Regulation 722.311).

When specifying the cable sizes for use in the EV charging equipment circuit, reference shall be made to either Appendix 4 of BS 7671, which gives current-carrying capacity and voltage drop for cables, or manufacturer's data.

[Where steel wire armoured cables are used, and the armour is used as the cpc \(either alone, or with an external parallel single-core insulated supplementary cpc\), account should be made of the reactance of the cable in the earth fault loop, as this affects the total earth fault loop impedance contribution of the cable. ~~Appendix M~~ \[Appendix M\]\(#\) summarizes the calculation method recommended in PD IEC/TR 50480.](#)

NOTE: [Reactance is usually ignored in calculations related to BS 7671 for conductor csa less than 16 mm². However, the csa of steel wire armour is usually greater than 16 mm².](#)

[5.4.3.2 Use of non-standard cables](#)

[To meet the requirements of BS 7671, every item of equipment must comply with a British or Harmonized Standard, in the absence of such, reference can be made to IEC standards or the appropriate standard of another country.](#)

[It is important that cables have approval from an independent testing organization and installers should ensure that all cables purchased have manufacturers' identification and a specification reference/standard number printed on the sheath to enable testing, if necessary, and traceability.](#)

[5.4.3.3 Cables that combine LV power and data](#)

[Specialist cables are starting to be made available that combine LV power and data into a single cable. Armoured versions are also available for direct burial. At the moment a](#)

constructional standard is not available for these cable types, and they should therefore be considered as non-standard cables, (see Section 5.4.3.25.4.3.2).

In terms of cable selection:

- (a) the cable should meet the fire performance requirements of BS 6701 (see Section 5.12.2.15.12.2.1);
- (b) the cable should have approval from an independent testing organization;
- (c) The cable should have manufacturers' identification and a specification reference/standard number printed on the sheath; and
- (d) data for these cable types is not provided in Appendix 4 of BS 7671, and therefore the designer and installer are reliant on data provided by the manufacturer.

Section 5.125.12 provides more information on telecommunications and control cabling installation requirements.

Cables that combine AC power and data should not be used for power over Ethernet (PoE) unless:

- (a) the manufacturer provides data for this specific use case; and
- (b) the cable is only operated within the conditions published by the manufacturer.

5.4.4 Buried and suspended cables

Appendix KAppendix K provides guidance on the minimum depth of buried cables, and minimum height of suspended cables.

5.5 Protection against electric shock

As required by BS 7671, basic protection against electric shock shall be provided by automatic disconnection of supply or electrical separation.

5.5.1 Automatic disconnection of supply

Where automatic disconnection of the supply is used to provide protection against electric shock for the EV charging equipment circuit, compliance with Section 411 of BS 7671 shall be ensured. (See Sections 5.3.25.3.2 and 5.3.35.3.3.)

5.5.2 Electrical separation

Where electrical separation is used to provide protection against electric shock for the EV charging equipment circuit, all the requirements of Section 413 of BS 7671 shall be met.

The EV charging equipment circuit shall be supplied through a fixed isolating transformer complying with BS EN 61558-2-4 and live parts of the separated circuit shall not be connected at any point to another circuit, including the protective conductor of the primary circuit.

This protective measure shall be limited to the supply of one EV supplied from one unearthed source through an isolation transformer complying with BS EN 61558-2-4. (See Section [5.3.45-3-4](#)).

5.5.3 Additional protection

Additional protection shall be provided by the installation of RCDs as specified in Section [5.65-6](#).

5.6 Requirements for the provision of RCDs

5.6.1 RCD selection and installation

Each [AC](#) connecting point shall be protected by a 30 mA RCD, appropriately selected for the nature of the residual fault currents expected and complying with BS EN 61008-1, BS EN 61009-1, BS EN 60947-2 or BS EN 62423.

BS 7671 has specific requirements for the RCDs, as follows:

722.531.3 Residual current devices (RCDs)

722.531.3.1 RCDs shall disconnect all live conductors.

722.531.3.101 Unless supplied by a circuit using the protective measure of electrical separation, each charging point incorporating a socket-outlet or vehicle connector complying with the BS EN 62196 series shall be protected [individually](#) by an RCD [of Type A, Type F or Type B and](#) having a rated residual operating current not exceeding 30 mA.

Except where provided by the EV charging equipment, protection against DC fault currents shall be provided by:

- an RCD Type B; or
- an RCD Type A or Type F in conjunction with a residual direct current detecting device (RDC-DD) complying with BS IEC 62955 as appropriate to the nature of the residual and superimposed currents and recommendation of the manufacturer of the charging equipment.

RCDs shall comply with one of the following standards: BS EN 61008-1, BS EN 61009-1, BS EN 60947-2 or BS EN 62423.

NOTE 1: Types of RCD are described in Regulation 531.3.3 in respect of their behaviour when exposed to DC components and frequencies.

NOTE 2: Requirements for the selection and erection of RCDs in the case of supplies using DC vehicle connectors according to the BS EN 62196 series are under consideration.

NOTE 3: An RCD Type A or Type F in conjunction with an RDC-DD can be arranged with the RDC-DD inside the EV charging equipment and the Type A or Type F RCD upstream in either the charging equipment or the installation.

5.6.2 Co-ordination (selectivity)

There should be co-ordination (selectivity) between any RCD installed at the connecting point or incorporated in the charging equipment and the protection at the origin of the circuit [supplying the EVSE](#).

Under some circumstances, due to other requirements of BS 7671, [co-ordination selectivity between RCDs within, or close to, EVSE, and those upstream in the installation](#), is not

1575 practicable, for example, where part of a circuit supplying the connecting point is concealed in
1576 a wall at a depth less than 50 mm.

1577 5.6.3 RCD types and standards

1578 Only RCDs complying with BS EN 61008, BS EN 61009, BS EN 60947-2, BS EN 62423 or
1579 equivalent, that disconnect all live conductors, including the neutral, shall be used. BS 7671
1580 requires an RCD that is either Type A, Type F or Type B.

1581 A Type A RCD is an RCD for which tripping is ensured for residual sinusoidal alternating
1582 currents; residual pulsating direct currents; and residual pulsating direct currents
1583 superimposed by a smooth direct current of 6 mA, with or without phase-angle control,
1584 independent of the polarity.

1585 A Type F RCD is an RCD for which tripping is ensured as for Type A, and in addition, for
1586 composite residual currents, whether suddenly applied or slowly rising, intended for circuits
1587 supplied between line and neutral or line and earthed middle conductor; and residual pulsating
1588 currents superimposed on direct currents.

1589 A Type B RCD is an RCD for which tripping is ensured as for Type F, and in addition, for
1590 residual sinusoidal currents up to 1 kHz; residual sinusoidal currents superimposed by a pure
1591 direct current; pulsating direct currents superimposed by a pure direct current; and residual
1592 currents which may result from rectifying circuits, three-pulse star connection or six-pulse
1593 bridge connection, two-pulse bridge connection line-to-line with or without phase-angle
1594 monitoring, independently of the polarity.

1595 **Note**NOTE: Single-module RCBOs designed to fit an existing consumer unit or distribution board may not comply
1596 with this requirement, as the neutral may be a solid link that does not disconnect upon tripping. Some
1597 single-phase RCBOs may disconnect all poles, and therefore be suitable, but may only incorporate
1598 overcurrent detection in the phase, not the neutral.

1599 5.6.4 LabelsInstruction notices for RCDs

1600 An instruction notice ~~label~~ describing the requirement for regular user operation and testing
1601 of the RCD using its in-built test device, as shown in Figure 5.5 ~~Figure 5.5~~, shall be fitted in a
1602 visible position, adjacent to the installed location of each device. For installations in domestic
1603 (household) premises or similar locations, BS 7671 permits the notice to be omitted where
1604 certification for initial verification, complete with Guidance for Recipients as detailed in
1605 Appendix 6 of BS 7671, has been issued to the person ordering the work.

Figure 5.5 Examples of the notice for periodic user testing ~~Label for the regular cycling~~ of an RCD required by Regulation 514.12.2 of BS 7671

a. general use (font size 14 pt)

This installation, or part of it, is protected by a device which automatically switches off the supply if a fault develops. Test six-monthly by pressing the relevant test button(s) which should operate the device. Afterwards, manually switch on the device. If the device does not operate, or indicates a fault, seek expert advice.

b. use on surfaces less than 10 cm² (font size 7 pt)

This installation, or part of it, is protected by a device which automatically switches off the supply if a fault develops. Test six-monthly by pressing the relevant test button(s) which should operate the device. Afterwards, manually switch on the device. If the device does not operate, or indicates a fault, seek expert advice.

This installation, or part of it, is protected by a device which automatically switches off the power supply if an earth fault develops. **Test every six months** by pressing the button marked 'T' or 'Test'. The device should switch off the supply and should then be switched on to restore the supply. If the device does not switch off the supply when the button is pressed seek expert advice.

5.7 Requirements for isolation and switching

5.7.1 Emergency switch

Because all [AC](#) EV charging equipment and connecting points are required to be protected by a 30 mA RCD, an emergency switch is not usually required. However, the particular needs of the installation and the charging equipment manufacturer's instructions shall be considered. If an emergency switch is provided, it shall be located in a position that is readily accessible and shall be suitably identified by marking and/or labelling.

5.7.2 Isolation

A means of isolating the EV charging equipment circuit shall be provided, in accordance with Regulation 537.2 of BS 7671. This isolating device shall be located in a position that is readily accessible for maintenance purposes and shall be suitably identified by marking and/or labelling.

5.7.3 Functional switching

Additional forms of switching for functional purposes may be required, for example, to prevent the unauthorized use of socket-outlets located outside buildings that may be accessible to the public. These shall be discussed and agreed with the client.

5.8 ~~IP ratings~~External influences

5.8.1 IP rating of charging equipment (Regulation 722.512.2)

The EV charging equipment being installed shall have an IP rating suitable for the proposed installation location. For example, charging equipment that is to be installed in an outdoor location shall have an IP rating of at least IP44.

5.8.2 IP rating of installation components

The installer shall ensure that any connectors, glands, conduits, etc. used to connect the power supply to the EV charging equipment are of an appropriate IP rating, and are installed in such a way as to maintain a suitable IP rating, in accordance with BS 7671.

5.8.3 ~~Mechanical~~ impact

Equipment shall be protected against foreseeable damage by position and/or by external protection.

EV charging equipment installed in publicly accessible locations, for example, car parks, shall be protected against a minimum impact severity of AG32, as defined in Appendix 5 of BS 7671. Regulation 712.512.2.203 advises that this could -be achieved by one or more of the following:

- (a) the position or location of equipment shall be selected to avoid damage by any reasonably foreseeable impact;
- (b) local or general mechanical protection shall be provided, for example by the use of appropriate impact barriers; and/or
- (c) equipment shall be installed that complies with a minimum degree of protection against external mechanical impact of IK08 in accordance with the requirements of BS EN 62262.

BS EN IEC 61439-7 defines three classifications of resistance to mechanical impact:

1. Low impact resistance, which is a minimum of IK07;

- 1651 2. ~~M~~medium impact resistance, which is a minimum of IK08, plus additional tests for
1652 resistance to static load, and mechanical strength of doors, as defined in Table 702 of
1653 BS EN IEC 61439-7; and
- 1654 3. ~~H~~high impact resistance, which is a minimum of IK10, plus additional tests for
1655 resistance to static load, mechanical strength of doors, resistance to shock load, and
1656 resistance to torsional stress, as defined in Table 702 of BS EN IEC 61439-7.

1657 For publicly-accessible EVSE, Clause 8.2.1.702 of BS EN IEC 61439-7 requires a minimum
1658 mechanical impact resistance classification of:

- 1659 (a) high impact resistance classification, for EVSE that is ground-mounted, or wall-
1660 mounted where any part of the EVSE is at a height of less than 0.9 m from the ground
1661 or finished floor; or
- 1662 (a)(b) medium impact resistance, for EVSE that is wall-mounted, and all parts of the
1663 EVSE are at a height of at least 0.9 m from the ground or finished floor.

1664 **5.9 Socket-outlets and connectors**

1665 The requirements are found in Regulation 722.55.101 and discussed in Section 2.32-3.

1666 **5.10 Surge protection (Sections 443 and 534 of BS 7671) Lightning** 1667 **protection systems**

1668 **5.9.15.10.1 Surge protection for the electrical installation in general**

1669 Where a building has a lightning protection system, reference shall be made to BS EN 62305
1670 and Regulation 411.3.1.2 of BS 7671. BS 7671 requires appropriate surge protection to be
1671 provided where the consequences of overvoltages could result in:

- 1672 (a) serious injury to, or loss of, human life;
1673 (b) failure of a safety service, as defined in Part 2 of BS 7671; and
1674 (c) significant financial or data loss.

1675 For all other cases, protection against transient overvoltages shall be provided unless the
1676 owner of the installation declares it is not required due to any loss or damage being tolerable
1677 and they accept the risk of damage to equipment and any consequential loss. In considering
1678 the risks of loss or damage, installers should advise the owner of the installation that electric
1679 vehicles, along with the charging equipment, are expensive assets.

1680 Where a building or installation has a lightning protection system, or is supplied from an
1681 overhead LV supply cable, omission of surge protection could constitute a risk of serious injury
1682 to, or loss of, human life, and surge protection should not generally be omitted. Where the
1683 installation contains a lightning protection system, the requirements of BS EN 62305 series
1684 apply.

1685 Where surge protection is provided as part of the overall lightning protection system, or where
1686 the charging point is some distance from a building, cables serving charging points located
1687 outdoors may require additional surge protection.

5.10.2 Information and communications systems and cabling

BS 7671 refers to BS 6701 in general for telecommunications systems, and BS EN 50174 series of standards in respect of surge protection. Failure to address surge protection of information and communications systems and cabling may defeat any surge protection provided for the electrical installation.

Except where fibre communications cables are used, information and communications cabling for charging equipment should be provided with surge protection, where appropriate, to BS EN 50174-3. Networking and communications equipment intended for indoor use, particularly that used in homes, may not be suitable for connection to copper information and communications cabling connecting to equipment outdoors.

Where the installation contains a lightning protection system, the requirements of BS EN 62305 series apply.

5.10.5.11 Prosumer's electrical installations and having other alternative sources of supply

Some installations may have an alternative source of supply that can be used when the public supply fails. Examples include:

- (a) energy storage systems that can operate in island mode (that is, with the public supply disconnected); and
- (b) back-up generators/uninterruptible power supplies (UPS).

In such systems, when the alternative source is used:

- (a) the means of earthing may change; and
- (b) loop impedances will change, and in many systems will reduce, sometimes dramatically.

In relevant installations, the above factors should be taken into account if the EV charging equipment is to be powered from both the alternative supply and the public supply.

The projected wider adoption of electrical energy storage systems may increase the number of installations that are affected. Section 9.4 of the IET *Code of Practice for Electrical Energy Storage Systems* provides guidance for ensuring electrical safety in island-mode operation and for assessing the impact of an alternative means of earthing and impact on earth fault loop impedances.

Certain open-PEN detection devices are ineffective when the grid is disconnected, and this may lead to earth conductor potential rises due to diverted neutral current from other installations being detected. See Section 5.3.5.55-3.5.5.

5.12 Telecommunications and auxiliary cabling

5.12.1 Introduction

To facilitate load curtailment, or to provide management of EVSE from home energy management or smart grid systems, cabling is required for data connectivity, control and/or monitoring purposes. Typical applications include:

(a) Integration with smart energy infrastructure, building energy management and control systems, and cloud/smartphone applications via telecommunications cabling (see Section 5.12.2). Ethernet may be used, or, alternatively, Modbus or CANbus over ANSI/TIA/EIA-485-A (sometimes referred to by its older reference 'RS 485').;

(b) Integration with billing systems, for example, via Ethernet through an internet router, where GSM connectivity is not practicable.

(c) Current transformer connections for monitoring demand of an installation (or part of an installation) for load curtailment purposes using auxiliary cabling.;

(d) Volt-free contact and analogue signals, for example, meeting the requirements of Clauses 5.2 and 5.3 of BS EN 62381-2, for control and monitoring using auxiliary cabling.;

5.12.2 Telecommunications cabling

Telecommunications cabling should be selected and installed to comply with BS 7671, plus the standards that supplement BS 7671 for telecommunications cabling, in particular BS 6701 and BS EN 50174 series.

Typical conductive cabling will comprise 4-pair cabling technologies, typically Cat5e, Cat6, Cat 7, dependent on data rate requirements. –These cable types are used for Ethernet connectivity, but are often suitable for ANSI/TIA/EIA-485-A applications, unless 78 Ω multidrop terminations are required. Fibre optic cabling can also be used, and avoids the need for surge protection and separation from LV power cabling.

See also Sections 5.4.3.25.4.3.2 and 5.4.3.35.4.3.3 regarding the use of certain cable types.

5.12.2.1 Telecommunications cabling within buildings

Cabling infrastructure shall comply with BS 7671, BS 6701 and BS EN 50174-2. BS 6701 states:

5.4.4 Information technology cabling within buildings and other structures

5.4.4.1 Electromagnetic interference

The segregation of cabling with regard to electromagnetic interference shall be in accordance with BS EN 50174-2.

5.4.4.2 Protection of telecommunications cabling and attached equipment

NOTE The following requirements represent the "Local regulations for safety" referred to in

BS EN 50174-2:2009+A2:2014, 6.1.

Telecommunications cabling shall not be installed in any compartment of a cable management system that contains LV electricity supply cabling with unenclosed live terminals.

Telecommunications cabling and LV power supply cabling shall be separated by a distance:

- a) ≥ 150 mm;
- b) ≥ 50 mm, where the separation is provided and maintained by a partition as specified in BS 7671; or
- c) 50 mm where one or more of the following conditions are met:

- 1) the LV electricity supply cables are enclosed in a separate conduit or trunking which, if metallic, is bonded in accordance with BS 7671;
- 2) the LV electricity supply cables are of a mineral-insulated type;
- 3) the LV electricity supply cables are of an earthed armoured construction;
- 4) the LV electricity supply cables are of a flexible, insulated and sheathed type (e.g. "kettle leads" supplying LV mains power to telecommunications equipment in cabinets)

Where telecommunications cables and the electricity supply cables cross and there is a risk of damage, mechanical protection shall be provided at the crossing point.

BS 7671 describes the conditions under which separation between Band 1 and Band 2 circuits can be ignored. However, as can be seen within buildings, BS 6701 requires:

- (a) An absolute minimum of 50 mm physical separation between LV power cabling and telecommunications cabling, even where both are separated by a metallic barrier (for example, separate conduit or trunking); and
- (b) Telecommunications cabling not to be installed in any compartment of a cable management system that contains LV electricity supply cabling with unenclosed live terminals.

Note that the BS 6701 fire performance requirements for cables within buildings are more onerous than those in BS 7671:

5.1.3.1 Fire performance of telecommunications cables

For new installations and the refurbishment or extension of existing installations, cables installed in the spaces bounded by the external fire barriers of buildings and other structures shall meet the following requirements:

- a) installation cables (as defined in Clause 3) shall, as a minimum, meet the requirements of EuroClass C_{ca}-s1b,d2,a2, in accordance with BS EN 13501-6; and
- b) all other telecommunications cables shall, as a minimum, either:
 - 1) meet the requirements of EuroClass E_{ca}, in accordance with BS EN 13501-6; or
 - 2) meet the recommended requirements of BS EN 60332-1-2.

NOTE BS EN 13501-6 uses the term "class" in place of the term "EuroClass" which is widely used in industry.

The installation of cables penetrating the external fire barrier of buildings shall conform to the BS EN 50174 series of standards.

5.1.3.2 Compatibility with fire extinguishing systems

The potential for damage to, and subsequent interruption of service provided by, the telecommunications equipment and telecommunications cabling to be installed following activation of the fire extinguishing system shall be identified, documented and given to the owner of the premises housing, and/or the operator of, the telecommunications system.

5.12.2.2 Telecommunications cabling outside buildings

Cabling infrastructure shall comply with BS 7671, BS 6701 and BS EN 50174-3. BS 6701 states:

5.4.5 Underground information technology cabling

5.4.5.1 Electromagnetic interference

The segregation of cabling with regard to electromagnetic interference shall be in accordance with BS EN 50174-3.

5.4.5.2 Protection of telecommunications cabling and attached equipment

Information technology cabling underground shall be installed in accordance with BS EN 50174-3.

5.4.6 Aerial information technology cabling

5.4.6.1 Electromagnetic interference

The segregation of cabling with regard to electromagnetic interference shall be in accordance with BS EN 50174-3.

5.4.6.2 Protection of telecommunications cabling and attached equipment

Information technology cabling above ground shall be installed in accordance with BS EN 50174-3 where the recommendations are treated as normative.

Clause 6 of BS EN 50174-3 recommends in all cases as great a separation as is practicable should be provided between the information technology cables and buried metallic parts of power cables. It requires a minimum separation of:

- (a) 50 mm between buried LV power cabling and buried telecommunications cabling unless all cabling is insulated for the highest voltage present in accordance with BS 7671; and
- (b) 300 mm between buried HV power cabling and buried telecommunications cabling unless either cable is installed in a non-conducting conduit or duct, or they are separated by a non-conducting barrier of equivalent insulating performance.

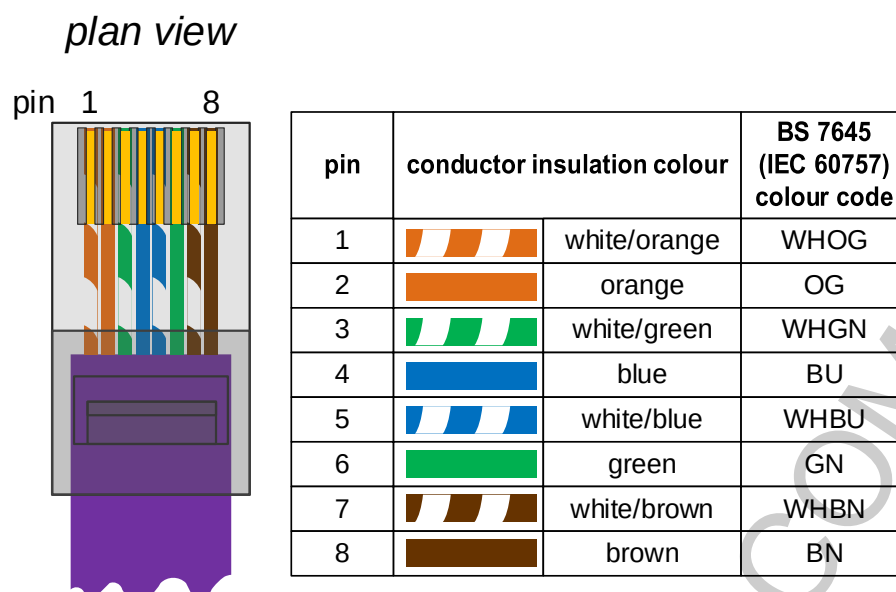
Appendix K provides guidance on the minimum depth of buried cables, and minimum height of suspended cables.

5.12.2.3 Telecommunications cabling termination

The most common types of termination for cabling infrastructure are insulation displacement connectors and RJ45 plugs.

Some ANSI/TIA/EIA-485-A products have RJ45 socket-outlets, which are arranged so that the EIA/TIA-T-568-B pin assignment (see Figure 5.6) can be used at both ends of the cabling, enabling standard 'uncrossed' Ethernet cables to be used. Other ANSI/TIA/EIA-485-A connections on products are made by insulation displacement, screwless or screw terminals.

Figure 5.6 EIA/TIA-T-568-B pin assignment for RJ45 plugs



5.12.3 Auxiliary cabling

Auxiliary cabling should be selected and installed in accordance with BS 7671.

The output of most current transformers should be treated as FELV unless the transformer is guaranteed to meet SELV or PELV requirements.

NOTE: ~~With~~ With most current transformers the voltage will exceed ELV limits if the output becomes open-circuit (for example, during maintenance, or a fault).

5.12.4 Surge protection of telecommunications and auxiliary cabling

See Section 5.105.10 (in particular, Section 5.10.25.10.2).

6 ~~Electrical requirements~~ — ~~d~~Dwelling installations

6.1 Scope

This ~~s~~section applies to premises that can be classified as a self-contained unit designed to accommodate a single household, or any outbuildings supplied by the electrical installation of this type of premises, such as a detached garage.

The following types of premises are not included:

- (a) buildings exclusively containing rooms for residential purposes, such as nursing homes, student accommodation and similar; and
- (b) buildings that accommodate more than one household, such as flats.

6.2 Adequacy of existing installation and supply arrangements~~Demand~~

6.2.1 General

In dwellings, the total demand, including the EV charging equipment, should not exceed the rating of the supply cut-out after consideration of demand, which may include load curtailment. Some charging equipment may include load curtailment capabilities (see Section ~~12.11~~12.1).

Combined with time-of-use tariffs, charging controls can allow charging to be carried out at reduced rates.

It is normally unnecessary to incorporate hardware into the installation to achieve timer control of EV charging, as most ~~E~~Vs have such controls built in already.

6.2.2 Maximum demand

There are three types of maximum demand:

1. Maximum demand of an installation to size the DNO supply;
- 1.
2. Maximum demand to size switchgear assemblies, meter tails and similar consumer-owned equipment at the origin of an installation, or for sizing distribution circuits within an installation; and
- 2.
3. Maximum demand of a final circuit to size final circuit conductors and overcurrent protection requirements.

Cases ~~(2b)~~ and ~~(3e)~~ are within the scope of BS 7671, and guidance can be found in the IET On-Site Guide to the Wiring Regulations and IET Guidance Note 1: Selection ~~and~~ Erection. Due to the length of time the circuits are often used, unless load curtailment is adopted, it is recommended to assess circuits supplying EVSE at full load, for both cases ~~(b2)~~ and ~~(e)~~3.

Case ~~(1a)~~ is, however, outside the scope of BS 7671, and has traditionally been addressed between the DNO and designer, or by using DNO's own methods. At present, installers and

designers are advised to consult with the DNO regarding maximum demand in relation to the DNO's supply.

Where EVSE uses automatic import limitation for load curtailment, it shall comply with ENA Engineering Recommendation G100.

6.2.3 Looped supplies

Installers should be aware that, in some parts of the UK, older dwellings, and occasionally other premises, are supplied by what is termed a looped supply. This is where a single cable from the main in the street serves two or more properties. The feeder from the street goes to the first property's service head, and loops are taken from this to subsequent properties.

The service heads at properties at the end of loops have only a single cable entering, and so an installer cannot tell whether a supply is looped.

EV charging installations are strongly discouraged on looped supplies, as it is possible for DNO cables or equipment to be inadvertently overloaded, perhaps leading to fires. If an installation is being carried out in an area where looped supplies are used, the installer is advised to check with the DNO prior to work commencing. If installers are in any doubt, they should contact the DNO.

6.2.4 Consumer unit ratings

The manufacturer's ratings for consumer units should not be exceeded.

A particular concern for EV charging equipment installations, is that they may have a large load current for a few hours at a time. Overcurrent protective devices heat up in use, and the more heavily loaded the circuit, and the more frequently the circuit is used, the more the device heats up. Manufacturer's instructions should be followed in respect of the placing of protective devices to consider the percentage load and duty cycle. For example, protective devices for frequently used heavily loaded circuits are not placed adjacent to each other in the consumer unit. Failure to follow such instructions may result in thermal damage to, or fire in or near, the consumer unit.

BS 7671:2018+A2:2022 has introduced a change in Regulation 551.7.2, which requires care when considering the current rating I_{nA} of a consumer unit into which generators (including solar PV, battery storage and V2G/V2H inverters) are connected. Guidance is provided in Section 1.1.14.1.1.

6.2.5 Connection of additional consumer units

Due to considerations discussed in Section 6.2.26-2.2, in existing dwellings, during new EV charging and renewable generation installation work, additional consumer units are often installed, by splitting off the meter tails before an existing consumer unit. This shall be achieved using suitable terminal blocks with insulated enclosures.

The split shall be made on the consumer's side of a supply-side isolator, which in turn should be fitted to the consumer's side of the fiscal meter.

NOTE: A supply-side isolator should be provided on the consumer's side of the fiscal meter if one is not already fitted, to facilitate safe maintenance of the terminal blocks and consumer units.

'Vampire' type line taps shall not be used: they are typically intended for outdoor overhead line use, where they are out of reach of persons and away from combustible materials.

Where a consumer unit connects generation (including solar PV, battery storage and V2G/V2H inverters) it may be necessary to provide an additional fuse to support overcurrent protection of the consumer unit(s) connecting generation. See Section 1.1.11.1.1 and Figures 10.4 to 10.6.

6.3 Earthing and protective equipotential bonding requirements

The earthing system requirements for the EV charging equipment will depend upon the earthing arrangements of the electrical supply to the charging equipment and upon the location of the charging equipment and/or the vehicle being charged, i.e. whether the charging equipment and vehicle being charged are within a building or outside.

A risk assessment must be carried out to identify whether any simultaneously accessible installations, or other parts of the same installation, having different earthing arrangements, present any hazard. The risk assessment should also identify any precautions necessary. A copy of the risk assessment shall be included in the installation documents given to the customer – see [Annex B Appendix B](#).

6.4 TT systems

For EV charging equipment installations that are to be connected to an existing TT system, the charging equipment may be connected to the existing earthing arrangement whether the charging equipment is installed within a building or not. The installer must confirm that the earthing and bonding arrangements meet the requirements of BS 7671 for a TT system, and that any deficiencies are rectified.

6.5 TN-S system

Unless it can be guaranteed by the relevant DNO that the TN-S system is TN-S back to source and will not be converted to TN-C-S as part of any ongoing network upgrades, such installations shall be treated as TN-C-S systems (PME supply).

For EV charging equipment installations that are part of a guaranteed TN-S system, the charging equipment may be connected to the existing earth whether the charging equipment is installed within a building or not. The installer must confirm that the earthing and bonding arrangements meet the requirements of BS 7671 for TN-S systems, and that any non-compliances are rectified.

6.6 TN-C-S system (PME supply)

6.6.1 General

When an EV charging point is to be supplied from an installation in a dwelling with a PME supply, the earthing and protective bonding arrangements to be adopted require careful consideration.

Regulation 722.411.4.1 of BS 7671 includes the provision that PME (TN-C-S) supplies may not be used for EV charging supplies, unless one of ~~five~~four conditions are met: – these are numbered ~~(i)~~, (ii), (iii), (iv) and (v) in the Regulation. Examining the ~~five~~four conditions:

~~(i) — refers to three-phase installations, so will only be applicable very infrequently for dwellings.~~

(ii) requires the installation of earth electrodes of a suitably low earth electrode resistance, $R_{A\text{ ev}}$.

(iii) ~~(iii)~~ — describes a voltage operated device that operates when the voltage between the general mass of Earth and the protective conductor at the charging point exceeds 70 V rms. BS 7671 states that this device may be incorporated into the charging equipment itself.

(iv) describes a voltage operated device for installations with single-phase supplies that operates when the line to neutral voltage at the charging point is outside a specified range.

(v) describes a device for detecting open PEN conditions, that provides no less a degree of safety than those described in (iii) or (iv).

NOTE: 722.411.4.1 (i) was deleted by BS 7671:2018+A2:2022.

For EV charging points located outdoors (or that might reasonably be expected to charge vehicles outdoors), the installer may select one of the following options:

(a) to install (or use charging equipment containing) a voltage operated device that disconnects the charging point, including the protective conductor, if there is a risk of the touch voltage between Earth and the vehicle body exceeding 70 V rms (Regulation 722.411.4.1(iii)) or a device which does not result in a lesser degree of safety (Regulation 722.411.4.1 (v));

(b) for installations with a single-phase supply, to install (or use charging equipment containing) a device that disconnects the charging point, including the protective conductor, when the line to neutral voltage is outside a specified utilization voltage range (Regulation 722.411.4.1 (iv)) or a device which does not result in a lesser degree of safety (Regulation 722.411.4.1 (v));

(c) to use the PME earth and install earth electrodes that will reduce the touch voltage in the event of an open circuit PEN in the supply to 70 V rms;

(d) to make the charging point part of a TT installation (this will also require earth electrodes; see Section ~~6.6.36-6.3~~); or

(e) to adopt electrical separation (see Section ~~5.3.45-3.4~~).

~~The touch voltage limit of 70 V rms in three of the options available in Regulation 722.411.4.1 of BS 7671 was adopted after reference to Table 2c of IEC TS 60479-5 Effects of current on human beings and livestock — Part 5: Touch voltage threshold values for physiological effects, Edition 1. This proposes a limit of 71 V rms for both hands-to-feet, in water-wet conditions with medium contact area (12.5 cm²).~~

Where the device described in 722.411.4.1 (iii) uses a measurement earth electrode, the location of the earth electrode requires careful consideration to prevent voltage transfer from buried metalwork connected to the PME earthing system masking the measurement; accordingly, a tripping voltage below 70 V rms will be necessary. These issues are discussed in detail in [Annex I Appendix H](#).

6.6.2 Using the PME earth

6.6.2.1 Indoor charging point

For vehicle connecting points installed such that the vehicle can only be charged within a building, for example, in a garage with a (non-extended) tethered lead, the PME earth may be used without additional earth electrodes (see [Figure 2.4](#)).

6.6.2.2 Outdoor PME charging point

For dwellings with single-phase supplies, an open PEN protection device, or charging point that contains an open PEN protection device, meeting 722.411.4.1 (iv), will often be the most appropriate solution. The manufacturer's installation instructions should be followed.

Note NOTE: The device described in Regulation 722.411.4.1 (iv) cannot be used for single-phase charging points in installations with three-phase supplies.

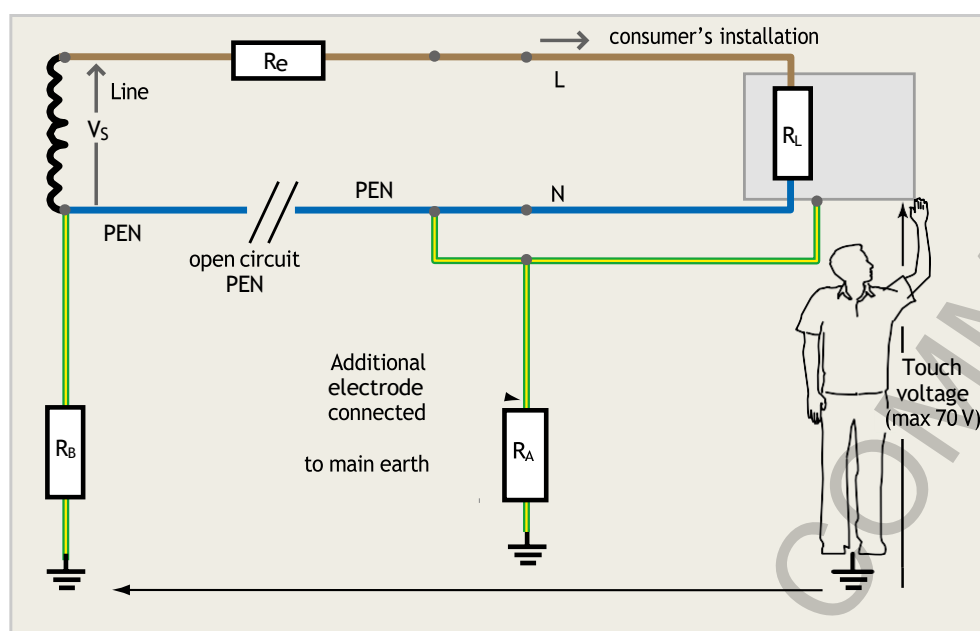
For dwellings with three-phase supplies, a charging point or protective device meeting 722.411.4.1 (iii) may be used. The manufacturer's installation instructions should be followed. Where the device uses a measurement earth electrode, see [Annex I Appendix H](#).

Note Note: When open PEN protection is used, additional bonding downstream of the protection device to parts or conductors connected to the PME earthing system should not be fitted, as this will defeat the open PEN protection.

The installer may also adopt the measures discussed in Section [5.3.45.3.4](#) (Electrical separation).

The installer may also meet the requirements of the regulations when using a PME earth by installing an earth electrode system that will reduce the touch voltage in the event of an open-circuit fault in the PEN conductor of the network supplying the installation to 70 V rms (Regulation 722.411.4.1 (ii)). See [Figure 6.1](#).

Figure 6.1 PME installation with additional earth electrode (R_A)



The ways of keeping the touch voltage down are:

- (a) ensuring that the electrode resistance to earth (R_A) is as low as is reasonably practicable; and
- (b) limiting the charging current; and
- (c) bonding extraneous-conductive-parts.

6.6.2.3 Installing an earth electrode system

See [Annex G](#) [Appendix F](#) [Appendix F](#).

6.6.3 TT charging circuits from PME supplies

NOTE Note: TT charging circuits from PME supplies may not always be the safest option, due to simultaneous contact issues, which are discussed in this section, along with the risks associated with interactions between earthing zones of the PME earthing system of the existing installation and the TT earth electrode system provided for the charging point(s), as discussed in [Annex H](#) [Appendix G](#) [Appendix G](#).

The options for installing a TT charging point are:

- (a) for outdoor connecting points, when a risk assessment shows that the EV charging equipment, connection point and vehicle on charge are not simultaneously accessible with conductive-parts connected to a PME earthing arrangement (for example, where the separation is more than 10 m), the charging circuit may be part of a TT installation.

Note: Remote garages may already be supplied from a TT arrangement that has been derived from a TN-C-S (PME) supply in the house.

- (b) when outdoor-installed EV charging equipment (and/or the connecting point) is to be installed close to the house, these items may be supplied from a TT supply obtained from the house's TN-C-S (PME) system, provided that:

- (i) a risk assessment is undertaken to assess the possibility of simultaneous contact between any accessible conductive-parts connected to a PME earth, for example, street lamps, and:
- any conductive-parts connected to the TT earth electrode, for example, the EV charging equipment (including the connecting point);
 - the vehicle on charge; ~~AND~~ and
- (ii) suitable precautionary measures are put in place to prevent all such identified means of simultaneous contact, for example, by covering a metal pipe with insulating material, inserting one or more lengths of plastic pipe in a metal pipe run, or by replacing a Class I luminaire with a Class II luminaire, etc.
- (c) if a risk assessment shows that the risk of simultaneous contact between any accessible conductive-parts connected to a PME earth, and any extraneous- or exposed-conductive-parts associated with outdoor-installed vehicle charging equipment (including the connecting point and the vehicle on charge etc.) cannot be prevented, the adoption of a TT system for the whole installation can be considered (see Section 5.3.3.25-3.3.2).

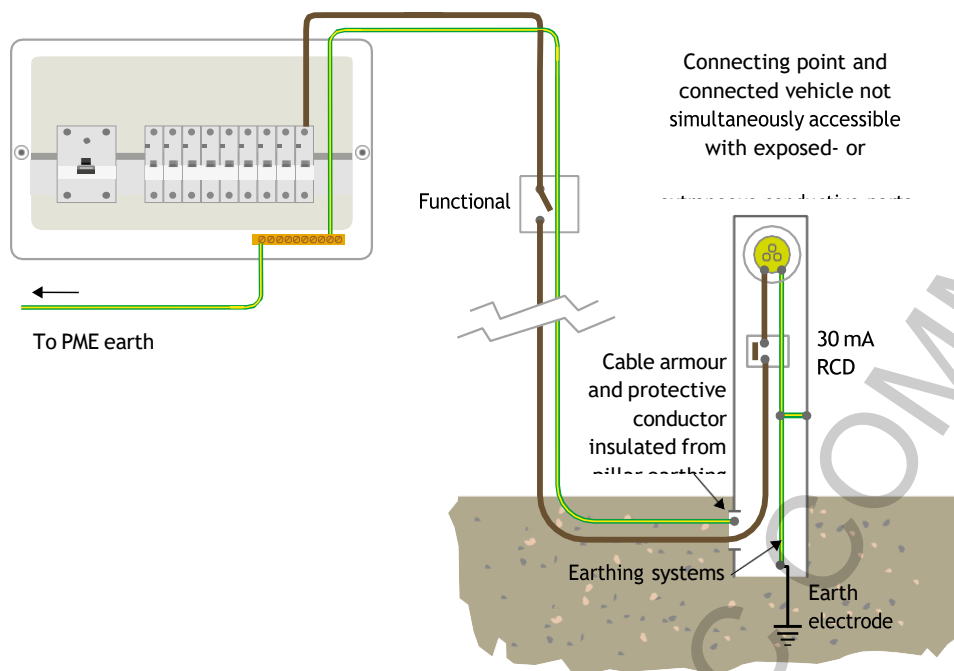
NOTESNotes:

1. Remote garages may already be supplied from a TT arrangement that has been derived from a TN-C-S (PME) supply in the house.
- ~~1-2.~~ When assessing the risks of simultaneous contact between conductive-parts in contact with different earthing systems within items (a), (b) and (c) above, this assessment must include all accessible conductive-parts including, for example, any conductive-parts associated with adjoining or nearby properties, and any other outdoor-installed electrical equipment, etc.
- ~~2-3.~~ The written risk assessment document must in each case be included with the installation documentation (Installation Certificate, etc.): see Annex B Appendix B ~~Appendix B~~.
- ~~3-4.~~ Separation below ground between the TT earth electrodes, and buried metalwork connected to the PME earthing system, is necessary. See Annex H Appendix G ~~Appendix G~~.
- ~~4-5.~~ In some installations, providing a separate TT system may not achieve the safety objective of removing a touch voltage for someone standing next to a vehicle plugged into the charging point. See Annex H Appendix G ~~Appendix G~~.

A suitable advisory label must be provided at the origin of every circuit supplied forming part of the TT system stating that this must not be connected to the PME earthing facility (see Sections 5.3.3.15-3.3.1 and 5.3.3.25-3.3.2).

Figure 6.2 ~~Figure 6-2~~ shows circuit schematics for a typical domestic installation with a PME supply where the EV charging equipment is installed such that conductive-parts associated with the connecting point and the exposed-conductive-parts of the vehicle are not simultaneously accessible with conductive-parts of the main installation connected to a PME earthing arrangement.

Figure 6.2 Typical domestic PME supply schematic with connecting point supplied by a simultaneously inaccessible 'TT' circuit



NOTES:

1. ~~Note:~~ Neutral omitted for clarity.
2. ~~Note:~~ The live conductors between the point where the armour of the cable to the charging point is insulated, and the RCD within the charging point, must be protected by the equivalent of double insulation.

6.7 Protective equipotential bonding

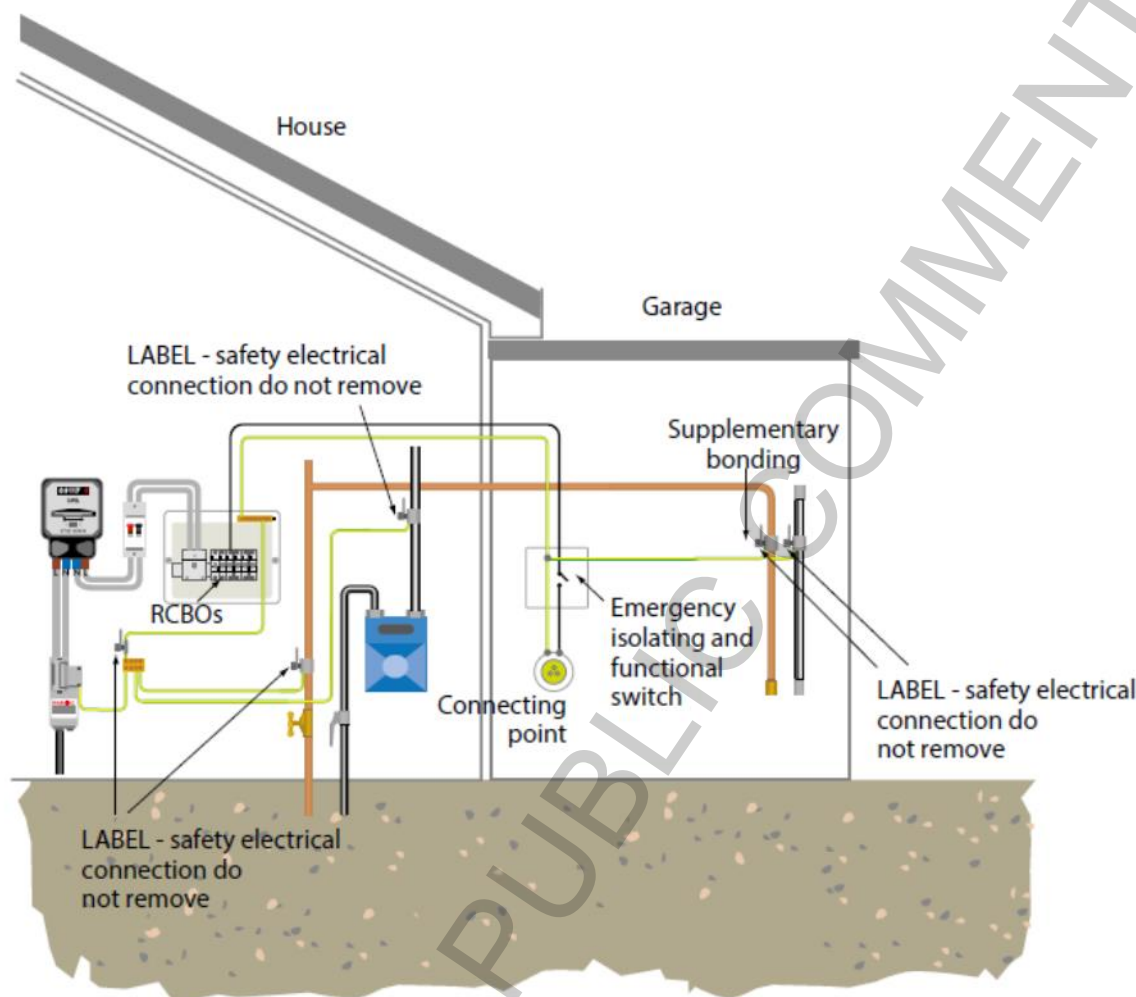
At the time of installation, it shall be confirmed that the earthing and bonding arrangements comply with the requirements of the current edition of BS 7671.

In cases where there is limited space around the vehicle, all extraneous-conductive- parts and exposed-conductive-parts accessible from any vehicle being charged ~~shall~~may be connected by supplementary protective bonding conductors to the charging point. This is ~~often appropriate~~beneficial where a vehicle is to be charged in a domestic garage, due to the large expanse of exposed-conductive-part (the vehicle's body) and the restricted space in a garage with the vehicle parked inside it. Figure 6.3~~Figure 6.3 shows such supplementary bonding for a domestic installation with the connecting point installed in a garage.~~

NOTE: RISCAuthority RC59 recommends that vehicles are charged outdoors where possible. See Section 6.166-16.

~~Figure 6.3 shows the supplementary bonding for a domestic installation with the connecting point installed in a garage.~~

Figure 6.3 Supplementary bonding for a domestic installation with the connecting point installed in a garage



6.8 General requirements for circuit design, cable specifications and dimensions

6.8.1 BS 7671 compliance

The electrical circuit for the EV charging equipment shall comply with the requirements of BS 7671, in particular, Section 722.

6.8.2 Dedicated final circuit (Regulation 722.533.101311)

A separate, dedicated electrical circuit, protected individually by an overcurrent protective device, shall be provided for the EV charging equipment or connecting point. However, more than one piece of EV charging equipment or connecting point may be fed from the same supply circuit, provided that the combined current demand of the equipment does not exceed the rating of the supply circuit.

6.8.3 Cable selection

The cable type and csa for the EV charging equipment circuit shall be chosen to ensure compliance with the requirements for:

- (a) protection against electric shock (refer to Section [5.55.5](#));
- (b) overcurrent protection (Chapter 43 of BS 7671); and
- (c) voltage drop (Section 525 of BS 7671).

When assessing the demand of installations, and distribution circuits supplying multiple EV charging points, load curtailment may be taken into consideration if it is provided (Regulation 722.311).

When specifying the cable sizes for use in the EV charging equipment circuit, reference shall be made to either Appendix 4 of BS 7671, which gives current-carrying capacity and voltage drop for cables, or manufacturer's data.

6.9 Protection against electric shock

As required by BS 7671, basic protection against electric shock shall be provided by automatic disconnection of supply or electrical separation.

6.9.1 Automatic disconnection of supply

Where automatic disconnection of the supply is used to provide protection against electric shock for the EV charging equipment circuit, compliance with Section 411 of BS 7671 shall be ensured.

6.9.2 Additional protection

For additional protection, RCDs shall be fitted, as specified in Section [6.106.10](#), and supplementary equipotential bonding installed, as described in Section [6.76.7](#).

6.10 Requirements for the provision of RCDs (Regulation 722.531.2)

6.10.1 RCD specification

Every [AC](#) charging point shall be protected by [an a 30 mA RCD](#), with [rated residual an operating current \(\$I_{\Delta n}\$ \) time not exceeding 30 mA, 40 ms at a residual current of 5 \$I_{\Delta n}\$. A Type B RCD should be used, unless the installer confirms the EVSE contains an RDC-DD according to BS IEC 62955, in which case a Type A or Type F RCD can be selected.](#)

[Dedicated EV charging equipment should EVSE may incorporate such a suitable an Type B RCD, or Type A or Type F RCD in conjunction with an RDC-DD](#), but the installer shall confirm this.

6.10.2 Co-ordination (selectivity)

There should be co-ordination (selectivity) between any RCD installed at the connecting point or incorporated in the charging equipment and the protection at the origin of the circuit (see Regulations 314.1 (i) and 536.4.1.4 of BS 7671).

6.10.3 RCD protection (Regulation 722.531.2.101)

Every [AC](#) charging point shall be individually protected by an RCD having the characteristics specified in Regulation 415.1.1. The RCD shall disconnect all live conductors, which, in accordance with the definitions in Part 2 of BS 7671, includes the neutral conductor.

The RCD protecting the charging point shall be at least a Type A RCCB complying with BS EN 61008-1 or RCBO complying with BS EN 61009-1 or a Type F RCCB to BS EN 62423. If it is known that the DC component of the residual current exceeds 6 mA, then a Type B RCD that complies with BS EN 62423 shall be installed.

For charging in Mode 3 or 4, the equivalent of Type B RCD protection is required – either by use of a Type B RCD or by a Type A or Type F plus additional DC protection devices to BS IEC 62955. Some charging equipment may incorporate DC fault protection and thus be compatible with a Type A or Type F RCD in the consumer unit.

For charging in Mode 2, Type A or Type F RCD protection is permitted, as DC fault protection is provided by the ICCB.

6.10.4 [Instruction notices for RCDs](#)~~Labels~~

~~An [label](#)~~[instruction notice](#) describing the operation and testing of the RCD, as shown in [Figure 5.5](#)~~Figure 5.5~~, shall be fitted in a visible position, adjacent to the installed location of each device. [The instruction notice does not have to be provided for domestic \(household\) premises or similar installations where certification for initial verification, complete with Guidance for Recipients as detailed in Appendix 6, has been issued to the person ordering the work.](#)

6.11 Requirements for isolation and switching

6.11.1 [Emergency switching off](#) (Regulation ~~722.537.4~~[537.3.3](#))

Because all [AC](#) EV charging ~~equipment and connecting~~ points are required to be protected by ~~a 30 mA an~~ RCD ~~with residual current rating not exceeding 30 mA~~, ~~an a means of~~ emergency [switching off](#) is not usually required. However, the particular needs of the installation and the charging equipment manufacturer's instructions shall be considered. For instance, a readily accessible means of switching off the charging equipment shall be provided when the vehicle is to be charged within the confines of a domestic garage. If an emergency switch is provided, it shall be located in a position that is readily accessible, shall be suitably identified by marking and/or labelling and shall disconnect all live conductors including the neutral.

6.11.2 Isolation

A means of isolating the EV charging equipment circuit shall be provided, in accordance with Regulation 537.2 of BS 7671. This isolating device shall be located in a position that is readily accessible for maintenance purposes and shall be suitably identified by marking and/or labelling.

6.11.3 Functional switching

Additional forms of switching for functional purposes may be required, for example to prevent the unauthorized use of socket-outlets located outside buildings that may be accessible to the public. These shall be discussed and agreed with the client.

6.12 External influences (Regulation Group 722.512.2)IP ratings

6.12.1 IP-rating of charging equipment (Regulation 722.512.2)

~~The EV charging equipment being installed shall have an IP rating suitable for the proposed installation location. For example, charging equipment that is to be installed in an outdoor location shall have an IP rating of at least IP44.~~

6.12.2 IP rating of installation components

The installer shall ensure that any equipment, including EVSE, along with enclosures, connectors, glands, conduits, etc. used to connect the power supply to the electric vehicle charging equipment EVSE, are of an appropriate IP ratingare suitable for the environment in which they are to be located, and are installed in such a way as to maintain a suitable IP and IK ratings, in accordance with BS 7671. In particular:

- (a) when installed outdoors, equipment, including EVSE, shall provide a degree of protection of at least IP44; and
- (b) when installed in public areas or car parks, equipment, including EVSE, shall be protected against mechanical damage by one or more of the following means:
 - (i) positioning or locating the equipment to avoid damage by any reasonably foreseeable impact; and/or
 - (ii) providing local or general mechanical protection to prevent mechanical impacts equivalent to those protected against by a minimum of IK08 in accordance with the requirements of BS EN 62262; and/or
 - (iii) Installing equipment so that that it complies with a minimum degree of protection against external mechanical impact of IK08 in accordance with the requirements of BS EN 62262.

Whilst vehicle connectors or socket-outlets may not meet the full IP rating when plugging or unplugging, they should meet the requirements both when connected and not in use. This may be achieved by weather protection flaps or covers for fixed outlets or connectors, and connectors of tethered cables could be provided, where appropriate, with a suitable holster or dock.

6.13 Lightning and surge protection systems

See sSection 5.105.10.

Most installations will require surge protection to be provided, but in some cases BS 7671 permits it to be omitted if the owner of the installation declares it is not required due to any loss or damage being tolerable and they accept the risk of damage to equipment and any consequential loss.

Surge protection may also be required for information and communications systems.

Where a building has a lightning protection system, reference shall be made to BS EN 62305 and Regulation 411.3.1.2 of BS 7671.

Where surge protection is provided as part of the overall lightning protection system, cables serving charging points located outdoors may require additional surge protection.

6.14 Prosumer's Electrical installations

6.14.1 Installations with island mode capability

See Section 1010.

6.14.2 Vehicle to home (V2H) and vehicle to grid (V2G) applications

See Section 1010.

6.15 Accessibility and mechanical protection

All charging points associated with dwellings shall be mounted so that the heights in Section 4.5.2.14.5.2.1 are observed, and so that tethered leads will not cause a trip hazard in use or storage.

Homes with disabled users may require some of the considerations of PAS 1899 for accessible public charging points to be considered (see Section 4.5.34.5.3).

Charging equipment associated with dwellings shall be installed in a location where accidental vehicle impact is not possible; unless:

- (a) impact barriers are provided to prevent accidental impact; or
- (b) the EVSE meets the IK08 impact rating.

6.16 Fire safety considerations for the location of EVSE

This sSection contains a summary of points for the fire safety considerations for EVSE installations in commercial and industrial premises, based on RISCAuthority RC59 Recommendations for fire safety when charging electric vehicles. A fuller explanation of the relevant points can be obtained from RC59 itself. These may not be the only considerations. For some installations it may be necessary to consult a fire safety specialist.

The fire safety strategy of the premises should consider relevant control measures required for the location of EVSE. The following are examples of considerations that might need to be considered for design and integration with the EV charging installation:

- (a) Charging points for electric road vehicles should normally be located outdoors. Outdoor charging areas should be adequately lit, and there should be adequate space around the space for access, connection and disconnection of cables, and safe maintenance of EVSE and associated electrical equipment.

2211 (b) Flammable or combustible material storage should not be located in or near a
2212 designated charging area, and this may be a factor when detached garages are being
2213 considered for EVSE installations.

2214 (c) Internal EVSE installations should be protected by an automatic fire detection
2215 installation, complying with BS 5839-6. Where smoke/heat alarms are used in
2216 dwelling, an interlinked system should be used to activate the sounders in the rest of
2217 the premises.

2218 (d) Some fire risk assessments, or devolved national building regulations requirements,
2219 may determine a sprinkler, or other type of fire suppression system is required. Any
2220 existing sprinkler/suppression systems should be checked to make sure they are
2221 suitable for the EVSE installation.

2222 (e) Where a new or existing sprinkler/suppression system will be used in the area in which
2223 EVSE is used, the sprinkler/suppression system installation should be interfaced with
2224 the EVSE installation, to automatically remove power when the sprinkler/suppression
2225 is activated.

7 Electrical requirements—On-street installations

7.1 Scope

7.1.1 General

This ~~section~~ Section contains specific requirements for the electrical installation of ~~EV charging equipment~~ EVSE at on-street locations. On-street EV charging installations are those that provide EV charging points for vehicles that will be parked on, or in parking bays directly associated with, the highway. They are characterized by the fact that they will be near or adjacent to the highway or its verges, typically accessible by the general public, and have a wide range of different users or be available for general use.

~~EVs~~ EVSE installations in car parks are considered to be commercial and/or industrial installations (see Section ~~88~~).

7.1.2 Supplies to on-street installations

On-street installations may be supplied by either:

- (a) a dedicated supply, via a distribution system that supplies feeder pillars.
- (b) repurposed supplies for existing lighting circuits, using spare capacity that may be available, where the DNO and local authority permit. This type of supply is only suitable for EVSE with power ratings between 3 and 7 kW.
- (c) repurposed supplies from existing street equipment, such as cable television or telephone communications cabinets that have surplus electrical capacity. The available capacity should be carefully assessed when considering the use of such supplies.

Note NOTE 1: Whilst the BS EN 61851 series demand curtailment via the control pillar requires at least 6 A to be available for a vehicle to begin charging, some vehicles will not charge from a supply current of 8 A. Therefore on-street installations for a single charging point should provide at least 10 A (2.3 kW). Similarly, where the installation supplies ~~in~~ charging points that are expected to be capable of simultaneous charging, the installation should be capable of providing at least $8 \times n$ A.

Note NOTE 2: Cut-outs in street furniture are typically rated at 25 A. This rating is determined in open air, not their operating environment, and therefore the effective rating may be less.

Ensuring an adequate supply is equally important for an on-street EV charging equipment installation, as for similar installations in commercial and industrial premises.

Load curtailment may be used to limit the demand. Where load curtailment is used across an EV charging equipment installation that uses repurposed existing cabling (for example, that was previously used for street lighting), the means of load curtailment should ensure that no cabling is overloaded. ~~It is recommended that~~ load curtailment complies shall comply with the principles of ENA Engineering Recommendation G100.

7.1.3 Physical installation locations, accessibility and mechanical impact

Smaller units rated up to 7 kW may be suitable for installation on an existing ~~lamp-post~~ lamppost, ~~sign-post~~ signpost or other street furniture.

Larger units, including rapid chargers, will typically require the construction of a dedicated plinth, along with associated duct work and the laying of larger cables.

On-street charging equipment shall be protected against vehicle impact by barriers, unless constructed to IK08.

For publicly accessible EVSE, Clause 8.2.1.702 of BS EN IEC 61439-7 requires a minimum mechanical impact resistance classification of:

(a) high impact resistance classification, for EVSE that is ground-mounted, or wall-mounted where any part of the EVSE is at a height of less than 0.9 m from the ground or finished floor; or

(b) medium impact resistance, for EVSE that is wall-mounted, and all parts of the EVSE are at a height of at least 0.9 m from the ground or finished floor.

NOTE: Section 5.8.35-8.3 provides a description of the three resistance to mechanical impact classifications to BS EN IEC 61439-7.

All on-street charging points shall be mounted so that the heights in Section 4.54.5 are observed, and so that tethered leads will not cause a trip hazard in use or storage.

Accessible on-street charging points shall be selected and installed to comply with PAS 1899 (see Section 4.5.34-5.3).

EVSE shall be installed:

- (a) as close as possible to the intended parking space;
- (b) so that charging cables in-use do not trail across footways and verges. This would be a trip hazard and impede access for users of wheelchairs and mobility equipment. Repeated impact from pedestrians, wheelchairs, mobility scooters and similar may cause damage to charging cables and present an electric shock/burn hazard.

~~so that controls and socket outlets are at a suitable height to comply with BS 8300-1 and BS 8300-2.~~

7.2 Planning and client specifications for an on-street installation

Whilst the survey for installation of the EVSE should be carried out by the installer, initial surveys should be carried out by the client (for example, the local authority), to determine:

- (a) the extent of services and street furniture in the area, and who owns them;
- (b) the DNOs and/or lighting distribution system operators to be consulted; and
- (c) any limitations in accuracy of the information ascertained from the survey.

The specific information should be provided with the client's specification.

~~NOTE:~~ Legacy connections may form part of a loop of supplies where the increased demand may cause utilization voltage issues. In addition, these loops were constructed using very small csa, for example, 4 mm² concentric.

7.3 Technical requirements for on-street installations

7.3.1 ENA Engineering Recommendation G12

The requirements of the current Energy Networks Association (ENA) Engineering Recommendation G12 Issue 4 (incorporating Amendment 21) 20222015 for on-street EV charging installations are as follows:

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6.2.16 Electric Vehicle Charging Points (EVCP)

This Section applies to EVCP which are either themselves street electrical fixtures or are connected to street electrical fixtures.

Where the EVCP is of Class I construction as defined in BS 7671, a PME earth terminal may be provided if the requirements of BS 7671 are satisfied and the connection point presents a 3-phase balanced load.

The risk of a neutral fault on EVCP installations which form part of a Class 1 construction street electrical fixture supplied at single phase or unbalanced 3 phase is sufficient to classify the structure as special situations where the consumer must utilise an additional or alternative form of protection to PME.

6.2.16.1 Alternative Form of Protection to PME

A mains-derived earthing terminal is not required for Class II installations. EVCPs should preferably be of Class II construction or equivalent as defined in BS 7671.

A TT system earthing arrangement is a suitable alternative earthing arrangement, which will remove the potential risk caused by the rise of voltage on a consumer's earth terminal in the event of an open neutral condition. Due to the higher tolerable voltages at on-street locations (compared to those specified in BS 7671), where individuals are likely to be wearing footwear and standing on high resistance surfaces such as tarmac, separation between the TT earth and underground metallic services is not considered necessary.

Where it is not reasonably practicable to install a TT system earthing arrangement an additional form of protection should be installed. Examples of where it may not be reasonably practical to install a TT system earthing arrangement is where the soil resistivity is high or where the installation of the EVCP does not involve any excavation.

6.2.16.2 Additional Form of Protection to PME

Section 6.2.14 and 6.2.15 of this document includes the use of a supplementary electrode as a suitable additional form of protection when used with PME. The assumptions made in determining this suitability were that a member of the public would not deliberately touch an installation such as a street lighting column or other street electrical fixture resulting in any contact being fleeting and infrequent. It was also assumed that any contact scenario would be during dry conditions with the individual wearing footwear.

For an EVCP installation the contact by a member of the public to the charging point, to connect and disconnect the vehicle and to the vehicle (which will become an extension of the charging point installation) will be frequent and less fleeting in nature than for a typical street electrical fixture installation. As EVCPs will be used in all weather conditions, the

contact scenario should be assumed to be in wet conditions. For these reasons, the value of impedance to earth of a supplementary electrode used as the sole means of additional protection for an electric vehicle charging point is required to be less than as described in Section 6.2.15. Consequently, this approach has been discounted for EVCPs.

Currently BS 7671 section 722 permits the protection against a neutral fault condition to be provided by the use of a protective device which responds to an open neutral condition.

Where an open neutral detection and earth disconnection device is used as the additional form of fault protection the designer, installer and owner of the device must ensure that the device is designed, installed, maintained and operated to protect members of the public from the risks associated with the rise of voltage on the street electrical fixture in the event of an open neutral condition.

As a minimum requirement, any open neutral detection and earth disconnection device must be designed to comply with the guidance in the current version of BS 7671 and to comply with all relevant national and international technical construction and design standards.

At the time of writing no definitive product standards were in existence for the design and construction of an open neutral detection and earth disconnection device. Until such standards are developed, in addition to the requirements above, it shall be demonstrated that the device is fit for purpose by type testing and certification at an independent test centre to:

- Verify that it responds to all likely fault scenarios, under typical system and environmental conditions.
- Verify it locks out on detection of a fault scenario.
- Demonstrate that it does not falsely operate under expected network operating conditions.

Demonstrate that it is fail-safe to prevent the operation of the charger if any major or significant component fails.

Therefore, where PME conditions apply to the supply to on-street EV charging equipment installations for conductive charging, ENA Engineering Recommendation G12/4 leads the designer to the following options:

(a) use a TT earthing arrangement; or

(b) where (a) is not practicable, use an open-PEN detection device that is certified by an independent test centre to meet the requirements of BS 7671 and G12/4, and any applicable product standards.

NOTE: The option of Class II or equivalent is not possible for conductive charging equipment to BS EN 61851-1, which requires a protective conductor to be connected to the vehicle for all charging modes. The vehicle and charging equipment would both be required to be Class II or equivalent construction.

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6.2.15 Street Electrical Fixtures not covered by 6.2.14

This Section covers roadside housings accessible to the public; examples are: cable television distribution cabinets, electric vehicle charging points, electrical distribution cabinets with load above 500W.

Note: A code of practice for electric vehicle charging equipment installation has been published by the IET.

Street electrical fixtures should preferably be of Class II construction or equivalent as defined in BS 7671. Examples are public telephones, pedestrian crossing bollards, ticket machines. No mains-derived earthing terminal is required, neither is a residual current device needed for earth fault protection.

Where the street electrical fixture is of Class I construction as defined in BS 7671, (examples include metal enclosures containing pumps, controls or communications equipment), a PME earth terminal may be provided if the requirements of BS 7671 are met and:

- 1 — For 3-phase equipment, the load is balanced, or:
- 2 — For 1 phase equipment and 3 phase equipment with unbalanced load, the maximum load and consumer earth electrode resistance bonded to their main earth terminal fulfil the requirements of Table 6.2.15.

Note: By agreement with the Network Operator, it may be permissible to take into account the effect of distributed earths in specific situations.

If the conditions for a Class I installation cannot be met, a PME terminal should not be offered. The earthing system of the installation should form part of a TT system by installing a separate earth electrode and fitting appropriate protection in accordance with BS 7671 (e.g. an RCD).

Extraneous conductive parts (e.g. safety barriers, pedestrian guard rails) should not be connected to a PME earth terminal.

The maximum consumer earth electrode resistances indicated in Table 6.2.15 of G12/4 allow slightly higher touch voltages than BS 7671. It is therefore recommended that the maximum earth electrode resistances given in Table 7.1 are used, if the option in Regulation 722.411.4.1 (ii) is relied upon for PME earthing systems.

Table 7.1 Estimate of maximum consumer earth electrode resistance (R_A) for PME supplies (applying the equation in Annex A722 of BS 7671)

Maximum 1-phase load or, for 3-phase, maximum overall load unbalance (kW)	I_m (A)	Maximum consumer earth electrode resistance allowed by BS 7671 (Ω)			
		Single-phase supplies	Three-phase supplies		
			$I_{L1} + I_{L2} + I_{L3} = 10$ A	$I_{L1} + I_{L2} + I_{L3} = 30$ A	$I_{L1} + I_{L2} + I_{L3} = 100$ A
0.5	2.1	46	NR	NR	NR
1	4.3	23	NR	NR	NR
2	8.7	11	NR	NR	NR
3	13.0	8	NR	NR	NR

4	17.4	6	23	NR	NR
5	21.7	5	11	NR	NR

NR earth electrode not required.

Note: For three phase calculations it has been assumed the EV load in column 1 is added to the three phase load $I_{L1}+I_{L2}+I_{L3}$.

Note: It is not usually practicable to achieve a sufficiently low earth electrode resistance for this approach to be effective for loads above 5 kW.

7.3.2 General

In addition to G12/4, the principal technical requirements for safety of the electrical installation are to be found in BS 7671.

EV charging equipment should not be connected to an unmetered supply (as is common for street furniture). Due to the size of the load and its unpredictability, EV charging equipment should always be fed via a metered supply.

Tariff metering must be provided if the use of the charging point is billed on an energy usage basis, and may be required for energy management purposes, for example, where Part L2 of the Building Regulations apply.

For on-street installations, metering may be included in EVSE, or installed in a feeder pillar where there is insufficient space within the charging equipment.

7.3.3 Earthing and protective equipotential bonding requirements

7.3.3.1 General

In addition to BS 7671, BS 7430 should be considered in terms of earthing requirements for on-street installations.

7.3.3.2 TN-S systems

Unless it can be guaranteed by the relevant DNO that the TN-S supply system is TN-S back to source and will not be converted to TN-C-S as part of any ongoing network upgrades, such installations shall be treated as TN-C-S systems (PME supply).

As it is unknown whether any other street furniture is, or at some point in the future may, be connected to a PME supply, EV charging equipment installations for on-street installations having TN-S supplies shall follow the requirements for PME supplies (see Section [7.3.3.37.3.3.3](#)).

7.3.3.3 TN-C-S systems (PME supply)

General

~~DNOs~~ distribution network operators will not provide the MET of a PME supply for street furniture with loads greater than 2 kW, unless ~~a consumer earth electrode is installed, that has a resistance to earth that complies with Table 6.2.15 of G12/4. BS 7671 requires lower consumer earth electrode resistances as per Table 7.1~~ they agree to the use of independently certified means of open-PEN detection device being used in accordance with Section 6.2.16.2 of G12/4.

~~Note: Some vehicles will not charge from a supply current of 8 A, and therefore on-street installations should provide at least 10 A (2.3 kW).~~

~~Alternatively, Consequently,~~ when on-street EV charging equipment is to be connected to a TN-C-S (PME) supply, a separate TT earthing system (see Section ~~7.3.3.4~~ 7.3.3.4) is often used for this charging equipment.

Where the ~~distribution network operator~~ DNO permits a device that detects open-circuit PEN conductors

Some ~~distribution network operator~~ DNOs may permit the use of TN-C-S supplies where equipment that detects open-circuit PEN conductor faults is installed at the charging equipment or at the feeder-pillar.

~~Note: Where the supply to the electrical installation is three-phase, the device discussed in Section 5.3.5.3 is not permitted by BS 7671. Most on-street installations have three-phase supplies.~~

For single-phase charging equipment, ~~the a three-phase~~ device described in Section ~~5.3.5.3.5~~ 5.3.5.2 may be fitted at the feeder pillar, and separate neutral and earth cables used to supply the EVSE from the feeder pillar.

~~Where three-phase charging equipment is used, the device described in Section 5.3.5.2 may be fitted either at the feeder pillar, with separate neutral and earth cables used to supply the EVSE from the feeder pillar, or alternatively, the device may be installed in the charging equipment.~~

7.3.3.4 TT systems

Before a TT system is installed, a risk assessment must be carried out so that risks of simultaneous contact with electrical installations, including other street furniture with PME earthing, are minimized (see ~~Annex C~~ Appendix C). Generally, this will require the charging equipment to be installed in a location that ensures that both the exposed-conductive-parts of this equipment and the vehicle on charge, are at least 2.5 m from:

- (a) other structures with exposed metalwork that are either connected to true Earth or connected to any other electrical earthing system; and
- (b) any extraneous- or exposed-conductive-parts of any other item of electrical equipment.

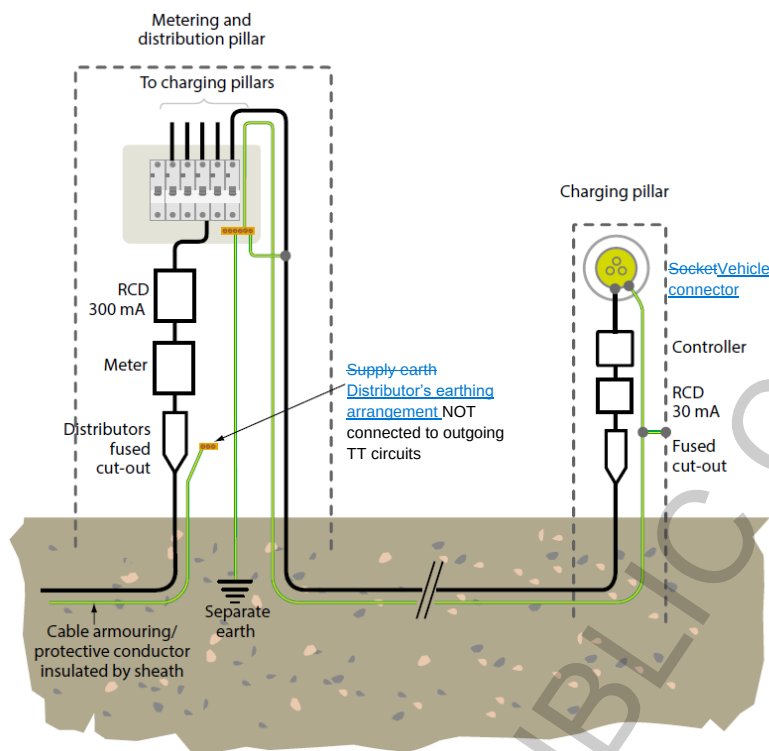
In addition, the TT earth electrode must be adequately separated below ground from buried metalwork connected to the PME earthing system, including:

- (a) PME earth electrodes;
- (b) supplementary earth electrodes for equipment supplied by the PME earthing system;
- (c) exposed-conductive-parts of equipment supplied by the PME earthing system;
- (d) metallic sheaths of cables; and
- (e) exposed-conductive-parts of installations supplied by the PME earthing system.

The separation distance below ground should be at least 2 m (see ~~Annex H~~ Appendix G, ~~Table G.1~~ Table G.1). Some ~~distribution network operator~~ DNOs may have greater separation requirements.

Figure 7.1 shows a typical on-street EV charging equipment installation forming part of a TT system.

Figure 7.1 Typical on-street EV charging equipment installation forming part of a TT system



Note: The supply earthing terminal within the feeder pillar should be suitably insulated or shrouded, to mitigate touch potentials.

7.3.4 Requirements for circuit design, cable selection and dimensions

7.3.4.1 BS 7671 compliance

The electrical circuit for the EV charging equipment shall comply with the requirements of BS 7671, in particular, Section 722.

7.3.4.2 Circuit design

Whilst it is common for ~~street lights~~ streetlights and street furniture to be wired on a loop basis, this approach is not advisable for EV charging equipment. On-street charging equipment installations shall be wired as part of a radial system.

A separate, dedicated electrical circuit shall be provided for the EV charging equipment. However, more than one piece of EV charging equipment may be fed from the same supply circuit, provided that the combined current demand of the equipment does not exceed the rating of the supply circuit (Regulation 722.311).

7.3.4.3 Cable selection

The cable type and csa for the EV charging equipment circuit shall be chosen to ensure compliance with the requirements for:

- (a) protection against electric shock (refer to Section [5.55.5](#));
- (b) overcurrent protection (Chapter 43 of BS 7671); and
- (c) voltage drop (Section 525 of BS 7671).

Final circuits, unless automatic controls curtail the maximum demand of the individual circuit.

When specifying the cable sizes for use in the EV charging equipment circuit, reference shall be made to either Appendix 4 of BS 7671, which gives current-carrying capacity and voltage drop for cables, or manufacturer's data.

7.3.4.4 Buried cables

[Appendix K](#) provides guidance on the minimum depth of buried cables, and minimum height of suspended cables. It also provides a commentary on the Street ~~w~~Works UK guidance for cables installed on the highway.

WARNING

~~Excavating in the street is dangerous work: damage to underground services can cause fatal or severe injury. The activity of excavating in the street needs to be addressed in a safe manner. See the Health and Safety Executive (HSE) publication HSG47 Avoiding dangers from underground services (this publication is available as a free download www.hse.gov.uk/pubns/priced/hsg47.pdf).~~

~~The work should be carried out by a specialist contractor.~~

Positioning and colour coding of underground utilities' apparatus

~~The National Joint Utilities Group (NJUG) has agreed colours, depths of cover and positions for ducts, pipes, cables and marker/warning tapes when laid in the street. These are reproduced in Table 7.2 and Figure 7.2. This gives guidance to designers as to the depth at which cables might reasonably be expected to be laid generally, for example, in car parks, as well as in public paths and highways.~~

WARNING

~~The information provided in Table 7.2 and Figure 7.2 is current practice and indicates where it is preferable for newly installed cables and pipes to be installed. Older cables and pipes may not use these colour identifiers, nor be located at these depths. See HSE publication HSG47 for further guidance.~~

Table 7.1 Table 7.2 Recommended colour-coding of other underground apparatus

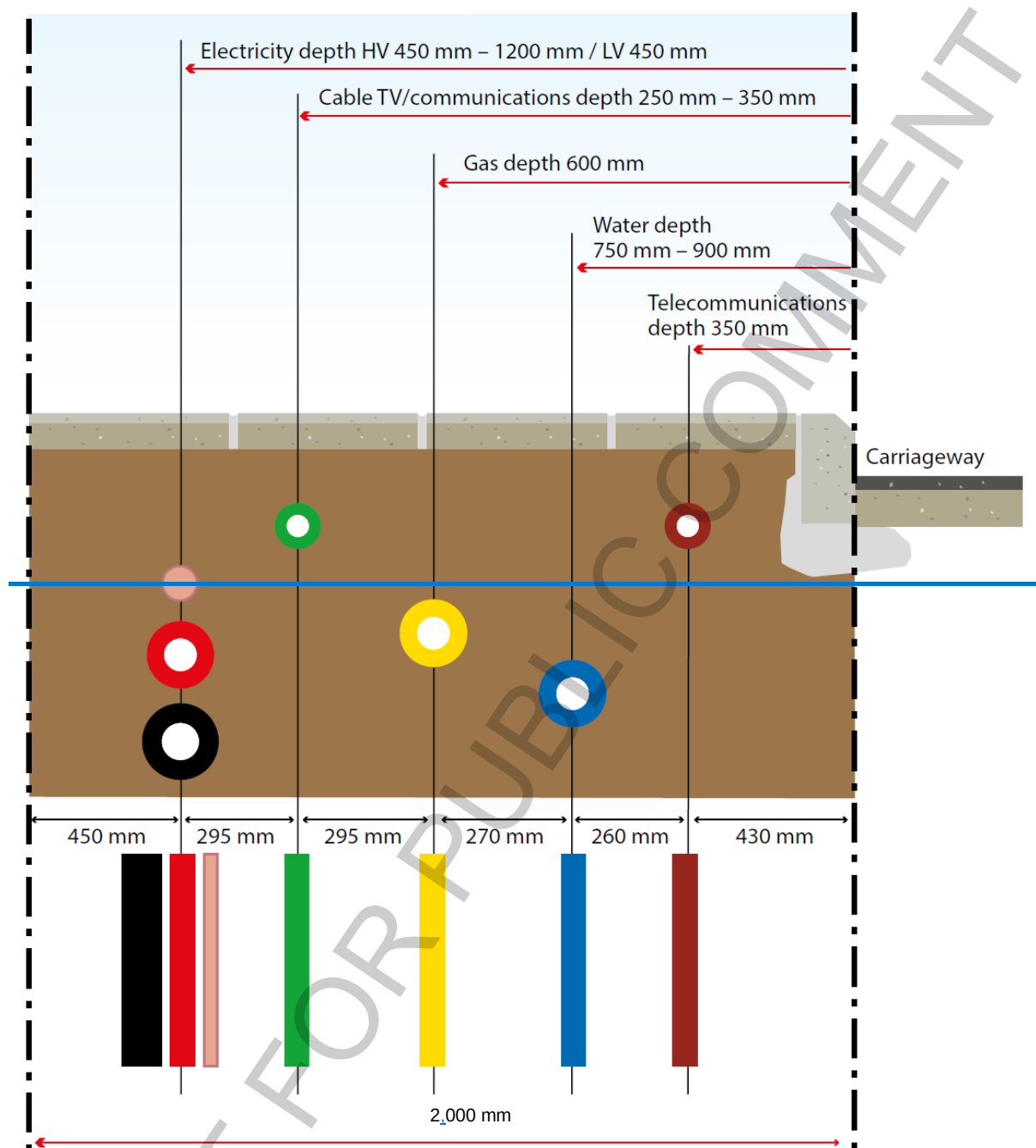
Note: These guidelines are taken from the 'NJUG Publication Volume 1 NJUG Guidelines on the Positioning and Colour Coding of Underground Utilities' Apparatus

Asset Owner	Duct	Pipe	Cable	Marker Systems	Recommended Minimum Depths	
					Footway	Carriageway
Electricity-HV (High-Voltage)	Black or red duct or tile	N/A	Black or Red	Yellow with black and red legend or concrete tiles	450-1200 mm	750-1200 mm
Electricity-LV (Low-Voltage)					450 mm	600 mm
Gas	Yellow	*** See row below	N/A	Black legend on PE pipes every linear metre.	600 mm footway 750 mm verge	750 mm
*** Pressure up to 2 bar yellow or yellow with brown stripes (removable skin revealing white or black core pipe). between 2 to 7 bar orange. Steel pipes may have yellow wrap or black tar coating or no coating. Ductile Iron may have plastic wrapping. Asbestos & Pit / Spun Cast Iron No distinguishable colour						
Water non Potable & Grey Water	N/A	Black with green stripes	N/A	N/A	600-750 mm	600-750 mm
Water Firefighting	N/A	Black with red stripes or bands	N/A	N/A	600-750 mm	600-750 mm
Oil / fuel pipelines	N/A	Black	N/A	Various surface markers-Marker tape or tiles above red concrete	900 mm All work within 3 m of oil / fuel pipelines must receive prior approval	900 mm All work within 3 m of oil / fuel pipelines must receive prior approval
Sewerage	Black	No distinguishing colour/material (e.g. Ductile Iron may be red; PVC may be brown)	N/A	N/A	Variable	Variable
Telecomms	Grey, white, green, black, purple	N/A	Black or light grey	Various	250-350 mm	450-600 mm
Water	Blue or Grey	Blue polymer or blue or uncoated iron / GRP. Blue polymer with brown stripe (removable skin revealing white or black pipe)	N/A	Blue or Blue/black	750 mm	750 mm
Water pipes for special purposes (e.g. contaminated ground)	N/A	Blue polymer with brown stripe (non removable skin)	N/A	Blue or Blue/black	750 mm	750 mm

Table 7.2 Cont.

Asset Owner	Duct	Pipe	Cable	Marker Systems	Recommended Min. Depths	
					Footway	Carriageway
Highway Authority Services						
At the time of publication the following were current examples of known highway authority apparatus colour coding						
Street Lighting						
England and Wales	Black or Orange*	N/A	Black	Yellow with black legend	450 mm	600 mm
	* Consult electricity company first					
Scotland	Purple	N/A	Purple	Yellow with black legend or purple	450 mm	
Northern Ireland	Orange	N/A	Black or Orange	Various	450 mm	450 mm
						
Other						
Traffic Control	Orange		Orange	Yellow with black legend		
Street Furniture	Black		N/A	Black	Yellow with black legend	450 mm
Telecoms	Purple or Orange	N/A	Black	Various		
						
Motorways and Trunk Roads						
England and Wales						
Communications	Purple	N/A	Grey	Yellow with black legend	450 mm	
Communications Power	Purple	N/A	Black	Yellow with black legend		
Road Lighting	Orange	N/A	Black	Yellow with black legend		
Scotland						
Communications	Black or Grey	N/A	Black	Yellow with black legend		
						
Road Lighting	Purple	N/A	Purple	Yellow with black legend		
						

Figure 7.2 National guidelines on the positioning of utility apparatus in a 2 m footway



7.3.5 Requirements for the provision of RCDs (Regulation 722.531.2)

7.3.5.1 RCD specification

Every AC charging point shall be protected by a 30 mA RCD with residual current rating ($I_{\Delta n}$) not exceeding 30 mA, according to Regulation group 722.531.3. Dedicated EV charging equipment should incorporate such an RCD, but the installer shall confirm this. The RCD shall disconnect all live conductors, which, in accordance with the definitions of Part 2 of BS 7671, includes the neutral conductor.

7.3.5.2 Co-ordination (selectivity)

There shall be co-ordination (selectivity) between any RCD installed at the connecting point or incorporated in the charging equipment and any other RCDs in the installation. For instance, where a 30 mA Type A, Type F or Type B RCD is installed in the charging equipment, a 100 mA, 300 mA or 500 mA Type S RCD could be fitted in the feeder pillar.

7.3.5.3 RCD type (Regulation 722.531.3.101)

The RCD protecting the charging point shall be at least a Type A RCCB complying with BS EN 61008-1 or RCBO complying with BS EN 61009-1 or BS EN 60947-2, or a Type F RCCB to BS EN 62423. If it is known that the DC component of the residual current exceeds 6 mA, then a Type B RCD that complies with BS EN 62423 shall be installed.

For charging in Modes 3 or 4, the equivalent of Type B RCD protection is required – either by use of a Type B RCD or by a Type A or Type F RCD plus an additional DC protection device to BS IEC 62955. Some charging equipment may incorporate DC fault protection and thus be compatible with a Type A or Type F RCD in the consumer unit.

For charging in Mode 2, Type A or Type F RCD protection is permitted, as DC fault protection is provided by the ICCB.

7.3.6 Requirements for isolation and switching

7.3.6.1 Emergency switching off and firefighter's switches (Regulations 537.3.3 and 722.537.4)

Because all EV charging equipment and connecting points are required to be protected by a 30 mA an RCD with residual current rating (I_{Δn}) not exceeding 30 mA, an a means of emergency switching off, and firefighter's emergency switches, are ~~is~~ not usually required.

NOTE: Firefighter's switches are required for installations associated with fuel filling stations- (See Section 4.2.24.2.2).

~~However~~, the particular needs of the installation and the charging equipment manufacturer's instructions shall be considered. If an emergency switch is provided, it shall be located in a position that is readily accessible, shall be suitably identified by marking and/or labelling and shall disconnect all live conductors, including the neutral.

7.3.6.2 Means of isolation for safe maintenance

Suitable means of isolation for maintenance of EVSE and associated equipment shall be provided. This isolating device should be located in a position that is readily accessible for maintenance purposes and suitably identified by marking and/or labelling. For on-street installations, the means of isolation will generally be inaccessible to members of the public, and accessed by a key or tool.

7.3.7 IP ratings External influences (Regulation Group 722.512.2)

The installer shall ensure that any equipment, including EVSE, along with enclosures, connectors, glands, conduits, etc. used to connect the power supply to the electric vehicle charging equipment EVSE, are of an appropriate IP rating are suitable for the environment in

2497 which they are to be located, and are installed in such a way as to maintain a suitable IP and
2498 IK ratings, in accordance with BS 7671. In particular:

2499 (a) when installed outdoors, equipment, including EVSE, shall provide a degree of protection
2500 of at least IP44;

2501 (b) when installed in public areas or car parks, equipment, including EVSE, shall be protected
2502 against mechanical damage by one or more of the following means:

2503 (i) — positioning or locating the equipment to avoid damage by any reasonably
2504 foreseeable impact; and/or

2505 (i) —

2506 (ii) — providing local or general mechanical protection to prevent mechanical impacts
2507 equivalent to those protected against by a minimum of IK08 in accordance with the
2508 requirements of BS EN 62262; and/or

2509 (ii) —

2510 (iii) — installing equipment so that that it complies with a minimum degree of protection
2511 against external mechanical impact of IK08 in accordance with the requirements of
2512 BS EN 62262.

2513 Whilst vehicle connectors or socket-outlets may not meet the full IP rating when plugging or
2514 unplugging, they should meet the requirements both when connected and not in use. This
2515 may be achieved by weather protection flaps or covers for fixed outlets or connectors, and
2516 connectors of tethered cables could be provided, where appropriate, with a suitable holster or
2517 dock.

2518 For publicly accessible EVSE, Clause 8.2.1.702 of BS EN IEC 61439-7 requires a minimum
2519 mechanical impact resistance classification of:

2520 (a) high impact resistance classification, for EVSE that is ground-mounted, or wall-
2521 mounted where any part of the EVSE is at a height of less than 0.9 m from the ground
2522 or finished floor; or

2523 (b) medium impact resistance, for EVSE that is wall-mounted, and all parts of the EVSE
2524 are at a height of at least 0.9 m from the ground or finished floor.

2525 NOTE: Section 5.8.35-8.3 provides a description of the three resistance to mechanical impact classifications to
2526 BS EN IEC 61439-7.

2527 **7.3.7.1 — IP rating of charging equipment (Regulation 722.512.2.201)**

2528 The EV charging equipment being installed shall have an IP rating suitable for the installation
2529 location. For on-street installations, this means that charging equipment shall have an IP rating
2530 of at least IP44.

2531 **7.3.7.2 — IP rating of installation components**

2532 The installer shall ensure that any connectors, glands, conduits, etc. used to connect the
2533 power supply to the EV charging equipment are of an appropriate IP rating, and are installed
2534 in such a way as to maintain a suitable IP rating, in accordance with BS 7671.

7.3.7.3 Impact

~~On-street EV charging equipment installations shall be protected against a minimum impact severity of AG2, as defined in Appendix 5 of BS 7671.~~

7.4 Typical supply and earthing arrangements for dedicated supplies

7.4.1 Overview

This ~~section~~ Section discusses arrangements where a new supply is provided direct to EV charging equipment, via new cabling, from new or existing feeder pillars.

7.4.2 Arrangements at the feeder pillar

7.4.2.1 TN-C-S (PME) supplies

Some ~~distribution network operator~~ DNOs may permit the use of a device that detects open-circuit PEN conductor faults ~~as identified in G12 Issue 4, see Section 7.3.17.3.1, in accordance with indent (iii) of Regulation 722.411.4.1.~~

~~In installations that incorporate single-phase EVSE, an open-circuit PEN detection device should be installed at the three-phase feeder pillar, for the following reasons:~~

~~(a) — devices complying with 722.411.4.1 (iii) without a measurement earth electrode require all three phases of the supply to be available; and~~

~~(b) — provision of adequate separation below ground between the measurement earth electrode and buried conductors and metalwork connected to the PME earthing system is less likely to be available at the charging equipment location (see Annex I).~~

Where an open-circuit PEN detection device is not permitted by the DNO, the TN-C-S (PME) earthing arrangement shall not be used, and a separate TT earthing arrangement shall be provided (see Section 7.4.2.3 ~~7.4.2.3~~).

7.4.2.2 TN-S supplies

It is recommended that the approach in Section 7.4.2.1 ~~7.4.2.1~~ is followed.

7.4.2.3 TT supplies

A typical arrangement for TT supplies from a feeder pillar is shown in Figure 7.1 ~~Figure 7.1~~. Where the EV charging system is being fed from an existing feeder pillar, then either that feeder pillar should be converted for TT supplies (if it is safe for all equipment fed from it to be supplied by a TT system), or a new TT feeder pillar should be installed downstream.

An earth electrode arrangement shall be installed at each feeder pillar. The earth electrode arrangement shall be separated from buried metalwork connected to a PME earthing system (see Section 7.3.3.4 ~~7.3.3.4~~).

A main RCD is required for the supply at the point of formation of the TT supply, and all RCDs shall have appropriate RCD protection (see Section 7.3.5 ~~7.3.5~~), in addition to overcurrent

protection. Consideration should be given to selectivity with downstream RCDs, in accordance with BS 7671.

7.4.3 Arrangements at the charging point

7.4.3.1 Where a TT supply is provided from a feeder pillar

The supply will be provided as per Section [7.4.2.3](#) ~~7.4.2.3~~ [4.2.3](#). Simultaneous contact assessments are required.

The installation of EVSE onto metal ~~lamp-posts~~ [lampposts](#), ~~sign-post~~ [signposts](#) or other existing metal street furniture is only acceptable where they are supplied from the same TT earthing system as the EVSE.

7.4.3.2 Where a TN-C-S (PME) or TN-S supply is provided from a feeder pillar

The supply will be provided as per Sections [7.4.2.1](#) ~~7.4.2.1~~ [and or 7.4.2.2](#) ~~7.4.2.2~~.

Where an open PEN detection device as described in Section 5.3.5.2 is intended to be used, and the circuit supplying the EVSE does not have that protection provided at the feeder pillar, then either the EVSE should contain the device, or it should be fitted at the EVSE.

If the circuit supplying the EVSE is single-phase, then an open PEN detection device shall be installed at the feeder pillar.

A simultaneous contact assessment should be made in respect of any street furniture not connected to the PME earthing system.

Important Notes:

Note-NOTE 1: Exposed-conductive-parts of EVSE, and protective conductors of the supply to it downstream of the open PEN protection device, shall not be connected by supplementary bonding, or direct physical connection, to any other equipment forming part of the PME earthing system. Such bonding will defeat the open PEN protection device.

Note-NOTE 2: ~~Note-NOTE 1~~ generally precludes the installation of EV charging points protected by open PEN detection devices onto existing street furniture, including metal ~~lamp-posts~~ [lampposts](#) (unless that street furniture or lamp-post is supplied by the same feeder pillar) on a circuit protected by the same open PEN detection device.

7.5 Supply and earthing arrangements for re-purposed street lighting supplies

Where a re-purposed street lighting supply is being considered for use on-street, the designer will consider the arrangement of the lighting main cable, as well as the supply earthing arrangements.

[Table 7.1](#) ~~Table 7.1~~ [Table 7.3](#) provides an overview of the options available to the designer.

Table 7.1 [Table 7.3 Protection requirements](#) [EVSE earthing arrangement options](#) based on the [supply](#) earthing arrangements and lighting main cable type for re-purposed street lighting supplies

Earthing arrangement of supply to lighting main				
Lighting main cable types	TN-S supply	TT supply	TN-C-S (PME) supply	
			TT conversion	Open detection PEN (Note 2)
Single-phase, SNE cable	If the system can be guaranteed to be TN-S back to the transformer, TN-S may be used. Otherwise, PME should be assumed.	A simultaneous contact assessment should be conducted.	Conversion of the whole installation to TT supply, provided that separation and simultaneous contact assessments determine this is feasible.	Single-phase or three-phase device meeting 722.411.4.1 (iii) may be fitted at the feeder pillar provided that no further bonding is conducted downstream of the protective device. Single-phase device meeting 722.411.4.1 (iii) or (iv) may be fitted at the lighting column or in the EVSE (Note 2).
Three-phase, SNE cable				Three-phase device meeting 722.411.4.1 (iii) may be used, provided that all three-phases are made available at the lighting column.
Single-phase, CNE cable	n/a	n/a	Conversion of lighting column to TT, provided that separation and simultaneous contact assessments determine this is feasible.	A single-phase device meeting 722.411.4.1 (iii) or (iv) may be fitted at the lighting column or in the EVSE (Note 2).
Three-phase, CNE cable	n/a	n/a		Three-phase device meeting 722.411.4.1 (iii) may be used, provided that all three-phases are made available at the lighting column.

Note 1: Where permitted by the DNO.

Note 2: Only to be used in cases where the supply to the street lighting system is derived from a single-phase supply.

8 ~~Electrical requirements~~ — Commercial and industrial installations

This ~~section~~ Section contains specific requirements on the electrical installation of EV charging equipment at commercial and industrial locations. This includes installations in, or adjacent to, business premises, such as shops, offices, factories, and so on, and public and private car parks (single-level or multi-storey). These requirements are also applicable to installations in the car-parking areas of multiple-occupancy buildings, such as apartment blocks.

8.1 General

8.1.1 Scope and limitations

The installation arrangement that may be adopted in commercial and industrial installations is so wide that specific guidance cannot be provided that covers all installations.

8.1.2 Supply earthing arrangements

It is in commercial and industrial installations that private 11,000/400 V substations may be installed and where a TN-S supply may be available, simplifying the vehicle charging installation design and risk assessment.

Where PME conditions apply, or the earthing arrangement is TN-S and substation is not privately owned and operated, Ccommercial and industrial installations, however small, must comply with ~~sub-clauses (i), (ii) and (iii) of~~ Regulation 722.411.4.1 (see Section 5.2.45.2.4).

8.1.3 Adequacy of supply and maximum demand

Some applications for charging in commercial and industrial installations, and in car parks, require large amounts of power. It may be necessary to bring in an additional supply, perhaps via dedicated HV substation, to meet these needs, and the designer will need to assess the costs and practicability of this at the planning stage. The substation design should be conducted to BS EN 61936-1 and BS EN 50522, and such design is outside the scope of this Code of Practice. It may be necessary to separate earthing systems of the new supply, and/or those of HV and LV supplies.

There are three types of maximum demand:

1. ~~M~~maximum demand of an installation to size the main supply;
2. ~~M~~maximum demand to size switchgear assemblies and distribution arrangements within an installation; and
3. ~~M~~maximum demand of a final circuit to size final circuit conductors and overcurrent protection requirements.

Due to the wide range of commercial and industrial applications, the guidance in the IET *On-Site Guide to the Wiring Regulations* and IET Guidance Note 1: *Selection and Erection* is fairly limited, and the Designer will use estimation models and experience to determine maximum demand.

Due to the length of time the circuits are often used, unless load curtailment is adopted, it is recommended to assess circuits supplying EVSE at full load, for case (c3).

Cases (a1) and (b2) may depend on loads in the installation other than EV charging loads, and also on any local generation sources that will operate in parallel with the main supply. Where the installation predominantly serves EVSE, such as a dedicated supply for EVSE, or supplies to car parks and similar facilities, it is recommended to assess circuits supplying EVSE at full load unless load curtailment is used.

Where EVSE uses automatic import limitation for load curtailment, it shall comply with ENA Engineering Recommendation G100.

8.2 Earthing and protective equipotential bonding requirements

8.2.1 TT systems

For EV charging equipment installations that form part of a TT system, the charging equipment may be connected to the existing earth whether the charging equipment is installed within a building or not. The installer must confirm that the earthing and bonding arrangements meet the requirements of BS 7671 for a TT system, and that any deficiencies are rectified.

When there is an adjacent installation connected to a PME earth terminal, the vehicle charging equipment may be supplied from a TT supply, provided that:

(a) a risk assessment is undertaken to assess the possibility of simultaneous contact between any accessible conductive parts connected to a PME earthing arrangement, and:

(i)

any conductive parts connected to the main earthing terminal of the TT system, for example, the EV charging equipment, including the connecting point;

(i)

(ii) the vehicle on charge.

(b) suitable precautionary measures are put in place to prevent all such identified means of simultaneous contact, for example, by inserting a length of plastic pipe into a metal pipe, or by replacing a Class I luminaire with a Class II luminaire, etc.

Notes:

- (a) The written risk assessment document must in every case be included with the installation documentation (Installation Certificate, etc.). See Annex D Appendix D.
- (b) A suitable advisory label/warning notice must be provided at the origin of every circuit supplied from a TT system stating that this must not be connected to a PME earthing facility.

8.2.2 TN-S systems

Unless it can be guaranteed by the relevant DNO that the TN-S supply system is TN-S back to source and will not be converted to TN-C-S as part of any ongoing network upgrades, such installations shall be treated as TN-C-S systems (PME supply).

For EV charging equipment installations that are part of a guaranteed TN-S system of an installation, for example, where the charging equipment is supplied via an 11 kV transformer at the installation, the charging equipment may be connected to the existing earthing arrangement whether the charging equipment is installed within a building or not. The installer must confirm that the earthing and bonding arrangements meet the requirements of BS 7671 for a TN-S system, and that any deficiencies are rectified.

8.2.3 PME supply

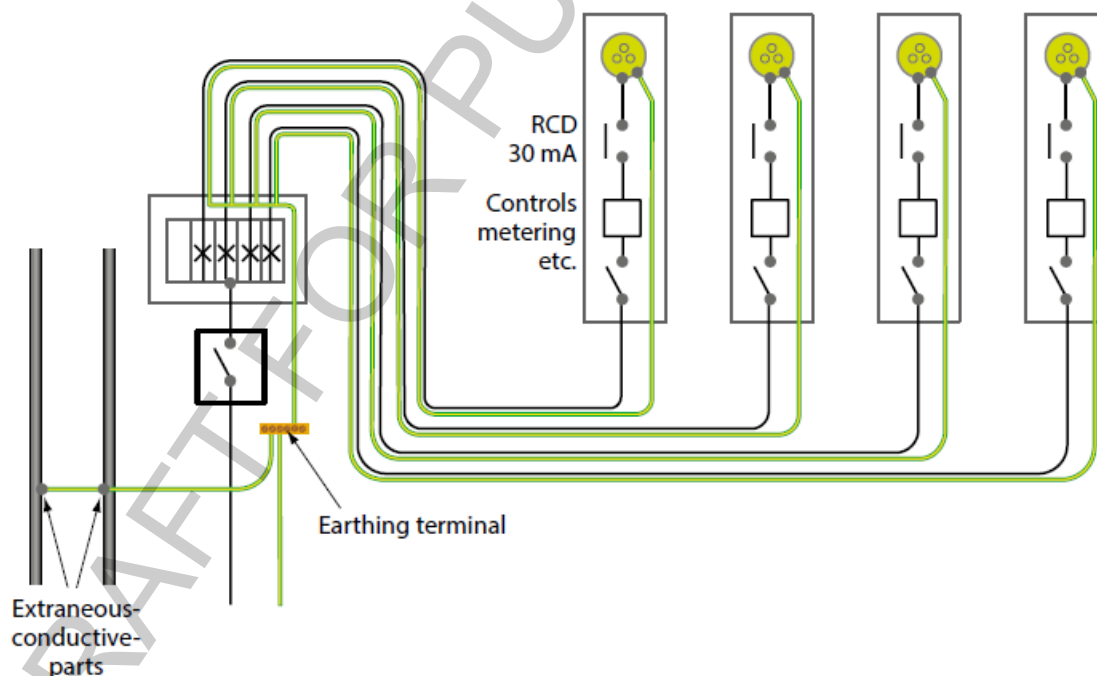
8.2.3.1 Inside buildings

For electric vehicle charging equipment installations supplied from installations with a PME supply (part of a TN-C-S system), the charging equipment may be connected to the PME earthing arrangements if the charging equipment is located inside the building and if it can be ensured that the vehicle being charged will always be within that same building (for example, an underground car park, multi-storey car park, and so on). It is necessary to ensure that the protective bonding provisions comply with the requirements of BS 7671 where PME conditions apply. Note in particular Regulations 411.3.1.2 and 544.1.1.

It will also be necessary to take care to balance the loading on the three phases of the installation so as to reduce touch voltages in the event of an open circuit in the PEN conductor of the supply.

[Figure 8.1](#) shows a typical enclosed car park installation with multiple charge points.

Figure 8.1 Typical enclosed car park installation with multiple charge points



8.2.3.2 Outside buildings

If the EV charging equipment and/or the vehicle being charged are located outside the building, BS 7671 imposes the particular requirements of Regulation 722.411.4.1.

Three-phase supplies

Regulation 722.411.4.1(i) can be met for three-phase supplies if the three phases are evenly loaded.

9.5.11 Electric Vehicle Charging Equipment

Where electric vehicle (EV) charging equipment is installed at filling stations reference shall be made to the latest edition of the IET *Code of Practice for Electric Vehicle Charging Equipment*.

Regulation 722.411.4.1

(i) The charging point forms part of a three-phase installation that also supplies loads other than for electric vehicle charging and, because of the characteristics of the load of the installation, the maximum voltage between the main earthing terminal of the installation and Earth in the event of an open-circuit fault in the PEN conductor of the low voltage network supplying the installation does not exceed 70 V rms.

Note: Annex 722, item A722.2 gives some information relating to (i).

Annex A722 of BS 7671 provides calculations to be used where the loading on the phases is balanced Annex J in this Code of Practice derives a rule of thumb which may be used where power factors on each phase are similar, and the effects of triple harmonics can be ignored.

Note: It is strongly recommended that this method is not used without suitable robust calculations to back up the load data. For existing installations, suitable data may include a 6-12 month load profile.

If in doubt, or where power factors in each phase are not similar, the maximum voltage between the MET of the installation and Earth in the event of an open-circuit fault in the PEN conductor of the low voltage network that supplies the installation must be calculated using Millman's Theorem, to determine that it is unlikely to exceed 70 V rms. The effects of triple harmonics should also be considered.

Note: In this case, a suitably modelled new installation may well have this data to hand, but it is unlikely to be practicable for many existing installations.

Alternatively, a charging point or protective device meeting 722.411.4.1 (iii) may be used. The manufacturer's installation instructions should be followed. Where the device uses a measurement earth electrode, see Annex I.

Note: When an open PEN protection is used, additional bonding downstream of the protection device, to parts or conductors connected to the PME earthing system should not be fitted, as this will defeat the open PEN protection.

Single-phase supplies

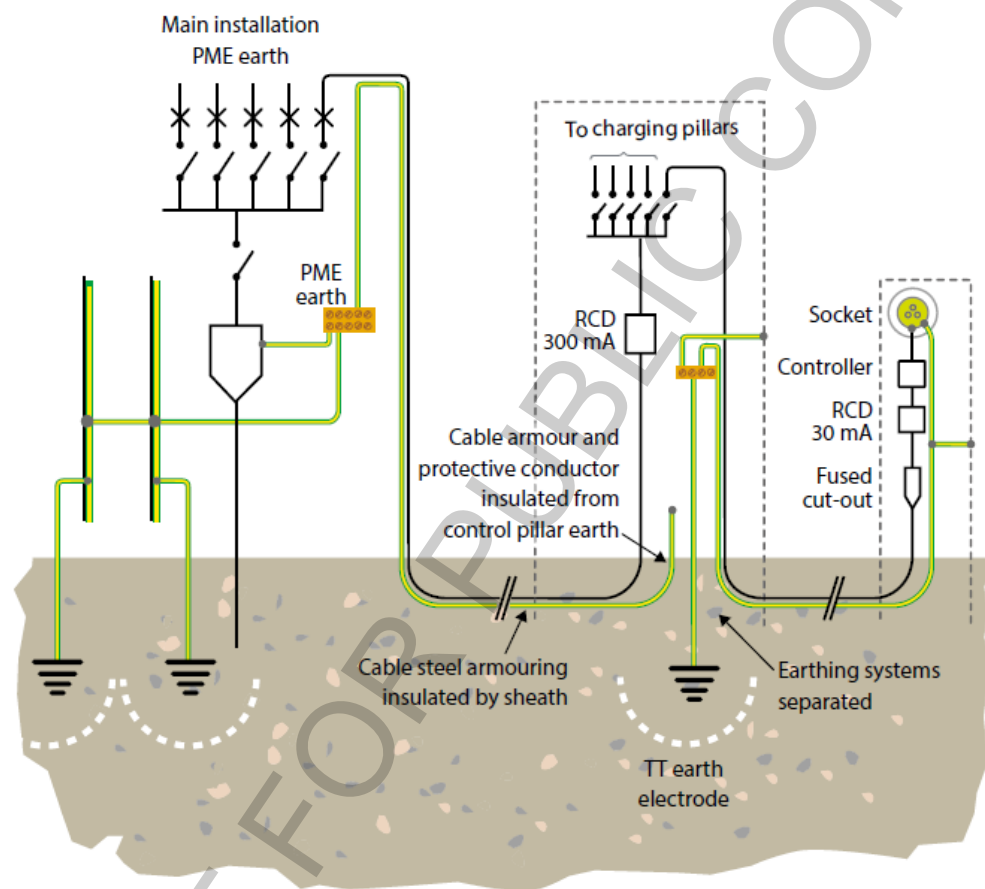
A charging point or open-PEN protective device meeting 722.411.4.1 (iii), (iv) or (v) may be used. The manufacturer's installation instructions should be followed.

NoteNOTE: When an open PEN protection is used, additional bonding downstream of the protection device to parts or conductors connected to the PME earthing system should not be fitted, as this will defeat the open PEN protection.

If the installation is associated with a building that has a substantial steel structure in contact with Earth, suitable to act as an earth electrode, then the approach in 722.411.4.1 (ii) could be used, although this will be rarely possible due to the low resistances required (see Appendix FAppendix F).

Figure 8.2Figure 8.2 shows a typical open-air car park installation utilizing a separate, dedicated TT earthing system.

Figure 8.2 Typical open-air car park installation utilizing a separate, dedicated TT earthing system



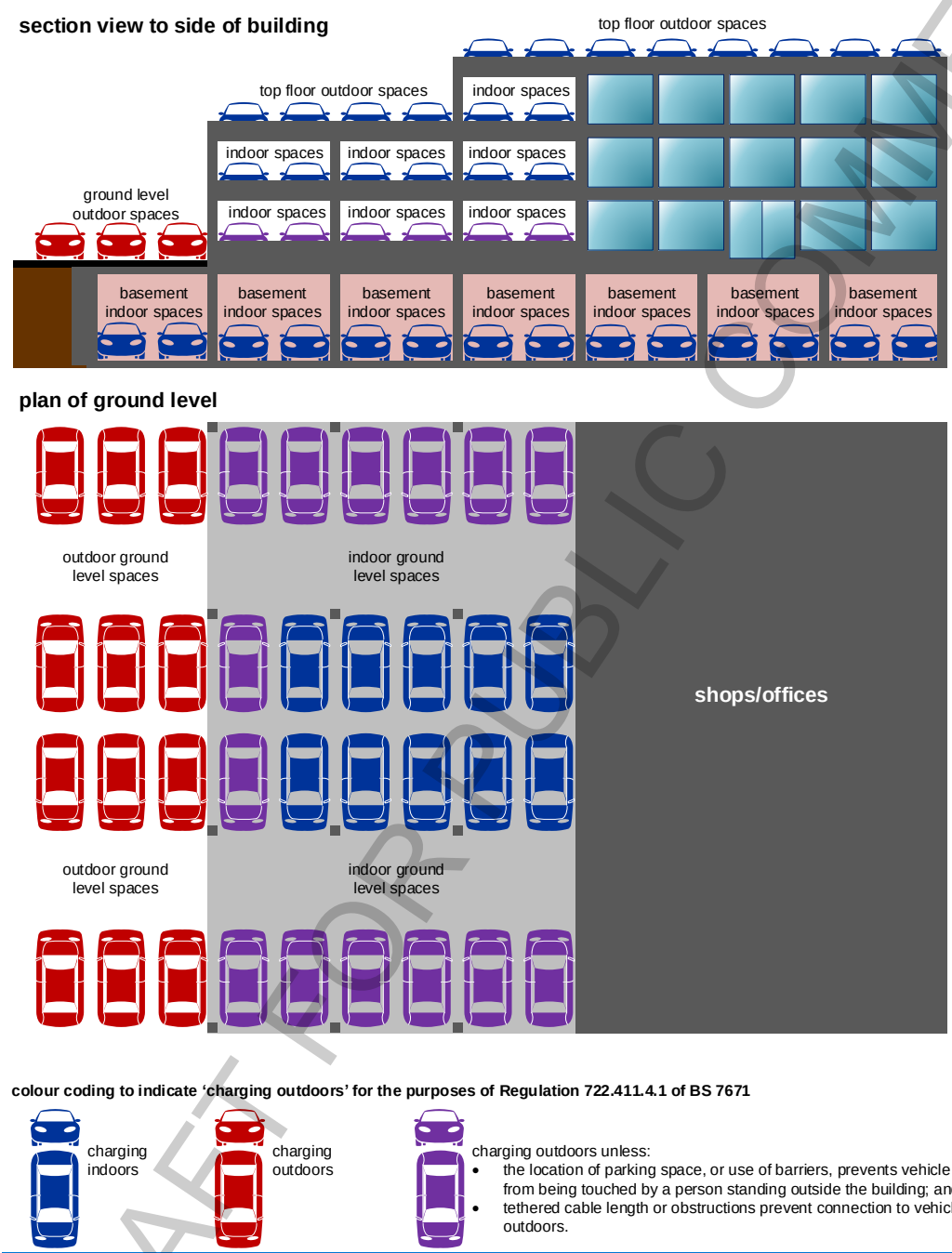
8.2.3.3 Multistorey car parks and buildings with a combination of indoor and outdoor car parking arrangements on different floors

In a number of built environments, vehicles may be parked either indoors or outdoors, and on different levels of the structure. Whether a parking space is considered 'charging outdoors' the purposes of Regulation 722.411.4.1 of BS 7671 help determine if special provisions are necessary to utilize a PME earthing arrangement for charging points.

As discussed in Section 5.3.15.3.1, Regulation 722.411.4.1 is concerned with situations where the vehicle body may be at a different potential to the feet of a person touching the vehicle. If

the vehicle and adjacent purpose are both on a surface within the influence of the main protective bonding of a building, such as a storey, basement, or outdoors on an upper storey, of a building, this is effectively 'charging indoors'. This is illustrated in Figure 8.3

Figure 8.3 Examples of vehicle spaces considered to be indoors or outdoors for the purposes of Regulation 722.411.4.1



NOTES: 1. 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'.

2. Where vehicles charging indoors and outdoors have different earthing arrangements, and where vehicles charging outdoors are close to exposed-conductive-parts or extraneous-

[conductive-parts connected to a different earthing arrangement, a simultaneous contact assessment is required.](#)

8.3 Requirements for circuit design, cable selection and dimensions

8.3.1 BS 7671 compliance

The electrical circuit supplying the EV charging equipment shall comply with the requirements of BS 7671, in particular, Section 722.

8.3.2 Circuit design [\(Regulation 722.533.101\)](#)

EV charging equipment installations shall be wired as part of a radial system.

A separate, dedicated electrical circuit, [with its own overcurrent protective device](#) shall be provided for the EV charging equipment. However, more than one piece of EV charging equipment may be fed from the same supply circuit, provided that the combined current demand of the equipment does not exceed the rating of the supply circuit ~~—(Regulation 722.311).~~

[Where EVSE uses automatic import limitation for load curtailment, it shall comply with ENA Engineering Recommendation G100.](#)

8.3.3 Cable selection

The cable type and csa for the EV charging equipment circuit shall be chosen to ensure compliance with the requirements for:

- (a) protection against electric shock (refer to Section 5.5);
- (b) overcurrent protection (Chapter 43 of BS 7671); and
- (c) voltage drop (Section 525 of BS 7671).

Final circuits should not have diversity applied, unless automatic controls curtail the maximum demand of the individual circuit.

When specifying the cable sizes for use in the EV charging equipment circuit, reference shall be made to either Appendix 4 of BS 7671, which gives current-carrying capacity and voltage drop for cables, or manufacturer's data.

8.4 Protection against electric shock

As required by BS 7671, basic protection against electric shock shall be provided by automatic disconnection of supply or electrical separation.

8.4.1 Automatic disconnection of supply

Where automatic disconnection of the supply is used to provide protection against electric shock for the EV charging equipment circuit, compliance with Section 411 of BS 7671 shall be ensured.

8.4.2 Additional protection

Additional protection shall be provided by the fitment of RCDs as specified in Section 8.5.

8.5 Requirements for the provision of RCDs (Regulation 722.531.2)

8.5.1 RCD specification

Every AC charging point shall be protected by a 30 mA n RCD with residual current rating ($I_{\Delta n}$) not exceeding 30 mA. Dedicated EV charging equipment should incorporate such an RCD, with, where required, an RDC-DD, but the installer shall confirm this.

8.5.2 Co-ordination (selectivity)

There shall be co-ordination (selectivity) between any RCD installed at the connecting charging point or incorporated in the charging equipment and the protection at the origin of the circuit.

8.5.3 RCD protection (Regulation 722.531.2.101)

Every AC charging point shall be individually protected by an RCD ~~having the characteristics specified in Regulation 415.1.1~~ with residual current rating ($I_{\Delta n}$) not exceeding 30 mA. The RCD shall disconnect all live conductors, which, in accordance with the definitions of Part 2 of BS 7671, includes the neutral conductor.

The RCD protecting the charging point shall be a Type A RCCB complying with BS EN 61008-1 or RCBO complying with BS EN 61009-1, or a Type F RCCB to BS EN 62423. If it is known that the DC component of the residual current exceeds 6 mA then a Type B RCD that complies with BS EN 62423 shall be installed.

For charging in Modes 3 or 4, the equivalent of Type B RCD protection is required – either by use of a Type B RCD or by a Type A or Type F RCD plus an additional DC protection device to BS IEC 62955. Some charging equipment may incorporate DC fault protection and thus be compatible with a Type A or Type F RCD in the consumer unit.

~~For charging in Mode 2, Type A or Type F RCD protection is permitted, as DC fault protection is provided by the ICCB.~~

8.6 Requirements for isolation and switching

8.6.1 Emergency switch (Regulation 722.537.4)

Because all EV charging equipment and connecting points are required to be protected by a 30 mA RCD, an emergency switch is not usually required. However, the particular needs of the installation and the charging equipment manufacturer's instructions shall be considered. For instance, a readily accessible means of switching off the charging equipment shall be provided when the vehicle is to be charged within the confines of a single garage. If an emergency switch is provided, it shall be located in a position that is readily accessible, shall be suitably identified by marking and/or labelling and shall disconnect all live conductors, including the neutral.

8.6.2 Isolation

A means of isolating the EV charging equipment circuit shall be provided, in accordance with Regulation 537.2 of BS 7671. This isolating device ~~shall~~ should be located in a position that is readily accessible for maintenance purposes and ~~shall be~~ suitably identified by marking and/or labelling. It may be necessary to locate the means of isolation so that it is behind a panel or door accessible by a key or tool, provided that panel or door does not give access to any equipment that is not protected by barriers, obstacles, or similar, offering a degree of protection at least IP2X / IPXXD.

8.6.3 Functional switching

Additional forms of switching for functional purposes may be required, for example, to prevent the unauthorized use of socket-outlets located outside buildings that may be accessible to the public. These shall be discussed and agreed with the client.

8.7 IP ratings

8.7.1 IP rating of charging equipment (Regulation 722.512.2)

The EV charging equipment being installed shall have an IP rating suitable for the proposed installation location. For example, charging equipment that is to be installed in an outdoor location shall have an IP rating of at least IP44.

8.7.2 IP rating of installation components

The installer shall ensure that any connectors, glands, conduits, etc. used to connect the power supply to the EV charging equipment are of an appropriate IP rating, and are installed in such a way as to maintain a suitable IP rating, in accordance with BS 7671.

8.7.3 Impact

See Section 8.108.10 EV charging equipment installed in publicly accessible locations, for example, car parks, shall be protected against a minimum impact severity of AG2, as defined in Appendix 5 of BS 7671.

8.8 Lightning and surge protection systems

Where a building has a lightning protection system, reference shall be made to BS EN 62305 and Regulation 411.3.1.2 of BS 7671.

Where surge protection is provided as part of the overall lightning protection system, any power and data cables serving charging points intended for charging vehicles outside existing premises may require surge protection devices.

8.9 Accessibility

All charging points associated with commercial and industrial installations with socket-outlets or tethered cables shall be mounted so that the heights in Section 4.54.5 are observed, and so that tethered leads will not cause a trip hazard in use or storage.

Where Mode 4 EVSE with ACDs, or MF-WPT charging equipment, is installed, any controls controls, indications and displays intended for operation from ground level shall be mounted so that the heights in Section 4.54.5 are observed.

NOTE: Some MF-WPT or Mode 4 ACDs with ACDs may have controls and indications within the vehicle, or that may be required to be viewed by a driver from within the vehicle.

Mechanical protection shall be considered when assessing accessibility.

Accessible conductive charging points, particularly those accessible by the public, for example in public car parks, shall be selected and installed to comply with PAS 1899 (see Section 4.5.34.5.3).

8.10 Mechanical protection

To comply with BS 7671, charging equipment associated with commercial and industrial installations shall either meet the impact requirements of IK08, or be protected by impact barriers, unless it is possible to install the EVSE in a location where accidental vehicle impact is not possible.

For publicly accessible EVSE, Clause 8.2.1.702 of BS EN IEC 61439-7 requires a minimum mechanical impact resistance classification of:

(a) high impact resistance classification, for EVSE that is ground-mounted, or wall-mounted where any part of the EVSE is at a height of less than 0.9 m from the ground or finished floor; or

(b) medium impact resistance, for EVSE that is wall-mounted, and all parts of the EVSE are at a height of at least 0.9 m from the ground or finished floor.

NOTE: Section 5.8.35-8.3 provides a description of the three resistance to mechanical impact classifications to BS EN IEC 61439-7.

For other EVSE in commercial or industrial applications, the same impact resistance classifications are recommended, or barriers installed to provide equivalent protection against mechanical impact.

8.11 Fire safety considerations for provision of EVSE

The fire safety strategy of the premises should consider relevant control measures required for the location of EVSE. This should be assessed in conjunction with the client and operator of the site for commercial and industrial EVSE installations.

RISCAuthority RC59 Recommendations for fire safety when charging electric vehicles provides guidance and a checklist for some issues to be considered. These may not be the only considerations, and may not be appropriate for all installations, and the designer/installer are advised to review fire safety provisions with the cClient and/or operator of the installation, who are in turn advised to consider the requirements of their insurer, and compatibility with the fire risk assessments and fire safety strategy for the premises. For some installations it may be necessary to consult a fire safety specialist.

9 Inspection, testing and maintenance requirements

9.1 BS 7671

During and on completion of the installation, and before being put into service, the installation shall be inspected and tested to verify that it complies with BS 7671 and the charging equipment manufacturer's instructions.

On completion, an Electrical Installation Certificate, together with schedules of inspection and schedules of test, shall be given to the client.

Periodic inspection and testing shall be carried out in accordance with BS 7671. Guidance on initial verification and periodic inspection and testing is given in IET Guidance Note 3: *Inspection & Testing*. Upon completion of a periodic inspection, an Electrical Installation Condition Report should be issued (see Regulation 653.1 and Appendix 6 of BS 7671).

Inspection, testing and maintenance requirements for filling station installations should comply with the APEA/EI publication *Design, construction, modification, maintenance and decommissioning of filling stations*.

NOTE: Instruments to BS EN 61557 series that monitor for earth voltage rise during testing should have the limit set to 25 V, rather than 50 V, for testing at fuel filling stations.

9.2 EV charging equipment functional checks

The correct functioning of the charging equipment shall be verified.

Where controls from a filling station emergency switching system are provided, these shall be verified as operational.

9.3 Customer care

The correct operation of the charging equipment shall be demonstrated to the client.

9.4 Maintenance

The client shall be provided with the instruction manual for the equipment. Inform the client of any maintenance requirements for the equipment and of the need to add the equipment to any existing maintenance schedules.

9.5 Frequency of inspection and test

Charging equipment installations should be routinely checked, inspected and tested in accordance with the charging equipment manufacturer's recommendations. In the absence of any manufacturer's recommendations, inspection and testing should be undertaken with the frequency recommended in IET Guidance Note 3: *Inspection & Testing*, for the particular installation type.

For filling stations, refer to the APEA/EI publication *Design, construction, modification, maintenance and decommissioning of filling stations*.

9.6 Particular considerations for initial and periodic verification in accordance with BS 7671

9.6.1 Insulation resistance tests

Installations incorporating EVSE, and connected vehicles, naturally contain a lot of electronic equipment. BS 7671 and IET Guidance Note 3: *Inspection and Testing* recommend that:

- (a) Cables of the fixed installation are tested during installation, prior to connection of live conductors for the first time (but after connection of protective conductors) at the relevant voltage, usually 500 V DC for 400/230 V systems.
- (b) following connection in the installations, during initial and periodic verification, tests are carried out between coupled live conductors and Earth, at 250 V DC.

The minimum value of insulation resistance in both cases is 1 MΩ.

9.6.2 Earth electrode tests

Regulation 643.1 of BS 7671 requires that earth electrodes are tested in accordance with Regulation 643.7.2 before the installation is energized. This test would also be recommended if the installation is re-energized following additions or modifications, particularly of the earthing arrangements.

Earth electrode tests will also be required where earth electrodes are provided for Mode 4 EVSE that incorporates separation (see Appendix J).

The 'two-clamp method' illustrated in Figure 9.1 (Test Method E2 using two coils as described in Section 2.6.13 of IET Guidance Note 31: *Selection and Erection*) whilst indicating a reading higher than the actual earth electrode resistance, enables the test to be carried out without hazardous voltages and currents being present. It is possible to use this method in situations where it is not possible to use multi-stake or clamp-and-stake methods due to lack of sufficient open ground, or interference by buried metallic services etc.

NOTE: Instruments to BS EN 61557 series that monitor for earth voltage rise during testing should have the limit set to 25 V, rather than 50 V, for testing at fuel filling stations.

The test will only work if there is at least one other path through the general mass of Earth back to the installation main earthing terminal (MET). This may be provided by:

- (a) Extraneous-conductive-parts;
- (b) the distributor's means of earthing; or
- (c) temporary earth electrodes connected for the measurement.

The instrument reading obtained will always be higher than the actual earth electrode resistance:

$$R_{\text{reading}} = R_E + \frac{1}{\frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_n}}$$

where:

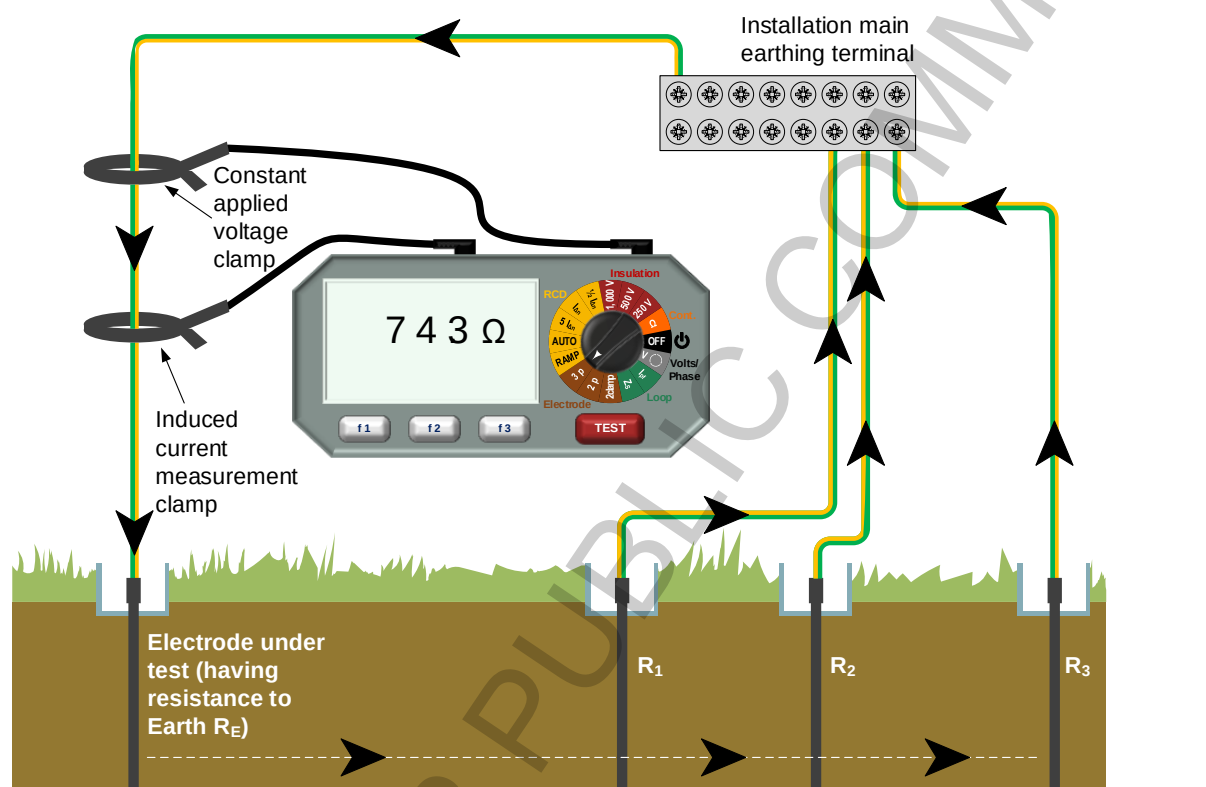
R_{reading} is the resistance reading given by the test instrument

R_E is the actual resistance of the earth electrode under test

$R_1, R_2, etc.$ Are the resistances of the other 'earth electrodes' forming the parallel return paths

This is not an issue for initial and periodic verification, because the objective of the test is to verify that the measured resistance is less than or equal to a maximum resistance value.

Figure 9.1 The two-clamp method of earth electrode testing



NOTE: Instruments to BS EN 61557 series that monitor for earth voltage rise during testing should have the limit set to 25 V, rather than 50 V, for testing at fuel filling stations.

9.6.3 Testing at Mode 3 EVSE socket-outlets or tethered cable vehicle connectors

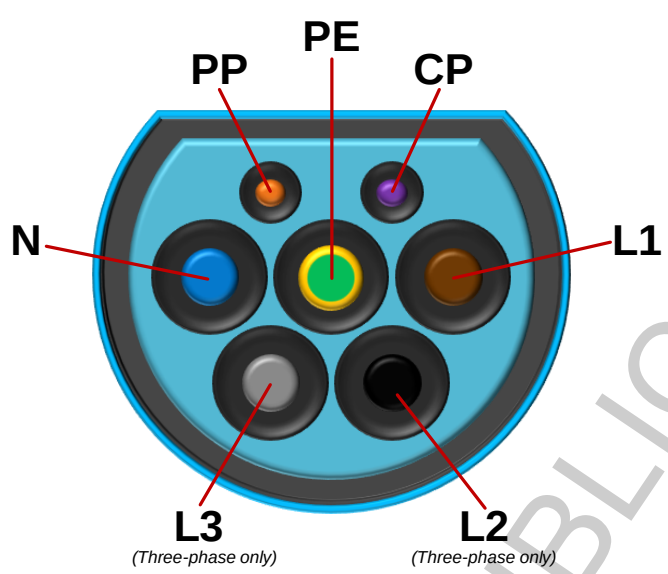
It may be necessary to conduct certain tests, for example, those for earth fault loop impedance and functional testing of RCDs, at the vehicle connectors of EVSE.

EVSE will not connect live conductors, that is line(s) and neutral, to the outlet or connector, until the EVSE has completed the relevant 'handshaking' with a vehicle using the pilot connectors. Where tests are required to be performed at energized socket-outlets or vehicle connectors supplied from EVSE, a 'vehicle simulator' and appropriate test equipment and test leads meeting the criteria in Health & Safety Guidance Note GS38, should be used. Commercial versions are readily available, which provide a BS EN 61936-2 Type 2 socket-outlet and/or shrouded 4 mm test equipment sockets which can be used with electricians' test equipment, or further adaptors for test.

Vehicle simulators are required to test prospective fault current, earth fault loop impedance, and RCD functionality at the outlet or connector. Vehicle simulators should be used in accordance with the manufacturer's instructions for both the simulator and EVSE.

NOTE: Instruments to BS EN 61557 series that monitor for earth voltage rise during testing should have the limit set to 25 V, rather than 50 V, for testing at fuel filling stations.

Figure 9.2 Pin designations for a BS EN 61936-2 outlet on EVSE, or at the vehicle end of a tethered cable



9.6.4 Determination of earth fault loop impedance and prospective fault current in PEIs

It should be noted that earth fault loop impedance and prospective fault current measurements may be distorted by the presence of local inverters (connected to V2G/V2H EVSE, solar PV, battery storage, and so on).

NOTE: See BS 7671, Regulation 826.7 and -NOTE 1 to Regulation 643.7.3.1.

This may be due to the following:

- (a) when testing in island mode; an inverter may appear to act as a constant current source, and indicate a far higher than usual prospective fault current and a far lower than usual loop impedance value, if tests are carried out at currents below the sum of the current limits of the inverters connected at the time of the test. If these tests are carried out in island mode, particularly where inverter output currents are of the order of 16 A or less, the tests may not provide an adequate reading before inverter current limit protection operates; and
- (b) when testing in connected mode; the inverter output tracks the change in supply voltage during a prospective fault current or earth fault loop impedance test, so the contribution to prospective fault current from the inverter may not be detected by the test instrument.

3016 It is therefore strongly recommended that:

3017 (a) external earth fault loop impedance and prospective fault current measurements to
3018 determine Z_e are carried out at the origin of a PEI, with inverters isolated.

3019 (b) earth fault loop impedance and prospective fault current measurements for the remainder
3020 of the PEI are not taken unless all the inverters in the system are isolated. In order to
3021 provide verification for automatic disconnection of supply, the following can be used:

3022 **i. for PEI connected mode operation:**

3023 the verification of earth fault loop impedance (Z_{DB} and Z_S) is based on the external earth
3024 fault loop impedance, Z_e , plus measured (R_1+R_2) values. Prospective fault current should
3025 be the measured prospective fault current plus the sum of the current limit of all
3026 connected-mode inverters.

3027 **ii. for PEI island mode operation:**

3028 if applicable, verification of earth fault loop impedance (Z_{DB} and Z_S) is determined using
3029 measured (R_1+R_2) values, plus the manufacturer's information regarding the value of Z_e
3030 to be assumed for the relevant PCE within the installation. Prospective fault current
3031 should be the sum of the current limit of all inverters connected in island mode.

3032 **NOTE:** Instruments to BS EN 61557 series that monitor for earth voltage rise during testing should have the limit
3033 set to 25 V, rather than 50 V, for testing at fuel filling stations.

3034 **9.5.19.6.5 RCD testing**

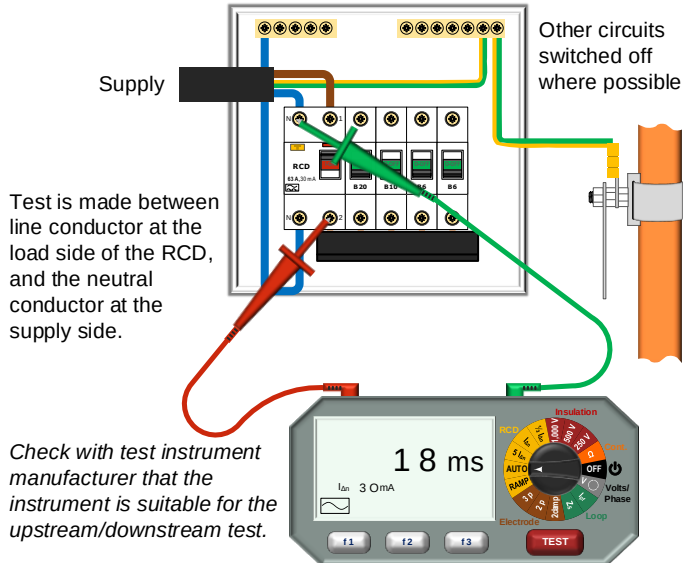
3035 Installations of EV charging equipment may occasionally have 'cascaded' RCDs, where there
3036 is insufficient, or no, selectivity between an upstream and downstream RCD. The probability
3037 of this occurring increases if the vehicle is to remain connected in a PEI in island mode.

3038 The 9th Edition of Guidance Note 3: *Inspection and Testing* includes a second method for
3039 testing RCDs in this situation, known as the 'upstream/downstream' method. The
3040 upstream/downstream method for RCD testing will prevent unwanted operation of an
3041 upstream RCD during RCD tests and enables the downstream RCD to be tested without
3042 bridging out the upstream RCD.

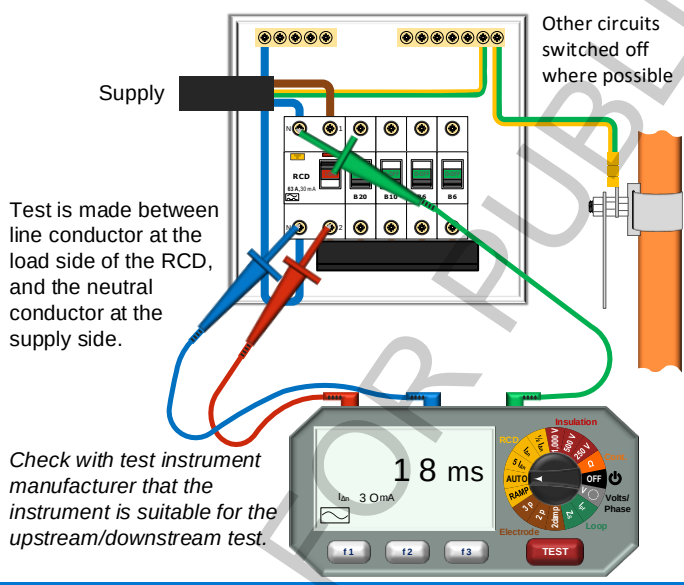
3043 **NOTE:** Instruments to BS EN 61557 series that monitor for earth voltage rise during testing should have the limit
3044 set to 25 V, rather than 50 V, for testing at fuel filling stations.

Figure 9.3 The upstream/downstream method for RCD testing

a. 2-lead test (where supported by test equipment)



b. 3-lead test



NOTE 1: The instrument, test leads, and probes, must be rated for the line-to-line voltage of the three-phase system at appropriate overvoltage category.

NOTE 2: This example is included to illustrate the principles only. The person carrying out the test should take all practicable steps to avoid the risk of contact with live parts. The test should only be performed with covers removed, in equipment where all line conductors have basic protection by either insulation, or barriers or enclosures achieving IP2X/IPXXB.

The client shall be advised that all RCDs of the installation should be tested at least every six months (by pressing the test button).

10 Vehicle as storage

10.1 Scope

This ~~section~~ Section concerns EVs that use their energy storage capacity for non-traction purposes, typically in controlled locations with known vehicles connecting to the charging equipment.

NOTE~~ete~~: Installations where more than one vehicle is used to support energy storage could require additional, perhaps complex, design considerations, which are outside the scope of this Code of Practice.

This ~~section~~ Section is intended to be read in conjunction with the IET *Code of Practice for Electrical Energy Storage Systems*.

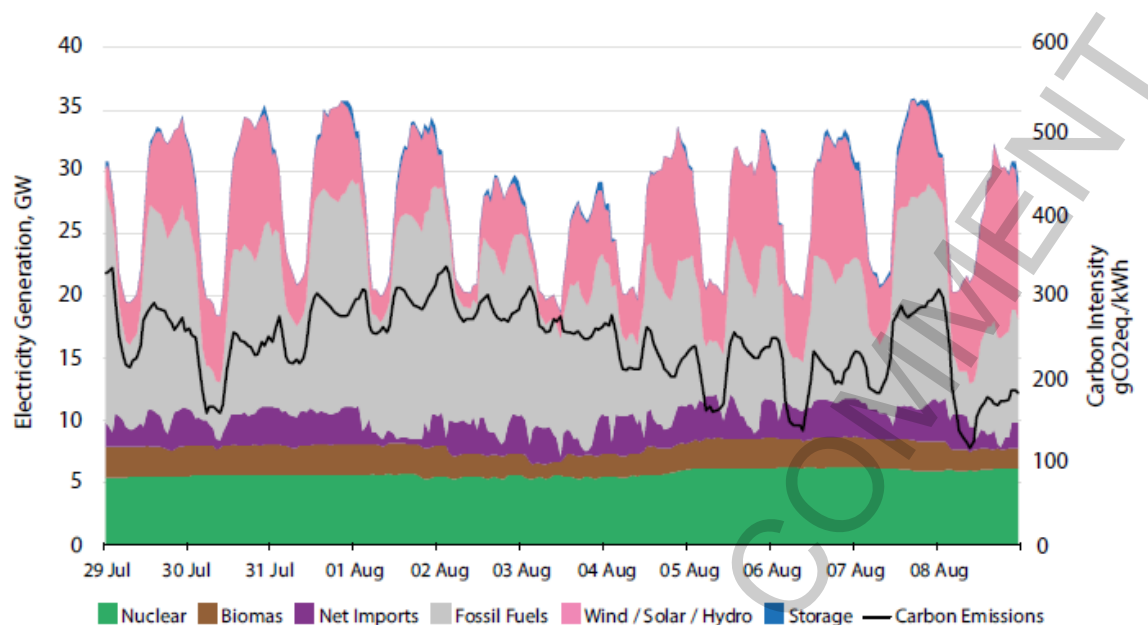
Vehicle as storage may be referred to in the industry by other terms, including 'vehicle to grid' (V2G), 'vehicle to home' (V2H), ~~ete~~both now being encompassed under a general term 'V2X' which is also used to cover other grid-connected vehicle as storage applications.

10.2 Background

10.2.1 EVs and the grid

Decarbonization will shift a higher proportion of our energy requirements onto the electricity network, including through the significant electrification of the transportation and heating sectors. Decarbonization of transport using batteries is part of that journey and it brings flexibility in terms of when and how much electricity is used to charge vehicle batteries. Utilizing that flexibility correctly can reduce the cost of vehicle charging by taking advantage of cheaper energy; the vehicle charging rate and timing also affects the carbon intensity and generation mix of electricity. This is particularly true as an increasing amount of electricity is generated using variable low-carbon sources like wind and solar (see ~~Figure 10.1~~Figure 10.1). In addition, energy stored in ~~Evs~~ EVs has the opportunity to help cover energy peaks, which in turn, mitigates network reinforcement costs and associated delays in implementation.

Figure 10.1 British electricity mix in Summer 2019 (Source MyGridGB, Elexon, Sheffield Solar)



The future electricity mix will see increasing generation from low-carbon sources and potentially increased electricity demand due to EVs.

There is also an opportunity to flexibly discharge some battery capability in vehicles to support the electricity grid, particularly if EVs include considerably more energy storage capability than is required to meet day-to-day travel needs. Energy in batteries is already discharged back to the grid to increase power system resilience, such as providing frequency response and back-up for when major power stations fail.

It is worth remembering that if just 10 % of the battery capacity in a million modern electric cars was made available to the grid in the future, it would have seven times more energy available than the Cruachan pumped hydro scheme. This indicates how EVs might be useful in the future national energy system. An overview of some of the different ways that this charge/discharge can be used is provided in [Table 10.1](#).

Table 10.1 Examples of vehicle-to-grid (V2G) services

Service category	Description
Ancillary services	Services used to maintain power quality. For example, frequency response and power system reserve (procured by the electricity system operator directly or through third-party aggregators).
Energy matching/trading	Selective charging/discharging of the EV battery in line with price signals, peak demands or the carbon intensity of electricity.
Behind the meter service	Services that provide benefits directly to consumers. For example, charging an EV battery from behind the meter solar generation or using the EV battery to provide back-up power to a consumer during a power outage.

Network services	Using the vehicle charging or discharging to support the cables and substations of the electricity network, for example, to reduce peak loads and therefore reduce investment needs for electricity distribution.
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10.2.2 Enabling vehicle as storage

Vehicle as storage services are enabled when a combination of factors allow this. These factors include, but are not limited to, the functionality of the vehicle enabled by the manufacturer, the state of the vehicle battery's charge, the choices of the vehicle owner or user, the availability of these services at a particular location and the commercial models under which the vehicle is charged or owned.

Regardless of any of these factors, suitable charging infrastructure is needed to enable vehicles as storage. Therefore when working on EV charging infrastructure, it is important to ensure that vehicle as storage factors are considered in design, installation and operation (as outlined in this Code of Practice), particularly if it is desired to future-proof that infrastructure for vehicle as storage.

10.3 Overall system design considerations

Due to the potential for two-way power flows, some charging infrastructure types must be considered as potential consumers and generators of electricity.

Many of the considerations for vehicle as storage overlap with the IET *Code of Practice for Electrical Energy Storage Systems* (and subsequent documentation). This is because, like storage, vehicle charging needs to be designed to consume electricity from the supply and also, potentially, to feed that electricity back through the supply.

Accordingly, regulations, protection and design practices for generation and loads need to be applied.

The following ~~sections~~ Sections of the IET *Code of Practice for Electrical Energy Storage Systems, 2nd Edition* will help the designer to consider whether it is appropriate to provide vehicle as storage for a particular installation:

- Section 3 ~~System~~ EESS components and architectures
- Section 4 ~~EESS~~ System operating states and applications
- Section 6 ~~System~~ Other EESS components
- Section 7 ~~EESS~~ s Safety and planning considerations
- Section 8 ~~Specification of an EESS~~ Overall system specification, including sizing considerations
- Section 9 Design ~~for electrical safety~~ of an EESS

10.4 Isolation and switching off for maintenance

10.4.1 Hazards associated with multiple sources of supply

An installation containing an electrical energy storage system (EESS), including ~~vehicle-to-grid~~ V2G systems, will have parts of the installation that might be supplied by at least two sources. Isolation procedures for those parts of the installation may not always be simple.

It is imperative that those working on the installation can clearly and easily identify the device(s) required to isolate the part(s) of the installation they are working on, and are aware of the safe working procedures required to protect themselves and others from electric shock.

10.4.2 Isolation and switching off for maintenance in dwellings

In a dwelling, there should ideally be a single point of isolation that removes power from all final circuits in the installation. For types of installation supplied by single-phase supplies, BS 7671 requires a main isolator to disconnect all live conductors (i.e., both line and neutral).

10.4.3 Isolation and switching off for maintenance in other types of premises

The Electricity at Work Regulations 1989 apply. The HSE publication HSG85 *Electricity at work: Safe working practices* provides guidance on these matters.

10.4.4 Isolation using multiple devices

Parts of the installation not capable of being isolated by a single device will require a warning notice in accordance with Regulation 537.1.2 of BS 7671. All isolators should have their function clearly marked in accordance with Regulation 537.2.7 of BS 7671.

10.5 Special considerations for vehicle to grid V2G services

10.5.1 Multiple sources of generation

A vehicle as storage installation could (from installation or during its operational life) form part of an overall energy management and renewable generation strategy for a particular electrical installation. Where this is the case, the vehicle power converting equipment (PCE) may operate in parallel with other generators, such as renewable generation and/or electrical energy storage.

Careful systems integration design is required to ensure that all energy systems work together in a rational form. For example, power from a vehicle as storage system might not normally be used to charge other energy storage systems in the installation.

All sources of generation that are connected (whether in parallel operation or island-mode operation) may contribute to faults.

Only a single neutral-earth bond should be in place at any one time. In parallel operation, DNO notification requirements are based on the total generation capability of the installation, and not just the new generation added to the installation.

10.5.2 DNO notification for generation

DNO notification will be required when a vehicle as storage system is installed that can operate in parallel with the grid supply (i.e. as a generator). The notification requirements are in accordance with the following ENA Engineering Recommendations:

- (a) G98 — *Requirements for the connection of Fully Type Tested Micro-generators (up to and including 16 A per phase) in parallel with public Low Voltage Distribution Networks on or after 27 April 2019; and*

(b) G99 —Requirements for the connection of generation equipment in parallel with public distribution networks on or after 27 April 2019.

The actual requirements will depend on the total generation at the site that operates in parallel with the grid supply. Some systems require prior notification. (See Section 11 for further information.) Information is also available via the ENA, for example, at <https://www.energynetworks.org/operating-the-networks/connecting-to-the-networks/> <https://www.energynetworks.org/operating-the-networks/connecting-to-the-networks/> <https://www.energynetworks.org/electricity/futures/electric-vehicles-and-heat-pumps.html>.

10.5.3 Electrical considerations for parallel operation

The IET Code of Practice for Electrical Energy Storage Systems recommends that the designer considers:

- (a) addressing the installation design to ensure that the storage so that it does not impact on the safety of the installation in parallel mode;
- (b) checking that RCDs are compatible with the inverters;
- (c) the additional fault currents the inverter contributes, for both fault current protection and thermal effects (Chapters 42 and 43 of BS 7671);
- (d) the effects of the inverter on overload protection for circuits in the installation, in accordance with Regulation 551.7.2 of BS 7671; and
- (e) Additional ratings of components to enable potentially higher currents and different power flows.

Vehicle as storage inverters shall not be installed downstream of RCDs providing additional protection or fault protection to multiple final circuits. In installations where RCDs are used to provide fault protection for distribution circuits, such as in TT installations, a suitably rated RCD shall additionally be provided on the output of the inverter.

The DNO must ensure that the statutory voltage is maintained. If a capacity of generation greater than the customer's export capacity is installed, the DNO is required to undertake ENA Engineering Recommendation G100 assessments to ensure that voltage excursion during the operating time of the limitation scheme is <1 % above statutory voltage and that the cut-out fuse or air circuit breaker (ACB) does not operate.

10.5.410.5.3 Enabling vehicle as storage services

The mechanisms required to activate, control and leverage value from all vehicle to grid V2G services (such as those listed in Table 10.1Table 10.1) will have bespoke requirements. At the very least, designers should consider the following:

- (a) the metering configuration and types required to ensure accurate and compliant billing;
- (b) the data connections and instrumentation required to control, activate or monitor services between the vehicle and the charging equipment, within the charging equipment and to external communication systems;

- (c) the electrical safety, wiring and protection requirements as outlined in this [Section](#);
- (d) how services are enabled, for example, how the charging schedule may be enabled through the charger and/or the vehicle [e](#); [and](#); [and](#)
- (e) special considerations for island-mode operation (see [Section 10.7.3](#)).

10.6 Electrical considerations for parallel operation

The IET Code of Practice for Electrical Energy Storage Systems recommends that the designer considers:

- (a) addressing the installation design to ensure that the storage so that it does not impact on the safety of the installation in parallel mode;
- (b) checking that RCDs are compatible with the inverters;
- (c) the additional fault currents the inverter contributes, for both fault current protection and thermal effects (Chapters 42 and 43 of BS 7671);
- (d) the effects of the inverter on overload protection for distribution boards and circuits in the installation, in accordance with Regulation 551.7.2 of BS 7671 (see [Figure 10.2](#)); and
- (e) Additional ratings of components to enable potentially higher currents and different power flows.

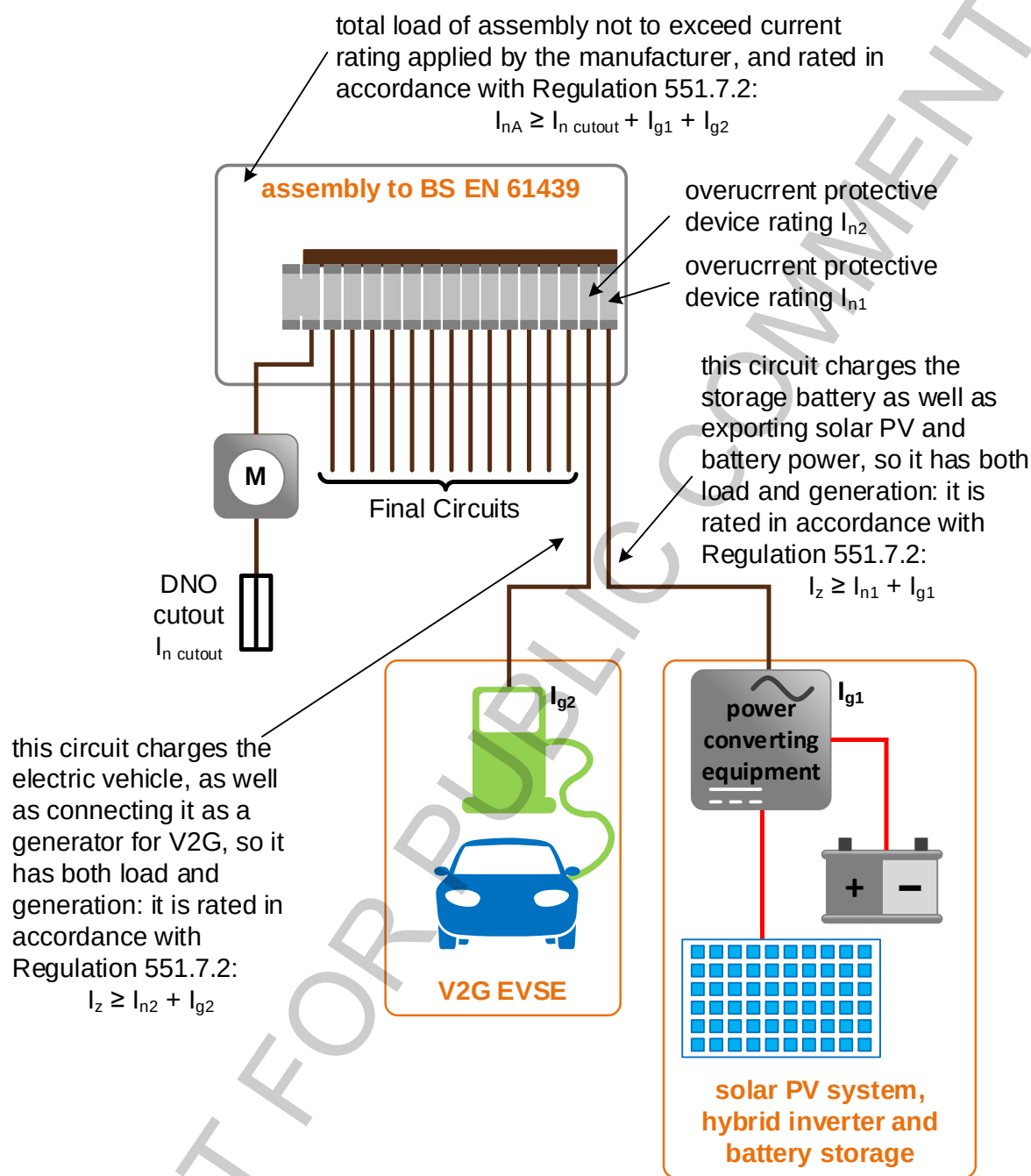
The voltage drop between an inverter and the grid connection point (sometimes termed 'voltage rise') when the inverter is exporting should be kept as low as possible. In all cases, the inverter manufacturer's instructions shall be followed, as exceeding these limits may lead to instability or excess harmonics. In domestic installations, it is strongly recommended to limit the voltage drop between inverter and point of connection to the grid to 1 %.

NOTE: Voltage drop requirements in Section 525 of BS 7671 relate only to the voltage drop between the origin of the installation, and loads (current-using equipment). These requirements, and the percentage voltage drops referred to in Appendix 4, Section 6.4, of BS 7671, are not relevant to solar PV inverter circuits, and exceed the recommendations of many inverter manufacturers.

Vehicle as storage inverters shall not be installed downstream of RCDs providing additional protection or fault protection to multiple final circuits. In installations where RCDs are used to provide fault protection for distribution circuits, such as in TT installations, a suitably rated RCD shall additionally be provided on the output of the inverter.

The DNO must ensure that the statutory voltage is maintained. If a capacity of generation greater than the customer's export capacity is installed, the DNO is required to undertake ENA Engineering Recommendation G100 assessments to ensure that voltage excursion during the operating time of the limitation scheme is <1 % above statutory voltage and that the cut-out fuse or air circuit-breaker (ACB) does not operate.

Figure 10.2 Ratings of connecting cables and distribution boards for vehicle-to-grid V2G and other microgenerators



10.6.10.7 Electrical considerations for island-mode operation

10.6.10.7.1 What is island-mode operation?

Island-mode operation is where the grid is disconnected, but at least some circuits are powered by local generation sources.

The designer will consider that the conditions and provisions for fault protection and overcurrent protection are likely to change as the prospective fault current drops and earth fault loop impedances increase.

It should be noted that the grid supply may be unavailable because a fault within the installation itself has caused the operation of a supply-side protective device (for example, a service head fuse). Section 9.4.5 of the IET *Code of Practice for Electrical Energy Storage Systems* describes the designer's consideration in this case. It recommends that island-mode operation should not be retro-fitted to installations where final circuits and distribution circuits protected by re-wireable fuses are powered during island-mode operation.

NoteNOTE: The consumer is required to have their own earth electrode, as BS 7671 precludes an island-mode system from relying on the distributor's means of earthing. See Section [10.7.6](#)~~10.7.6~~.

~~10.6.2~~[10.7.2](#) **Back-up island mode isolator and system referencing relay**

~~A back-up~~[An island-mode](#) isolator [and system referencing relay \(sometimes called N-E bond relay\)](#) arrangement is required that simultaneously performs the following functions:

- (a) ~~the island mode isolator disconnects~~[isolates](#) the grid supply [from circuits that continue to be energized in island mode](#), as the installation moves from parallel operation to island-mode operation; and
- (b) ~~the system referencing relay~~ establishes a neutral-earth bond (if required) just after, but at substantially the same time as, the grid supply is isolated, [so that there is an effecting neutral for the installation in island mode](#).

When the back-up isolator switches, either to or from island-mode operation, parts of the installation may experience inrush currents, which can cause overloading of local generators/storage systems. In this case, phased powering of loads may be required. Loads with high inrush might also have to be isolated or unused during islanding events, where these cannot be supported by the back-up power source/storage device.

[The island mode isolator and system referencing relay may be part of the ~~vehicle-to-grid~~V2G system, or part of an electrical energy storage system within the installation. The designer will need to consider how the systems will communicate to ensure appropriate controls and safety are maintained. The control and management system of the ~~vehicle-to-grid~~V2G EVSE selected must be fully compatible with the electrical energy management systems for other components of the prosumer's electrical installation for the system controls to operate safely.](#)

~~10.6.3~~[10.7.3](#) **Automatic disconnection**

It is likely, particularly for dwellings and smaller commercial/industrial premises, that disconnection times can only be achieved by additional protection from 30 mA RCDs at the output of the inverter(s). It is important to check that any RCDs that are relied on for automatic disconnection in island mode can operate with the DC components that can be present.

Where the grid supply is TN-C-S or TN-S, the earthing provisions for some circuits of special locations may well be separate from the rest of the installation. This could include the EV charging supply circuit (see [Figure 10.4](#)~~Figure 10.4~~).

10.6.410.7.4 Protection against overcurrent and overload

The designer should consider whether back-up protection is required, as existing circuit protective devices may not operate due to reduced prospective fault currents.

10.6.510.7.5 Load-shedding

The local generation (vehicle as storage) inverters may not be able to support the demand for all loads in the installation. In addition, large loads will prematurely drain batteries.

Where the inverters and batteries are unlikely to support demand for the required period, load-shedding is recommended, so that only essential, low-power loads (for example, low-energy lighting, communications, etc.) are powered in island mode.

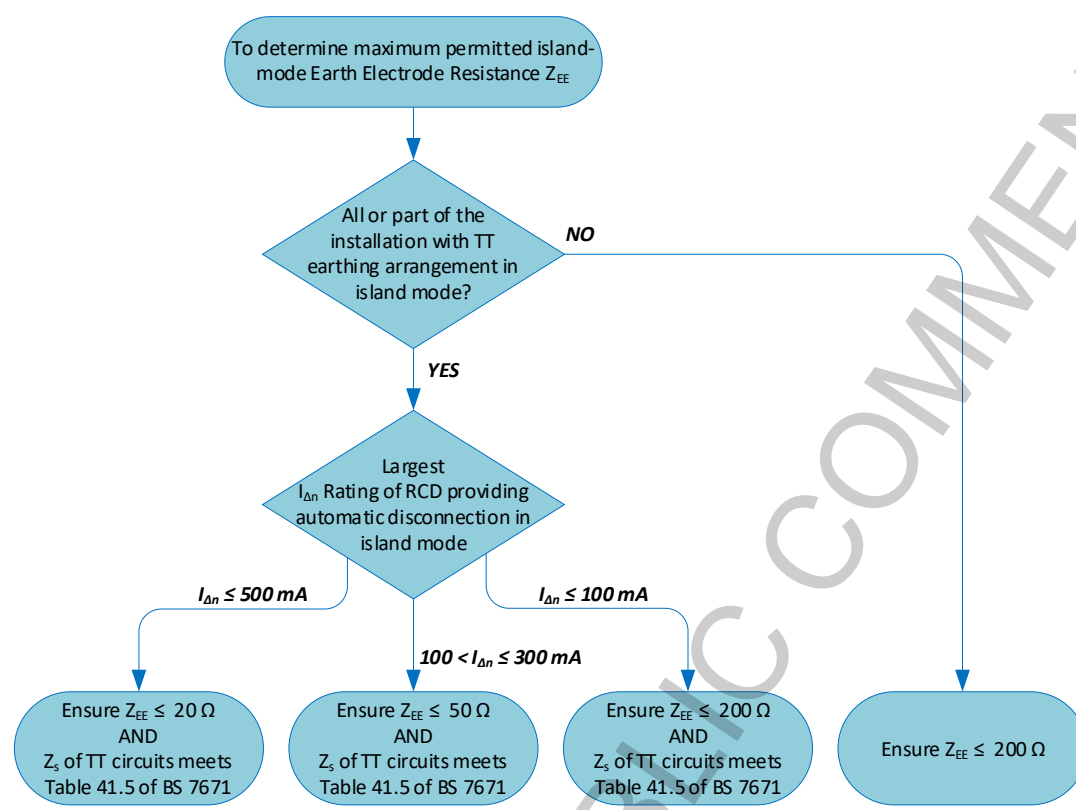
10.6.610.7.6 Means of earthing

Earthing and protection arrangements for installations incorporating vehicle as storage systems can be problematic for designers – particularly when the vehicle is to be used to provide back-up. This is especially true of TN-C-S (PME) and TN-S installations designed to operate in island mode, where the IET Code of Practice for Electrical Energy Storage Systems strongly recommends that the MET of the installation continues to be connected to the distributor's means of earthing.

In general, TN-S operation in island mode will help to minimize earth fault loop impedances. The switching operations required to establish TN-S in island mode, and the selection of appropriate consumer earth electrodes, should follow the IET *Code of Practice for Electrical Energy Storage Systems*.

Further, generators in island mode cannot rely on the supplier's means of earthing, as this may be disconnected for maintenance. The consumer therefore always requires its own earth electrode, to comply with Regulation 551.4.3.2.1 of BS 7671. The earth electrode resistance should never exceed 200 Ω , [although the maximum is required to be reduced where any part of the installation has a TT earthing arrangement in island mode, see Figure 10.3](#)[Figure 10.3, and for systems in excess of 6 kVA, should be less than 20 \$\Omega\$.](#)

Figure 10.3 Island mode maximum earth electrode resistance (from Figure 9.10 of the IET Code of Practice for Electrical Energy Storage Systems, 2nd Edition)



It is unlikely to be practicable for a vehicle as storage system to be the only generation operating in island mode, as the vehicle as storage has finite capacity and a reserve of energy may be required for transportation. In this case, the designer is presented with a more complex set of considerations for earthing and protection. A key consideration is that there must only be one neutral to earth bond relay in the installation.

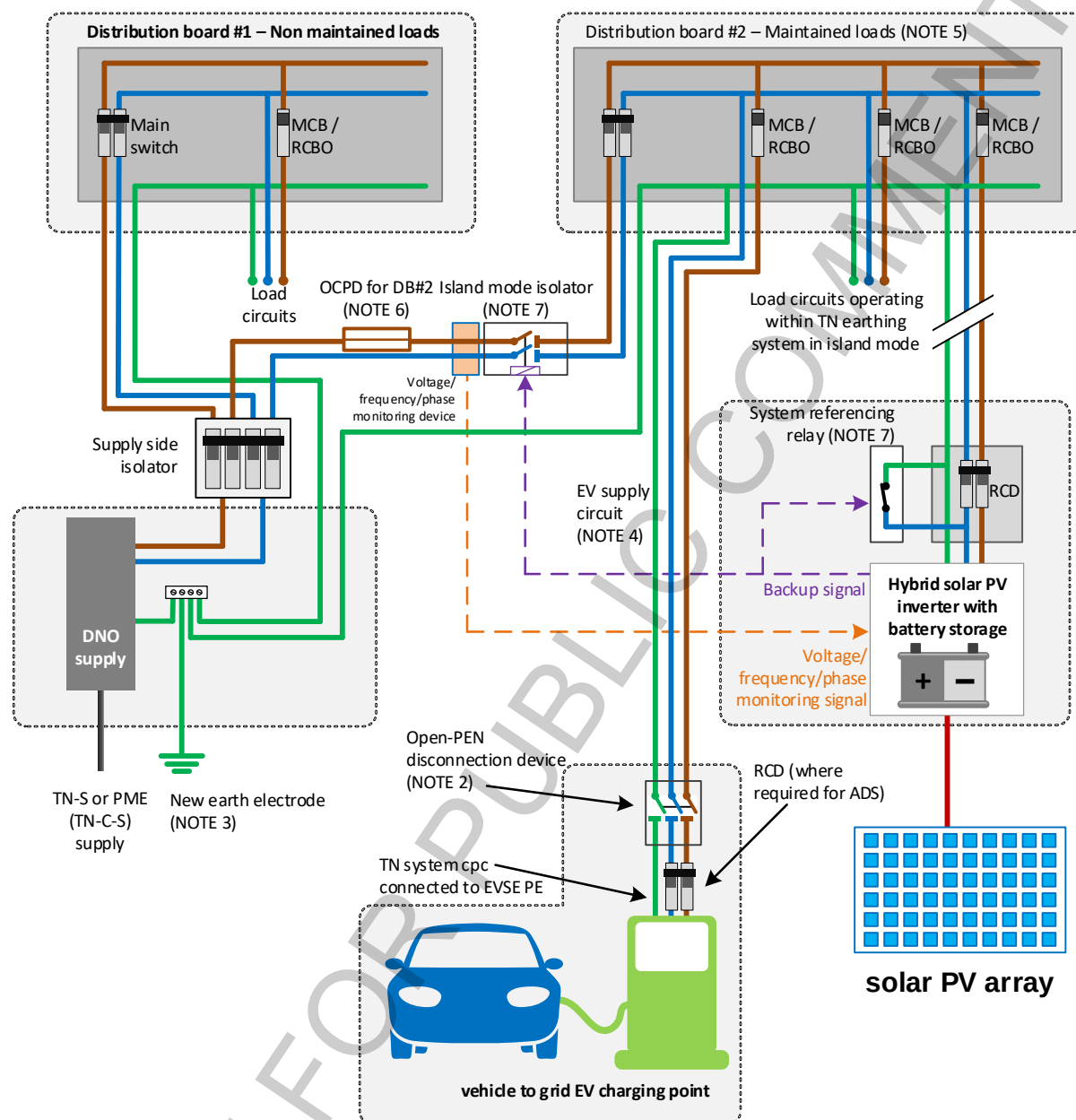
10.6.7 10.7.7 Example arrangements

Figures 10.4 to 10.6 10.2 to 10.4 are provided as supplementary to the IET Code of Practice for Electrical Energy Storage Systems:

- Figure 10.4 Figure 10.4 Figure 10.2 is an example of vehicle as storage in an installation with another electrical energy storage system, with a TN earthing arrangement, and the vehicle as storage having its own TT earth electrode;
- Figure 10.5 Figure 10.5 Figure 10.3 is an example of vehicle as storage in an installation with another electrical energy storage system, with a TN earthing arrangement, one of the requirements of Regulation 722.411.4.1 of BS 7671 being met; and
- Figure 10.6 Figure 10.6 Figure 10.4 is an example of vehicle as storage in an installation with another electrical energy storage system, with a TT earthing arrangement.

NOTE: In Figures 10.4 to 10.6, the island mode isolator and system referencing relay are shown associated with the electrical energy storage system. However, they may be incorporated into the vehicle to grid V2G EVSE.

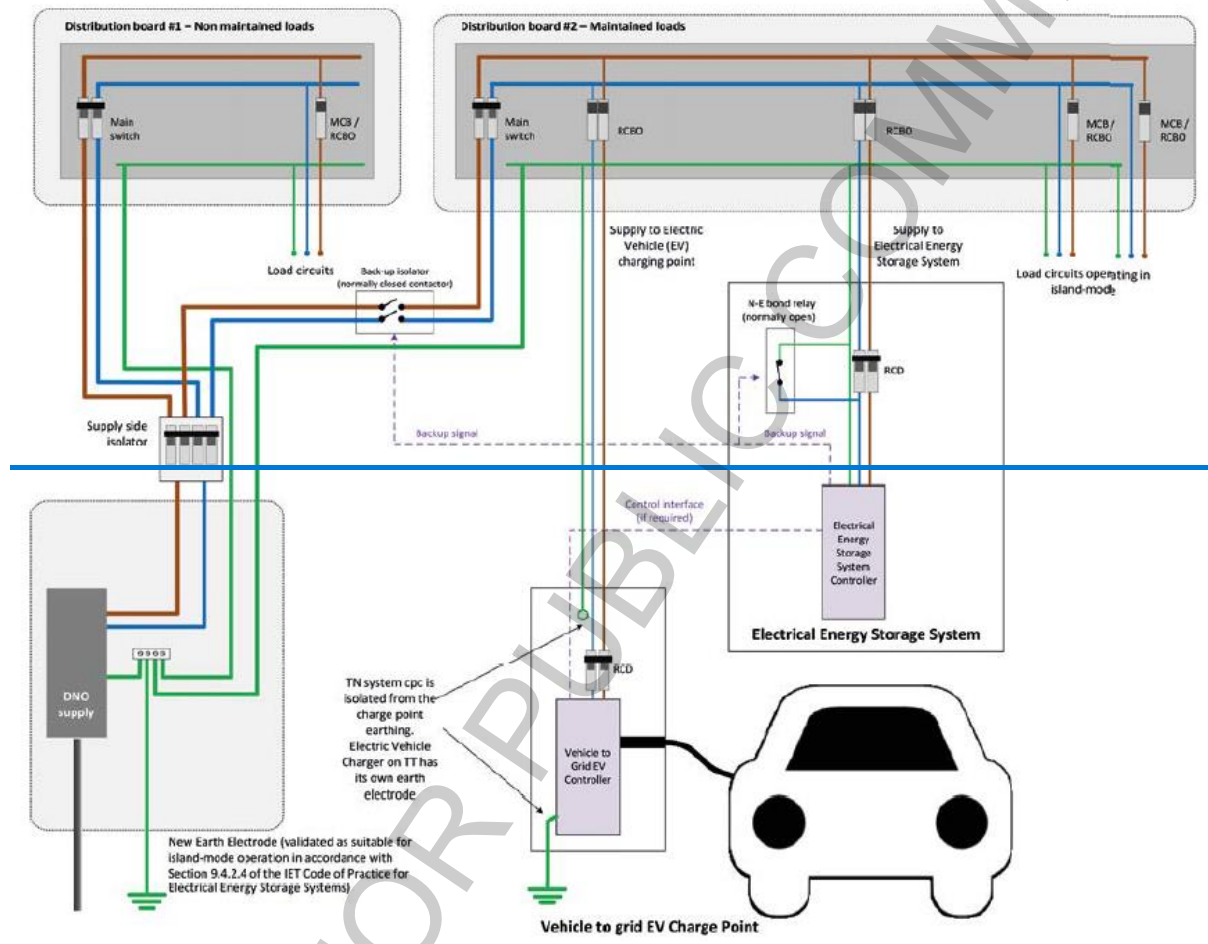
Figure 10.4 ~~Figure 10.2~~ Example of vehicle as storage in an installation with another electrical energy storage system, with a TN earthing arrangement, and the vehicle as storage having its own TT earth electrode



NOTES:

1. This arrangement with two electrodes is essential so that the vehicle body is never connected to the MET which always remains connected to the PME supply.
2. See Appendix G ~~Appendix G~~ regarding separation of the TT charge point earth electrode from earth electrodes and uninsulated buried conductive parts connected to the PME earthing system.
3. New earth electrode for the PEI operating in island mode (refer to the IET *Code of Practice for Electrical Energy Storage Systems*).
4. EV supply circuit rated in accordance with Regulation 551.7.2, so that $I_z > I_n + I_{g\ V2G}$, where:
 I_z is the tabulated current carrying capacity of the cable under conditions of operation
 I_n is the rating of the overcurrent protective device of the EV supply circuit at the distribution board
 $I_{g\ V2G}$ is the nominal output rating of the ~~vehicle to grid~~ V2G inverter at the charging point.

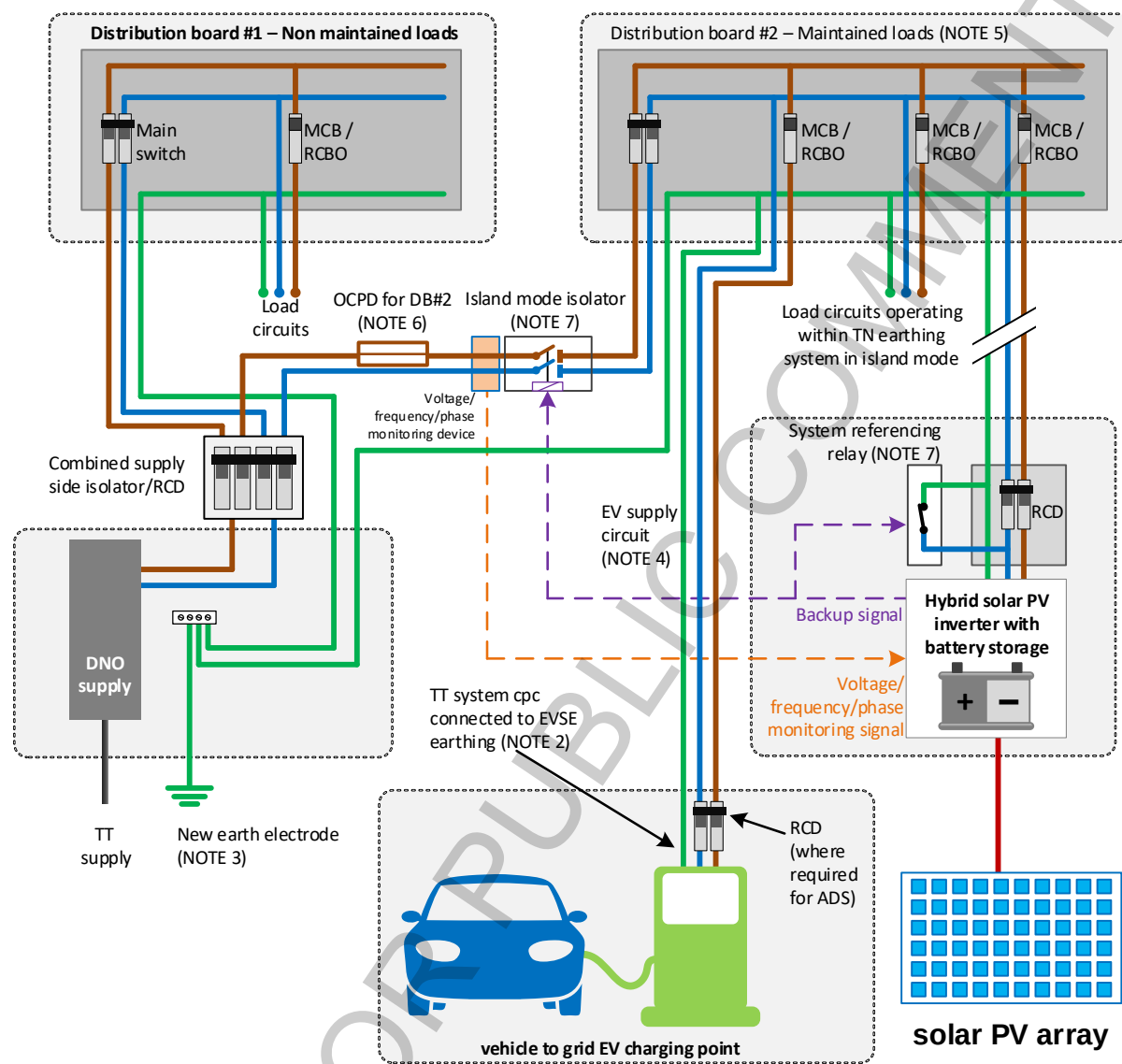
5. Consumer unit nominal current rating in accordance with Regulation 551.7.2 so that $I_{nA} > I_n + I_{g(s)}$, where: I_{nA} is the current rating of the distribution board as stated by the manufacturer I_n is the rating of the overcurrent protective in the supply circuit to the distribution board (in this case, the device highlighted in NOTE 6); $I_{g(s)}$ is sum of all generators connecting through the distribution board (in this case, the electrical energy storage system and the V2G inverter).
6. Overcurrent protective device to help reduce the required maintained loads board current rating I_{nA} .
7. The island mode isolator and system referencing relay are shown in island mode state.



NOTE 1: This arrangement with two electrodes is essential so that the vehicle body is never connected to the MET which always remains connected to the PME supply.

NOTE 2: See Annex H regarding separation of the TT charge point earth electrode from earth electrodes and uninsulated buried conductive parts connected to the PME earthing system.

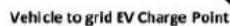
Figure 10.5 Example of vehicle as storage in an installation with another electrical energy storage system, with a TN earthing arrangement, one of the options in Regulation 722.411.4.1 of BS 7671 being met



NOTES:

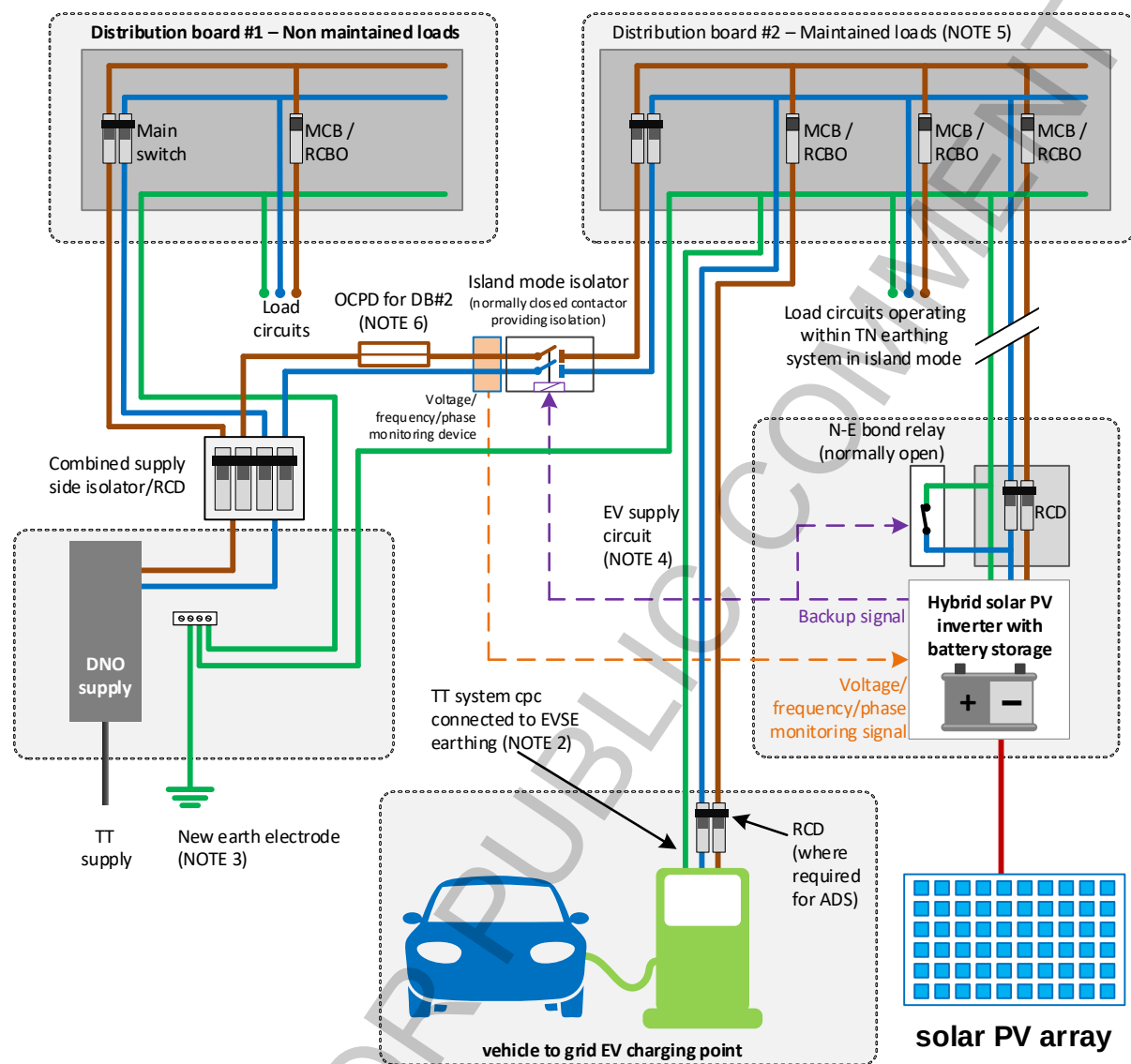
1. This arrangement is only valid where one or more of the options in Regulation 722.411.4.1 (iii), (iv) or (v) of BS 7671 are met.
2. In implementing 722.411.4.1, (iii), (iv) or (v), the device that disconnects all live conductors and the protective conductor must be placed on the installation side of the RCD at the vehicle to grid V2G EV controller.
3. New earth electrode for the PEI operating in island mode (refer to the IET Code of Practice for Electrical Energy Storage Systems).
4. EV supply circuit rated in accordance with Regulation 551.7.2, so that $I_z > I_n + I_{g\ v2G}$, where:
 I_z is the tabulated current carrying capacity of the cable under conditions of operation
 I_n is the rating of the overcurrent protective device of the EV supply circuit at the distribution board
 $I_{g\ v2G}$ is the nominal output rating of the vehicle to grid V2G inverter at the charging point.
5. Consumer unit nominal current rating in accordance with Regulation 551.7.2 so that
 $I_{nA} > I_n + I_{g(s)}$, where:
 I_{nA} is the current rating of the distribution board as stated by the manufacturer
 I_n is the rating of the overcurrent protective in the supply circuit to the distribution board (in this case, the

1.7. The island mode isolator and system referencing relay are shown in island mode state.



~~NOTE 3: If the option used is 722-411.4.1 (iii) and a measurement earth electrode is used, see Annex I. The measurement earth electrode is not shown.~~

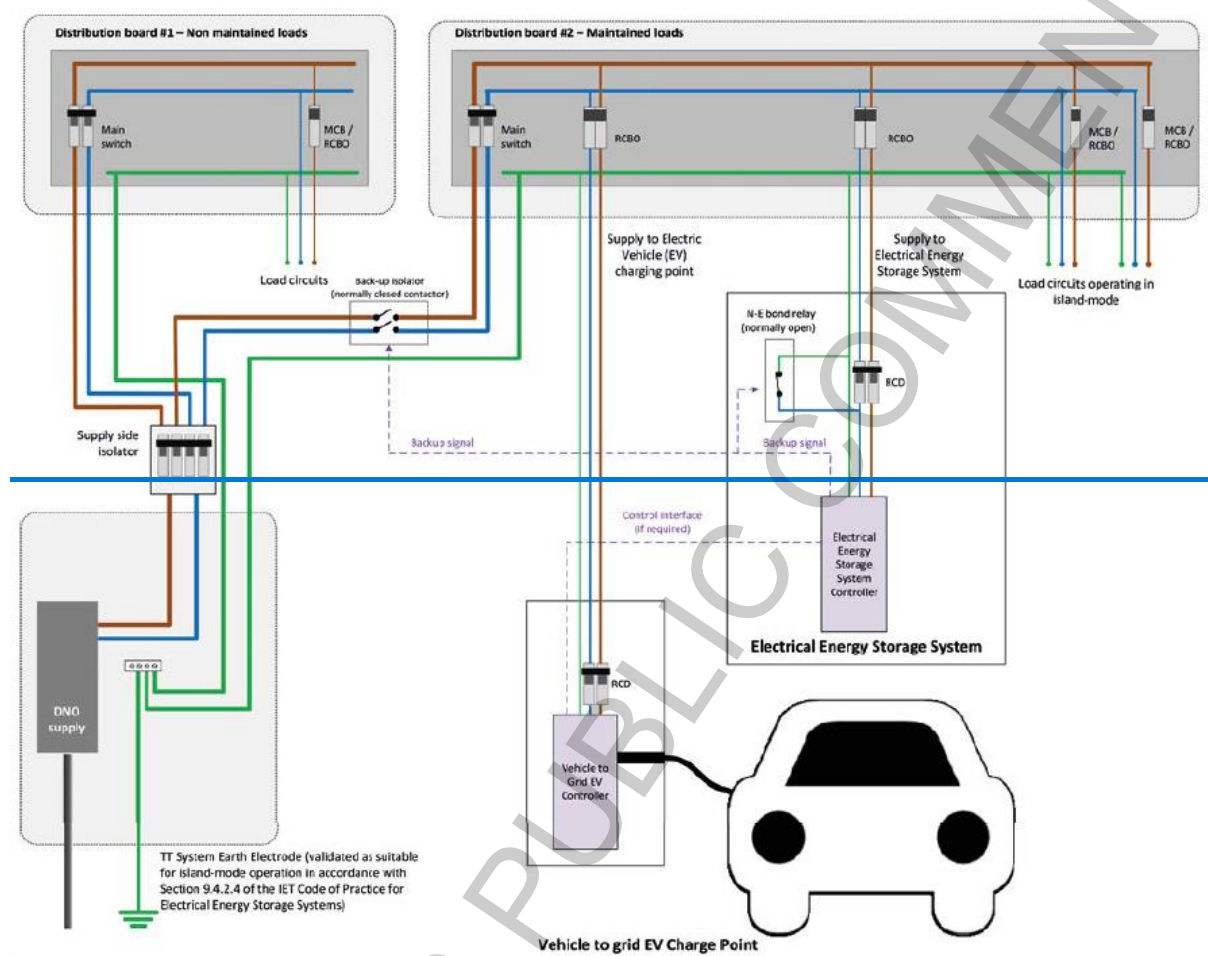
Figure 10.6 Example of vehicle as storage in an installation with another electrical energy storage system, with a TT earthing arrangement



NOTES:

1. This arrangement is only valid where the PEI has a TT earthing arrangement in connected mode.
2. Since PME conditions do not have to be assumed for this installation, Regulation 722.411.4.1 does not apply, and the TT system cpc can be used for the EVSE.
3. Consumer's earth electrode should be selected to comply with BS 7671 for connected mode, and also for the PEI operating in island mode (refer to the IET Code of Practice for Electrical Energy Storage Systems).
4. EV supply circuit rated in accordance with Regulation 551.7.2, so that $I_z > I_n + I_{g\ V2G}$, where:
 I_z is the tabulated current carrying capacity of the cable under conditions of operation
 I_n is the rating of the overcurrent protective device of the EV supply circuit at the distribution board
 $I_{g\ V2G}$ is the nominal output rating of the vehicle-to-grid V2G inverter at the charging point.
5. Consumer unit nominal current rating in accordance with Regulation 551.7.2 so that
 $I_{nA} > I_n + I_{g(s)}$ where:
 I_{nA} is the current rating of the distribution board as stated by the manufacturer
 I_n is the rating of the overcurrent protective in the supply circuit to the distribution board (in this case, the device highlighted in NOTE 6);
 $I_{g(s)}$ is sum of all generators connecting through the distribution board (in this case, the electrical energy storage system and the V2G inverter).

- 6. [Overcurrent protective device to help reduce the required maintained loads board current rating \$I_{nA}\$.](#)
- 7. [The island mode isolator and system referencing relay are shown in island mode state.](#)



10.710.8 System labels and safety signs

Signage for multiple supplies will be required, in accordance with [BS 7671](#) and ENA Engineering Recommendations G98/13 or G99/1. [This meets the requirements of Regulation 514.15.1 of BS 7671.](#)

10.810.9 System handover and documentation

- It is important that all users of the installation:
- (a) understand whether the system is operating normally;
 - (b) know what alarms or error messages mean;
 - (c) are aware of the power limitations in island mode;
 - (d) understand the implications for the charge status of the vehicle and know how to prevent the vehicle from discharging where it may be needed for journeys; and

- 3423 (e) know how to shut down the system to a safe state.
- 3424 Additional information should be provided to ensure that the system can be safely maintained,
3425 inspected and tested through its life. This includes:
- 3426 (a) drawings of electrical, communication and control systems;
- 3427 (b) documentation associated with the charging equipment;
- 3428 (c) guidance on any special restrictions associated with the charging itself;
- 3429 (d) a document clearly outlining whether the charging equipment is installed in a manner
3430 appropriate for island operation and details on the design features that enable this;
- 3431 (e) clear written instructions on how to safely isolate the charging installation, including when
3432 the vehicle is and is not connected; and
- 3433 (f) regulations and requirements describing disposal at the end of life.

11 Distribution network operator (DNO) notification

11.1 All EVSE installations

In the case of dedicated EV charging equipment, the installer shall ensure that the appropriate DNO has been notified of the installation. Where the installation of charging equipment results in the property's maximum demand (load) exceeding 13.8 kVA (and not metered via current transformer), an application to connect is required to be submitted to the relevant DNO prior to installation. This will enable DNOs to track increases in low-diversity demand from EV charging and thus mitigate the risks of distribution substation overloading and of voltages on the distribution network moving outside statutory limits.

The EV notification/application process and associated documents are subject to change. Installers should always access the ENA website for up-to-date information, instructions and the latest documents: ~~https://www.energynetworks.org/operating-the-networks/connecting-to-the-networks/~~ <https://www.energynetworks.org/operating-the-networks/connecting-to-the-networks/> ~~http://www.energynetworks.org/electricity/futures/electric-vehicle-infrastructure.html~~.

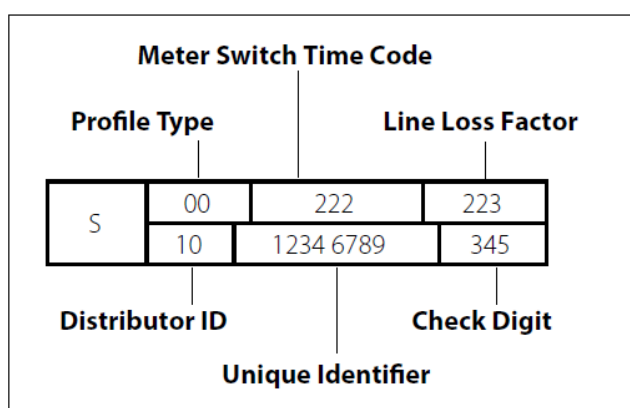
For Electric Vehicle Charging Equipment Installation, installers shall:

- (a) where the maximum demand (load), including the new EV charging equipment of a property, is less than or equal to 13.8 kVA, send the notification within 28 days of installation directly to the DNO through the email addresses found in a table of contact details, accessible from the following web address: ~~https://www.energynetworks.org/operating-the-networks/connecting-to-the-networks/connecting-electric-vehicles-and-heat-pumps~~ <https://www.energynetworks.org/operating-the-networks/connecting-to-the-networks/connecting-electric-vehicles-and-heat-pumps> ~~http://www.energynetworks.org/electricity/futures/electric-vehicles-and-heat-pumps.html~~; or
- (b) where the maximum demand (load), including the new EV charging equipment of a property, is greater than 13.8 kVA, or where an issue has been identified with the adequacy or safety of the existing service equipment, contact the DNO prior to installation to establish the supply capacity.

Note that the notification and application form is designed to inform the DNO of installations of EV charging equipment. As described in Section 3, if the new load will exceed the existing supply, or if there is a planned programme of charging equipment installations in a close geographic region, the installer shall discuss the installation project with the local DNO at the earliest opportunity. The DNO will undertake an assessment of the impact that these connections may have on the network and then specify conditions for connection.

The Meter Point Administration Number (MPAN) or Meter Point Reference Number (MPRN) in Northern Ireland is essential in determining the location of the EV charging installation; this information can be found on the customer's bill or by contacting the energy supplier. ~~Figure 11.1~~ [Figure 11.1](#) details the numerical information that constitutes the MPAN.

Figure 11.1 Example of MPAN information



11.2 EV installations with V2G/V2H

V2G/V2H installations will necessitate a DNO notification under ENA Engineering Recommendations G98 or G99.

A G98 can usually be used if the installation in which all of the following apply:

- (a) all grid-connected inverters are approved type-tested models;
- (b) the total sum of all grid-connected inverter rated output currents does not exceed 16 A per phase (3.68 kVA single-phase, or 11.04 kVA three-phase); and
- (c) there is no island mode capability.

Where the works only affect a single installation, it may be possible to complete a post-installation notification for G98. However, if works affect more than one installation, or there is a large number of PEIs already in the area, notification prior to works, and approval from the DNO, are required.

G99 applications should be used for all other installations. A fast-track route may be possible where there is no island mode capability, and only type-tested inverters are used. Notification and approval are required prior to work commencing.

Further detail on G98 and G99 notification can be found in the relevant publications, and explanations are also included in the IET Code of Practice for Grid-Connected Solar PV Systems and the IET Code of Practice for Electrical Energy Storage Systems.

12 Integration and smart infrastructure

12.1 What is 'smart charging'?

The term 'smart charging' covers a number of features that can be addressed by various means of control. [Some smart features are required for the Electric Vehicles \(Smart Charge Points\) Regulations 2021 \(see Section 3.1.1-\)](#). Examples ~~ss~~ [of \(current and predicted\) smart charging applications \(current and predicted\)](#) include:

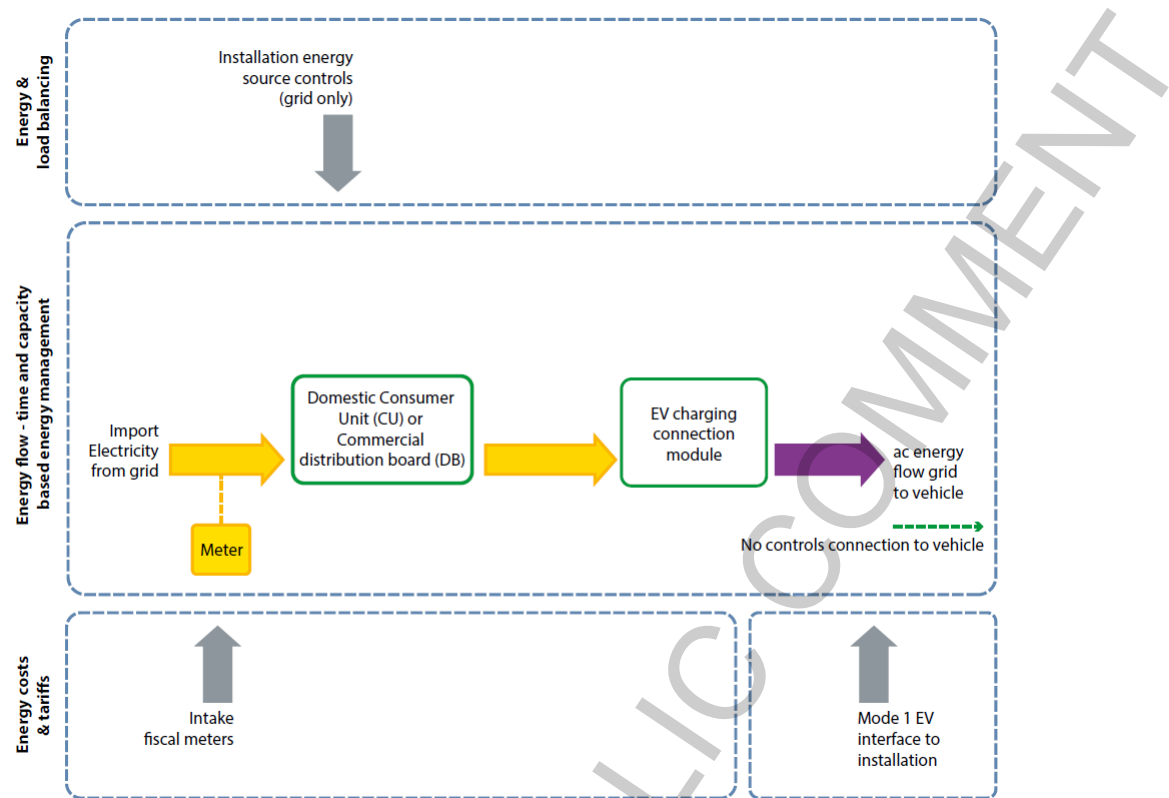
- (a) uni-directional (current through the charger flows to the car only):
 - (i) unrestricted charging, which may or may not use a smart meter, and is simply a connection point from a fixed installation via an EV charging point to the vehicle;
- (b) timed charging control, to permit the vehicle to be charged at times when tariffs are typically lower;
- (c) managed charging, where electricity use by chargers is managed by the charging point operator (CPO) to defer DNO network upgrades;
- (d) demand-limiting (or load curtailment) charging, for example, where high-power appliances in the same installation cause load shedding or throttling of the charger;
- (e) smart meter integration, permitting selection of charging options to ensure the car charges at the cheapest available rate, or enabling the charger to respond to dynamic tariffs [and peaks in local demand](#); ~~and~~
- (f) optimization for self-use (charging power is modulated to minimize export of generation to the grid and maximize self-consumption); ~~and~~
- (g) bi-directional (current may flow to or from the car):
 - (i) ~~vehicle to home (car as storage V2H)~~ used to avoid [consumption-import of energy from the grid](#) during peak hours/peak rates;
 - (h) ~~vehicle to grid (V2G)~~: export from the car storage at peak demand, with car recharged more cheaply later; and
 - (i) off-grid systems: the vehicle may be used as storage in an overall off-grid system.

The following figures and text illustrate each of these points in more detail.

It should be noted that the figures are for guidance and are not intended to be definitive or exclusive. The final design solution for an installation may incorporate elements from more than one example to reach a satisfactory hybrid solution for any one installation. This will be particularly relevant where a solution incorporates bi-directional connections to and from the main electrical installation to the grid and also bi-directional connections to and from the EV.

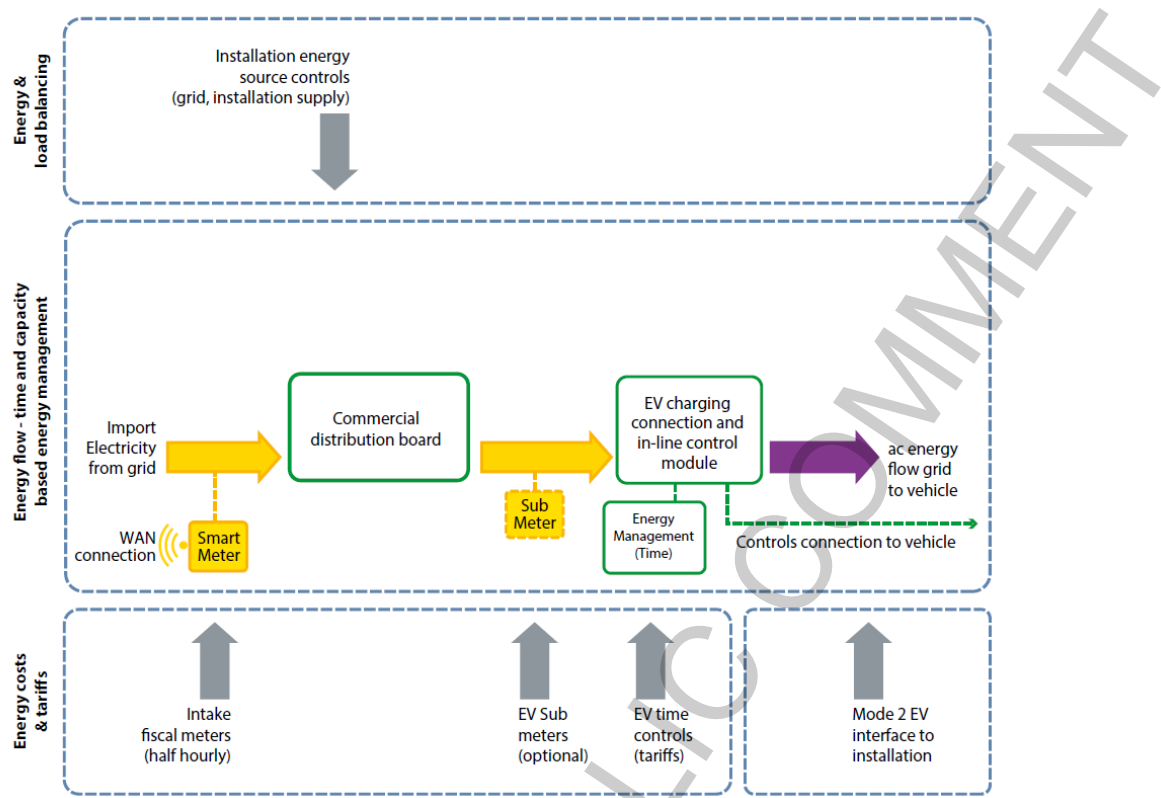
The figures show typical energy flows for ~~ed~~ different infrastructure models from the point of supply to the point of use in the middle. The bottom parts of the figures show typical points for fiscal meters or sub-meters. The top parts of the figures show typical load controls and control interfaces from the EV loads to the wider installation.

Figure 12.1 Unrestricted charging



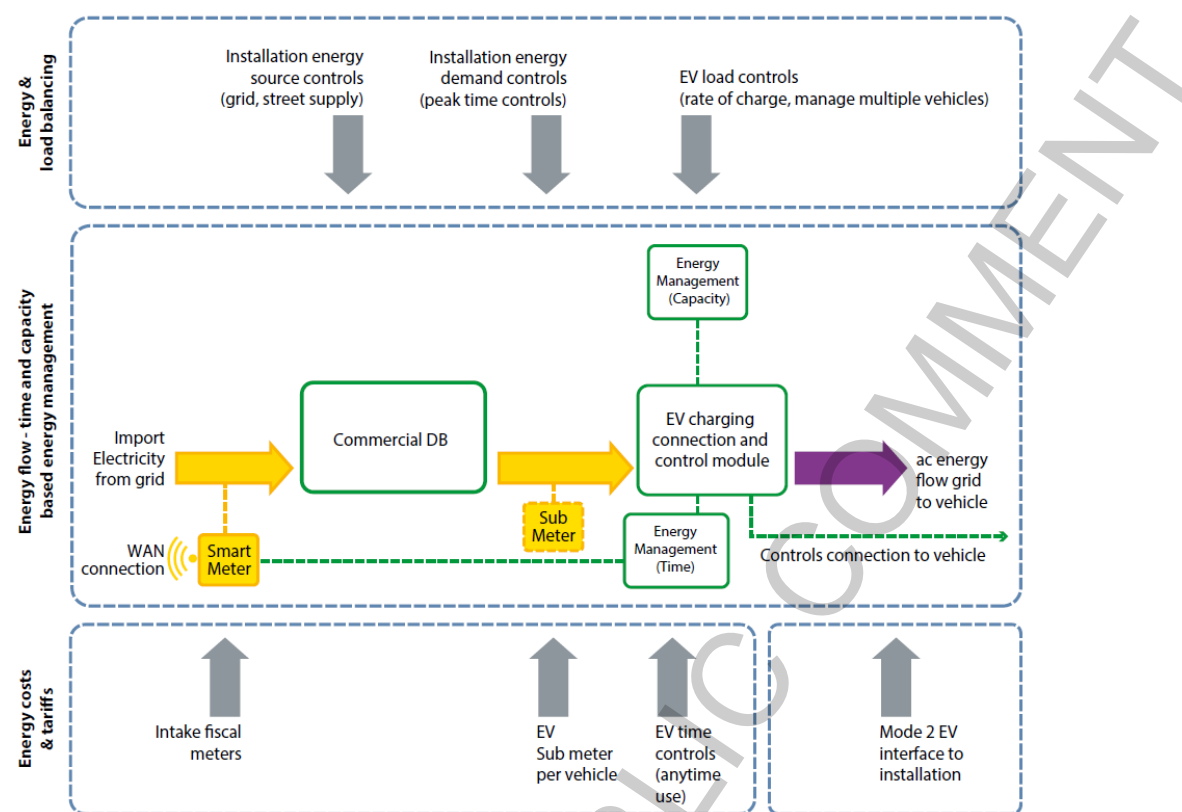
Criteria	Description
What	This is likely to be a singular EV charging system retro-fitted as an additional circuit to an existing electrical installation. The installation is not linked to any type of smart meter and the EV charging circuit will not have any sophisticated charging controls. It has a basic metered supply with simple electrical safety protective devices providing typical fault protection. There are typically no energy management controls.
When	Unrestricted charging means electricity use to charge the EV on demand without any restrictions on time of use or tariff – there is the potential to use the electrical connection during peak time. The impact could be maximum strain on the capacity of electrical distribution networks and possibly full exposure to higher electrical tariffs. Electrical consumption for charging the EV is entirely according to user demands. There could be specific user group requirements if EV charging cannot wait for cheaper periods, for example, public transport use or vehicles have priority use for emergency purposes.
How	Simple Mode 1 connection to grid-connected AC electrical supply via a general-purpose domestic socket. This should be on a dedicated radial circuit from the local consumer unit or distribution board. Conversion of AC to DC on board the vehicle. Simple electricity meter to record energy consumption of the main installation only. No smart metering to manage connection through off-peak timer or to provide any restriction of the energy flow.
Notes	There is no direct link to energy management controls (checking the electrical capacity) or monitoring of EV charging energy costs. The EV charger is in use whenever it is required by the user. With no controls to monitor energy transfer to the EV from the building, there is a risk of the charging cable overheating. Energy consumption for EV charging is not restricted; nor is it considered as an infrastructure risk by the energy supplier. High energy costs from peak time use is not considered as a problem by the consumer.

Figure 12.2 Timed charging control



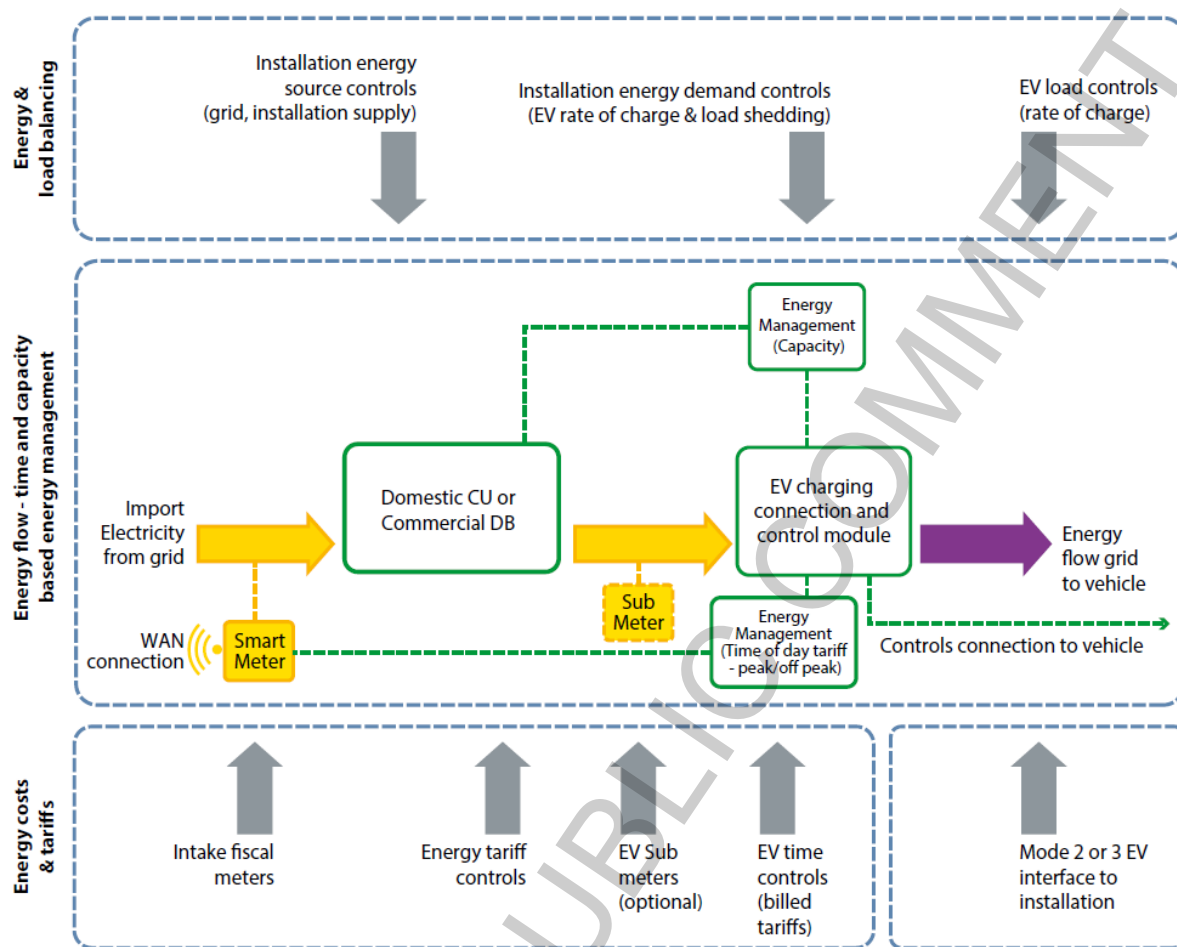
Criteria	Description
What	This is likely to be a singular EV charging system either retro-fitted as an additional circuit to an existing electrical installation or added as a circuit to a new installation. The main electrical intake has a smart meter. The installation also has compliant electrical safety protective devices providing typical fault protection. There is simple energy management control to allow some smart charging facilities.
When	Smart charging typically restricts electricity use by EV chargers to periods when off-peak tariffs are usually lower. An override on the EV charger might also be provided for any necessary peak-time charging. Energy consumption for EV charging may need manual checks against the total electrical capacity of the installation and the demands from other electrical loads.
How	This method uses a Mode 2 connection. A link to localized energy management controls permits the EV charger to use energy at off-peak times. Controls use basic timer control to the EV charger. Half-hourly reporting on the smart meter is used to assess energy consumption during off-peak periods and to recoup off-peak energy costs.
Notes	Energy management is mainly linked to consideration of an energy costs strategy and does not really consider grid capacity issues or local electrical supply capacity issues and the associated impact on other loads connected to the same installation. There is no link between the EV smart charging installation and the smart meter itself. A local sub-meter for the EV charging radial circuit is preferable.

Figure 12.3 Managed charging control



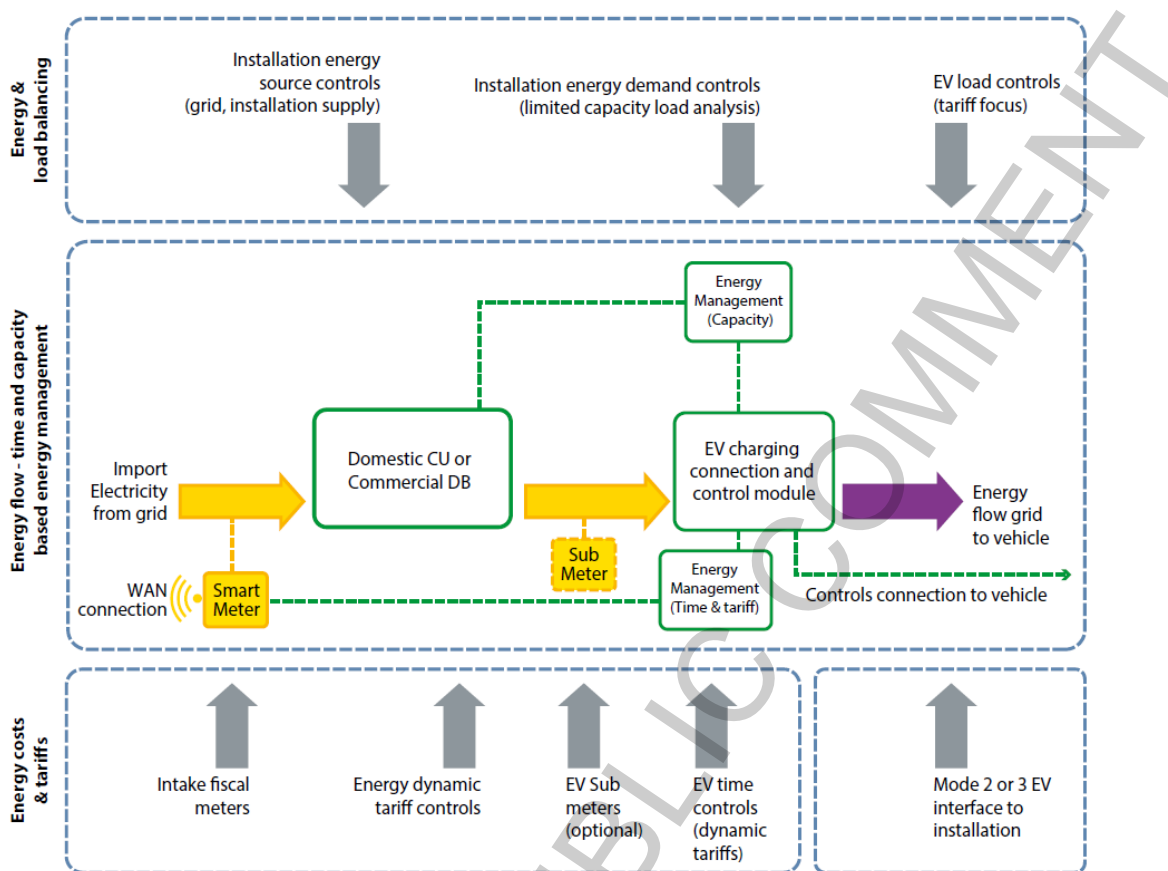
Criteria	Description
What	Generally, this will be based around multiple EV charging points, all added as new circuits to a new commercial EV-orientated installation. This will include public or workplace car parks focused primarily on EV charging electrical loads. The main electrical intake has a smart meter that will have links to a local energy management system. The installation also has compliant electrical safety protective devices providing typical fault protection.
When	Smart charging is managed by the CPO to control the total load on the whole installation. The EV charging requirements of each vehicle are balanced centrally, so that the electrical capacity of the whole installation is not exceeded. This method is necessary to defer or avoid DNO network upgrades, and reduces peak demands of multiple EVs charging simultaneously. Where network reinforcement is avoided, a cheaper network connection may be possible. A sub-meter at each charging point is essential and should be linked to both a common controls and a central fiscal billing system.
How	This method typically uses a Mode 2 connection. Controls at each of the multiple charging points are linked via a combined energy management system. Aggregated energy loads can then be balanced. This approach assists areas where DNOs have not been able to upgrade wider electrical infrastructure to cope with increasing demand. Premium users have the option to pay higher rates to charge their vehicles quicker, using more of the available power at any one time. Controls are through time of use and provide a DNO/licensed parking revenue stream.
Notes	Typically deployed to assist DNOs with an energy management strategy at network distribution level. This mitigates any constraints (risks due to capacity and/or resilience) on the wider electrical infrastructure. Costs of EV charging may be varied throughout the course of a day, depending on consumer demand.

Figure 12.4 Load curtailed Demand limited charging



Criteria	Description
What	This is used for monitoring and controlling electrical loads across the whole installation. If the total static installation electricity load is heading towards maximum electrical intake capacity and there is an additional requirement for EV charging, giving a risk of overload at the intake, capacity can be assessed by the energy management controls and electrical loads adjusted accordingly.
When	Integrated energy management controls can switch off high inertia (low priority) electrical loads in the building's fixed installation to allow capacity for quicker EV charging, whilst other low inertia (high priority) loads remain fully operational. Alternatively, the EV charging rate can be reduced to allow low inertia (high priority) loads to continue operating. This will mean that it will take longer to charge the EV.
How	This could be linked to Mode 2 or 3 EV charging, complete with controls communication with the vehicle. Smart metering is linked to energy management controls, to allow EVs to charge at full rate or to charge at a reduced rate, depending on the demands of the fixed electrical installation.
Notes	Energy management strategy is necessary because of capacity constraints on the electrical infrastructure within the existing installation or in the upstream DNO distribution network. Restrictions on EV charging could be placed on the installation by the energy provider (DNO). It may be necessary for large load (high-power) appliances in the same installation as the EV charger to load shed, to ensure that capacity constraints are not exceeded. If an EV is not required immediately, then slowing the rate of charge to the EV is preferable. Such an arrangement could also reduce network connection costs.

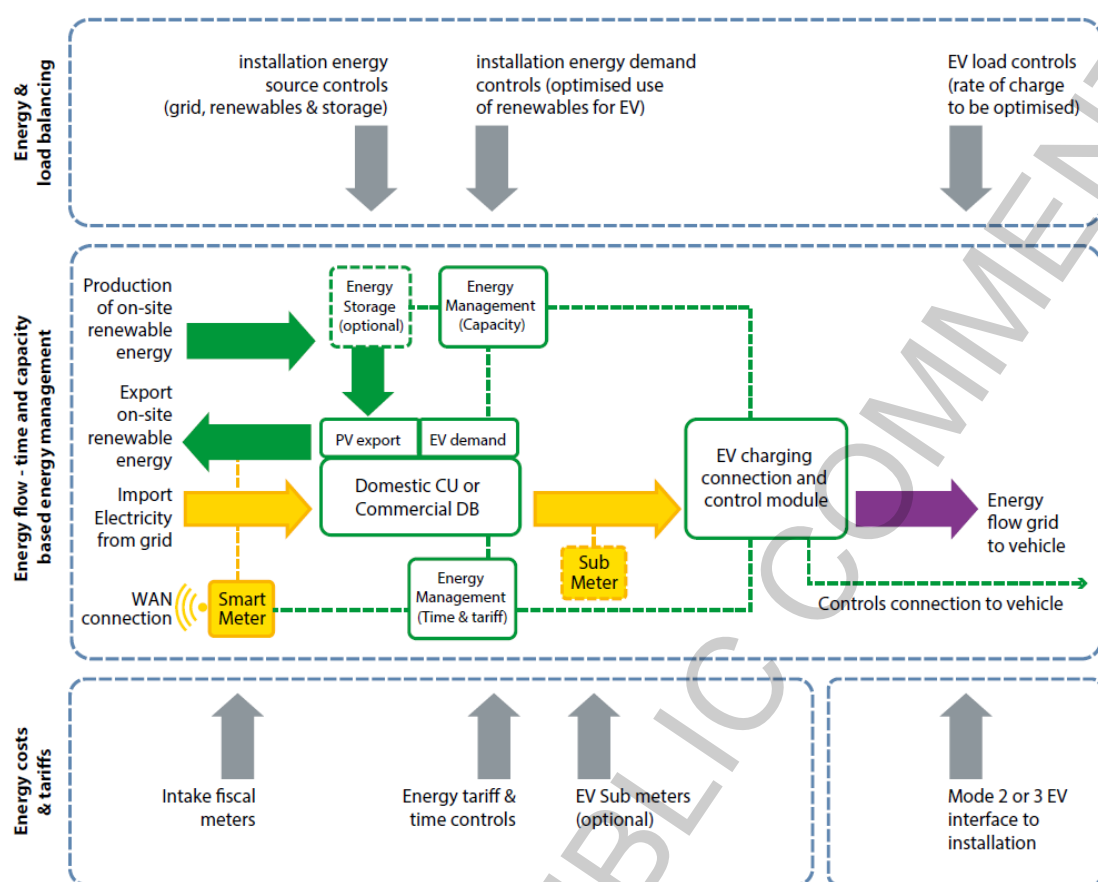
3536 **Figure 12.5** Smart meter integration charging



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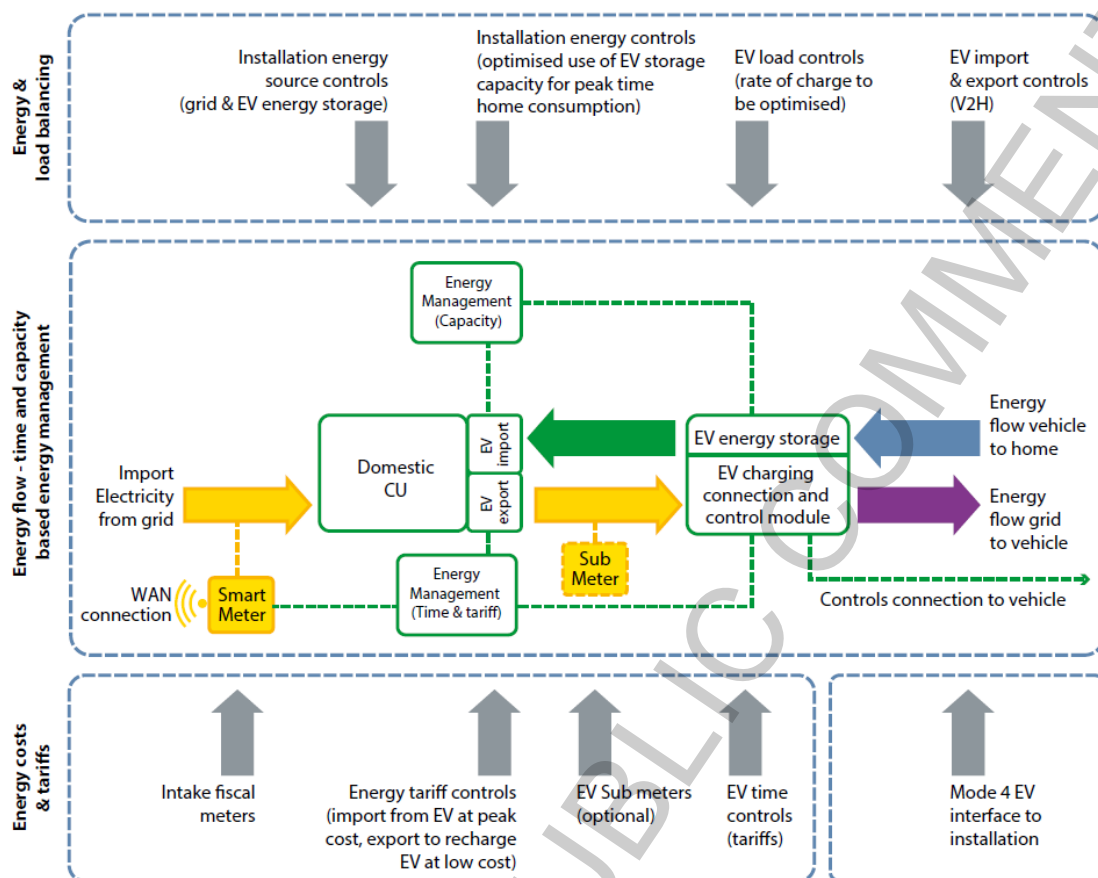
Criteria	Description
What	This is for monitoring and controlling energy costs and particularly the cost of EV charging. The primary focus of smart meter-led controls is to permit the EV charging to take place when tariffs are cheapest. Half-hourly readings, with feedback from the smart meter, will allow the selection of charging options to ensure that the EV charges at the cheapest available rate.
When	Electricity use by an EV charger is typically restricted to off-peak periods, when tariffs are usually lower.
How	Integration of smart metering enables the charger to automatically respond to dynamic tariffs, which can change on a half-hourly basis at frequent times throughout the day, and to reduce costs.
Notes	Energy management is based on an energy costs strategy model linked to the smart meter. This method does not necessarily consider the risks of energy supply limitations, the impact on other loads on the same installation or the impact on the capacity of the upstream infrastructure. These risks may require mitigation measures. Careful management of when the EV is actually used may also be necessary, as the vehicle may not be sufficiently charged when a journey is required.

Figure 12.6 Optimization for self-consumption of locally generated renewable energy use



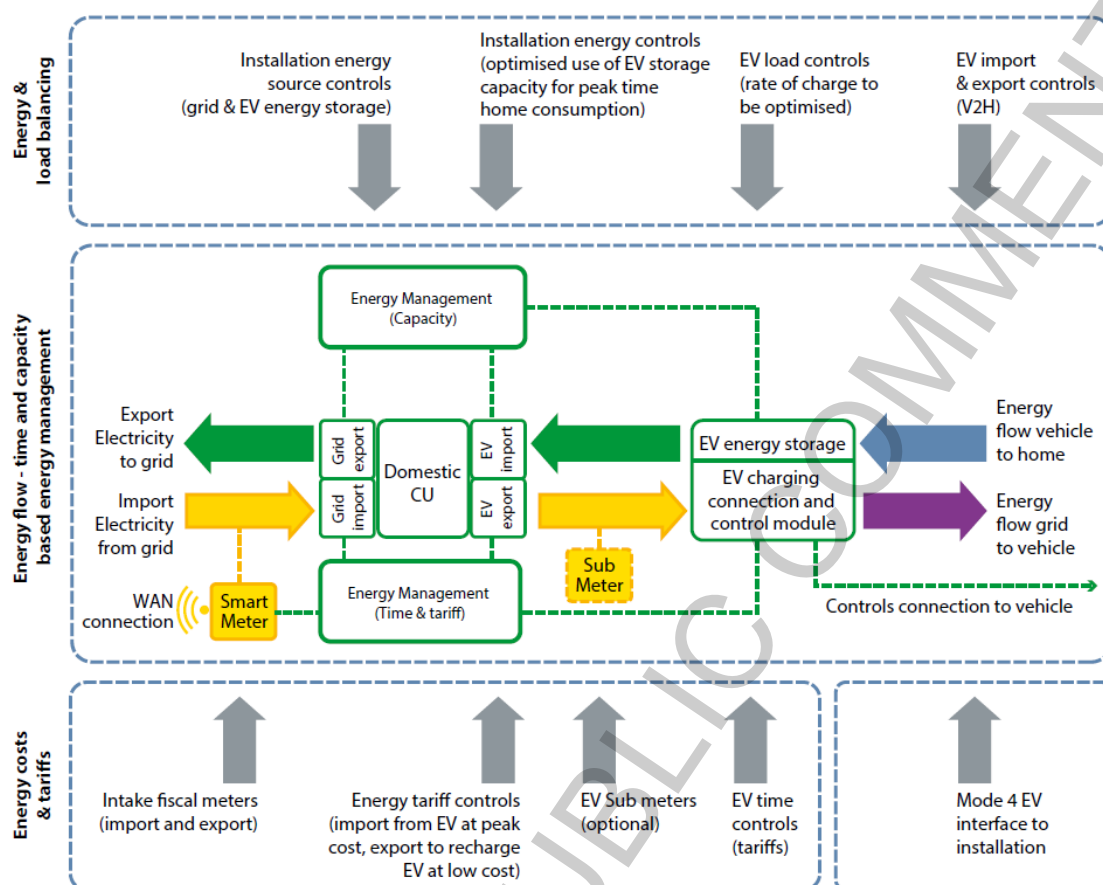
Criteria	Description
What	This involves the use of local generation, typically from on-site renewables, to reduce electricity consumption from the grid supply. Local energy storage may also be deployed to optimize when the energy is actually used, either on the fixed electrical installation or for EV charging.
When	Renewable energy is used on site, instead of being exported, to offset grid electrical energy consumption. Optimum use is usually peak time, when tariffs are typically higher and when off-grid power or storage is available.
How	Smart metering is linked to the building automation and control system (BACS) and the local generation controller. Metered to optimize off-peak energy costs and sub-metered to make use of on-site generation capacity. Reduces electricity bills by using less energy from the grid.
Notes	Energy management makes best use of all sources of energy, with priority given to local on-site energy sources and storage or grid-connected off-peak rates. Requirements for EV charging are modulated to minimize export of generation to the grid and to maximize self-consumption. The energy costs strategy is fully integrated with the energy management strategy. For sites with a legacy fixed-price export tariff, this approach may affect any export tariff revenue stream.

Figure 12.7 V2H (vehicle to home) (car as storage) used to avoid consumption during peak hours/peak rates



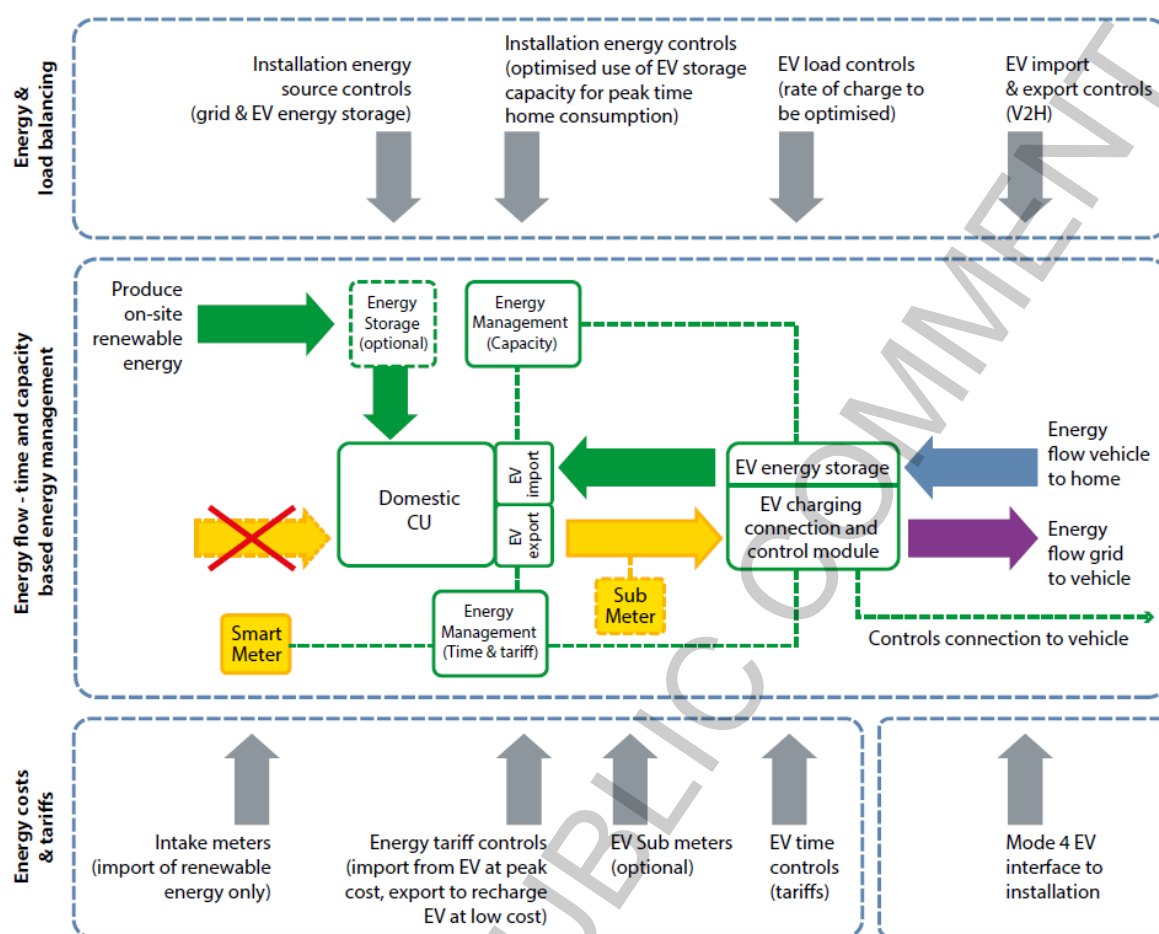
Criteria	Description
What	This is a bi-directional approach, using advanced EVSE connections, where the EV may draw energy from the electrical installation as normal and can also potentially provide to the installation. Full smart meter and local energy management integration will be required. A review of the existing electrical installation is recommended. Remedial works could be necessary to allow for energy management control at the consumer unit (or distribution board) and also to update protective devices for electrical safety compliance.
When	The design of this infrastructure allows the EV to act as a potential energy store, drawing energy from the grid, via the installation, during cheaper tariff off-peak times, for subsequent consumption within the installation at times when the tariff is more expensive or when the installation loads exceed the capacity of the installation intake. The EV could also be used to import energy that has previously been drawn from another installation.
How	Energy management is required to balance the needs of the EV and the installation. The user interface needs to be intuitive and easy to follow. A smart metering interface will determine peak and off-peak controls. Control algorithms need to be clarified to optimize energy imports from the EV and energy exports to the EV.
Notes	The export of energy from the vehicle to the installation needs to be carefully considered against the typical energy profile of the whole installation. The process should not restrict the vehicle's capacity to undertake its next journey by completely depleting energy from the EV battery source.

Figure 12.8 V2G vehicle-to-grid: export from the car storage at peak demand, with car recharged more rapidly later



Criteria	Description
What	This is a bi-directional approach, using advanced EVSE connections in charging Mode 3 or 4, developed further to allow energy to be exported from the vehicle via the installation to the main grid beyond the smart meter. Full smart meter and sophisticated local energy management integration will be required. Licensing arrangements to export electrical energy with the local grid supplier (DNO) will also be necessary. A review of the existing electrical installation is recommended. Remedial and/or replacement works will be necessary to allow for energy management control at the consumer unit (or distribution board) and also to update protective devices for electrical safety compliance.
When	The EV will be a potential energy store, drawing energy from the grid, via the installation, during cheaper tariff off-peak times, for subsequent export back to the grid when demand in the locality is high.
How	Advanced energy management is required to balance the needs of the EV, the installation and the grid. The user interface needs to be intuitive, easy to follow and should communicate with the DNO. A smart metering interface will determine peak and off-peak controls and needs to be seamless with the energy management system. Control algorithms need to be clarified to optimize energy imports from the EV and energy exports to the EV.
Notes	The export of energy from the vehicle to the grid will be subject to external controls driven by the DNO, but these need to be carefully considered against the typical energy profile of the whole installation. The process should not restrict the vehicle's capacity to undertake its next journey by completely depleting energy from the EV battery source.

Figure 12.9 Off-grid systems: the vehicle may be used as storage in an overall off-grid system



Criteria	Description
What	This bi-directional approach, using advanced EVSE connections in charging Mode 3 or 4, provides a potential solution for an off-grid electrical installation. It allows energy generated locally to be exported from the installation to the vehicle. The EV then acts as energy storage for the consumption within the installation when it is required. The WAN communication function of the smart meter may not be required.
When	The EV will be an energy store, drawing energy from the renewable supply, via the installation, during optimum generation periods, for subsequent export back to the off-grid installation when load demand is required.
How	Advanced energy management is required to balance the capacity of the renewable energy supply, the needs of the EV and the demands of the installation. The user interface needs to be intuitive and easy to follow. A smart metering interface will assist with monitoring renewable energy sources. Control algorithms need to be clarified to optimize energy imports from the EV and energy exports to the EV.
Notes	The export of energy from renewable energy sources to the vehicle and back to the installation needs to be carefully considered. The typical energy profile of the whole installation will need careful design to minimize loads and match those to the capacity of the EV battery. The process may well restrict the vehicle's capacity to undertake its next journey, by completely depleting energy from the EV battery source if energy delivery from the renewable sources is intermittent.

12.2 Means of control

Control by purely electromechanical means (relay or contactor switching) is not recommended. It introduces limitations in the system's flexibility and in the implementation of newer features as they become available over time. In some cases, the use of electromechanical control may cause charge control software to pause vehicle charging until the user intervenes (for example, acknowledging an alarm or status change).

Using a charger's micro-processor-based controller, in conjunction with web/smartphone application interfaces, smart meters and other controllers in the building, such as a building management system (BMS), supervisory control and data acquisition (SCADA) system or home automation systems (home and building electronic systems – HBES), provides far more flexibility and allows opportunities for future upgrades as more options become commercially available.

[Table 12.1](#) provides some examples of control features and options that may be available to system designers. A system may exploit a number of features and means of control.

Table 12.1 Examples of control features and options

Smart feature	Control type	Stand-alone control options	Integrated control options
Timed charging	Programmable/configurable	- Internal timed charging - Manual over-ride	- Mobile device applications or web-page (over the internet) for manual over-ride - External control from BMS, SCADA or HBES
Smart Meter meter	Programmable/configurable	Manual over-ride	- Smart_meter interface to charge at cheapest rate - Mobile device applications or web-page (over the internet) for manual over-ride - Demand limiting based on overall current use in installation read from smart meter interface - Export optimization decisions
Demand limiting	Programmable/configurable	Manual over-ride	- Mobile device applications or web-page (over the internet) for manual over-ride - Mobile external control from BMS, SCADA or HBES - Smart meter interface permits vehicle charge controller to manage charge load based on installation demand

Optimization for self-use of local generation	Electromechanical	• Manual over-ride	• Smart meter interfaces are used to monitor generation and installation demand to govern vehicle charge control
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12.3 Data integration planning considerations

12.3.1 Smart metering interfaces

Further information can be found in the BEAMA guide Consumer Access Devices. Applications for Data in the Consumer Home Area Network (C HAN) and Wider Market Considerations.

Information on becoming a registered Data Communications Company (DCC) user is available from the DC www.smartdcc.co.uk.

Opportunities may exist in the future for integration with SMART Grid.

12.3.2 Protocol compatibility

When selecting interface protocols, it is necessary to consider the impact on:

- (a) the cost of compatible devices to be integrated;
- (b) the required competence and training for programming/configuration in commissioning and maintenance; and
- (c) the requirements for physical interface cabling (or wireless interface infrastructure).

[PAS 1878 Energy smart appliances - System functionality and architecture – Specification and PAS 1879 Energy smart appliances - Demand side response operation - Code of practice aim to provide a common protocol framework for SMART integration of equipment.](#)

12.3.3 Privacy and information security

The Data Protection Act [1998](#)[2018](#), Regulation of Investigatory Powers Act 2000, and the Computer Misuse Act 1990 apply. The means of integration should consider both the privacy of individuals and information security.

It is strongly recommended that:

- (a) any data gathered by commercial data collection systems that is provided to third parties for purposes other than billing and service provision is anonymized by design so that individuals and individual households cannot be identified;
- (b) users and building owners are made aware of exactly what data is gathered and how that is going to be used, and that they provide their consent for that; and
- (c) the means by which data is transmitted, accessed and encrypted is carefully considered, so that sensitive private or commercial information is not accessed without the correct authorization.

Further information can be found in the IET Code of Practice for Connected Systems Integration in Buildings and the BEAMA guide Consumer Access Devices. Applications for Data in the Consumer Home Area Network (C HAN) and Wider Market Considerations.

Information on becoming a registered DCC user for smart metering is available from the DCC website: www.smartdcc.co.uk.

12.4 Physical requirements for integration

12.4.1 Automation and control interfaces

Automation and control interfaces provide industry-standard communication protocols between devices that are optimized for control and monitoring purposes. Suitable interfaces may include:

(a) Metering Data, using one or more of the following:

(i) smart metering:

- BS EN 62056 series Electricity metering data exchange;
- BS EN 50491-11 HBES smart metering user display; and
- PD CEN/CLC/ETSI TR 50572 Functional reference architecture for communications in smart metering systems;

(b) PD CLC/TS 50568-4 and PD CLC/TS 50568-8 Electricity metering data exchange;

(c) BS EN 61968-9 system interfaces for utility metering interface and control;

(d) Ethernet BS ISO/IEC/IEEE 8802-3-series standard for wired and wireless local area networks;

(e) ISO/IEC/IEEE 8802.15-4 standard for wireless personal area networks ([for example, e.g. Zigbee](#));

(f) KNX (BS ISO/IEC 14543-series compliant);

(g) LonWorks (BS EN 14908-series compliant);

(h) OPC (BS EN 62541-series);

(i) Profibus and Profinet (BS EN 62769-series);

(j) BACnet (BS EN 61484-5); and

(k) Modbus, CANbus and Modbus over Ethernet.

12.4.2 Ethernet protocol for local area network and internet interfaces

Ethernet communication may be required for devices that connect to the home network, the internet (for example, to allow mobile device integration) or a corporate network for enterprise application integration.

Where the charger is required to communicate with devices on an Ethernet network, the first decision to make is whether to utilize a wired or wireless network.

3630 Wired local area networks require suitable (CAT 5, 6 or 7, or fibre optic) physical connections
3631 to the local network or internet router or switch.

3632 It should be considered whether the user knows how to maintain the network, should they
3633 need to replace any of their networking equipment.

3634 Some of the considerations for network interfaces will be treated differently for installations
3635 using private data networks or broadband connections in dwellings, compared with those in
3636 infrastructure, commercial and industrial installations. In infrastructure, commercial and
3637 industrial installations, such differences may include, for example, the following points:

- 3638 (a) electromagnetic compatibility (EMC) may be more of an issue with both wired and wireless
3639 networks¹;
- 3640 (b) network management and security may be managed in line with corporate strategies and
3641 policies. This may drive the selection of particular products or protocols¹;
- 3642 (c) the question as to whether there is sufficient wireless coverage for all devices to be
3643 connected may be considered and whether there is sufficient capacity to support
3644 numerous devices at distance from any single wireless access point to the wider network¹;
- 3645 (d) there may be more restrictions on shared networks¹;
- 3646 (e) products may be required to operate using virtual private networks¹;
- 3647 (f) devices may be required to be configurable to have fixed IP addresses⁷, or use a specific
3648 domain name server¹;
- 3649 (g) firewalls are likely to have greater restrictions¹;
- 3650 (h) 'plug and play' type interfaces may have more restrictions or have firewall blocks
3651 preventing their use¹;
- 3652 (i) remote device/system management and data logging may be prohibited from outside the
3653 corporate network¹; and
- 3654 (j) the minimum standard of domestic broadband connection to support the connection of
3655 additional devices, including an EV charging point, may be considered.

3656 12.4.3 General design considerations

3657 12.4.3.1 Wired interfaces

3658 Careful consideration should be given to electrical interference and EMC between power
3659 supply and PCE, and the data interface cabling. The requirements of Section 444 of BS 7671
3660 apply.

3661 Fibre optic connections are less susceptible to EMC issues⁷, but are more expensive.

3662 Copper-wired networks are usually specified only to work within a building, according to BS
3663 EN 50174-2. Copper wiring to equipment outdoors, particularly at some distance from the
3664 building, should be considered in line with BS EN 50174-3. In addition, when equipment is
3665 copper-wired outdoors, the designer should consider whether the network equipment has the
3666 correct installation overvoltage category to prevent damage or fire from overvoltages. This is
3667 typically more of a problem for commercial and infrastructure installations and industrial sites.
3668 However, it may be an issue for installations associated with dwellings if the wiring extends

some distance from the main building, and if there are utility, railway or other installations nearby that may provide overvoltage impulses.

[Design and installation requirements for information technology cabling infrastructure are discussed in Section 5.125-12.](#)

12.4.3.2 Wireless interfaces

Wireless networks enable communication without physical wiring.

It is worth considering whether there is a suitable wireless transmission path for the devices to be connected. For example, are there any building materials between the devices that might block the transmission path? In addition, some phenomena may affect coverage at certain times or under certain conditions. Starting a boiler, for instance, or switching on fluorescent lights in the vicinity of the devices, might affect communications.

12.4.3.3 Controls and data resilience

Communications systems may include connections to allow links between:

- (a) the EV charging module and the EV integral control panel;
- (b) the EV charging module and the energy management system in the electrical installation; and
- (c) the EV charging module and the end-user device, for example, a smartphone.

These communications systems will typically be internet-based and may involve wireless connectivity over some distance. Controls strategies for normal operation should also consider scenarios if these communication channels are not working.

- (a) How will the charging operation be affected?
- (b) Will the EV charging cease until communication channels are operational again?
- (c) How will electrical safety of the charging operation be maintained to ensure the protection of people and property?
- (d) Will the lack of communications inhibit the fiscal recharging of energy consumption in commercial EV charging facilities?

12.4.3.4 [Cyber Ssecurity](#)

Connecting any device to an existing information and communications technology (ICT) network provides a channel that can compromise either the security of the device itself or the network. This connection could be seen as a weak link in a cyber-security chain. An EV in this context is a device linked to an ICT network.

[The Electric Vehicles \(Smart Charge Points\) Regulations 2021 stipulate a significant set of cyber security requirements for many private charge point installations.](#)

The loss of the vehicle, through targeted theft, and its subsequent connection to a charging system it has previously visited, could provide a channel for other activities that compromise wider cyber-security in a vulnerable installation.

Where EVs are connected to commercial/industrial and public charging systems, via apps and the internet of things (IoT), it is recommended that additional guidance is sought from documents such as:

- (a) ETSI Technical Specification ~~103-645~~[ETSI EN 303 645](#) *Cyber Security for Consumer Internet of Things: Baseline Requirements*;
- (b) BS EN ISO/IEC 27001:2017. *Information technology. Security techniques*.
- (c) Information security management systems. Requirements; and
- (d) PAS 1192-5:2015 *Specification for security-minded building information modelling, digital built environments and smart asset management*.

NOTE: Whilst the software and firmware in products is outside the immediate control of the installer, it is the installer's responsibility to help inform the client in selection of suitable products.

12.5 Software maintenance and lifecycle

Software (including firmware) often requires updating to address continuing functionality and to patch security flaws. This is particularly important for devices that may connect to the internet.

In dwellings, it is worth considering whether this is something the user/homeowner can or should be able to do themselves. For example, in systems with simple smartphone applications, the firmware/software in a controller may require updating for the applications to continue to operate.

In commercial and public charging installations, matching the firmware/software upgrade paths with the corporate IT policies and strategies is imperative. How change is notified by manufacturers/software providers is a key part of this strategy, as well as the time between notification and the requirement for the update to be applied. The selection of particular software vendors and equipment manufacturers may in fact be driven as much by the corporate IT requirements as by the functional requirements of the installation, and certain functional requirements may be curtailed accordingly.

12.6 Software failures and system recovery

Software control may not be able to perform normally for a number of reasons, for example:

- (a) there has been a software error or crash;
- (b) connectivity to a data provider or service becomes temporarily unavailable; or
- (c) there is a hardware failure within communications or data-processing parts of the EVSE.

The system should be designed so that, as far as practicable, the ability to charge vehicles when this happens is not lost. Where software is used to manage loads, it may be necessary to limit curtail the charge current (or number of chargers available) to prevent overload of the installation. The system should continue to be safe in these conditions. It may be necessary in some cases to prevent charging sessions when certain software controls fail, for example, failure of billing systems for public charging points.

Performance in relevant failure modes should be considered very carefully to ensure electrical safety. For example, where controls are used to modulate the use of EVSE to prevent overloads of the installation (to prevent the system exceeding its maximum demand), the following might be necessary in a dwelling:

- (a) when telemetry or communications that facilitate the function ceases, the software stops control of charging. The available charge current is curtailed completely or limited to prevent overload.
- (b) to facilitate charging during failure, a manual switching arrangement is used as back-up, removing power from high-power loads (such as a shower, cooking appliances, etc.) equal to the maximum load of the charging system. The user can then opt to use either the EVSE or the other loads when automatic control is not available.

12.7 Electrical safety

No part of the EV installation should be allowed to compromise electrical safety within an installation. Compliance is required with BS 7671 and reference shall also be made to the additional measures within Section 722 of BS 7671 for EV installations.

Control systems should not lead to unsafe states. In particular, the following should be considered in the design of the installation and verified in commissioning:

- (a) safe isolation. The control system should not be used for isolation for maintenance, inspection and testing. A manual means of isolation should be provided to facilitate safe working on all circuits, in accordance with BS 7671.
- (b) protection against overload. Where the control system is used to modulate the use of EVSE to manage demand, relevant failure modes should be taken into account to prevent overload (which might in turn lead to equipment damage, fire, and so on). See Section 12.6 for examples. Control systems should not impede the function of overload devices within the installation.
- (c) control systems should not impede the function of electrical fault protection devices within the installation.

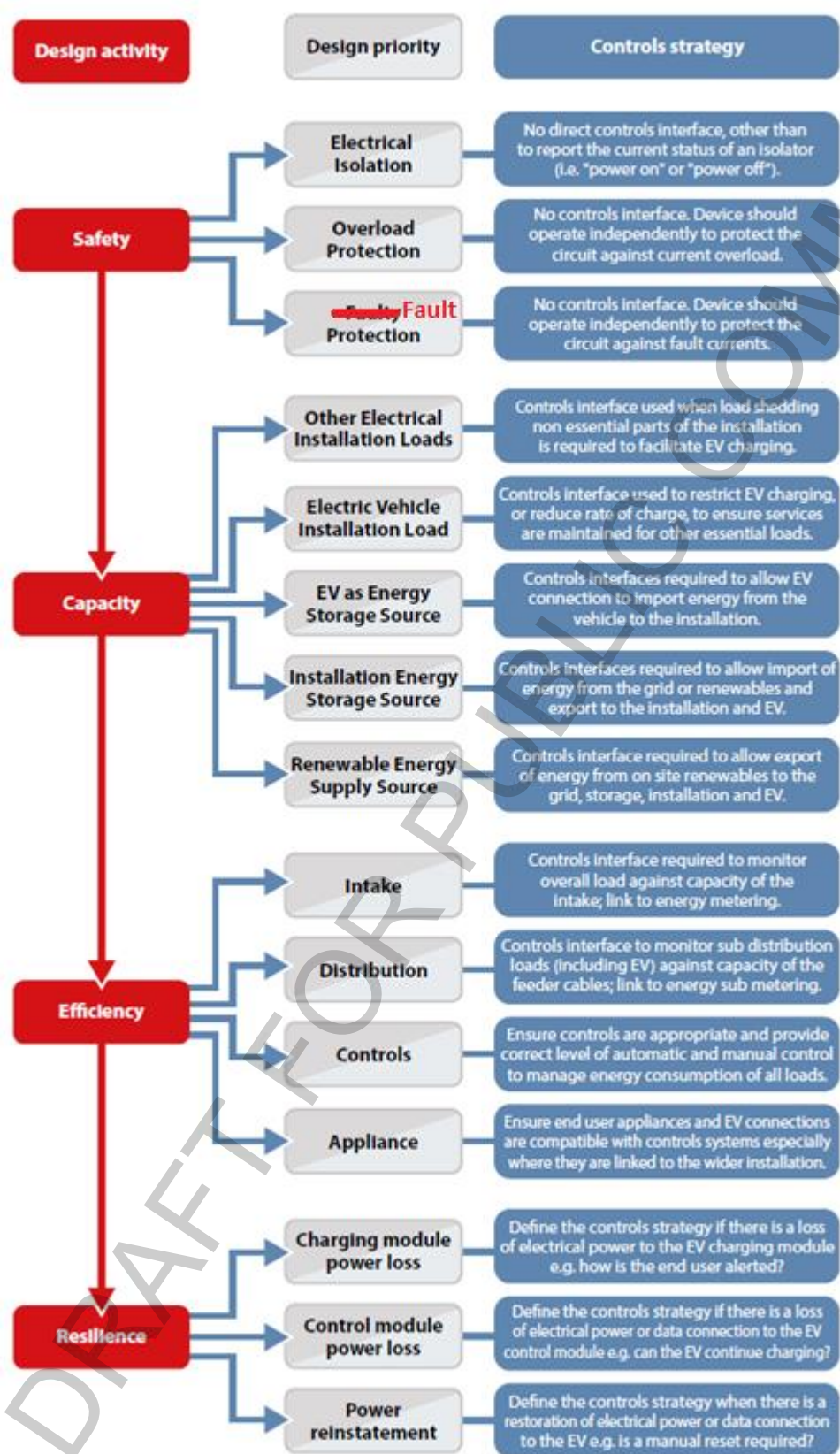
12.8 Electrical design hierarchy and the influence of controls

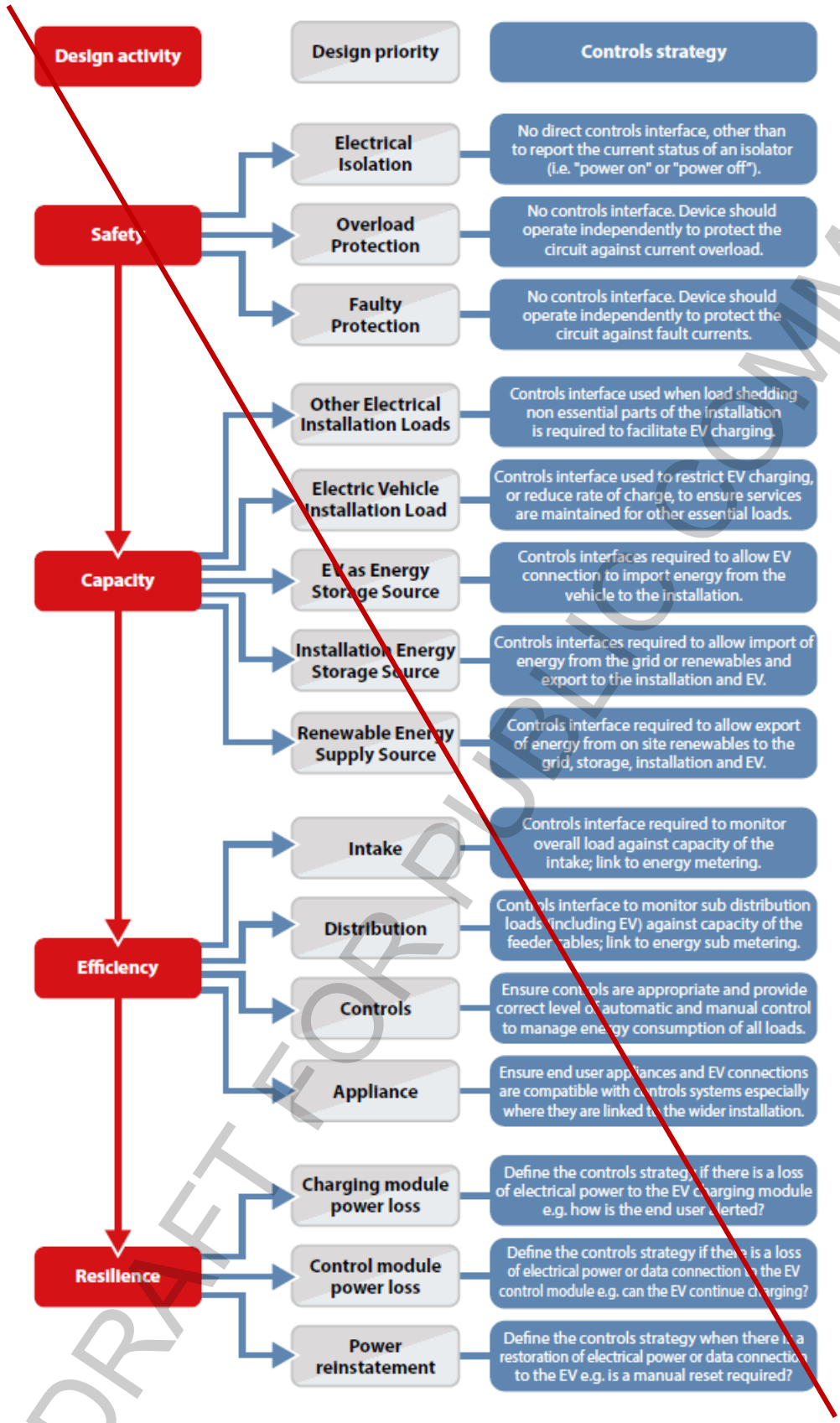
A typical electrical installation designed to BS 7671 focuses on the requirements of compliance with electrical safety and matching loads to the minimum capacity of the supply. More complex installations will also take into account efficiency, in accordance with Appendix 17 to BS 7671; others will also add resilience as a focus.

The IET *Designer's Guide to Energy Efficient Electrical Installations* notes the four facets of safety, capacity, efficiency and resilience, as key activities within an electrical installation design hierarchy. Within each of these activities, key design priorities can be identified that will influence how an EV charging system and the EV itself are integrated into the electrical and data installations. The controls interfaces for each of these design priorities will need to be carefully considered.

[Figure 12.10](#) highlights some of the headline considerations and interfaces. The list is not exhaustive and should be added to if required.

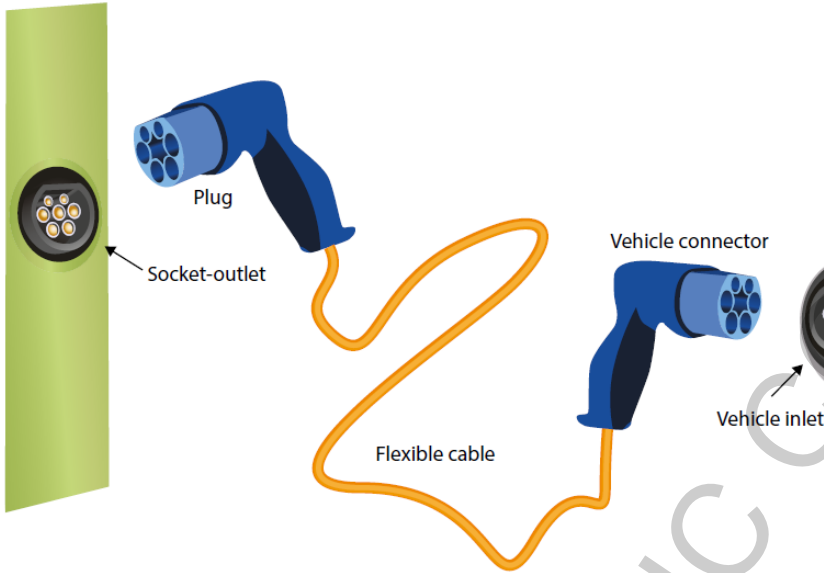
Figure 12.10 Electrical installation design hierarchy and EV charging controls





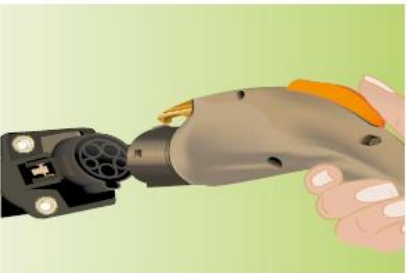
3789 **Appendix A Charging connectors and charging cable**
3790 **types**

3791 **Figure A.1** Nomenclature of charging connection components



3792 **Figure A.2** Mode 3 vehicle connector and vehicle inlet types

3793 BS EN 62196-2 Type 1 Vehicle Inlet and
Vehicle Connector
Also known as the SAE J1772 connector
or Yazaki connector



BS EN 62196-2 Type 2 Vehicle Inlet and
Vehicle Connector
Also known as the Mennekes connector



3794 BS EN 62196-2 Type 3 Vehicle Inlet and
Vehicle Connector
Also known as the EV Plug Alliance
connector



Figure A.3.A.3.1 Case A charging connection – charging cable and plug permanently attached to the EV

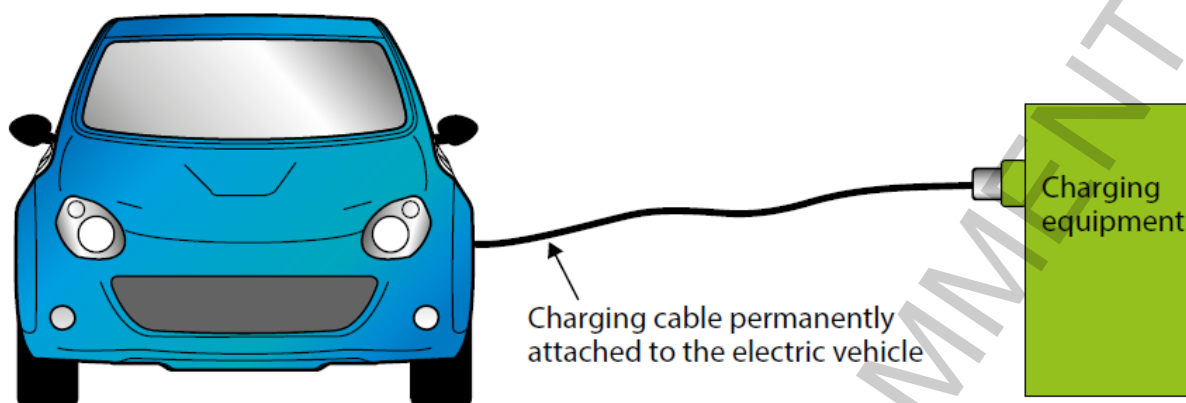


Figure A.4.A.3.2 Case B charging connection – detachable charging cable assembly with a vehicle connector and plug

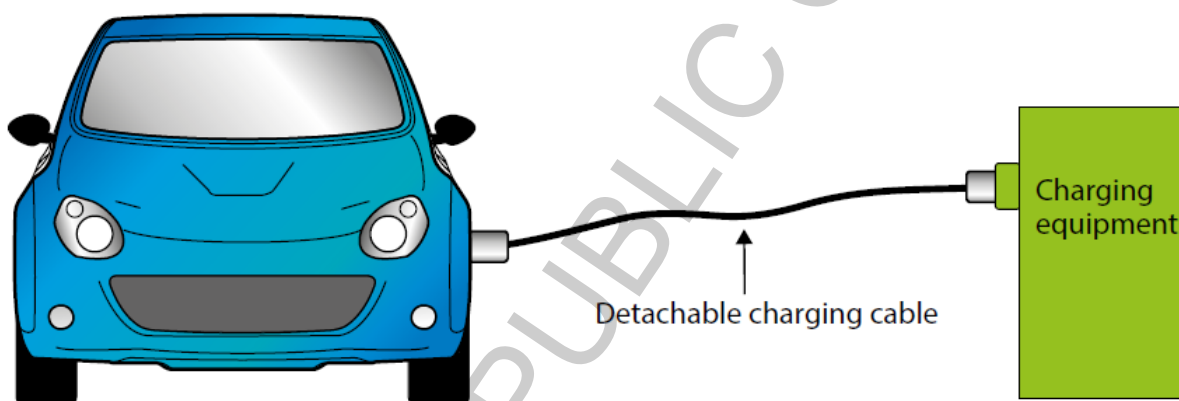


Figure A.5.A.3.3 Case C charging connection – charging cable permanently attached to the charging equipment (tethered cable)

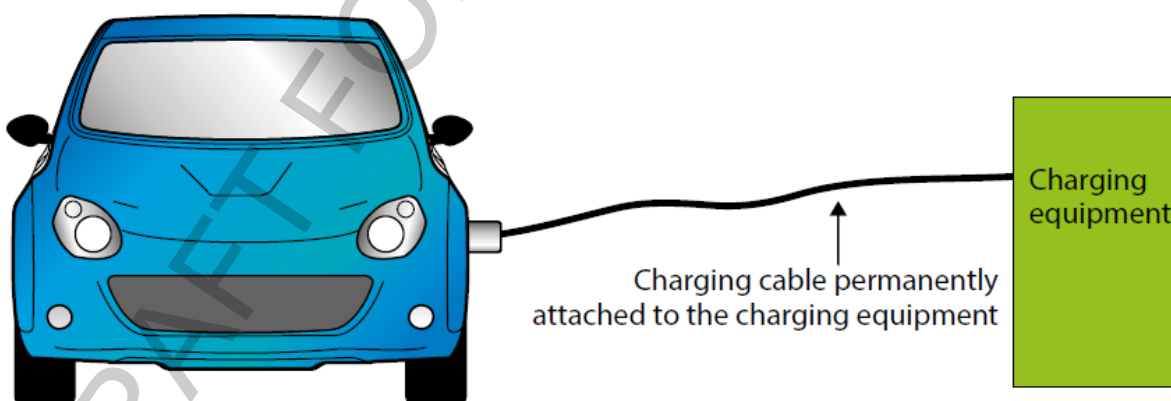


Figure A.6.A.4 Mode 4 Charging – charger with both combined charging system (CCS) and CHAdeMo tethered outlets



Figure A.7 Mode 4 Charging via pantograph-down (Case D) automatic coupler system



Figure A.8 Mode 4 Charging via pantograph-up (Case E) automatic coupler system



Appendix B Checklists for dwelling installations

(Form to be included with forms for certification given to the person ordering the work.)

Arrangements prior to installation – Dwelling installations				
CoP Ref	CHECK	YES	NO	N/A
3.33.2 6.26.23.2	Is the existing supply adequate for the additional demand?			
6.36.33.3 3	Has the earthing arrangement of the incoming power supply been established?			
	Are the existing earthing and bonding arrangements compliant with BS 7671?			
6.56.5 and 6.66.6	Is the supply TN-C-S (PME) or TN-S?			
6.46.4	Is the supply TT?			
6.66.66.7 and 6.8	If TN-C-S or TN-S, have the precautions necessary been identified? (for example, isolating transformer/ electrical separation, voltage operated protective device <u>open-PEN detection device</u> , additional electrode system, adopting TT)?			
5.1.25.1-2 , 5.3.35.3-3 , 6.6.36.6-6.36.8 , 6.76.7 6.9 and Annexes G, H and I	Has a simultaneous contact and earthing arrangements assessment been carried out? See form B1			
3.73.73.6	Has the installer reviewed the installation instructions provided by the charging equipment manufacturer?			
3.83.83.7	Has planning permission and/or Building Regulations approval been granted for the EV charging equipment installation?			
3.103.103.9	Have any constraints or difficulties of the proposed installation been discussed and agreed with the client?			
	Have any necessary repairs to the existing installation been agreed with the client?			
5.65.6 and 6.106.106.12	Has the correct type of RCD been selected in relation to the charging equipment (Type B for Mode 3 or Mode 4 charging equipment, unless the equipment has in-built DC residual current protection; Type A or Type F in all other cases)?			
11.241.2	<u>If the installation has V2X capability, has a G98 or G99 request been approved?</u>			

Physical installation requirements – Dwelling installations				
CoP Ref	CHECK	YES	NO	N/A
4.34.34. 2	Has the charging equipment been installed in an optimum location with respect to the intended vehicle parking position?			
4.44.44. 3	Has the EV charging equipment been installed in a location to minimize the likelihood of vehicle impact damage?			
	If required, have protective barriers been provided?			
4.54.54. 4	Are the main operating controls and any socket-outlets between 0.75 m and 1.2 m above the ground, and displays between 1.2 m and 1.4 m above ground? <u>at an appropriate height?</u>			
4.64.64. 5	Is there sufficient space around the charging equipment to open all <u>equipment</u> doors and covers?			
4.74.74. 6	Is there sufficient space around the charging equipment for ventilation and cooling purposes?			
4.64.64. 7	Have all trip hazards been considered and, where possible, avoided?			
4.84.84. 9	Have any BS 1363 socket-outlets <u>intended for EV charging</u> been labelled as EV connecting points, <u>and checked to see that they are marked 'BS 1363/EV' on the rear in accordance with BS 1363-2?</u>			

Electrical installation requirements – Dwelling installations				
CoP Ref	CHECK	YES	NO	N/A
	Pre-work survey of installation carried out including: - rating and condition of existing equipment - suitability for additional load - earthing and bonding			
	Pre-work tests of installation carried out including: - earth continuity, polarity and insulation resistance - earth fault loop impedance - operation of RCDs			
	Isolation of installation			
	Precautions taken to prevent inadvertent energizing			
	Defects in existing installation identified and notified to the client			
	Electrical Installation Certificate to hand, with preliminaries complete, including signatures for design			
	Installation isolated and precautions to prevent inadvertent switching on taken			
<u>99</u>	Preceding testing, inspection carried out on disconnected installation			
<u>99</u>	Inspections carried out as per BS 7671 Schedule of Inspections			
<u>99</u>	Schedule of Inspections completed			
<u>99</u>	Dead tests carried out as required by BS 7671 <i>prior to</i> energizing, and appropriate parts of the test schedule completed			
<u>99</u>	Remaining tests carried out as required by BS 7671 <i>after</i> energizing, and appropriate parts of the test schedule completed			
<u>99</u>	Electrical Installation Certificate completed, complete with schedule of inspections and schedule of test results			
<u>99</u>	Copy of certificates issued to the person ordering the work			
<u>99</u>	Customer advised in writing of any defects in the electrical installation not rectified			
<u>99</u>	Competent person scheme provider notified of completion			
<u>9.39.4</u>	Correct operation of the charging equipment demonstrated to the client			
<u>9.49.4</u>	Client provided with the instruction manual for the equipment and informed of any maintenance requirements			
<u>1141</u>	DNO notification form for the installation submitted via the Energy Networks Association website and, for V2X capability, post-installation notification to the DNO in accordance with G98/G99?			

Risk assessment form B1 IET Standards

Premise with PME supply and vehicle charging equipment to be installed outdoors where a TT system is proposed to be adopted for charging equipment only

(Form to be included with forms for certification given to the person ordering the work.)

Name and address of client	Installation Address
.....	
.....	
.....	
Postcode.....	Postcode.....
....	
Supply taken from, e.g. main building/ house/garage/other	
	
	
Location of EV charging equipment considered in this risk assessment, (approximate distance to reference points)	
	
	
	
	
	

Step	Record
Step 1 Identify the hazards	
(a) Does the building from which the charging supply is to be obtained have a PME (TN-C-S) or public TN-S supply?	Yes/No
(b) Is the vehicle charging equipment to be installed outdoors?	Yes/No
(c) Is a TT system to be adopted for the vehicle charging equipment only?	Yes/No
	<i>If the answer to all three of the above questions is Yes, the hazard will be:</i>
	In the event of an open-circuit neutral in the PME supply system, all conductive- parts connected to the main PME earthing terminal, e.g. any exposed- or extraneous- conductive-parts that may be directly, or indirectly, or otherwise connected to this earthing terminal, may become raised to a dangerous voltage relative to true Earth.

Step 2 Simultaneous contact – decide who might be harmed and how	Any person who can simultaneously touch any conductive-parts or conductor that might be connected to the main PME earth terminal of the building, e.g. a water tap, or metallic gas/water or fuel pipe, or metallic conduit, or item of Class I electrical equipment such as an outside light, switch or socket-outlet, or a boiler flue, or structural steel work, etc., AND the vehicle being charged OR any other conductive-parts or conductor that might be directly or indirectly or otherwise connected to the TT earth terminal of the vehicle charging equipment.
Step	Record
Step 3 Simultaneous contact – evaluate the risks and decide on precautions (1) Is it possible to simultaneously touch any conductive-parts or conductor that might be connected to the main PME (TN-C-S) or public TN-S earthing terminal AND the vehicle being charged OR any conductive-parts or conductor that might be connected to the TT earth terminal of the vehicle charging equipment? NB: All possible locations and positions of the vehicle on charge, and the charging lead and connector must be considered here. (2) If the answer to question (1) is Yes, can this simultaneous contact be reliably prevented, e.g. by fitting an insulating section into any pipe or conduit, or replacing any item of Class I equipment with Class II equipment, or by providing a permanent barrier or enclosure, or by applying permanent insulation, etc.?	Yes/No <i>If the answer to question 1 is No, retain the following text; if Yes, delete the following text:</i> ‘THIS RISK ASSESSMENT SHOWS THAT IT IS NOT CURRENTLY NECESSARY TO TAKE ANY PRECAUTIONS TO PREVENT RISK OF SIMULTANEOUS CONTACT BETWEEN ANY CONDUCTIVE-PARTS OR CONDUCTOR THAT MIGHT BE CONNECTED TO THE MAIN PME EARTHING TERMINAL AND THE VEHICLE BEING CHARGED OR ANY OTHER CONDUCTIVE-PARTS OR CONDUCTOR THAT MIGHT BE CONNECTED TO THE TT EARTH TERMINAL OF THE VEHICLE CHARGING EQUIPMENT. THE CUSTOMER HAS BEEN INFORMED IN WRITING THAT A FURTHER RISK ASSESSMENT MUST BE UNDERTAKEN TO CHECK WHETHER THE CHARGING EQUIPMENT WILL REMAIN SAFE TO ENERGIZE AND/OR USE IF THIS SITUATION CHANGES.’ Yes/No <i>If the answers to question 1 and question 2 are both Yes, record here the essential precautions required to prevent the possibility(ies) of simultaneous contact identified by question (2):</i> <i>And</i> THE CUSTOMER HAS BEEN INFORMED IN WRITING THAT THE CHARGING EQUIPMENT WILL BECOME UNSAFE TO ENERGIZE AND/ OR USE IF THE PRECAUTIONS LISTED ABOVE ARE REMOVED OR OTHERWISE BECOME INEFFECTIVE.

	<i>If the answer to question 1 is Yes and the answer to question 2 is No, retain the following text here (otherwise delete):</i> 'THIS RISK ASSESSMENT SHOWS THAT IT IS NOT CONSIDERED TO BE SAFE TO PROVIDE A TT EARTHED OUTDOOR VEHICLE CHARGING POINT AT THE CHOSEN LOCATION AND/OR TO CHARGE A TT EARTHED EV AT THE CHOSEN LOCATION. THIS HAS BEEN MADE KNOWN TO THE CUSTOMER IN WRITING.'
--	--

Step	Record
Step 4 Separation of earthing systems – decide who might be harmed and how	Any person who may be touching the vehicle being charged OR any other conductive-parts or conductor that might be directly or indirectly or otherwise connected to the TT earth terminal of the vehicle charging equipment, under either of the following conditions: (a) buried metalwork connected to the PME earthing system is not adequately separated from earth electrode(s) or buried metalwork connected to the TT earthing system, in accordance with Table H1; or (b) the potential of the ground on which they are standing is subject to rise of earth potential during a PME neutral conductor fault, as described in Appendix GAppendix GAnnex H, Clause G5H5.
Step 5 Separation of earthing systems – evaluate the risks and decide on precautions Is adequate separation of the TT earthing system available, and the risk of return of PME touch voltage assessed to be negligible?	Yes/No <i>If the answer to this question is No, retain the following text here (otherwise delete):</i> 'THIS RISK ASSESSMENT SHOWS THAT IT IS NOT CONSIDERED TO BE SAFE TO PROVIDE A TT EARTHED OUTDOOR VEHICLE CHARGING POINT AT THE CHOSEN LOCATION AND/OR TO CHARGE A TT EARTHED EV AT THE CHOSEN LOCATION. THIS HAS BEEN MADE KNOWN TO THE CUSTOMER IN WRITING.'
Step 6 Record your findings and implement them If the precautions are inadequate, is it less of a risk to convert the complete installation to TT? If precautions are likely to be inadequate, consider the risks associated with the conversion of the complete installation to TT, considering, for example, adjoining properties on TN-C-S or TN-S, or adjoining properties with extraneous-conductive-parts or exposed-conductive-parts within reach of a vehicle on charge.	All precautions required by step 3 completed. Signature..... Date carried out.....

Step 7 Review the assessment and update if necessary	To be reviewed whenever further work is carried out on the installation, including any inspection and testing
--	---

Appendix C Checklists for on-street installations

(Form to be included with forms for certification given to the person ordering the work.)

Arrangements prior to installation – On-street installations				
CoP Ref	CHECK	YES	NO	N/A
3.23.23.4	Has the installation of a new meter point been arranged with the DNO?			
7.3.37.3.3 and 7.57.5	Is the supply PME (TN-C-S) or a public TN-S supply?			
7.3.37.3.3 and 7.57.5	Is TT to be adopted for the installation?			
7.3.37.3.3 , 7.57.5 and Annexes G, H and I	Has a simultaneous contact and earthing arrangements assessment been carried out?			
	See risk assessment form C1.			
3.63.63.5	Has mobile network coverage of the proposed installation location been checked? <i>Note: Some EVSE manufacturers require a minimum of 3G coverage.</i>			
3.73.73.6	Has the installer reviewed the installation instructions provided by the EV charging equipment manufacturer?			
3.93.93.8	Has a Traffic Management Regulation Order (TMRO) been created and duly consulted on for the EV charging equipment installation?			
3.103.103.9	Have the details of the proposed installation been discussed and agreed with the client?			

Physical installation requirements – On-street installations				
CoP Ref	CHECK	YES	NO	N/A
4.34.34. 2	Has the charging equipment been installed in an optimum location with respect to the intended vehicle parking position?			
4.44.44. 3	Has the EV charging equipment been installed in a location to minimize the likelihood of vehicle impact damage?			
	If no, have protective barriers been provided?			
4.54.54. 4	Has accessibility been addressed?			
	Are the main operating controls and any socket-outlets between 0.75 m and 1.2 m above the ground, and displays between 1.2 m and 1.4 m above the ground?			
	Have you made sure there are no changes of level between the vehicle and EVSE controls?			
	Is there adequate space for wheelchair access to the EVSE, controls and between two vehicles being charged?			
4.64.64. 5	Is there sufficient space around the charging equipment to open all doors and covers?			
4.74.74. 6	Is there sufficient space around the charging equipment for ventilation and cooling purposes?			
4.64.64. 7	Have all trip hazards been considered and, where possible, avoided?			

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Electrical installation requirements – On-street installations				
CoP Ref	CHECK	YES	NO	N/A
	Pre-installation			
	Have New Roads and Street Works Act 1991 (NRSWA) notices been issued?			
<u>7.3.4</u> 7.3.4	Are drawings to hand of the electric cables and other services in installation locations?			
<u>7.3.4</u> 7.3.4	Have any potential hazards, e.g. high voltage (HV) cables, been identified in the excavation location?			
<u>7.3.4</u> 7.3.4	Has the electricity supply cable been identified, and the position of the distribution pillar been confirmed?			
	Has a permit to work been issued (where required), confirming that the installation is isolated?			
	Has the location of the earth electrode been identified and confirmed with the installer?			
	Has the location and depth of the trenches been confirmed?			
	Are arrangements in hand for permanent reinstatement of the cable routes?			
	Before connection			
9	Inspections carried out as per BS 7671 Schedule of Inspections?			
	Schedule of Inspections completed			
	Dead tests carried out as required by BS 7671 <i>prior</i> to energizing, and appropriate parts of the test schedule completed?			
	After supply connected			
	Remaining tests carried out as required by BS 7671 <i>after</i> energizing, and appropriate parts of the test schedule completed?			
	Electrical Installation Certificate completed complete with schedule of inspections and schedule of test results?			
Risk Assessment C1	Risk Assessment form C1 completed and given to client?			
<u>9.39.3</u>	Correct operation of the charging equipment demonstrated to the client?			
<u>9.49.4</u>	Client provided with the instruction manual for the equipment and informed of any maintenance requirements?			
<u>11.11.1</u>	DNO notification form for the installation submitted via the Energy Networks Association website <u>and, for V2X capability, post-installation notification to the DNO in accordance with G98/G99?</u>			

Risk assessment C1 IET Standards

On-street charging equipment, TT system

(Form to be included with forms for certification given to the person ordering the work.)

Name and address of client	Installation Address
.....	
....	
.....	
....	
.....	
....	
Postcode.....	Postcode.....
..	
Supply taken from, e.g. distribution cable/ service cable/building, specify	
	
	
Location of EV charging equipment considered in this risk assessment, (approximate distance to reference points)	
	
	
	
	
	
	

Step	Record
Step 1 Identify the hazards	
Is the on-street charging equipment installed in a location that will result in this equipment and the vehicle on charge being at least 2.5 m from: • other structures with exposed metalwork that are either connected to true Earth or connected To Any other electrical earthing system? and • any extraneous- or exposed- conductive- parts of any other electrical equipment?	Yes/No If the answer to the above questions is No, the hazard will be: In the event of an open-circuit neutral in the PME supply system to street furniture or other installations, conductive-parts of such equipment may become raised to a dangerous voltage relative to the charging equipment or vehicle on charge.
Step 2 Simultaneous contact – decide who might be harmed and how	Any person who can simultaneously touch any conductive-parts of charging equipment or vehicle on charge and other street furniture or similar with an open-circuit neutral.

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Step	Record
Step 3 Simultaneous contact – evaluate the risks and decide on precautions (1) Is it possible to simultaneously touch any conductive-parts of faulty street furniture AND the vehicle being charged OR any conductive-parts or conductor that might be connected to the TT earth terminal of the vehicle charging equipment? NB: All possible locations and positions of the vehicle on charge, and the charging lead and connector, must be considered here.	Yes/No <i>If the answer to question (1) is No, retain the following text; if Yes, delete the following text:</i> ‘THIS RISK ASSESSMENT SHOWS THAT IT IS NOT CURRENTLY NECESSARY TO TAKE ANY PRECAUTIONS TO PREVENT RISK OF SIMULTANEOUS CONTACT BETWEEN ANY CONDUCTIVE-PARTS OR CONDUCTOR THAT MIGHT BE CONNECTED TO THE MAIN PME EARTHING TERMINAL AND THE VEHICLE BEING CHARGED OR ANY OTHER CONDUCTIVE-PARTS OR CONDUCTOR THAT MIGHT BE CONNECTED TO THE TT EARTH TERMINAL OF THE VEHICLE CHARGING EQUIPMENT. THE CUSTOMER HAS BEEN INFORMED IN WRITING THAT A FURTHER RISK ASSESSMENT MUST BE UNDERTAKEN TO CHECK WHETHER THE CHARGING EQUIPMENT WILL REMAIN SAFE TO ENERGIZE AND/OR USE IF THIS SITUATION CHANGES.’
(2) If the answer to question (1) is Yes, can this simultaneous contact be reliably prevented, e.g. by fitting an insulating section into any pipe or conduit, or replacing any item of Class I equipment with Class II equipment, or by providing a permanent barrier or enclosure, or by applying permanent insulation, etc.?	Yes/No <i>If the answers to question 1 and question 2 are both Yes, record here the essential precautions required to prevent the possibility(ies) of simultaneous contact identified by question (2):</i> And THE CUSTOMER HAS BEEN INFORMED IN WRITING THAT THE CHARGING EQUIPMENT WILL BECOME UNSAFE TO ENERGIZE AND/ OR USE IF THE PRECAUTIONS LISTED ABOVE ARE REMOVED OR OTHERWISE BECOME INEFFECTIVE. <i>If the answer to question 1 is Yes and the answer to question 2 is No, retain the following text here (otherwise delete):</i>

	THIS RISK ASSESSMENT SHOWS THAT IT IS NOT CONSIDERED TO BE SAFE TO PROVIDE A TT EARTHED OUTDOOR VEHICLE CHARGING POINT AT THE CHOSEN LOCATION AND / OR TO CHARGE A TT EARTHED EV AT THE CHOSEN LOCATION. THIS HAS BEEN MADE KNOWN TO THE CUSTOMER IN WRITING.
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Step	Record
Step 4 Separation of earthing system – decide who might be harmed and how	Any person who may be touching the vehicle being charged OR any other conductive- parts or conductor that might be directly or indirectly or otherwise connected to the TT earth terminal of the vehicle charging equipment, under either of the following conditions: (a) buried metalwork connected to the PME earthing system is not adequately separated from earth electrode(s) or buried metalwork connected to the TT earthing system, in accordance with Table H1; or (b) the potential of the ground on which they are standing is subject to rise of earth potential during a PME neutral conductor fault, as described in Annex H, Clause H5.
Step 5 Separation of earthing systems – evaluate the risks and decide on precautions Is adequate separation of the TT earthing system available, and the risk of return of PME touch voltage assessed to be negligible?	Yes/No <i>If the answer to this question is No, retain the following text here (otherwise delete):</i> 'THIS RISK ASSESSMENT SHOWS THAT IT IS NOT CONSIDERED TO BE SAFE TO PROVIDE A TT EARTHED OUTDOOR VEHICLE CHARGING POINT AT THE CHOSEN LOCATION AND/OR TO CHARGE A TT EARTHED EV AT THE CHOSEN LOCATION. THIS HAS BEEN MADE KNOWN TO THE CUSTOMER IN WRITING.'
Step 6 Record your findings and implement them	All precautions required by step 3 completed Signature..... Date carried out.....
Step 7 Review the assessment and update if necessary	To be reviewed whenever further work is carried out on the installation including any inspection and testing.

Appendix D Checklists for commercial and industrial installations

(Form to be included with forms for certification given to the person ordering the work.)

Arrangements prior to installation – Commercial and industrial installations				
CoP Ref	CHECK	YES	NO	N/A
4.24.24.1	Are there any hazardous zones where flammable/combustible gases may be present?			
4.24.24.1	Have the boundaries of any hazardous zones been identified?			
4.24.24.1	Can the installation be carried out so that the charged vehicle, cable and connectors are outside the hazardous area when charging?			
3.23.23.1	Is metering adequate for the intended use and billing model?			
3.33.3.8.1.38.1.33.2	Is the existing supply adequate for the additional demand?			
8.1.28.1.28	Has the earthing arrangement of the incoming power supply been established?			
	Are the existing earthing and bonding arrangements compliant with BS 7671?			
8.2.38.2.3	Is the supply PME (TN-C-S) or a TN-S public supply?			
8.2.38.2.3	If PME (TN-C-S), have precautions necessary to prevent danger in the event of an open-circuit neutral been identified and addressed?			
5.1.25.1.2, 5.3.35.3.3, 8.2.18.2.1 and Annexes Appendices G, H and I, G and H	If a TT earthing system is being provided for the charging equipment, has a simultaneous contact and earthing arrangements assessment been carried out?			
3.63.63.5	Has mobile network coverage of the proposed installation location been checked? <i>Note: Some EVSE manufacturers require a minimum of 3G coverage.</i>			
3.73.73.6	Has the installer reviewed the installation instructions provided by the charging equipment manufacturer?			
3.83.83.7	Has planning permission been granted for the charging equipment installation?			
3.103.103.9	Have the details of the proposed installation been discussed and agreed with the client?			
	Have any necessary repairs to the existing installation been agreed with the client?			

5.65.6 8.58.5	and	Has the correct type of RCD been selected in relation to the charging equipment (Type B for Mode 3 or Mode 4 charging equipment, unless the equipment has in-built DC residual current protection <u>then</u> Type A or Type F <u>in all other cases may be acceptable</u>)?			
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Physical installation requirements – Commercial and industrial installations					
CoP Ref	CHECK	YES	NO	N/A	
4.24.24.1	Has the charging equipment been installed outside any hazardous zones where flammable/combustible gases may be present?				
4.24.24.1	Have precautions been taken to ensure the charged vehicle, cable and connectors are outside the hazardous area when charging?				
4.34.34.2	Has the charging equipment been installed in an optimum location with respect to the intended vehicle parking position?				
4.44.44.3	Has the charging equipment been installed in a location to minimize the likelihood of vehicle impact damage?				
	If no, have protective barriers been provided?				
4.54.54.4	Are the main operating controls and any socket-outlets <u>between 0.75 m and 1.2 m above the ground, and displays between 1.2 m and 1.4 m above ground at an appropriate height</u> ?				
4.64.64.5	Is there sufficient space around the charging equipment to open all <u>equipment</u> doors and covers?				
4.74.74.6	Is there sufficient space around the charging equipment for ventilation and cooling purposes?				
4.64.64.7	Have all trip hazards been considered and, where possible, avoided?				
4.84.84.9	Have any BS 1363 socket-outlets <u>intended for EV charging</u> been labelled as EV connecting points, <u>and checked to see that they are marked 'BS 1363/EV' on the rear in accordance with BS 1363-2</u> ?				

Electrical installation requirements – General				
CoP Ref	CHECK	YES	NO	N/A
	Prior to installation checklist to hand and satisfactorily completed?			
<u>55</u> , <u>88</u>	Installation design to hand?			
	Design section of electrical installation signed?			
	Pre-work survey of installation carried out, including: - rating and condition of existing equipment? - suitability for additional load? - earthing and bonding?			
	Pre-work tests of installation carried out, including: - earth continuity, polarity and insulation resistance? - earth fault loop impedance? - operation of RCDs?			
	Defects in existing installation identified and notified to the client: - those affecting the new installation? - those not affecting the new installation?			
	Order to repair defects in existing installation affecting the new installation received?			
	Equipment to be worked on isolated?			
	Precautions taken to prevent inadvertent energizing?			
	Installation carried out?			
<u>99</u>	Testing			
<u>99</u>	Electrical Installation Certificate to hand, with preliminaries complete, including signatures for design?			
<u>99</u>	Installation isolated and precautions to prevent inadvertent switching on taken?			
<u>99</u>	Preceding testing, inspection carried out on disconnected installation?			
<u>99</u>	Inspections carried out as per BS 7671 Schedule of Inspections?			
<u>99</u>	Schedule of Inspections completed?			
<u>99</u>	Dead tests carried out as required by BS 7671 <i>prior to</i> energizing, and appropriate parts of the test schedule completed?			
<u>99</u>	Remaining tests carried out as required by BS 7671 <i>after</i> energizing, and appropriate parts of the test schedule completed?			

Electrical installation requirements – General				
CoP Ref	CHECK	YES	NO	N/A
<u>99</u>	Electrical Installation Certificate completed complete with schedule of inspections and schedule of test results?			
<u>99</u>	Copy of certificates issued to the person ordering the work?			
<u>99</u>	Customer advised in writing of any defects in the electrical installation not rectified?			
<u>99</u>	Competent person scheme provider notified of completion?			
<u>9.39.3</u>	Correct operation of the charging equipment demonstrated to the client?			
<u>9.49.4</u>	Client provided with the instruction manual for the equipment and informed of any maintenance requirements?			
<u>1144</u>	DNO notification form for the installation submitted via the Energy Networks Association website and, for V2X capability, post-installation notification to the DNO in accordance with G98/G99?			

Risk assessment D1 IET Standards

Installation with PME supply and vehicle charging equipment to be installed outdoors where a TT system is proposed to be adopted for charging equipment only

(Form to be included with forms for certification given to the person ordering the work.)

Name and address of client	Installation Address
.....	
.....	
.....	
.....	
Postcode.....	Postcode.....
.....	
Supply taken from, e.g. main intake, office unit z, store	
	
	
Location of EV charging equipment considered in this risk assessment, (approximate distance to reference points)	
	
	
	
	
	

Step	Record
Step 1 Identify the hazards (a) Does the building from which the charging supply is to be obtained have a PME supply? (b) Is the vehicle charging equipment to be installed outdoors? (c) Is a TT system to be adopted for the main installation and vehicle charging equipment?	Yes/No Yes/No Yes/No <i>If the answer to all three of the above questions is Yes, the hazard will be:</i> In the event of an open-circuit neutral in the PME supply system, all conductive-parts connected to the main PME earthing terminal, e.g. any exposed- or extraneous-conductive-parts that may be directly, or indirectly, or otherwise connected to this earthing terminal, may become raised to a dangerous voltage relative to true Earth.
Step 2 Simultaneous contact – decide who might be harmed and how	Any person who can simultaneously touch any conductive-parts or conductor that might be connected to the main PME earth terminal of the building, e.g. a water tap, or metallic gas/water or fuel pipe, or metallic conduit, or item of Class I electrical equipment, such as an outside light, switch or socket-outlet, or a boiler flue, or structural steel work, etc., AND the vehicle being charged OR any other conductive-parts or conductor that might be directly or indirectly or otherwise connected to the TT earth terminal of the vehicle charging equipment.

Step	Record
Step 3 Simultaneous contact – evaluate the risks and decide on precautions	

(1) Is it possible to simultaneously touch any conductive-parts or conductor that might be connected to the main PME earthing terminal AND the vehicle being charged OR any conductive-parts or conductor that might be connected to the TT earth terminal of the vehicle charging equipment? NB: All possible locations and positions of the vehicle on charge, and the charging lead and connector, must be considered here.

Yes/No

If the answer to question 1 is No, retain the following text; if Yes, delete the following text:

‘THIS RISK ASSESSMENT SHOWS THAT IT IS NOT CURRENTLY NECESSARY TO TAKE ANY PRECAUTIONS TO PREVENT RISK OF SIMULTANEOUS CONTACT BETWEEN ANY CONDUCTIVE-PARTS OR CONDUCTOR THAT MIGHT BE CONNECTED TO THE MAIN PME EARTHING TERMINAL AND THE VEHICLE BEING CHARGED OR ANY OTHER CONDUCTIVE-PARTS OR CONDUCTOR THAT MIGHT BE CONNECTED TO THE TT EARTH TERMINAL OF THE VEHICLE CHARGING EQUIPMENT.

THE CUSTOMER HAS BEEN INFORMED IN WRITING THAT A FURTHER RISK ASSESSMENT MUST BE UNDERTAKEN TO CHECK WHETHER THE CHARGING EQUIPMENT WILL REMAIN SAFE TO ENERGIZE AND/OR USE IF THIS SITUATION CHANGES.’

(2) If the answer to question (1) is Yes, can this simultaneous contact be reliably prevented, e.g. by fitting an insulating section into any pipe or conduit, or replacing any item of Class I equipment with Class II equipment, or by providing a permanent barrier or enclosure, or by applying permanent insulation, etc.?

Yes/No

If the answers to question 1 and question 2 are both Yes, record here the essential precautions required to prevent the possibility(ies) of simultaneous contact identified by question (2):

.....
.....
.....
.....
.....

And

THE CUSTOMER HAS BEEN INFORMED IN WRITING THAT THE CHARGING EQUIPMENT WILL BECOME UNSAFE TO ENERGIZE AND/OR USE IF THE PRECAUTIONS LISTED ABOVE ARE REMOVED OR OTHERWISE BECOME INEFFECTIVE.

If the answer to question 1 is Yes and the answer to question 2 is No, retain the following text here (otherwise delete):

‘THIS RISK ASSESSMENT SHOWS THAT IT IS NOT CONSIDERED TO BE SAFE TO PROVIDE A TT EARTHED OUTDOOR VEHICLE CHARGING POINT AT THE CHOSEN LOCATION AND/OR TO CHARGE A TT EARTHED EV AT THE CHOSEN LOCATION. THIS HAS BEEN MADE KNOWN TO THE CUSTOMER IN WRITING.’

Step	Record
Step 4 Separation of earthing system – decide who might be harmed and how	Any person who may be touching the vehicle being charged OR any other conductive- parts or conductor that might be directly or indirectly or otherwise connected to the TT earth terminal of the vehicle charging equipment, under either of the following conditions: (a) buried metalwork connected to the PME earthing system is not adequately separated from earth electrode(s) or buried metalwork connected to the TT earthing system, in accordance with Table H1; or (b) the potential of the ground on which they are standing is subject to rise of earth potential during a PME neutral conductor fault, as described in Annex H, Clause H5.
Step 5 Separation of earthing systems – evaluate the risks and decide on precautions Is adequate separation of the TT earthing system available, and the risk of return of PME touch voltage assessed to be negligible?	Yes/No <i>If the answer to this question is No, retain the following text here (otherwise delete):</i> ‘THIS RISK ASSESSMENT SHOWS THAT IT IS NOT CONSIDERED TO BE SAFE TO PROVIDE A TT EARTHED OUTDOOR VEHICLE CHARGING POINT AT THE CHOSEN LOCATION AND/OR TO CHARGE A TT EARTHED EV AT THE CHOSEN LOCATION. THIS HAS BEEN MADE KNOWN TO THE CUSTOMER IN WRITING.’
Step 6 Record your findings and implement them If the precautions are inadequate, is it less of a risk to convert the complete installation to TT?	All precautions required by step 3 completed. Signature..... Date carried out.....
Step 7 Review the assessment and update if necessary	To be reviewed whenever further work is carried out on the installation, including any inspection and testing.

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Appendix E Checklists for fuel filling installations

(Form to be completed by a person suitably competent in fuel filling station installations and included with forms for certification given to the person ordering the work.)

Arrangements prior to installation — Fuel filling station installations				
CoP Ref	CHECK	YES	NO	N/A
4.1	Is this form being completed by a person suitably experienced in fuel filling station electrical installations?			
4.1	Is the installation being carried out by contractors with operatives who are trained and qualified in accordance with the Petrol Retail Forecourt Contractors safety passport scheme?			
4.1r	Have the boundaries of any hazardous zones been identified?			
4.1	Can the installation be carried out so that the EVSE is located outside the hazardous area?			
4.1	Can the installation be carried out so that the charged vehicle, cable and connectors are outside the hazardous area when charging?			
3.1	Is metering adequate for the intended use and billing model?			
3.2	Is the existing supply adequate for the additional demand?			
8	Has the earthing arrangement of the incoming power supply been established?			
	Are the existing earthing and bonding arrangements compliant with BS 7671 and EI/APEA publication 'Guidance for Design, Construction, Modification, Maintenance and Decommissioning of Filling Stations'?			
8.2.3	Is the supply PME (TN-C-S) or a TN-S public supply?			
8.2.3	If PME (TN-C-S), have precautions necessary to prevent danger in the event of an open circuit neutral been identified and addressed?			
5.1.2, 5.3.3, 8.2.1 and Annexes G, H and I	If required, has a simultaneous contact and earthing arrangements assessment been carried out?			
3.5	Has mobile network coverage of the proposed installation location been checked? <i>Note: Some EVSE manufacturers require a minimum of 3G coverage. Mobile network must not affect safety of hazardous areas.</i>			
3.6	Has the installer reviewed the installation instructions provided by the charging equipment manufacturer?			
3.7	Has planning permission been granted for the charging equipment installation?			
3.9	Have the details of the proposed installation, and associated risk assessments, been discussed and agreed with the client?			

	Have any necessary repairs to the existing installation been agreed with the client?			
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Physical installation requirements — Fuel filling station installations				
CoP Ref	CHECK	YES	NO	N/A
5.6 and 8.5	Has the correct type of RCD been selected in relation to the charging equipment (Type B for Mode 3 or Mode 4 charging equipment, unless the equipment has in-built DC residual current protection; Type A or Type F in all other cases)?			
4.1	Has the charging equipment been installed outside any hazardous zones where flammable/combustible gases may be present?			
4.1	Have precautions been taken to ensure the charged vehicle, cable and connectors are outside the hazardous area when charging?			
4.1.2	Where a separate utility company supply is provided for the EVSE, has a prominent warning label been mounted on the supply cubicle to indicate that the charger is fed from this separate supply and is not controlled by the filling station main switch?			
4.1.2	Has control for the EVSE supply by the forecourt emergency switching system been provided?			
4.1.2	If control by the emergency switching system has not been provided, because a separate utility supply has been used for the EVSE, has a prominent label been provided on the EVSE to indicate that it is not controlled by the filling station main switch? <i>Note: The EIAPEA publication 'Guidance for Design, Construction, Modification, Maintenance and Decommissioning of Filling Stations' requires the filling station emergency switching to control the supply to the EVSE.</i>			
4.2	Has the charging equipment been installed in an optimum location with respect to the intended vehicle parking position?			
4.1.2	Does the EVSE have tethered cable only?			
4.3	Has the charging equipment been installed in a location to minimize the likelihood of vehicle impact damage? If no, have protective barriers been provided?			
4.4	Are the main operating controls and any socket outlets between 0.75 m and 1.2 m above the ground, with displays 1.2 m and 1.4 m above the ground?			
4.5	Is there sufficient space around the charging equipment to open all doors and covers?			
4.6	Is there sufficient space around the charging equipment for ventilation and cooling purposes?			
4.7	Have all trip hazards been considered and, where possible, avoided?			

Electrical installation requirements — General				
CoP Ref	CHECK	YES	NO	N/A
	Prior to installation checklist to hand and satisfactorily completed			
5, 8	Installation design to hand			
	Design section of electrical installation signed			
	Pre-work survey of installation carried out, including: — rating and condition of existing equipment — suitability for additional load — earthing and bonding			
	Pre-work tests of installation carried out, including: — earth continuity, polarity and insulation resistance — operation of RCDs <i>Note: Earth fault loop impedance testing is not permitted by the EI/APEA publication 'Guidance for Design, Construction, Modification, Maintenance and Decommissioning of Filling Stations' and therefore it will be necessary to determine the earth fault loop impedance by other means as detailed in the EI/APEA publication and to conform with BS 7671.</i>			
	Defects in existing installation identified and notified to the client: — those affecting the new installation — those not affecting the new installation			
	Order to repair defects in existing installation affecting the new installation received, or, where necessary, provided to a contractor competent to work in hazardous areas of filling stations.			
	Equipment to be worked on isolated			
	Precautions taken to prevent inadvertent energizing			
	Installation carried out			
9	Testing			
9	Electrical Installation Certificate to hand, with preliminaries complete, including signatures for design			
9	Installation isolated and precautions to prevent inadvertent switching on taken			
9	Preceding testing, inspection carried out on disconnected installation			
9	Inspections carried out as per schedule of inspections and testing outlined in the EI/APEA publication 'Guidance for Design, Construction, Modification, Maintenance and Decommissioning of Filling Stations'			
9	Schedule of Inspections completed			
9	Dead tests carried out as required by schedule of inspections and testing outlined in the EI/APEA publication 'Guidance for Design, Construction, Modification, Maintenance and Decommissioning of Filling Stations'			
9	Remaining tests carried out as required by the EI/APEA 'Guidance for Design, Construction, Modification, Maintenance and Decommissioning of Filling Stations'			

Electrical installation requirements — General				
CoP Ref	CHECK	YES	NO	N/A
9	Electrical Installation Certificate completed complete with schedule of inspections and schedule of test results			
9	Copy of certificates issued to the person ordering the work			
9	Customer advised in writing of any defects in the electrical installation not rectified			
9	Competent person scheme provider notified of completion			
9.3	Correct operation of the charging equipment demonstrated to the client			
9.4	Client provided with the instruction manual for the equipment and informed of any maintenance requirements			
11	DNO notification form for the installation submitted via the Energy Networks Association website			

Risk assessment E1 IET Standards Filling station electrical installations

(Form to be completed by a person suitably competent in fuel filling station installations and included with forms for certification given to the person ordering the work.)

Name and address of client	Installation Address
.....	
.....	
.....	
Postcode.....	Postcode.....
Supply taken from, e.g. main intake, separate DNO supply	
	
	
Location of EV charging equipment considered in this risk assessment (approximate distance to reference points)	
	
	
	
	
	

Step	Record
Step 1 Identify the hazards	

(a) Is any part of the filling station from which the charging supply is to be obtained earthed separately to the hazardous area TT supply?	Yes/No
(b) Is a TT system to be adopted for the main installation and vehicle charging equipment?	Yes/No
Note: EVSE will almost always be TT at a filling station. Occasionally, site supplies, including the hazardous area, may be found to be PME, or TN-S from a dedicated transformer. Either the entire site will be provided with a TT earthing system, or none of the site will. The hazardous area should never be a different earthing system to the rest of the site.	
If the answer to both of the above questions is Yes, the hazard will be: First: in the event of an open-circuit neutral in the PME supply system, all conductive parts connected to the main PME earthing terminal, e.g. any exposed or extraneous conductive parts that may be directly, or indirectly, or otherwise connected to this earthing terminal, may become raised to a dangerous voltage relative to true Earth. Second: in general, equipment in the hazardous area of the filling station should NOT be supplied by TN-C-S (PME) supplies: THIS SHOULD NOT HAPPEN AT A FILLING STATION. The implications of this MUST be addressed with the person responsible for the safety of the filling station.	

Step	Record
Step 2 Simultaneous contact – decide who might be harmed and how	Any person who can simultaneously touch any conductive parts or conductor that might be connected to the main PME earth terminal of the building, e.g. a water tap, or metallic gas/water or fuel pipe, or metallic conduit, or item of Class I electrical equipment, such as an outside light, switch or socket outlet, or a boiler flue, or structural steel work, etc., AND the vehicle being charged OR any other conductive parts or conductor that might be directly or indirectly or otherwise connected to the TT earth terminal of the vehicle charging equipment. Anyone affected by explosion or ignition risks in the hazardous area, should the vehicle on charge be located in the hazardous area, or the charging equipment located in the hazardous area.

Step	Record
Step 3 Simultaneous contact – evaluate the risks and decide on precautions	

(1) Is it possible to simultaneously touch any conductive parts or conductor that might be connected to the main PME earthing terminal AND the vehicle being charged OR any conductive parts or conductor that might be connected to the TT earth terminal of the vehicle charging equipment? NB: All possible locations and positions of the vehicle on charge, and the charging lead and connector, must be considered here.	Yes/No <i>If the answer to question 1 is No, retain the following text; if Yes, delete the following text:</i> 'THIS RISK ASSESSMENT SHOWS THAT IT IS NOT CURRENTLY NECESSARY TO TAKE ANY PRECAUTIONS TO PREVENT RISK OF SIMULTANEOUS CONTACT BETWEEN ANY CONDUCTIVE PARTS OR CONDUCTOR THAT MIGHT BE CONNECTED TO THE MAIN PME EARTHING TERMINAL AND THE VEHICLE BEING CHARGED OR ANY OTHER CONDUCTIVE PARTS OR CONDUCTOR THAT MIGHT BE CONNECTED TO THE TT EARTH TERMINAL OF THE VEHICLE CHARGING EQUIPMENT. THE CUSTOMER HAS BEEN INFORMED IN WRITING THAT A FURTHER RISK ASSESSMENT MUST BE UNDERTAKEN TO CHECK WHETHER THE CHARGING EQUIPMENT WILL REMAIN SAFE TO ENERGIZE AND/OR USE IF THIS SITUATION CHANGES.'
(2) If the answer to question (1) is Yes, can this simultaneous contact be reliably prevented, e.g. by fitting an insulating section into any pipe or conduit, or replacing any item of Class I equipment with Class II equipment, or by providing a permanent barrier or enclosure, or by applying permanent insulation, etc.?	Yes/No <i>If the answers to question 1 and question 2 are both Yes, record here the essential precautions required to prevent the possibility(ies) of simultaneous contact identified by question (2):</i> And THE CUSTOMER HAS BEEN INFORMED IN WRITING THAT THE CHARGING EQUIPMENT WILL BECOME UNSAFE TO ENERGIZE AND/OR USE IF THE PRECAUTIONS LISTED ABOVE ARE REMOVED OR OTHERWISE BECOME INEFFECTIVE. <i>If the answer to question 1 is Yes and the answer to question 2 is No, retain the following text here (otherwise delete):</i> 'THIS RISK ASSESSMENT SHOWS THAT IT IS NOT CONSIDERED TO BE SAFE TO PROVIDE A TT EARTHED OUTDOOR VEHICLE CHARGING POINT AT THE CHOSEN LOCATION AND/OR TO CHARGE A TT EARTHED EV AT THE CHOSEN LOCATION. THIS HAS BEEN MADE KNOWN TO THE CUSTOMER IN WRITING.'

Step	Record
Step 4 Separation of earthing system—decide who might be harmed and how	Any person who may be touching the vehicle being charged OR any other conductive parts or conductor that might be directly or indirectly or otherwise connected to the TT earth terminal of the vehicle charging equipment, under either of the following conditions: (a) buried metalwork connected to the PME earthing system is not adequately separated from earth electrode(s) or buried metalwork connected to the TT earthing system, in accordance with Table H1; or (b) the potential of the ground on which they are standing is subject to rise of earth potential during a PME neutral conductor fault, as described in Annex H, Clause H5.
Step 5 Separation of earthing systems—evaluate the risks and decide on precautions Is adequate separation of the TT earthing system available, and the risk of return of PME touch voltage assessed to be negligible?	Yes/No <i>If the answer to this question is No, retain the following text here (otherwise delete):</i> 'THIS RISK ASSESSMENT SHOWS THAT IT IS NOT CONSIDERED TO BE SAFE TO PROVIDE A TT EARTHED OUTDOOR VEHICLE CHARGING POINT AT THE CHOSEN LOCATION AND/OR TO CHARGE A TT EARTHED EV AT THE CHOSEN LOCATION. THIS HAS BEEN MADE KNOWN TO THE CUSTOMER IN WRITING.'
Step 6 Record your findings and implement them	All precautions required by step 3 completed. Signature..... Date carried out.....
Step 7 Review the assessment and update if necessary	To be reviewed whenever further work is carried out on the installation including any inspection and testing.

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Appendix E Wireless power transfer (WPT) installations

F1E1 Overview

WPT charging is an [emerging](#) technology ~~currently in development~~. It ~~will~~ offers the ability to charge vehicle batteries without physical wiring between the vehicle and the charging equipment. Charging ~~will instead be~~ [is instead](#) carried out wirelessly, for example, via magnetic field (inductive charging, termed MF-WPT) or microwave.

At the time of publication of the current edition of this Code of Practice, ~~manufacturers are advertising that MF-WPT charging solutions are close to production installed and being used in various trials in towns and cities around the UK. It is therefore likely that we will see a requirement to install related charging equipment within the lifecycle of this edition of the Code of Practice.~~

This ~~Appendix annex~~ provides some guidance on ~~how this Code of Practice might be used to support inductive MF-WPT~~ charging installations.

F2E2 Standards

E2-1 Introduction

~~Three A series sets~~ of standards ~~has have~~ been developed to support MF-WPT systems.

E2-2 SAE J2954 202208

[SAE International have published the J2954 standard aimed at being an industry-wide specification for interoperability, electromagnetic compatibility, electromagnetic field emissions, performance, safety and testing for WPT of light duty electric vehicles. This standards approach has been adopted by several manufacturers.](#)

E2-3 BS EN ISO 19363:2021

[BS EN ISO 19363 provides safety and interoperability requirements for MF-WPT charging. It supersedes PD ISO/PAS 19373:2017.](#)

~~F2-1~~E2-4 BS EN IEC 61980 series

~~A draft for public comment (DPC) has been released for BS EN IEC 61980-1, published in January 2021, which covers general requirements for EV WPT equipment. This is based on the proposed Edition 2 of IEC 60980-1.~~

Two further parts of the standard, PD [CLC](#) IEC/-TS 61980-2 and PD [CLC](#) iEC/-TS 61980-3, were published in June 2019. The former covers requirements for communication between EVs and WPT charging equipment, and the latter addresses specific requirements for magnetic field WPT systems.

[Two further standards are in development, drafts for which were circulated for public comment in the second half of 2020:](#)

- [1. Proposed BS EN IEC 61980-2 which is planned to cover requirements for communication between EV and MF-WPT infrastructure \(charging equipment\); and](#)
- [2. Proposed BS EN IEC 61980-3 which is planned to cover requirements for MF-WPT charging.](#)

F3E3 Considerations for MF-WPT charging equipment installation

Section 722 of BS 7671 does not apply to inductive charging equipment (see Regulation 722.1 of BS 7671). The general rules of BS 7671 apply to MF-WPT installations. Specifically, the restrictions regarding the supply earthing arrangement do not apply to MF-WPT charging equipment installations.

In general, this Code of Practice applies equally to WPT and conductive charging installations. It is anticipated that the control and power requirements will be similar to Mode 3 or Mode 4 charging systems, but of course, plug and socket connections would not be used. Some proposed systems use a paddle and cable to facilitate the power transfer.

If the WPT system has neither socket-outlets nor exposed-conductive-parts, and no conductive connection is made between the vehicle and protective conductors of the supply to the charging equipment, then supply from a PME system may be appropriatecan be used; particularly in cases where the installation is associated with single dwelling.

Particular risks and issues relating to MF-WPT installations are discussed in Table E.1~~Table E.1~~Table F1.

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Table E.1 Particular risks and issues relating to WPT installations

Risk/Issue	Recommendations	Standards and guidance
Underground services and buried cables	Cabling to inductive charging equipment shall be adequately routed and protected. Excavation work and buried services co-ordination may be necessary; Section 7.4.4 of this Code of Practice should be followed.	BS 7671
Electromagnetic compatibility	The manufacturer's instructions relating to proximity of inductive charging equipment to other electrical equipment, and wiring of the electrical installation, shall be followed.	BS 7671 (in particular, Section 444) Electromagnetic Compatibility Regulations 2016 (as amended) BS EN 61000-6 series EMC requirements for MF-WPT charging equipment are addressed in the product standards (see Appendix E, Section E2E2) .
Electromagnetic fields	The effects of electromagnetic fields on human beings and livestock shall be considered. The installer shall use manufacturer's information to ascertain the risks, and follow the manufacturer's recommendation for any required monitoring, controls and interlocks. In places of work, the installer shall liaise with the relevant duty-holder in relation to their obligations under the Control Of Electromagnetic Fields at Work Regulations 2016 The effects of electromagnetic heating of objects foreign to the WPT system shall be considered. For MF-WPT systems, such objects would usually be metallic objects that can be heated inductively. Prevention of burns, fire and similar heating damage should be considered.	It is UK Government's policy to adopt the International Commission on Non-Ionizing Radiation Protection (ICNIRP) 1998 guideline limits for public exposure to electromagnetic fields. HSE Guidance HSG281 <i>A guide to the Control of Electromagnetic Fields at Work Regulations 2016</i> Demonstration of compliance of equipment and exposure in the workplace: • BS EN 50664 • BS EN 50499 Assessment of electrical and electronic equipment related to human exposure restrictions: • BS EN 50665 • BS EN 62311 Measurement and calculation procedures for human exposure: • BS EN 50413 • BS EN 50500 Protection of humans against exposure to electromagnetic fields, and heating of metallic objects foreign to the WPT system, are to be addressed in the product standards for MF-WPT charging equipment (see Appendix E, Section E2E2).
External influences	Equipment outdoors should have an ingress protection rating of at least IP44 according to BS EN 60529. Where mounted in the ground, higher IP rating is required due to the risk of submersion or flooding. It is recommended that equipment installed in public areas and car park sites are protected against mechanical damage (high severity AG3) as described in Regulation 722.512.2.203 of BS 7671.	General rules of BS 7671 apply to ensure equipment is suitable for the anticipated external influences.

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Appendix F Installing an earth electrode system to enable use of a PME supply earth, in accordance with Regulation 722.411.4.1 (ii) of BS 7671

G1F1 Estimation of resistance to earth

The resistance of an earth electrode system can be estimated as follows. Resistance (R_r) of one vertical electrode is given by:

$$R_r = \frac{\rho}{2\pi L} \left[\log_e \left(\frac{8L}{d} \right) - 1 \right]$$

where:

R_r is the resistance of single rod or pipe, in ohms (Ω);

L is the length of rod, in metres (m);

d is the diameter of rod or pipe, in metres (m);

ρ is the soil resistivity in ~~ohm-metres~~ ohm-metres (Ωm).

The resistance of n parallel-aligned vertical electrodes can be estimated using:

$$R_t = \frac{1}{n} \cdot \frac{\rho}{2\pi L} \left[\log_e \left(\frac{8L}{d} \right) - 1 + \frac{\lambda L}{s} \right]$$

where:

$$\lambda = 2 \sum_{k=2}^{k=n} \left(\frac{1}{k} \right)$$

$$\lambda = 2 \sum \left(\frac{1}{2} + \dots + \frac{1}{n} \right)$$

s is the rod spacing, in metres (m).

For further arrangements, see BS 7430 *Code of practice for protective earthing of electrical installations*.

Tables G1F.1 and G1F.2 provide estimates of electrode system resistance (R_t) for assumed soil resistivities (ρ) and number of earth rods (n).

Table F.1 Estimate of earth electrode system resistance (R_t) for an earth rod of length (L) 2.4 m and rod spacing(s) of 3 m

Number of rods (n)	Soil resistivity (ρ)				
	10	20	50	100	1000
1	4	8	20	40	400
2	2.3	4.6	11	23	228
3	1.6	3.3	8.2	16	163
4	1.3	2.6	6.4	13	129
5	1.1	2.1	5.3	11	107

Table F.2 Estimate of earth electrode system resistance (R_t) for an earth rod of length (L) 1.2 m and rod spacing(s) of 3 m

Number of rods (n)	Soil resistivity (ρ)				
	10	20	50	100	1000
1	7.1	14	35	71	715
2	3.3	7.6	19	38	384
3	2.7	5.4	13	27	267
4	2.1	4.2	10	21	207
5	1.7	3.4	8	17	170

G2F2 Required resistance to earth

The earthing system resistance (rod electrode, bare cable, etc.) required for a given installation current is given by:

$$R_{A\text{ ev}} = \frac{70U_0C_{\max}}{I_{\text{inst}}(U_0C_{\max} - 70)}$$

where:

I_{inst} is the rms maximum demand current of a single-phase installation (in amps), including that of the EV charging load and any other loads, determined in accordance with Regulation 311.1;

$R_{A\text{ ev}}$ is the sum of the resistances of the earth electrode and the protective conductor connecting it to the MET of the installation (in ohms), in item A722.3;

U_0 is the nominal AC rms line voltage to Earth; and

$C_{\max}$ is the voltage factor of 1.1 for a supply derived in accordance with the ESQCR. The maximum values of $R_{A\text{ ev}}$ for given I_{inst} are shown in [Table F.3](#).

The installation maximum demand current is the sum of the maximum EV charging current plus the simultaneous demand of the rest of the installation. Although the vehicle maximum charging current will be known, the demand of the remainder of the installation is difficult to estimate.

~~Table G3 assumes an installation demand of 2 kW.~~

Table F.3 ~~G.3~~ Maximum electrode resistance ($R_{A\text{ ev}}$) required to limit the touch voltage to 70 V for single-phase supplies

EV charging current Installation demand I_{inst} (amps) [*] (see NOTE)	$R_{A\text{ ev}}$ (ohms)
10 40	2.4 5.1
20 60	1.6 3.3
32 80	1.2 2.4
60 100	0.9 1.4

^{*} Assumes an installation current of 2 kW (9 A) excluding the vehicle charging current.

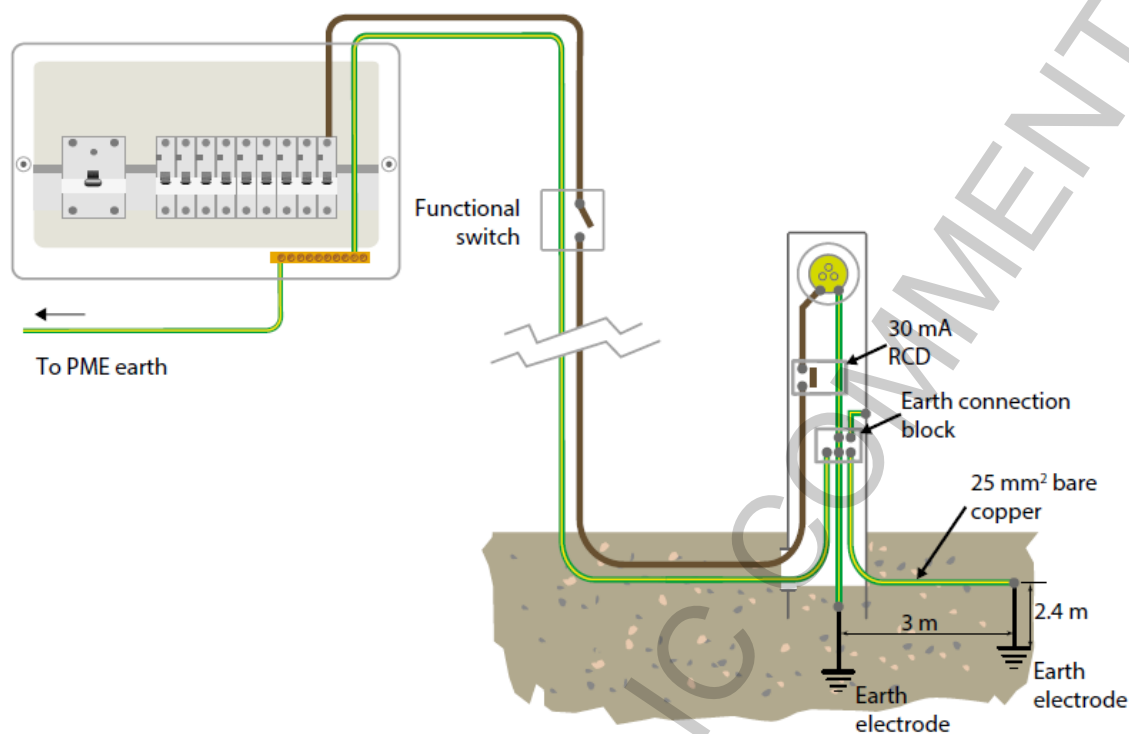
NOTE: ~~Installation maximum demand including EV charging load.~~

Tables ~~GE.1~~, ~~GE.2~~ and ~~GE.3~~ together demonstrate that in many installations it will not be practicable to achieve the required electrode system resistances to earth.

However, it is recommended that a minimum of two 2.4 m or three 1.2 m electrodes separated by 3 m are installed.

~~The top of rods used as earth electrodes should be buried to a depth of at least 600 mm, to mitigate against frozen or dried ground conditions. Refer to Annex H regarding the risk of striking underground services when driving rods. The csa of uninsulated conductors used as electrodes, or earthing connections, along with the means of connection and termination, should be selected in accordance with BS 7671.~~

Figure F.1 Typical domestic PME supply schematic with additional earth electrodes



Note: Neutral omitted for clarity.

F3 Earth electrode installation practices

See [Appendix I](#) for further guidance on installation practices for earth electrodes.

Appendix G Separation of earth electrode zones where a TT (or Mode 4 IT system) is used separate from other earthing arrangements, and installation of electrodes

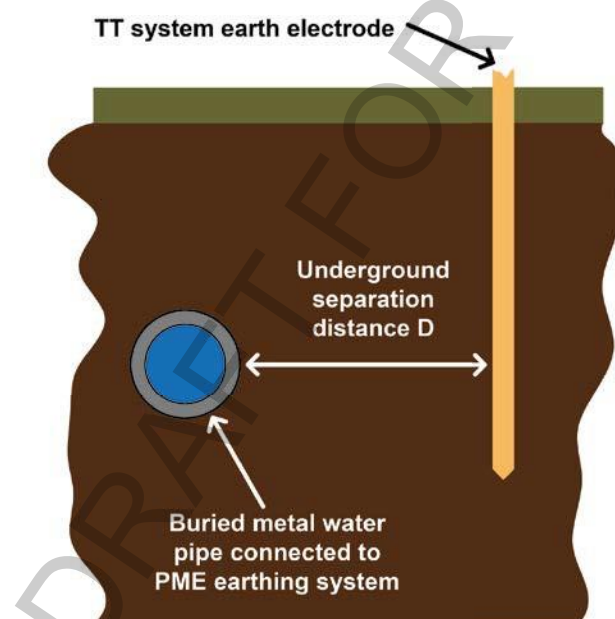
G1 Introduction

As the ground is at least partly conductive, the voltage of uninsulated buried conductors in the PME earthing system can be transferred to earth electrodes of TT or IT systems. This may include (but is not limited to):

- (a) metallic service pipes for water and gas.
- (b) metallic parts of a fuel oil tank and associated pipework.
- (c) structural steelwork of the building.
- (d) earth electrodes connected to the PME earthing system. Supplementary earth electrodes are added at service joints and termination equipment, in addition to the statutory minimum locations.
- (e) metallic equipment such as metal outside lamp posts, etc., if connected to the PME earthing system.
- (f) paper insulated lead-sheathed cables (PILC), which may be present in the ground closer to older buildings, even where the cut-out has been replaced for a more modern type.

Similarly, buried extraneous-conductive-parts and exposed-conductive parts of the TT system should also be separated.

Figure G.1 Illustration showing separation between earth electrode and a buried metal water pipe (Source G Kenyon Technology Ltd)



H2G2 Consequence of not providing adequate separation between PME (or TN-S) and TT earthing systems below ground

If a TT earth electrode system is too close to buried, uninsulated, conductive parts connected to the PME (or TN-S) earthing system, then:

(a) rise of earth potential experienced by the PME system (or by a TN-S system that has sections of combined neutral and earth cabling sections in the distribution network), due to a broken combined neutral and earth conductor in the distribution network, will be transferred to the TT system; and

(b) under some circumstances, the TT system may experience power frequency fault voltages (U_f) up to those shown in Table 44.1 of BS 7671 for TN systems.

Table 44.1 of BS 7671 indicates that power frequency fault voltage for TT systems does not have to be considered, as the TT system should be separated from a global earthing system. This is clearly not the case where there is inadequate separation of a TT earthing system from a TN earthing system.

H3G3 What is an adequate separation distance?

The voltage transferred to a TT earth electrode from buried conductive parts connected to a PME (or TN-S) earthing system can be estimated using Figure 16 of BS 7430. This is represented in [Figure G.2](#).

[Table G.1](#) provides minimum recommended separation distances depending on the purpose of the TT system.

Figure G.2 [H.2](#) Ground surface potentials around a single vertical earth electrode, and three vertical electrodes in a line

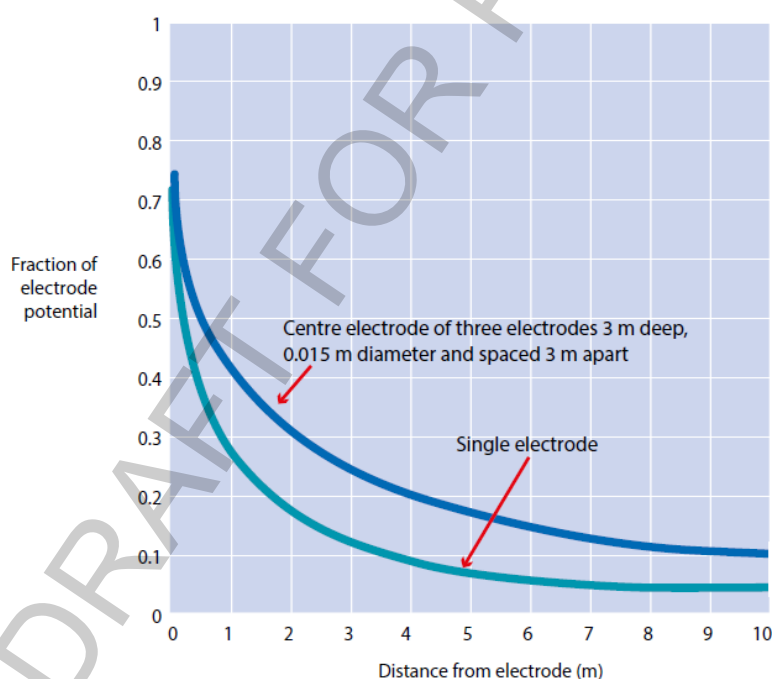


Table G.1 H.1 Recommended minimum separation distances below ground between buried conductors and earth electrodes of a TT or IT system from those connected to a PME or TN-S earthing system

Purpose of TT system	Recommended minimum separation distance D (Note-NOTE 1)	Worst-case voltage fraction transferred	Voltage transferred for an earth potential rise of 253 V rms on a PME earthing system
Whole installation conversion to TT (Note-NOTE 2)	10 m (Note-NOTE 3)	10.0 %	25 V rms
TT provided for charging equipment only (other than on-street)	2.5 m (Note-NOTE 4)	27.5 %	70 V rms
TT system for on-street charging equipment	2.0 m (Note-NOTE 4)	30.0 % (Note-NOTE 5)	76 V rms (Note-NOTE 5)

Note-NOTE 1: Separation distance should be applied also to buried extraneous-conductive-parts and exposed-conductive-parts connected to the TT earthing system.

Note-NOTE 2: External metal water pipe services could have an insulating section applied immediately on the entry to the premises. This is not always practicable for metallic gas pipes.

Note-NOTE 3: This separation distance is recommended in Section 7.5.6 of IET *Guidance Note 7 Special locations*, to ensure that the TT earthing system for a caravan site is adequately separated from a PME earthing system.

Note-NOTE 4: Some DNOs may require separation in excess of this value, and in those cases, the DNO requirement should be met.

Note-NOTE 5: With on-street installations, a reduced separation distance is stated. This is because electric shock risk is typically lower, due to higher resistivity of concrete, paving slabs and tarmac surfaces. Further, touch voltages during broken CNE conductor events are, in general, reduced, because of the extent of the infrastructure and the need to avoid the problems that a larger separation distance may otherwise bring (see H5 below). Some separation is, however, required to prevent the power frequency fault voltage, U_f , being transferred to the TT system.

G4 Earth electrode installation practices

[See Appendix I Appendix I for further guidance on installation practices for earth electrodes.](#)

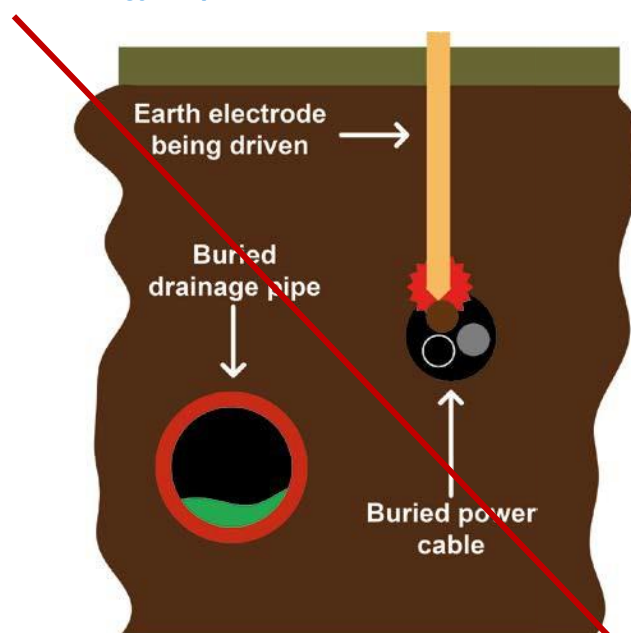
H4 ~~Risk of striking underground services when driving rods~~

~~When a driven rod is used as an earth electrode, there is an inherent risk of striking buried services, and this must be taken into account when selecting a location for an earth electrode. Utility maps can also be consulted to identify a suitable location, although they are not always accurate.~~

~~It is not always possible to accurately detect the presence or position of buried services using detectors and scanning equipment used for underground services surveys. Training and experience in the use of such equipment is essential to ensure its effective use.~~

A hole of a suitable depth could be excavated, using safe excavation procedures to avoid striking services, prior to driving rods.

Figure H.3 Example of underground services strike risk when driving rods (Source G Kenyon Technology Ltd)



H5G5 The risk of returning a PME touch voltage where TT is used for charging equipment

Note NOTE: This section is provided for illustrative purposes only and should NOT be used to determine the risk of receiving an electric shock, which depends on touch current and not simply touch voltage. Touch current additionally depends on soil/ground resistivity, and further calculation is required.

When the potential on the PME earthing system rises, due to a broken neutral conductor in the distribution system, underground conductive parts connected to the PME system can affect the potential at the surface of the ground itself.

Consider the arrangement shown in [Figure G.3](#). Using the formula in Section 9.6.2.2 of BS 7430, we can calculate the voltage fraction of the potential transferred to the surface of the ground from the pipe, due to a broken neutral in the PME supply. For a single electrode (or a single pipe), this formula reduces to:

$$\text{Surface potential } E = \frac{20 \log_e \left(v_l + \sqrt{v_l^2 + 1} \right)}{\log_e \left(\frac{L^2}{hd} \right)}$$

Using this formula to calculate the ground potential rise (GPR) due to the earth potential rise (EPR) on a buried conductor 50 mm diameter, 10 m long, at a depth of 600 mm, gives the results shown in [Table G.2](#).

For a 3.5 m separation distance between earth electrode and the water pipe, as shown in Figure H.4, the touch voltage on the vehicle for a person standing above the pipe could be 41 % of the EPR on the PME earthing system, and for a 10 m separation distance, it could be 57 %.

Where the installation is supplied from a three-phase distribution system, the EPR on the PME system due to a broken CNE conductor can approach 253 V.

It is therefore extremely important to consider the risk of inadvertently returning the PME touch voltage we are trying to avoid by providing a separate TT system for a charging point. It is anticipated that this risk is greatest in small curtilage properties, such as many dwellings, where there are buried conductive parts connected to the PME earthing system.

Figure G.3 H.4-Returned PME touch voltage when providing a separate TT earthing system for the charging point (Source G Kenyon Technology Ltd)

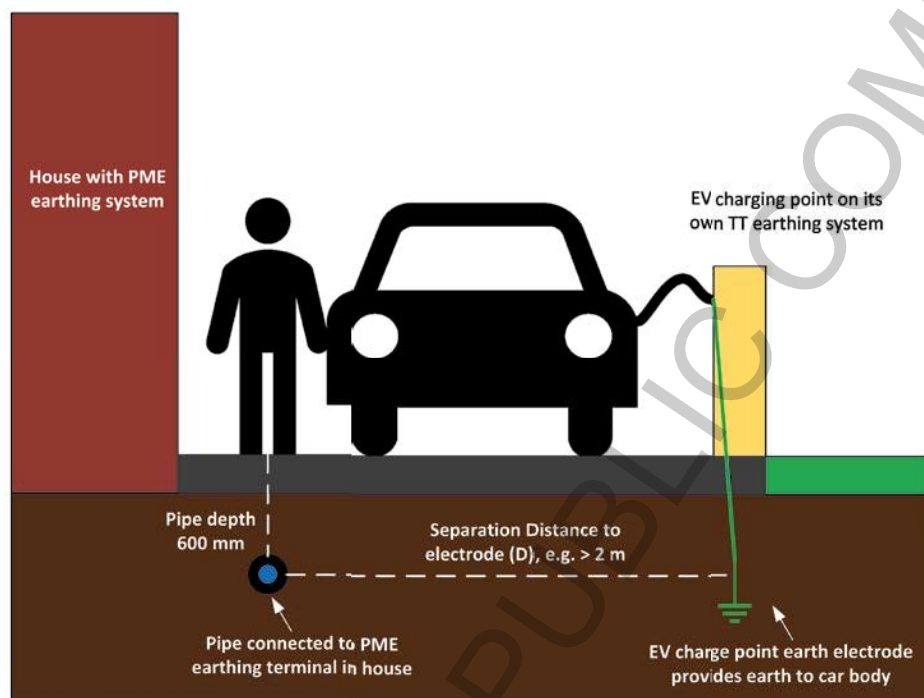


Table G.2 H.2 Ground potential rise (GPR) due to earth potential rise (EPR) on a buried horizontal conductor 50 mm diameter, 10 m long, buried 600 mm below the surface

Horizontal distance from electrode (m)	0.0	0.5	1.0	1.5	2.0	2.5	3.0	3.5
Voltage fraction E at surface	0.69	0.63	0.53	0.46	0.40	0.35	0.31	0.28
GPR (V) for EPR of 70 V	49	44	37	32	28	24	22	20
GPR (V) for EPR of 100 V	69	63	53	46	40	35	31	28
GPR (V) for EPR of 120 V	83	76	64	55	48	42	37	34
GPR (V) for EPR of 170 V	118	107	91	77	67	59	53	48
GPR (V) for EPR of 220 V	153	139	117	100	87	76	69	62
GPR (V) for EPR of 270 V	188	170	144	123	107	94	84	76

Horizontal distance from electrode (m)	4.0	5.0	6.0	7.0	8.0	9.0	10.0	11.0	12.0
Voltage fraction E at surface	0.26	0.22	0.19	0.16	0.15	0.13	0.12	0.11	0.10
GPR (V) for EPR of 70 V	18	15	13	11	10	9	8	8	7
GPR (V) for EPR of 100 V	26	22	19	16	15	13	12	11	10
GPR (V) for EPR of 120 V	31	26	22	20	17	16	14	13	12
GPR (V) for EPR of 170 V	44	37	32	28	25	22	20	18	17
GPR (V) for EPR of 220 V	56	48	41	36	32	29	26	24	22
GPR (V) for EPR of 270 V	69	58	50	44	39	35	32	29	27

Note: This table is provided for illustrative purposes only and should NOT be used to determine the risk of receiving an electric shock, which depends on touch current and not simply touch voltage. Touch current additionally depends on soil/ground resistivity, and further calculation is required.

Appendix H Determining a suitable location and voltage tripping threshold for a measurement earth electrode if used for compliance with Regulation 722.411.4.1 (iii) of BS 7671

H1 Impact of the voltage measured by a measurement earth electrode due to voltage transfer through the ground from buried conductive metalwork connected to the PME earthing system

Voltage in buried conductors in the PME earthing system can be transferred to a measurement earth electrode in a similar manner as discussed in Annex H relating to TT earth electrodes. This may include (but is not limited to):

- (a) metallic service pipes for water and gas;
- (b) metallic parts of a fuel oil tank and associated pipework;
- (c) structural steelwork of the building;
- (d) earth electrodes connected to the PME earthing system; and
- (e) metallic equipment such as metal outside ~~lamp posts~~[lampposts](#), etc., if connected to the PME earthing system.

The maximum voltage on the PME system due to a broken CNE conductor is $C_{\max}U_0$ or 253 V rms for a 230/400 V distribution system provided in accordance with the ESQCR. The threshold voltage that the measurement earth electrode is looking for is 70 V, according to Regulation 722.411.4.1 (iii) of BS 7671.

The voltage transferred to the measurement earth electrode can be estimated by following guidance in BS 7430. Using the upper line (3 electrodes) in ~~Figure H.2~~[Figure G.2](#)~~Figure G.2~~, the voltage transferred to a measurement electrode can be ascertained at various distances from buried metalwork connected to the PME earthing system, for the worst-case voltage (253 V rms) and the threshold voltage (70 V rms). The result is shown in ~~Table H.1~~[Table H.1](#)~~Table H.1~~[Table H.1](#).

Table H.1 ~~Table H.1~~ Voltage transferred to measurement earth electrode from PME earthing system

	Voltage transferred (V) from buried to measurement earth electrode at a distance of									
	1 m	2 m	3 m	4 m	5 m	6 m	7 m	8 m	9 m	10 m
Voltage fraction (upper line in Figure H.2)	0.41	0.32	0.25	0.21	0.18	0.16	0.14	0.12	0.11	0.10
253 V rise of PME system earth potential	103.7	81.0	63.3	53.1	45.5	40.5	35.4	30.4	27.8	25.3
70 V rise of PME system earth potential	28.7	22.4	17.5	14.7	12.6	11.2	9.8	8.4	7.7	7.0

The voltage measured between the cpc at the charging point and the measurement earth electrode is the difference between the voltage on the cpc, U_{cpc} , and the voltage at the measurement earth electrode, U_{ME} , or

$$\text{Measured voltage } U_{\text{measured}} = U_{cpc} - U_{ME}$$

Table H.2 Table H.2 Table I-2 shows how the distance of the measurement earth electrode to buried conductive parts connected to the PME earthing terminal affects the voltage measured at the measurement electrode.

Table H.2 Table I-2 Voltage measured between measurement earth electrode and protective conductor at the EV charging point, due to voltage transferred to the measurement earth electrode

Voltage of PME earthing terminal and CPC of charging point with respect to Earth	Voltage measured (V) between CPC at charging point and measurement earth electrode at a distance of									
	1 m	2 m	3 m	4 m	5 m	6 m	7 m	8 m	9 m	10 m
253 V rms	149.3	172.0	189.7	199.9	207.5	212.5	217.6	222.6	225.2	227.7
70 V rms	41.3	47.6	52.5	55.3	57.4	58.8	60.2	61.6	62.3	63.0

Based on the data in Table H.2 Table I-2, any device intended to provide the protection described in indent (iii) of Regulation 722.411.4.1 of BS 7671, which uses an earth electrode as a reference for Earth, must be designed or configured to trip at a voltage well below 70 V rms to be effective.

Recommended tripping voltages are shown in Table H.3 Table I-3.

Table H.3 Table I-3 Recommended tripping voltage vs separation distance to meet the requirements of Regulation 722.411.4.1 (iii)

	Voltage measured (V) between CPC at charging point and measurement earth electrode at a distance of									
	1 m	2 m	3 m	4 m	5 m	6 m	7 m	8 m	9 m	10 m
Recommended maximum rms tripping voltage	36 V	42 V	47 V	50 V	52 V	54 V	55 V	56 V	57 V	58 V

Further, some minimum physical underground separation distance is required between the measurement earth electrode and uninsulated buried conductive parts connected to the PME earthing system. This may not be practicable in existing installations, particularly with small curtilage properties.

I2—Risk of buried services strike

~~In all cases, driving vertical rods or excavating to install other types of earth electrode carries some inherent risk of striking buried services.~~

~~Scanning equipment may not always detect buried items accurately. Drawings of underground services routes on many existing premises are unavailable, and services may have been disturbed by ground movement and other works in the past.~~

~~Measurement earth electrodes need not achieve comparably low values of earth electrode resistance as earth electrodes for protective earthing purposes. However, it may be necessary~~

4185 to achieve a similar depth in some circumstances, to improve effectiveness of the
4186 measurement electrode.

4187 **H2 Earth electrode installation practices**

4188 See Appendix I ~~Appendix I~~ for further guidance on installation practices for earth electrodes.

4189 **I3H3 Conclusion**

4190 Guidance and installation instructions from the manufacturer of a protective device providing
4191 protection described in item (iii) of Regulation 722.411.4.1 of BS 7671, which uses an earth
4192 electrode as a reference for Earth, should be followed for its effective and safe operation.

4193 Typically, such devices would be required to trip at 40 V rms, and the installation instructions
4194 should recommend a separation distance of at least 2 m in all directions (horizontally and
4195 vertically) from buried conductors connected to the PME earthing system.

4196 The installation of such devices requiring a measurement earth electrode may not be
4197 practicable in all cases, and particular care should be exercised in small curtilage properties,
4198 such as many dwellings.

Appendix I Installation practices for earth electrodes

I1 Installing earth electrodes

Earth electrodes should be installed in accordance with BS 7430 and BS 7671. The following points should be considered:

(a) Driven rods are not the only option for earth electrodes. Other options are available, including (but not limited to):

(i) mats;

(ii) plates;

(iii) discs;

(iv) copper tape, pipes or tubes;

(v) structural metallic parts of buildings, provided they are suitably protected against corrosion and erosion; and

(vi) certain other extraneous-conductive-parts where this complies with BS 7671, and provided those extraneous-conductive-parts are under the control of the installation owner or operator.

(b) When driving rods, or excavating for electrodes, there is an inherent risk of striking buried services. However, due to the length of rods often required, the risks increase. See I2I2 for further information. PAS 128 Underground utility detection, verification and location. Specification provides further details on approaches that can help determine the presence of underground services.

(c) Earth electrode performance varies throughout the year, and is affected by drying out, and frost-heave. Any parts of earth electrodes that are not buried at a depth of at least 600 mm should therefore be considered ineffective:

(i) Plates, discs, copper tape, pipes and tubes should be buried at a depth of at least 600 mm; and

(ii) The length of vertical rods, pipes and tubes should be increased to account for any part of the length not driven to a depth of 600 mm (for example, e.g. if 2.5 m of rod is calculated for, but it is only being driven so that the uppermost end is 100 mm below the surface, a 3 m rod is required).

(d) Electrodes (particularly rods, pipes and tubes) should not generally protrude from the ground, as this causes personal injury hazards, and can accelerate corrosion.

(e) The connection point to electrodes below ground should be made in a suitable inspection pit to facilitate inspection and testing, and to help keep the termination free of soil contamination.

(f) The csa of uninsulated conductors used as electrodes, or earthing connections, along with the means of connection and termination, should be selected in accordance with BS 7671.

I2 Risk of striking underground services when driving rods

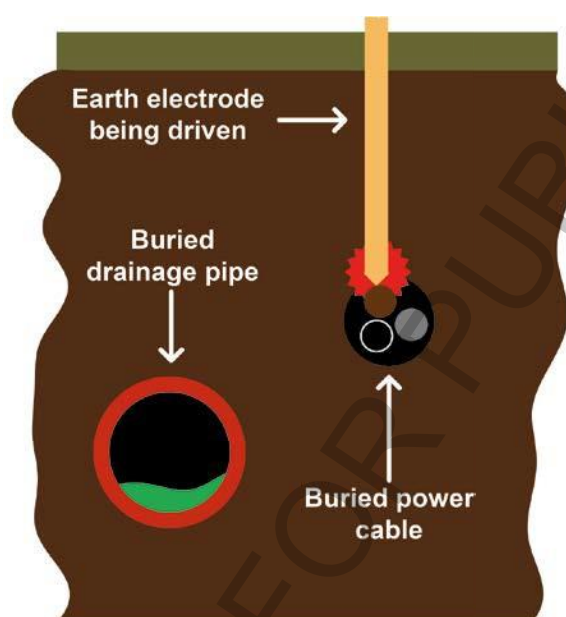
When a driven rod is used as an earth electrode, there is an inherent risk of striking buried services, and this must be taken into account when selecting a location for an earth electrode. Utility maps can also be consulted to identify a suitable location, although they are not always accurate.

It is not always possible to accurately detect the presence or position of buried services using detectors and scanning equipment used for underground services surveys. Training and experience in the use of such equipment is essential to ensure its effective use.

A hole of a suitable depth could be excavated, using safe excavation procedures to avoid striking services, prior to driving rods.

Where older buried pipework is present, such as iron gas pipes and drainage, this may be badly corroded, and easily fracture if the ground surrounding the pipework is disturbed, or through vibration of surrounding ground.

Figure I.1 Example of underground services strike risk when driving rods (Source G Kenyon Technology Ltd)



I3 Measurement of earth electrode resistance

Following dead tests on initial verification, BS 7671 requires earth electrode resistances to be measured before the installation is energized (or re-energized). See Section 9.6.29.6.2 of this Code of Practice for further details.

Appendix JA rule of thumb for three-phase system balance in accordance with Regulation 722.411.4.1 (i) of BS 7671

J1 Introduction

In some three-phase installations, particularly where the EV charging loads are small in respect of the overall maximum demand, it may be possible to rely on the exception stated in indent (i) to Regulation 722.411.4.1 of BS 7671.

Note: The method demonstrated in this Annex may only be used where:

- (a) — there is robust load data to determine the worst-case unbalance between phases;
- (b) — the power factor of loads on each phase is similar; and
- (c) — the neutral current is not subject to the effects of triple harmonics.

Where loads on each of the phases have different power factors, a phasor calculation using Millman's Theorem is necessary.

J2 The impact of neutral unbalance (A722.2 of BS 7671)

A722.2 of BS 7671 states:

A722.2 Load balance

Where triple harmonics can be neglected, condition (i) of Regulation 722.411.4.1 may be assumed to apply where the following condition is met. This formula should take account of C_{max} in line with PD CLC/TR 50480:

$$\frac{I_m U_0 C_{max}}{I_{L1} + I_{L2} + I_{L3}} \leq 70 \text{ V}$$

I_m can be calculated using the formula in A722.1 of BS 7671:

$$I_m = \sqrt{I_{L1}^2 + I_{L2}^2 + I_{L3}^2 - I_{L1}I_{L2} - I_{L1}I_{L3} - I_{L2}I_{L3}}$$

Therefore, we are looking for the condition:

$$\frac{U_0 C_{max} \sqrt{I_{L1}^2 + I_{L2}^2 + I_{L3}^2 - I_{L1}I_{L2} - I_{L1}I_{L3} - I_{L2}I_{L3}}}{I_{L1} + I_{L2} + I_{L3}} \leq 70 \text{ V}$$

J3 Expression in terms of line current unbalance

If the largest of the unbalanced line currents I_{LA} , the other two line currents can be expressed using the per-unit fractions c_B and c_C as $c_B I_{LA}$ and $c_C I_{LA}$. If we substitute these currents for the line currents in the above expression, we can see that this becomes:

I_{LA} cancels, and the expression reduces to:

This demonstrates that, where power factors of loads supplied by the phases are approximately equal, the neutral voltage depends only on the relative unbalance of the line currents, and the line to neutral voltage, U_0 .

$$\frac{U_0 C_{\max} \sqrt{I_{LA}^2 + C_B^2 I_{LA}^2 + C_C^2 I_{LA}^2 - I_{LA} C_B I_{LA} - I_{LA} C_C I_{LA} - C_B I_{LA} C_C I_{LA}}}{I_{LA} + C_B I_{LA} + C_C I_{LA}} \leq 70 \text{ V}$$

Using the quadratic formula, we can solve for c_c in terms of c_b :

$$c_c \geq \frac{(U^2 + 9800)(1 + C_B) - \sqrt{(U^2 + 9800)^2(1 + C_B)^2 - 4(U^2 - 4900)\{U^2 - 4900 - (U^2 + 9800)C_B + (U^2 - 4900)C_B^2\}}}{2(U^2 - 4900)}$$

where $U = U_0 C_{\max}$

Note: The positive root case for the quadratic formula leads to $c_c > c_b$ and this can be ignored by definition.

Table J1 shows the per unit and percent unbalance factors that lead to the expression in A722.2 not being satisfied, for supplies in accordance with the ESQCR ($U_0 = 230 \text{ V}$, and $C_{\max} = 1.1$).

Table J1 Per unit and percent unbalance that would lead to an earth potential rise of 70 V or more for supplies in accordance with the ESQCR

Per unit unbalance factors		Percent unbalance factors	
c_b	c_c leading to 70 V	$(c_b \times 100)$	$(c_c \times 100)$ leading to 70 V
1.00	0.350	100 %	35.0 %
0.90	0.337	90 %	33.7 %
0.80	0.335	80 %	33.5 %
0.70	0.347	70 %	34.7 %
0.60	0.377	60 %	37.7 %
0.50	0.435	50 %	43.5 %
0.40	Not possible to use PME system	40 %	Not possible to use PME system
0.30		30 %	
0.20		20 %	
0.10		10 %	
0.00		0 %	

Note 1: The largest line current in the system is I_{LA} . The second largest is I_{LB} and $I_{LB} = C_B I_{LA}$. The smallest line current is I_{LC} and $I_{LC} = C_C I_{LA}$ (therefore, according to this definition, $1 \geq c_B \geq c_C$).

Note 2: 'Not possible to use PME system' means that the condition in A722.2 of BS 7671 is not met, and therefore indent (i) to Regulation 722.411.4.1 of BS 7671 does not apply.

Table J1 may be used instead of calculating the expressions in A722.1 and A722.2 of BS 7671.

J4 Rule of thumb

To avoid detailed calculation, the information in Table J1 can be used to derive a rule of thumb:

If the largest line current in the system is I_{LA} , the second largest is I_{LB} and the smallest line current is I_{LC} , then the PME earthing terminal for EV charging equipment can be used where either:

(a) $I_{LB} \geq 60 \% I_{LA}$ and $I_{LC} \geq 40 \% I_{LA}$

OR

(b) $I_{LB} \geq 50 \% I_{LA}$ and $I_{LC} \geq 50 \% I_{LA}$

Note: It is imperative that I_{LA} , I_{LB} and I_{LC} represent the worst-case unbalance conditions anticipated in the installation.

4310 ~~Appendix K~~ **Appendix J** Supply and earthing arrangements 4311 for Mode 4 DC EVSE

4312 ~~K1J1~~ **Introduction to Mode 4 charging systems**

4313 Mode 4 DC EVSE should comply with BS EN 61851-23. Three arrangements are discussed
4314 in the standard, [with a further two Cases for pantograph systems described in the draft of BS](#)
4315 [EN 61851-23-1:](#)

- | | |
|--|--|
| System A (configuration AA) | (a) Provides DC output of up to 500 V, intended for passenger vehicles and light trucks, using a CHAdeMo connector.
(b) Separate CAN-bus communication circuit to BS EN 61851-24 is provided through two contacts.
(c) Protective earth is required at the vehicle, although this could be derived from a separate earth electrode.
(d) DC supply is separated, with earth leakage detection to detect the first earth fault (and provide disconnection). An insulation monitoring device (IMD) to
(e) BS EN 61557-8 may also be used. |
| System B (configuration BB) | (a) Separate CAN-bus communication circuit to BS EN 61851-24 is provided through two contacts.
(b) Protective earth is required at the vehicle, although this could be derived from a separate earth electrode.
(c) DC supply is separated and an IMD to BS EN 61557-8 is used. |
| System C
(configurations EE and FF) | (a) Provides DC output of up to 500 V (CCS1 in configuration EE) or 1,000 V and up to 400 A (CCS2 connector in configuration FF).
(b) Protective earth is required at the vehicle, although this could be derived from a separate earth electrode.
(c) Communication with the vehicle is provided using control pilot and protective earth conductors.
(d) DC supply may be separated (IT system), where leakage current monitoring or an IMD to BS EN 61557-8 is used. |

[Cade D \(see NOTE\)](#)

[A pantograph-down automatic coupler system, using System A, System B or System C power and communications arrangements.](#)

Case E (see NOTE)

A pantograph-down automatic coupler system, using System A, System B or System C power and communications arrangements.

NOTE: In Case D or Case E, as defined in the draft BS EN 61851-23-1, power and communications are made through the automatic coupler system rather than a vehicle connector.

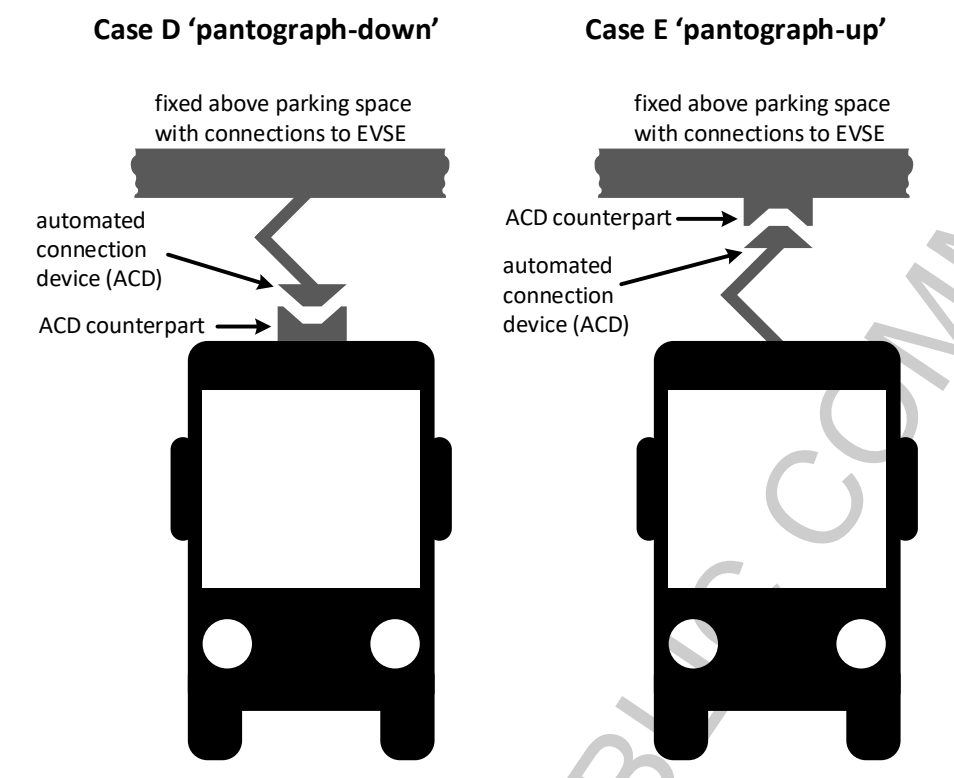
From the overview arrangements provided above, it is noted that all configurations require a protective earth connection to the vehicle.

In accordance with Regulation 722.413.1.2 of BS 7671:

- (a) Systems A and B (or cases D or E using System A or System B) require an isolating transformer to BS EN 61558-2-4; and
- (b) System C (or Cases D or E using System C) arrangements in which the DC is separated require an isolating transformer to BS EN 61558-2-4.

In pantograph systems, cases D and E as defined in the draft of BS EN 61851-23-1, the automatic coupler comprises an automated connection device (ACD), which is the movable element of the pantograph, with its associated connecting device, and this mates with an ACD counterpart (in other words, receptacle). In pantograph-up systems, the ACD is on the vehicle (for example, on the roof) and the ACD counterpart is in a fixed location above the vehicle parking space, and associated with the EVSE. In pantograph-down systems, the ACD is associated with the EVSE and located in a fixed position above the vehicle parking space, whereas the ACD counterpart is located on the vehicle itself (for example, on the roof). See Figure J.1.

Figure J.1 Cases D (pantograph-down) and E (pantograph-up) automatic coupler systems as defined in draft BS EN 61851-23-1



K2J2 System C configurations without separation

The power conversion unit is usually incorporated in the EVSE.

The manufacturer's instructions for earthing and protection should be considered.

BS 7671 does not, at present, require RCD protection for the DC output to the vehicle. An appropriate RCD should, however, be provided on the AC input to DC charging equipment without separation, according to Regulation 722.531.2.101.

The protective earth of the EVSE may only be connected to a PME earthing system in accordance with Regulation 722.411.4.1 (see Section 5.35.3).

Where a separate earth electrode is provided:

- the AC input supply should be provided as if the charging point were being supplied by a TT earthing system for the charging equipment being used (see Section 5.3.3.15.3.3.4).
- a simultaneous contact assessment should be undertaken for the vehicle and for exposed-conductive-parts of the EVSE.
- adequate separation of the earth electrode should be ensured below ground from metalwork connected to the PME earthing system (see Annex H Appendix G Appendix G).
- the earth electrode should be installed in accordance with BS 7671 and BS 7430 (see Appendix I Appendix I).

(e) manufacturers' instructions for earth fault protection of the DC output should be followed. Whether RCD protection on the AC input will operate for faults on the DC output depends on the type of convertor.

K3J3 Separated systems

The transformer providing separation, and the DC power conversion equipment, including the IMD(s), may be incorporated into each charging point's EVSE, or alternatively, a separate power unit may be provided.

Some separate power units supply multiple charging points – in this case, if a common transformer is used, each charging point must be supplied by its own separated secondary (Regulation 722.413.1.2 of BS 7671).

At present, BS 7671 does not require RCD protection for separated DC charging systems, on either the primary or secondary, but the system must incorporate means of detection of first fault, either through an IMD to BS EN 61557-8 and/or earth leakage detection according to BS EN 61851-23.

The protective earth to the vehicle is used for insulation monitoring as well as communications and safety functions in separated DC charging arrangements. EVSE may only be connected to a PME earthing system in accordance with Regulation 722.411.4.1 (see [Figure J.2](#) and [Section 5.3.3](#)).

Where a separate earth electrode is provided for the secondary ([see Figure J.3](#)):

- (a) the AC primary supply may be connected to the AC supply earthing system. In this particular case, Regulation 722.411.4.1 need not be considered, but Regulation 411.3.1.1 may preclude its use, depending on the design of the EVSE.
- (b) alternatively, the AC primary supply should be provided as if the charging point being supplied by a TT earthing system for the charging equipment were being used (see [Section 5.3.3.1](#)), and the secondary earth electrode used as the primary AC system earth electrode.
- (c) a simultaneous contact assessment should be undertaken for the vehicle and for exposed-conductive-parts of the EVSE connected to the earth electrode.
- (d) adequate separation of the earth electrode should be ensured below ground from metalwork connected to the PME earthing system (see [Annex H](#) and [Appendix G](#)).
- (e) the earth electrode should be installed in accordance with [BS 7671](#) and BS 7430 ([see Appendix I](#)).

Figure J.2 ~~Figure K.1~~ Example of separated DC charging system utilizing the earthing system of the primary AC supply

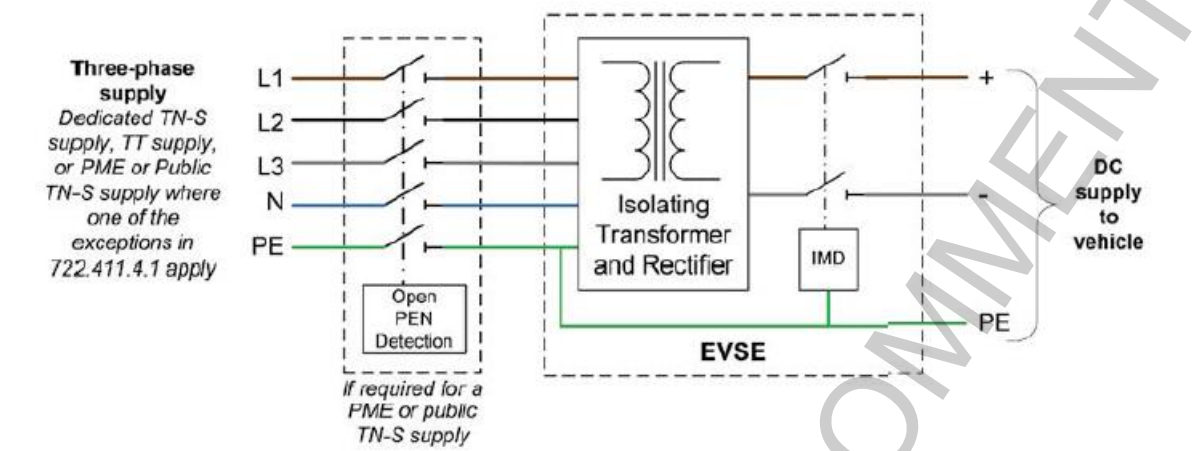
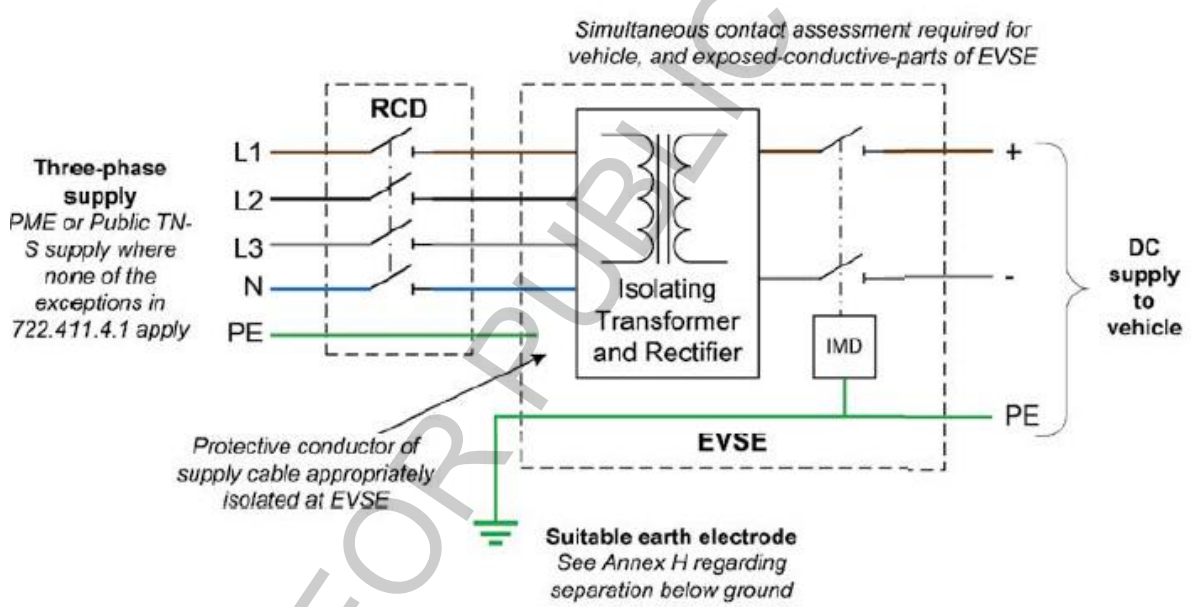


Figure J.3 ~~Figure K.2~~ Example of separated DC charging system utilizing a separate earth electrode



Appendix L Requirements for Electrical Installations BS 7671:2018 Amendment 1:2020

NOTE: BS 7671:2018+A1:2020 is reproduced in its entirety (except for front matter and index) along with corrections to the indentation of Note 5 in 722.411.4.1, the bolding of text in 722.511.101, the change to high severity AG3 in 722.512.2.203, the equation in A722.1 and the correction to the reference of Regulation 722.411.4.1 (iii) in A722.4.

Part 2 DEFINITIONS

Electric vehicle (EV), {722}. Any vehicle propelled by an electric motor drawing current from a rechargeable storage battery or from other portable energy storage devices (rechargeable, using energy from a source off the vehicle such as a residential or public electricity service), which is manufactured primarily for use on public streets, roads or highways.

- **Charging equipment.** An assembly including one or more charging points.
- **Electric vehicle charging point.** The point where the electric vehicle is connected to the fixed installation.

Note: The charging point is a socket outlet where the charging cable belongs to the vehicle, or a connector, where the charging cable is a fixed part of the electric vehicle supply equipment.

- **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 (according to BS EN 61851-1).
- **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.
- **Mode 3 charging.** Connection of the EV to the AC supply network utilizing dedicated electric vehicle supply equipment where the control pilot function extends to control equipment in the electric vehicle supply equipment, permanently connected to the AC supply network.
- **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.
- **Vehicle connector.** Part of a vehicle coupler integral with, or intended to be attached to, the flexible cable connected to the AC supply network (mains).
- **Vehicle coupler.** Means of enabling the manual connection of a flexible cable to an EV for the purpose of charging.

Note: A vehicle coupler consists of two parts: a vehicle connector and a vehicle inlet.

SYMBOLS USED IN THE STANDARD

Symbol	Meaning	Example	Symbol	Meaning	Example
$C_{\max}$	is the maximum voltage factor to take account of voltage variations depending on time and place, changing of transformer taps and other considerations. For a low voltage supply given in accordance with the ESQCR, $C_{\max}$ is given the value 1.1	A722.2	I_{L1}, I_{L2} and I_{L3}	are the rms values of current (in amperes) in lines 1, 2 and 3, respectively, that were used when determining the value of I_m	A722.1
I_{inst}	is the rms maximum demand current of a single-phase installation (in amperes), including that of the electric vehicle charging load and any other loads, determined in accordance with Regulation 311.1	A722.3	R_{A-ev}	is the sum of the resistances of the earth electrode and the protective conductor connecting it to the main earthing term215n stallinal of the ins215rotectallation (in ohms)	A722.3
I_m	is the rms maximum neutral current of a three-phase installation (in amperes), including that of the electric vehicle charging load and any other loads, determined in accordance with Regulation 311.1	A722.1			

PART 7 SPECIAL INSTALLATIONS OR LOCATIONS

CONTENTS

700 — GENERAL

722 — ELECTRIC VEHICLE CHARGING INSTALLATIONS

SECTION 700

GENERAL

The particular requirements for each section (special installation or location) in Part 7 supplement or modify the general requirements contained in other parts of BS 7671.

The absence of reference to the exclusion of a part, a chapter, a section or a regulation means that the corresponding general regulations are applicable.

The number appearing after a section number generally refers to the corresponding chapter, section or regulation within Parts 1 to 6. The numbering does not, therefore, necessarily follow sequentially and new numbers have been added as required. Numbering of figures and tables takes the number of the section followed by a sequential number.

SECTION 722

ELECTRIC VEHICLE CHARGING INSTALLATIONS

Note: Definitions relating to Section 722 can be found in Part 2 under electric vehicle (EV), [722].

722.1 Scope

The particular requirements of this section apply to circuits intended to supply electric vehicles for charging purposes.

The requirements of this section do not apply to electric vehicle charging points that:

- (i) employ inductive charging
- (ii) charge mobility scooters and similar vehicles of 10 A and less.

722.3 Assessment of general characteristics

722.31 Purposes, supplies and structure

722.311 Maximum demand and diversity

722.311.201 Load curtailment, including load reduction or disconnection, either

automatically or manually, may be taken into account when determining maximum demand of the installation or part thereof.

722.312 Conductor arrangement and system earthing

722.312.2.1 TN systems

A circuit supplying charging equipment for electric vehicles shall not include a PEN conductor.

722.4 Protection for safety

722.41 Protection against electric shock

722.410.3 General requirements

722.410.3.5 The protective measures of obstacles and placing out of reach (Section 417) shall not be used.

722.410.3.6 The protective measures of non-conducting location (Regulation 418.1) and earth-free local equipotential bonding (Regulation 418.2) shall not be used.

722.411.4 TN system

722.411.4.1 A PME earthing facility shall not be used as the means of earthing for the protective conductor contact of a charging point located outdoors or that might reasonably be expected to be used to charge a vehicle located outdoors unless one of the following methods is used:

- (i) The charging point forms part of a three-phase installation that also supplies loads other than for electric vehicle charging and, because of the characteristics of the load of the installation, the maximum voltage between the main earthing terminal of the installation and Earth in the event of an open-circuit fault in the PEN conductor of the low voltage network supplying the installation does not exceed 70 V rms.

NOTE 1: Annex 722, item A722.2 gives some information relating to (i).

NOTE 2: See also Regulation 641.5 when undertaking an addition or alteration to an existing installation.

- (ii) The main earthing terminal of the installation is connected to an installation earth electrode by a protective conductor complying with Regulation 544.1.1. The resistance of the earth electrode to Earth shall be such that the maximum voltage between the main earthing terminal of the installation and Earth in the event of an open-circuit fault in the PEN conductor of the low voltage network supplying the installation does not exceed 70 V rms.

NOTE 3: Annex 722, item A722.3 gives guidance on determining the maximum resistance required for the earth electrode in (ii).

- (iii) Protection against electric shock is provided by a device which electrically disconnects the vehicle from the live conductors of the supply and from protective earth in accordance with Regulation 543.3.3.101(ii) within 5 s in the event of the voltage between the circuit protective conductor and Earth exceeding 70 V rms due to an open-circuit fault in the PEN conductor of the low voltage network. The device need not operate if the voltage exceeds 70 V rms for less than 4 s. The device shall provide isolation and be selected in accordance with Table 537.4. Closing or resetting of the device shall be possible only if the voltage between the circuit protective conductor and Earth does not exceed 70 V rms. Equivalent means of functionality could be included within the charging equipment. NOTE 4: Annex 722, item A722.4 gives guidance on (iii).

- (iv) Protection against electric shock in a single-phase installation is provided by a device which electrically disconnects the vehicle from the live conductors of the supply and from protective earth in accordance with Regulation 543.3.3.101(ii) within 5 s in the event of the utilisation voltage at the charging point, between the line and neutral conductors, being greater than 253 V rms or less than 207 V rms. The device shall provide isolation and be selected in accordance with Table 537.4. Equivalent means of functionality could be included within the charging equipment. Closing or resetting of the device shall be possible only if the voltage between line and neutral conductors is in the range 207 to 253 V rms.

- (v) Protection against electric shock is provided by the use of an alternative device to those in (iii) or (iv) which does not result in a lesser degree of safety than using (iii) or (iv). Equivalent means of functionality could be included within the charging equipment. The device (or means of functionality) shall operate by electrically disconnecting the vehicle from the live conductors of the supply and from protective earth in accordance with Regulation 543.3.3.101(ii). It shall provide isolation and be selected in accordance with Table 537.4.

NOTE 5: See Section 511. BS 7671 does not deal with the safety requirements for the construction of electrical equipment. Where equipment to be used is not covered by a British or Harmonized

Standard or is to be used outside the scope of its standard, it is the responsibility of the electrical installation designer or other person responsible for specifying the installation to establish that the manufacturer of the equipment has ensured that the equipment satisfies the safety objectives of the relevant Directive(s), as it will not benefit from a presumption of conformity afforded by the appropriate product standard.

NOTE 5: See Section 511. BS 7671 does not deal with the safety requirements for the construction of electrical equipment. Where equipment to be used is not covered by a British or Harmonized Standard or is to be used outside the scope of its standard, it is the responsibility of the electrical installation designer or other person responsible for specifying the installation to establish that the manufacturer of the equipment has ensured that the equipment satisfies the safety objectives of the relevant Directive(s), as it will not benefit from a presumption of conformity afforded by the appropriate product standard.

Where buried in the ground, a protective conductor connected to an earth electrode for the purposes of (ii) or (iii) shall have a cross-sectional area not less than that stated in Table 54.1.

Protective conductors and exposed conductive parts downstream of a protective device provided for the purposes of (iii), (iv) and (v) shall have no connection to:

- (a) any protective conductors or exposed conductive parts of any circuit not protected by the same protective device; or
- (b) any extraneous conductive part.

NOTE 6: Creating a TT earthing system for charging equipment or the whole installation as an alternative to using a PME earthing facility with one of methods (i) to (v) above may not be an appropriate solution due to the inability to provide sufficient separation from buried metalwork connected to the supply PEN conductor

722.413 Protective measure: Electrical separation

722.413.1.2 This protective measure shall be limited to the supply of one electric vehicle supplied from one unearthed source. The circuit shall be supplied through a fixed isolating transformer complying with BS EN 61558-2-4.

NOTE: An example of an arrangement for the supply of a Class I electric vehicle charging point from a separated source is shown in Annex A722, Item A722.5.

722.5 Selection and erection of equipment

722.51 Common rules

722.511 Compliance with standards

722.511.1 Where an EV charging point is built into a low voltage switchgear or controlgear assembly the requirements of the relevant part of BS EN 61439 series shall apply.

722.511.101 EV charging equipment shall comply with the appropriate parts of the BS EN 61851 series. EV charging equipment shall comply with the appropriate parts of the BS EN 61851 series.

722.512 Operational conditions and external influences

722.512.2 External influences

722.512.2.201 Presence of water (AD)

Where installed outdoors, the equipment shall provide a degree of protection of at least IPX4.

~~722.512.2.202 Presence of solid foreign bodies (AE)~~

~~Where installed outdoors, the equipment shall provide a degree of protection of at least IP4X.~~

~~722.512.2.203 Impact (AG)~~

~~Equipment installed in public areas and car park sites shall be protected against mechanical damage (impact of medium high severity AG3). Protection of the equipment shall be afforded by one or more of the following:~~

~~—— the position or location shall be selected to avoid damage by any reasonably foreseeable impact~~

~~—— local or general mechanical protection shall be provided~~

~~—— equipment shall be installed that complies with a minimum degree of protection against external mechanical impact of IK08 in accordance with the requirements of BS EN 62262.~~

~~722.53 Protection, isolation, switching, control and monitoring~~

~~722.531 — Devices for protection against electric shock by automatic disconnection of supply~~

~~722.531.3 — Residual current devices (RCDs)~~

~~722.531.3.1 — RCDs shall disconnect all live conductors.~~

~~722.531.3.101 Unless supplied by a circuit using the protective measure of electrical separation, each charging point incorporating a socket outlet or vehicle connector complying with the BS EN 62196 series shall be protected by an RCD having a rated residual operating current not exceeding 30 mA.~~

~~Except where provided by the EV charging equipment, protection against DC fault currents shall be provided by:~~

~~(i) — an RCD Type B, or~~

~~(ii) — an RCD Type A or Type F in conjunction with a residual direct current detecting device (RDC-DD) complying with BS IEC 62955 as appropriate to the nature of the residual and superimposed currents and recommendation of the manufacturer of the charging equipment.~~

~~RCDs shall comply with one of the following standards: BS EN 61008-1, BS EN 61009-1, BS EN 60947-2 or BS EN 62423.~~

~~NOTE 1: Types of RCD are described in Regulation 531.3.3 in respect of their behaviour when exposed to DC components and frequencies.~~

~~NOTE 2: Requirements for the selection and erection of RCDs in the case of supplies using DC vehicle connectors according to the BS EN 62196 series are under consideration.~~

~~NOTE 3: An RCD Type A or Type F in conjunction with an RDC-DD can be arranged with the RDC-DD inside the EV charging equipment and the Type A or Type F RCD upstream in either the charging equipment or the installation.~~

722.533 — Devices for protection against overcurrent

~~722.533.101 Each charging point shall be supplied individually by a final circuit protected by an overcurrent protective device complying with BS EN 60947-2, BS EN 60947-6-2 or BS EN 61009-1 or with the relevant parts of the BS EN 60898 series or the BS EN 60269 series.~~

~~NOTE: The electric vehicle charging equipment may have multiple charging points.~~

722.55 Other equipment

722.55.101 — Socket outlets and connectors

~~722.55.101.0.201.1 Each AC charging point shall incorporate:~~

- ~~(i) one socket outlet complying with BS 1363-2 marked 'EV' on its rear and, except where there is no possibility of confusion, a label shall be provided on the front face or adjacent to the socket outlet or its enclosure stating: 'suitable for electric vehicle charging', or~~
- ~~(ii) one socket outlet or connector complying with BS EN 60309-2 which is interlocked and classified to clause 6.1.5 of BS EN 60309-1 to prevent the socket contacts being live when accessible, or~~
- ~~(iii) one socket outlet or connector complying with BS EN 60309-2 which is part of an interlocked self-contained product complying with BS EN 60309-4 and classified to clauses 6.1.101 and 6.1.102 to prevent the socket contacts being live when accessible, or~~
- ~~(iv) one Type 1 vehicle connector complying with BS EN 62196-2 for use with mode 3 charging only, or~~
- ~~(v) one Type 2 socket outlet or vehicle connector complying with BS EN 62196-2 for use with mode 3 charging only, or~~
- ~~(vi) one Type 3 socket outlet or vehicle connector complying with BS EN 62196-2 for use with mode 3 charging only.~~

~~NOTE: Vehicle manufacturers' instructions should be taken into account when determining the type of socket outlet to be installed.~~

~~722.55.101.0.201.2 Each socket outlet shall be installed in a distribution board in accordance with Regulation 722.51 or in its appropriate enclosure (e.g. flush or surface mounted socket outlet box) and mounted in a fixed position.~~

~~Portable socket outlets shall not be used but tethered vehicle connectors are permitted.~~

~~722.55.101.3 One socket outlet or vehicle connector shall supply only one electric vehicle.~~

~~722.55.101.4 In EV charging modes 3 and 4, an electrical or mechanical system shall be provided to prevent the plugging/unplugging of the plug unless the socket outlet or the vehicle connector has been switched off from the supply.~~

~~722.55.101.6 Precautions on supply of the fixed installation by the EV~~

4639 NOTE: Requirements for precautions on supply of the fixed installation by the EV are under consideration.

4640 **722.551.7.2** The socket-outlet or vehicle connector shall comply with BS EN 62196 series.

ANNEX A722 (Informative) GUIDANCE FOR TN SYSTEMS WHERE PME CONDITIONS APPLY

A722.1 Neutral current of a three-phase installation

Where the power factors of the currents in all three phases are similar and triple harmonics can be neglected, it may be assumed that the neutral current of a three-phase installation is given by:

$$I_m = \sqrt{I_{L1}^2 + I_{L2}^2 + I_{L3}^2 - I_{L1}I_{L2} - I_{L1}I_{L3} - I_{L2}I_{L3}}$$

NOTE: The maximum neutral current (I_m) occurs under conditions of maximum imbalance, not necessarily maximum overall demand.

A722.2 Load balance

Where triple harmonics can be neglected, condition (i) of Regulation 722.411.4.1 may be assumed to apply where the following condition is met. This formula should take account of C_{max} in line with PD CLC/TR 50480.

$$\frac{I_m U_0 C_{max}}{I_{L1} + I_{L2} + I_{L3}} < 70 \text{ V}$$

A722.3 Earth-electrode resistance

For the purposes of condition (ii) of Regulation 722.411.4.1, the sum of the resistances of the earth-electrode and the protective conductor connecting it to the main earthing terminal must meet the following condition, as applicable.

For a single-phase installation:

$$R_{A\text{ ev}} < \frac{70 U_0 C_{max}}{I_{inst}(U_0 C_{max} - 70)}$$

For a three-phase installation:

$$R_{A\text{ ev}} = \frac{70 U_0 C_{max}}{I_m U_0 C_{max} - 70(I_{L1} + I_{L2} + I_{L3})}$$

NOTE 1: The above three-phase formula for $R_{A\text{ ev}}$ is valid only where $I_m > \frac{70(I_{L1} + I_{L2} + I_{L3})}{U_0 C_{max}}$. Where this is not the case, this indicates that condition (i) of Regulation 722.411.4.1 applies and that an earth-electrode is not required for the purposes of condition (ii) of that regulation.

NOTE 2: The above currents and voltage are magnitudes only; they are not phasors.

NOTE 3: In determining I_m , I_{L1} , I_{L2} and I_{L3} , allowance must be made for single-phase vehicles being charged from three-phase charging points.

~~A722.4 — Guidance on voltage monitoring device described in Regulation 722.411.4.1 (iii)~~

~~Regulation 722.411.4.1 (iii) describes a device that measures the voltage between the circuit protective conductor of the electric vehicle charging equipment and Earth. During a PEN failure in the supply network, the neutral of a TN-C-S supply is no longer considered to be reliably connected to Earth, and a device that measures the voltages between the following points will fail to provide equivalent safety to the device described in Regulation 722.411.4 (iii): Regulation 722.411.4.1 (iii):~~

- ~~(i) the circuit protective conductor and neutral~~
- ~~(ii) the circuit protective conductor and the consumer's main earthing terminal.~~

~~Suitable arrangements include measurement of the voltage between either:~~

- ~~(a) the circuit protective conductor and a suitable measurement earth electrode, or~~
- ~~(b) the circuit protective conductor and a reference point derived from the line conductors of a three-phase system, provided that suitable precautions are also taken to disconnect the device when the supply to one or more line conductors is interrupted.~~

~~Where used, measurement earth electrodes should be located at a sufficient distance from other earth electrodes and/or other buried exposed conductive parts and/or extraneous conductive parts connected to the PME earthing terminal to reduce transfer of earth potential rise on the PME system during a PEN failure.~~

~~Applying Clauses 9.6.1 and 9.6.2 of BS 7430:2011+A1:2015, in conditions where only buried exposed and/or extraneous conductive parts equivalent to vertical and horizontal earth electrodes are being considered, a separation distance of at least 8 m reduces the voltage transfer from the PME earthing system to less than 20 % and, in these conditions, the voltage operated device should be arranged to operate at 56 V.~~

~~It is recommended that the minimum separation distance is 2 m, and at this separation distance the device should be arranged to operate at 40 V.~~

~~Where other types of earth electrodes are used, separation distances should be increased, or the operating voltage decreased, accordingly, using the guidance in BS 7430.~~

~~To protect a person touching the body of an electric vehicle, connected to the charging point, when an open circuit fault occurs in the PEN conductor of the supply, an enhanced safety provision may be offered. This may be achieved by a device that provides shorter disconnection times, depending on the detected voltage between the circuit protective conductor and Earth but also taking into account the need to limit the risk of unwanted tripping. Examples of shorter disconnection times are shown in Table A722 below. These disconnection times are based on IEC Technical Report IE_C TR 60479-5 and also on comparable requirements already included in Chapter 41 of BS 7671.~~

~~**TABLE A722 – Maximum disconnection times in relation to the voltage between the circuit protective conductor and Earth***~~

70V	100V	200V	400V
-----	------	------	------

1s	0.7s	0.2s	0.04s
----	------	------	-------

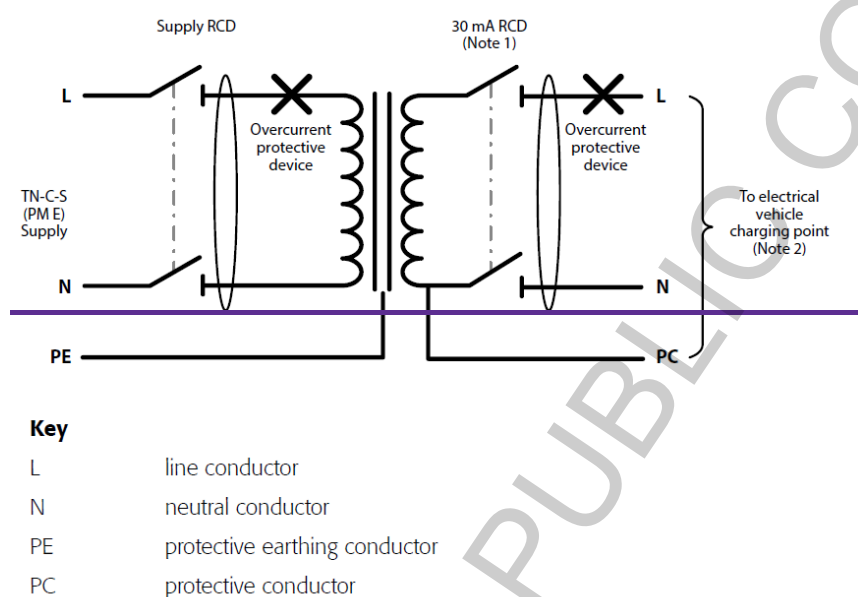
* Total voltage drop across the sensing element of the device and the earth electrode (if any) in series.

A722.5 Example arrangement of a separated system described in Regulation 722.413

An example arrangement of a separated system as described in Regulation 722.413 is shown in Fig 224 protective conductor A722.

Isolating transformers may have high inrush currents, and overcurrent protective devices in the primary circuit should be selected accordingly to prevent nuisance tripping.

Fig A722 Example of a separated system where protective conductor monitoring is required



NOTE 1: The RCD on the secondary, complying with Regulation 722.531.3.101, should be placed as close as possible to the transformer.

NOTE 2: Only one charging point may be supplied by each transformer, see Regulation 722.413.1.2.

APPENDIX 1 (Normative) BRITISH STANDARDS TO WHICH REFERENCE IS MADE IN THIS STANDARD

NOTE: Certain British Standards have been withdrawn since the issue of the previous Edition. From the date of withdrawal, certificates and marks already awarded may continue to apply to production until a date specified in the superseding standard. During the period between these dates, the withdrawn standard may be specified in contracts. However, it should be noted that this appendix may not list such standards, as only current British Standards are listed with some references to superseded standards. Where standards are not dated they are a multiple standard.

BS 1363-2	Specification for 13 A switched and unswitched socket-outlets	722.55.101.0.201.1(i)
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BS 7430:2011+A1:2015	Code of practice for protective earthing of electrical installations	A722.4
BS EN 60269 series	Low-voltage fuses	722.533.101
BS EN 60309-1	Plugs, socket outlets and couplers for industrial purposes—General requirements	722.55.101.0.201.1(iii)
BS EN 60309-2	Plugs, socket outlets and couplers for industrial purposes—Dimensional interchangeability requirements for pin and contact tube accessories	722.55.101.0.201.1(iii) 722.55.101.0.201.1(iiii)
BS EN 60309-4	Plugs, socket outlets and couplers for industrial purposes—Switched socket outlets and connectors, with or without interlock	722.55.101.0.201.1(iiii)
BS EN 60898 series	Specification for circuit-breakers for overcurrent protection for household and similar installations	722.533.101
BS EN 60947-2	Low-voltage switchgear and control gear—Circuit-breakers	722.531.3.101722.533.101
BS EN 60947-6-2	Multiple function equipment—Control and protective switching devices (or equipment) (CPS)	722.533.101
BS EN 61008-1	Residual current operated circuit-breakers without integral overcurrent protection for household and similar uses (RCCBs) General rules	722.531.3.101
BS EN 61009-1	Electrical accessories. Residual current operated circuit-breakers with integral overcurrent protection for household and similar uses (RCBOs) General rules Supersedes BS EN 61001:2004+A14:2012 but remains current	722.531.3.101 722.533.101
BS EN 61439 series	Low-voltage switchgear and controlgear assemblies General rules (see also BS EN 60439)	722.511.1
BS EN 61558-2-4	Safety of transformers, reactors, power supply units and similar products for supply voltages up to 1100 V. Particular requirements and tests for isolating transformers and power supply units incorporating isolating transformers	722.413.1.2
BS EN 61851 series	Electric vehicle conductive charging system. General requirements Current but partially replaced with BS EN 62752:2016	722.511.101
BS EN 62196	Plugs, socket outlets, vehicle connectors and vehicle inlets. Conductive charging of electric vehicles.	722.531.3.101 NOTE 2722.551.7.2
BS EN 62196-2	Dimensional compatibility and interchangeability requirements for a.c. pin and contact tube accessories	722.55.101.0.201.1(iv) 722.55.101.0.201.1(v) 722.55.101.0.201.1(vii)
BS EN 62262	Degrees of protection provided by enclosures for electrical equipment against external mechanical impacts (IK code)	722.512.2.203
BS EN 62423	Type F and type B residual current operated circuit-breakers with and without integral overcurrent protection for household and similar uses	722.531.3.101
BS IEC 62955	Residual direct current detecting device (RDC-DD) to be used for mode 3 charging of electric vehicles	722.531.3.101(iii)

PD CLC/TR 50480	Determination of cross-sectional area of conductors and selection of protective devices	A722.2
IEC TR 60479-5	Effects of current on human beings and livestock — Part 5: Touch voltage threshold values for physiological effects	A722.4

DRAFT FOR PUBLIC COMMENT

Appendix K Minimum depth of buried cables and height of overhead suspended cables

K1 General

The guidance in this Appendix applies to AC and DC LV and ELV cables, and telecommunications cables.

K2 Buried cables

The ESOCR require that all buried cables shall be marked or otherwise protected (Regulation 14(2)).

Before any excavation is undertaken for cable or other works HSE guidance booklet HSG47 *Avoiding danger from underground services* should be followed, as it provides valuable advice on safety aspects.

All buried cables are required to be marked by cable covers or a suitable marker tape and buried conduits or ducts must also be suitably identified. A warning tape above the duct or conduit run would be suitable.

Where cables or ducts are buried in soft ground, account should be taken of ground compression from vehicle or machinery movement over wet or damp ground, frost heave, and sinking of soft back-fill where trenches are dug. The initial depth of burial in soft ground should therefore be at least 400 mm deeper than those shown in Table K.1.

Table K.1 Minimum depth of burial of LV and ELV cables

<u>Area classification of ground under which cable is buried (NOTE 1)</u>	<u>Minimum depth of burial (NOTES 2 and 3)</u>	<u>References to requirements and guidance</u>
<u>General minimum depth (unless within ducts encased in concrete)</u>	<u>0.5 m</u>	<u>Regulation 522.8.10 of BS 7671.</u> <u>Section 5.7 of IET Guidance Note 1 Selection and Erection</u>
<u>Agricultural (general, and including areas where livestock graze)</u>	<u>0.6 m</u>	<u>Regulation 705.522 of BS 7671</u>
<u>Agricultural (arable or cultivated ground)</u>	<u>1.0 m</u>	
<u>Caravan sites</u>	<u>0.6 m</u>	<u>Regulation 708.521.7.2 of BS 7671</u>
<u>Marinas</u>	<u>0.5 m</u>	<u>Regulation 709.521.1.7 of BS 7671</u>
<u>Shore connection points for inland navigation vessels</u>	<u>0.6 m</u>	<u>Regulation 730.521.101.3.2 of BS 7671</u>
<u>Highway – footway, verge or bridleway (NOTE 4)</u>	<u>0.5 m</u>	<u>Regulation 522.8.10 of BS 7671.</u> <u>Section 5.7 of IET Guidance Note 1 Selection and Erection</u> <u>Street Works UK Publication Volume 1 – Street Works UK Guidelines on the Positioning and Colour Coding of Underground Utilities' Apparatus</u>
<u>Highway – carriageway (NOTE 4)</u>	<u>0.6 m</u>	

NOTE 1: Where an area under which cables are buried may come under two classifications, the most onerous (deepest) minimum depth applies.

NOTE 2: Depth is to top of duct (or top of cable if cables with earthed metallic armour are directly buried).

NOTE 3: Where cables or ducts are buried in soft ground, the depths should be increased by 400 mm to account for ground compression from vehicle or machinery movement over wet or damp ground, frost heave, and sinking of soft ground back-fill.

NOTE 4: See also Table K.2 and Figure K.1.

Positioning and colour-coding of underground utilities' apparatus

Street Works UK has agreed colours, depths of cover and positions for ducts, pipes, cables and marker/warning tapes when laid in the street. These are reproduced in Table K.2 and Figure K.1. This gives guidance to designers as to the depth at which cables might reasonably be expected to be laid generally, for example, in car parks, as well as in public paths and highways.

WARNING

The information provided in Table K.2 and Figure K.1 is current practice and indicates where it is preferable for newly installed cables and pipes to be installed. Older cables and pipes may not use these colour identifiers, nor be located at these depths. See HSE publication HSG47 for further guidance.

Table K.2 Recommended colour-coding of other underground apparatus

NOTE: These guidelines are taken from Street Works UK the 'Streetworks UK Publication Volume 1—Streetworks UK Guidelines on the Positioning and Colour Coding of Underground Utilities' Apparatus' *Street works UK guidance on the positioning and colour coding of underground utilities' apparatus. Volume 1.*

Asset Owner	Duct	Pipe	Cable	Marker Systems	Recommended Minimum Depths	
					Footway	Carriageway
Electricity HV (High Voltage)	Black or red duct or tile	N/A	Black or Red	Yellow with black and red legend or concrete tiles	450-1200 mm	750-1200 mm
Electricity LV (Low Voltage)					450 mm	600 mm
Gas	Yellow	*** See row below	N/A	Black legend on PE pipes every linear metre.	600 mm footway 750 mm verge	750 mm
*** Pressure - up to 2 bar - yellow or yellow with brown stripes (removable skin revealing white or black core pipe). - between 2 to 7 bar - orange. Steel pipes may have yellow wrap or black tar coating or no coating. Ductile Iron may have plastic wrapping Asbestos & Pit / Spun Cast Iron - No distinguishable colour						
Water non Potable & Grey Water	N/A	Black with green stripes	N/A	N/A	600 - 750 mm	600 - 750 mm
Water Firefighting	N/A	Black with red stripes or bands	N/A	N/A	600 - 750 mm	600 - 750 mm
Oil / fuel pipelines	N/A	Black	N/A	Various surface markers Marker tape or tiles above red concrete	900 mm <i>All work within 3 m of oil / fuel pipelines must receive prior approval</i>	900 mm <i>All work within 3 m of oil / fuel pipelines must receive prior approval</i>
Sewerage	Black	No distinguishing colour/material (e.g.: Ductile Iron may be red; PVC may be brown)	N/A	N/A	Variable	Variable
Telecomms	Grey, white, green, Black, purple	N/A	Black or light grey	Various	250 - 350 mm	450 - 600 mm
Water	Blue or Grey	Blue polymer or blue or uncoated Iron / GRP. Blue polymer with brown stripe (removable skin revealing white or black pipe)	N/A	Blue or Blue/black	750 mm	750 mm
Water pipes for special purposes (e.g. contaminated ground)	N/A	Blue polymer with brown stripe (non-removable skin)	N/A	Blue or Blue/black	750 mm	750 mm

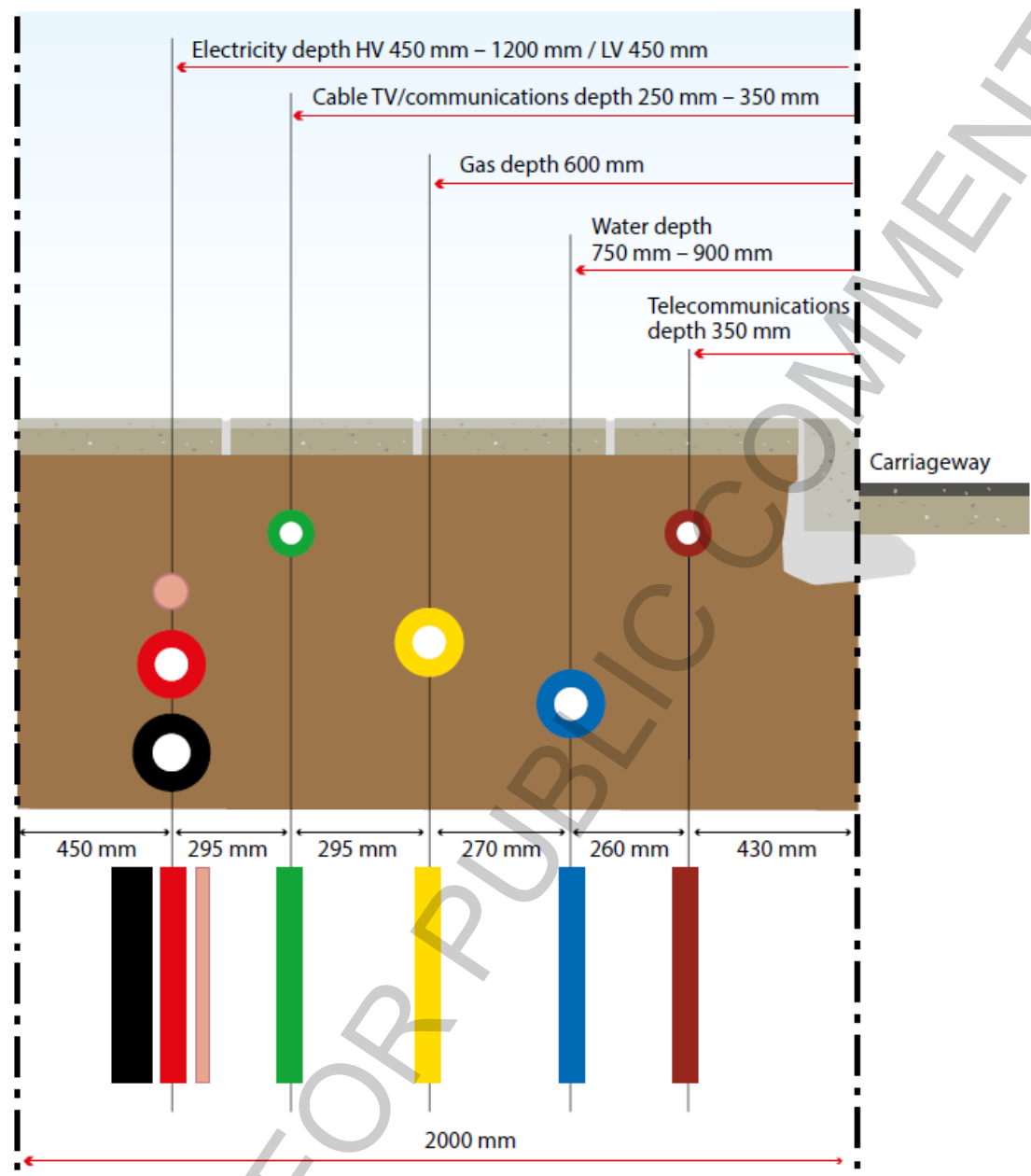
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Table K.2 Table K.2 (continued) cont.

Asset Owner	Duct	Pipe	Cable	Marker Systems	Recommended Min. Depths	
					Footway	Carriageway
Highway Authority Services						
At the time of publication the following were current examples of known highway authority apparatus colour coding						
Street Lighting						
England and Wales	Black or Orange*	N/A	Black	Yellow with black legend	450 mm	600 mm
	<i>* Consult electricity company first</i>					
Scotland	Purple	N/A	Purple	Yellow with black legend or purple	450 mm	
Northern Ireland	Orange	N/A	Black or Orange	Various	450 mm	450 mm
Other						
Traffic Control	Orange		Orange	Yellow with black legend		
Street Furniture	Black	N/A	Black	Yellow with black legend	450 mm	600 mm
Telecoms	Purple or Orange	N/A	Black	Various		
Motorways and Trunk Roads						
England and Wales						
Communications	Purple	N/A	Grey	Yellow with black legend	450 mm	
Communications Power	Purple	N/A	Black	Yellow with black legend		
Road Lighting	Orange	N/A	Black	Yellow with black legend		
Scotland						
Communications	Black or Grey	N/A	Black	Yellow with black legend		
Road Lighting	Purple	N/A	Purple	Yellow with black legend		

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Figure K.1 National guidelines on the positioning of utility apparatus in a 2 m footway



K3 Overhead suspended LV and ELV cables

All overhead cables should be located at a suitable height to prevent their damage in foreseeable circumstances. Unsupported spans should be avoided if at all possible where the regular use of lifting and/or access equipment in envisaged.

The minimum height, and location from personnel access areas of uninsulated cables should be considered to meet the requirements of placing out of reach (i.e. at least 3.5 m vertical distance to lowest point of cable span) in accordance with BS 7671. Uninsulated overhead conductors are not permitted in certain special locations in Part 7 of BS 7671 (see Table K.3 Table K.3).

Table K.3 Minimum height of overhead cables

Area classification over which cable is suspended (NOTES 1 and 2)	Minimum vertical height between cable and ground	References to requirements and guidance
General minimum heights for cables over roads or subject to vehicular traffic	5.8 m	Electricity Safety, Quality and Continuity Regulations (Regulation 17)
General minimum height of uninsulated cables not over roads	5.3 m	Section 9.5.4 of IET Guidance Note 5 <i>Protection against electric shock</i>
General insulated cables not over roads accessible to vehicular traffic.	4.3 m	
Agricultural (all areas), caravan parks (vehicle movement areas), and marinas (vehicle movement areas)	6.0 m	Regulations 705.522, 708.521.7.3, 709.521.1.8 and 730.521.101.3.3 of BS 7671
Caravan parks and marinas (all other areas)	3.5 m (NOTE 3)	

NOTE 1: Where an area over which cables are suspended may come under two classifications, the most onerous (highest) minimum height applies.

NOTE 2: Conductors of all overhead lines in areas covered by Sections 705, 708, 709 and 730 of BS 7671 shall be insulated, and are subject to a minimum height of 6.0 m, with the exception of caravan parks and marinas outside vehicle movement areas, where the minimum height is reduced to 3.5 m (unless other conditions, such as those shown in Table K.3 Table K.3, apply).

NOTE 3: Unless ESQCR Regulation 17 applies, see Section 9.5.4 of IET Guidance Note 5 *Protection against electric shock*.

Appendix L Regulatory marking

Following the UK's exit from the European Union, regulatory marking requirements in Great Britain and Northern Ireland have changed. 'UKCA' and 'UKNI' marking came into effect on 1 January 2021, although there is a cutover period until 31 December 2024 wherein CE marking may continue to be used.

Equipment may continue to be put on the market with the 'CE' mark (Figure L.1) until 31 December 2024, unless changes to relevant UK legislation is made. From 1 January 2025, goods placed on the market in Great Britain should carry the 'UKCA' mark (Figure L.2). The 'UKCA' mark can be used from 1 January 2021. In Northern Ireland, the 'UKNI' mark (Figure L.3) is used under certain circumstances, with similar implementation and cutover dates.

Figure L.1 CE Mark



Figure L.2 UKCA Mark



Figure L.3 UKNI Mark



Further guidance is provided by the UK Government Department for Business, Energy and Industrial Strategy (BEIS), via the following web addresses:

- <https://www.gov.uk/guidance/using-the-ukca-marking>
- <https://www.gov.uk/guidance/placing-manufactured-goods-on-the-market-in-northern-ireland>

Appendix M Earth fault loop impedance contribution of steel wire armour cables (Annex NA of PD IEC/TR 50480)

M1 Introduction

Multicore or single-core cables with steel wire armour, with armour used as cpc, will often be selected for AC supplies to EV charging equipment installations. It will usually be necessary to consider the reactance of the cpc. For example, for BS 5467 cables, as indicated in Table M.5, the gross cross-sectional area (csa) of armour exceeds 16 mm² in:

(a) three-, four- and five-core multicore cables with conductor csa 1.5 mm²;

(b) all SWA cables with conductor csa of 2.5 mm².

This Appendix explains the method used to account for reactance in such cables, when calculating or assessing earth fault loop impedance, and prospective earth fault currents. This method is recommended by UK National Annex NA to PD IEC/TR 50480 *Determination of cross-sectional area of conductors and selection of protective devices*.

NOTE: Because reactance is being taken into account, this Appendix uses (Z_1+Z_2) instead of (R_1+R_2) for the loop impedance contribution of the cable arrangement.

The resistance and reactance per metre for a line conductor and cpc (steel wire armour), where the armour of a steel wire armoured cable is used as cpc are determined as shown in Table M.1.

Where an external single-core sheathed (non-armoured) cable is used in parallel with the steel wire armour to form the cpc, the resistance and reactance per metre for a line conductor and cpc (steel wire armour in parallel with the external cpc) are determined as shown in Table M.2.

Table M.1 Resistance and reactance per metre of the line conductor and cpc of steel wire armour cable where the armour is used as the cpc (NA.4.4 of PD CLC/TR 50480)

Resistance and reactance per metre		Complex number representation
r	x	
$R_1 + 1.1 \times R_2$	<u>0.3 mΩ</u>	$(Z_1 + Z_2) = (R_1 + 1.1R_2) + 0.3j \text{ m}\Omega/\text{m}$
<u>where:</u> R_1 is the resistive (r) component of the resistance of the line conductor in mΩ/m R_2 is the DC resistance of the steel wire armour in mΩ/m NOTE: Values for R_1 and R_2 for BS 5467 cables can be obtained from Table M.3 for multicore cables and Table M.4 for single-core cables. These values should be adjusted for temperature and other factors in accordance with Appendix 4 to BS 7671.		

Table M.2 Resistance and reactance per metre of the line conductor and cpc where the steel wire armour is used, connected in parallel with an external cpc (NA.4.5 of PD CLC/TR 50480)

Resistance and reactance per metre		Complex number representation
r	x	
$R_1 + \frac{1.1 \times R_{2a} \times R_{2p}}{1.1 \times R_{2a} + R_{2p}}$	<u>0.4 mΩ</u>	$(Z_1 + Z_2) = \left(R_1 + \frac{1.1 \times R_{2a} \times R_{2p}}{1.1 \times R_{2a} + R_{2p}} \right) + 0.4j \text{ m}\Omega/\text{m}$
<u>where:</u> R_1 is the resistive (r) component of the of the line conductor in mΩ/m R_{2a} is the DC resistance of the steel wire armour in mΩ/m (see Table F.7A) R_{2p} is the resistive (r) component of the parallel protective conductor in mΩ/m NOTE: Values for R_1 and R_{2a} for BS 5467 cables can be obtained from Table M.3 for multicore cables and Table M.4 for single-core cables. These values should be adjusted for temperature and other factors in accordance with Appendix 4 to BS 7671.		

Table M.3 Resistance of conductor and armour (mΩ/m) at 20 °C for multicore thermosetting (90 °C) 600/1,000 V insulated armoured cables to BS 5467

1	2		3		4	5	6	7
Nominal cross-sectional area of conductor (mm ²)	Conductor impedance (mΩ/m) (NOTES 3, 4 and 5)				DC resistance R _{DC} (mΩ/m) of armour (NOTES 3, 5)			
	Copper		Aluminium		Steel wire armour			
	r	x	r	x	Two-core	Three-core	Four-core	Five-core
1.5 (NOTE 1)	12.1	—	—	—	10.2	9.5	8.8	8.2
2.5 (NOTE 1)	7.41	—	—	—	8.8	8.2	7.7	6.8
4 (NOTE 1)	4.61	—	—	—	7.9	7.5	6.8	6.2
6 (NOTE 1)	3.08	—	—	—	7.0	6.7	4.3	3.9
10 (NOTE 1)	1.83	—	—	—	6.0	4.0	3.7	3.4
16 (NOTE 1)	1.15	—	1.91	—	3.7	3.5	3.1	2.2
25 (NOTE 1)	0.727	0.081	1.20	0.083	3.2	2.3	2.1	1.8
25 (NOTE 2)	0.727	0.081	1.20	0.083	3.7	2.5	2.3	—
35 (NOTE 1)	0.524	0.078	0.868	0.081	2.2	2.1	1.9	1.6
35 (NOTE 2)	0.524	0.078	0.868	0.081	2.6	2.3	2.0	—
50 (NOTE 1)	0.387	0.078	0.641	0.080	2.0	1.8	1.3	1.1
50 (NOTE 2)	0.387	0.078	0.641	0.080	2.3	2.0	1.8	—
70 (NOTE 1)	0.268	0.075	0.443	0.078	1.4	1.3	1.2	0.94
70 (NOTE 2)	0.268	0.075	0.443	0.078	2.0	1.8	1.2	—
95 (NOTE 1)	0.193	0.075	0.320	0.075	1.2	1.2	0.76	—
95 (NOTE 2)	0.193	0.075	0.320	0.075	1.4	1.3	1.1	—
120 (NOTE 1)	0.153	0.075	0.253	0.075	1.1	0.76	0.69	—
120 (NOTE 2)	0.153	0.075	0.253	0.075	1.3	1.2	0.76	—
150 (NOTE 2)	0.124	0.073	0.206	0.075	1.2	0.78	0.68	—
185 (NOTE 2)	0.0991	0.073	0.164	0.075	0.82	0.71	0.61	—
240 (NOTE 2)	0.0754	0.072	0.125	0.072	0.73	0.63	0.54	—
300 (NOTE 2)	0.0601	0.070	0.100	0.072	0.67	0.58	0.49	—
400 (NOTE 2)	0.0470	0.070	—	—	0.59	0.52	0.35	—

NOTES to Table M.3:

1. Circular or compacted circular stranded conductor (Class 2).
2. Shaped stranded conductor (Class 2).
3. Source for resistances BS 5467:2016 Table F.2, and for aluminium conductors BS 5467:1997+A3:2008 Table H.2.
4. Conductor reactance (for calculation of voltage drop, line-to-line and line-to-neutral faults) calculated from BS 7671 Tables 4E4B (copper conductors) and 4J4B (aluminium conductors).
5. See Tables M.2 and M.2 regarding total combined line and protective conductor impedance (resistance and reactance) for calculation of earth fault current.
6. Temperature correction factor C_r to correct from 20 °C to 70 °C and 90 °C are shown in Table M.7.

Table M.4 Resistance of conductor and armour (mΩ/m) at 20 °C for single-core thermosetting (90 °C) 600/1,000 V insulated armoured cables to BS 5467

1	2		3		4
Nominal cross-sectional area of conductor (mm ²) (NOTE 1)	Conductor impedance (mΩ/m) (NOTES 2, 3 and 4)				DC resistance R_{DC} (mΩ/m) of aluminium armour (NOTES 2, 4)
	Copper		Aluminium		Aluminium armour
	r	x	r	x	Single-core
50	0.387	0.105	0.641	0.110	1.3
70	0.268	0.100	0.443	0.105	0.75
95	0.193	0.098	0.320	0.101	0.67
120	0.153	0.095	0.253	0.100	0.61
150	0.124	0.093	0.206	0.098	0.42
185	0.0991	0.093	0.164	0.095	0.38
240	0.0754	0.090	0.125	0.093	0.34
300	0.0601	0.088	0.100	0.093	0.31
380	—	—	0.0800	0.090	—
400	0.0470	0.087	—	—	0.22
480	—	—	0.0633	0.089	—
500	0.0366	0.085	—	—	0.20
600	—	—	0.0515	0.088	—
630	0.0283	0.084	—	—	0.18
740	—	—	0.0410	0.085	—
800	0.0221	0.081	—	—	0.13
960	—	—	0.0313	0.081	—
1,000	0.0176	0.078	—	—	0.12
1,200	—	—	0.0250	0.080	—

NOTES to Table M.4:

1. Circular or compacted circular stranded conductor (Class 2).
2. Source for resistances BS 5467:2016 Table F.1, and for cables with aluminium conductors BS 5467:1997+A3:2008 Table H.1.
3. Conductor reactance (for calculation of voltage drop, line-to-line and line-to-neutral faults) calculated from BS 7671 Tables 4E3B (copper conductors) and 4J3B (aluminium conductors). Reactances are for cables arranged as single-phase touching or three-phase touching in trefoil.
4. See Tables M.1 and M.2 regarding total combined line and protective conductor impedance (resistance and reactance) for calculation of earth fault current.
5. Temperature correction factor C_r to correct from 20 °C to 70 °C and 90 °C are shown in Table M.7.

Table M.5 Gross cross-sectional area of armour wires in single-core and multicore thermosetting (90 °C) 600/1,000 V insulated armoured cables to BS 5467

Nominal cross-sectional area of conductor (mm ²)	Gross cross-sectional area of armour wires (mm ²)				
	Single-core (aluminium armour)	Two-core	Three-core	Four-core	Five-core
1.5 (NOTE 1)	—	15	16	17	19
2.5 (NOTE 1)	—	17	19	20	22
4 (NOTE 1)	—	19	20	22	25
6 (NOTE 1)	—	22	23	36	40
10 (NOTE 1)	—	26	39	42	46
16 (NOTE 1)	—	42	45	50	72
25 (NOTE 1)	—	51	72	80	88
25 (NOTE 2)	—	42	62	70	—
35 (NOTE 1)	—	74	80	90	100
35 (NOTE 2)	—	60	68	78	—
50 (NOTE 1)	26	86	92	131	144
50 (NOTE 2)	—	68	78	90	—
70 (NOTE 1)	42	128	138	150	166
70 (NOTE 2)	—	80	90	131	—
95 (NOTE 1)	47	144	153	220	—
95 (NOTE 2)	—	113	128	147	—
120 (NOTE 1)	52	160	220	245	—
120 (NOTE 2)	—	125	141	206	—
150 (NOTE 1)	76	—	—	—	—
150 (NOTE 2)	—	138	201	230	—
185 (NOTE 1)	84	—	—	—	—
185 (NOTE 2)	—	191	220	255	—
240 (NOTE 1)	94	—	—	—	—
240 (NOTE 2)	—	215	250	289	—
300 (NOTE 1)	104	—	—	—	—
300 (NOTE 2)	—	235	269	319	—
380 (NOTES 1, 4)	—	—	—	—	—
400 (NOTE 1)	147	—	—	—	—
400 (NOTE 2)	—	265	304	452	—
500 (NOTE 1)	163	—	—	—	—
630 (NOTE 1)	182	—	—	—	—
800 (NOTE 1)	260	—	—	—	—
1,000 (NOTE 1)	284	—	—	—	—

NOTES to Table M.5

1. Circular or compacted circular stranded conductor (Class 2).
2. Shaped stranded conductor (Class 2).
3. From BS 5467:2016, Tables G.1 and G.2, or, for single-core cables with aluminium conductors, BS 5467:1997+A3:2008 Tables I.1 and I.2.

Table M.6 Values of resistance/metre for Class 1 solid and Class 2 stranded copper and aluminium conductors (On-Site Guide Table I1)

Cross-sectional area (mm ²)		Resistance/metre or ($R_1 + R_2$)/metre (mΩ/m) at 20 °C	
Line conductor	Protective conductor	Copper	Aluminium
1	—	18.10	
1	1	36.20	
1.5	—	12.10	
1.5	1	30.20	
1.5	1.5	24.20	
2.5	—	7.41	
2.5	1	25.51	
2.5	1.5	19.51	
2.5	2.5	14.82	
4	—	4.61	
4	1.5	16.71	
4	2.5	12.02	
4	4	9.22	
6	—	3.08	
6	2.5	10.49	
6	4	7.69	
6	6	6.16	
10	—	1.83	3.08
10	4	6.44	
10	6	4.91	
10	10	3.66	6.16
16	—	1.15	1.91
16	6	4.23	—
16	10	2.98	—
16	16	2.30	3.82
25	—	0.727	1.20
25	10	2.557	—
25	16	1.877	—
25	25	1.454	2.40
35	—	0.524	0.87
35	16	1.674	2.78
35	25	1.251	2.07
35	35	1.048	1.74

NOTES to Table M.6

1. From BS EN 60228, Tables 1 and 2.
2. For larger sizes see Tables F.6 and F.7 in the IET *Electrical Installation Design Guide, 5th Edition*.
3. Temperature correction factor C_t to correct from 20 °C to 70 °C and 90 °C are shown in Table M.7.

Table M.7 Temperature correction factors for impedances of copper and steel

Conductor material	Coefficient of resistance at 20 °C	C _r to correct from 20 °C to 70 °C	C _r to correct from 20 °C to 90 °C
Copper	0.0040	1.200	1.280
Steel	0.0045	1.225	1.315

M2 Example calculation

An outdoor feeder pillar is used to supply a 7 kW single-phase EVSE in a car park, from a C32 mcb to BS EN 60898. The circuit length of buried 10 mm² 2-core BS 5467 steel wire armour cable between the feeder pillar and EVSE is 35 m. The steel wire armour is to be used as cpc. The cable is to be buried at a depth of at least 500 mm, and the ambient temperature for cables buried in the ground is assumed to be 20 °C. The cable conductors are to be designed to operate at 70 °C for compatibility with equipment terminals. The earth fault loop impedance Z_{DB} at the feeder pillar is 0.17 Ω.

To calculate the total earth fault loop impedance at the input terminals of the EVSE:

Step 1: Find the resistive and reactive values of the impedance of the cable length installed, corrected for operating temperature:

	Resistive part r	Reactive part x
Resistance and reactance per metre (as per Table M.1, resistances for copper conductor and armour from columns 2 and 4 of Table M.2, with temperature correction factors from Table M.7).	$\left(\frac{1.200 \times 1.83}{1,000} + 1.1 \times \frac{1.225 \times 6.0}{1,000} \right) \Omega$ $= (0.002196 + 0.008085) \Omega$ $= 0.010281 \Omega$	$\frac{0.3}{1,000} = 0.0003 \Omega$
Circuit length 35 m	$35 \times 0.010281 \Omega$ $= 0.3598 \Omega$	$35 \times 0.0003 \Omega$ $= 0.0105 \Omega$

NOTE: Only the resistive part is corrected for operating temperature. The reactive part is not.

Step 2: Combine the resistive part (r) and reactive part (x) to get the total (Z_1+Z_2):

$$(Z_1 + Z_2) = \sqrt{r^2 + x^2}$$
$$(Z_1 + Z_2) = \sqrt{0.3598^2 + 0.0105^2} \Omega$$
$$(Z_1 + Z_2) = \sqrt{0.1296} \Omega$$
$$(Z_1 + Z_2) = 0.36 \Omega$$

Step 3: use (Z_1+Z_2) to calculate the total earth fault loop impedance:

$$Z_s = Z_{DB} + (Z_1 + Z_2)$$
$$Z_s = 0.17 + 0.36 \Omega$$
$$Z_s = 0.53 \Omega$$

Appendix M Appendix N Glossary

ACD	Automatic connecting device. See illustration in Appendix J, Figure J.1 .
ACD counterpart	Passive device which is used in combination with an ACD to make the physical connection between EVSE and an EV without user interaction to provide an electromechanical interface. See illustration in Appendix J, Figure J.1 .
Automated connection device	Active device where the physical connection between EVSE and EV is made without user interaction providing an electromechanical interface. See illustration in Appendix J, Figure J.1 .
Automatic coupler	System comprising an ACD and an ACD counterpart. See illustration in Appendix J, Figure J.1 .
Client	In the context of this Code of Practice, 'client' means the designated representative of the person, company or body that has requested the EV charging equipment installation.
Competent person	In the context of this Code of Practice, 'competent person' means a person who possesses sufficient technical knowledge, relevant practical skills and experience for the nature of the electrical work undertaken and who is able, at all times, to prevent danger and, where appropriate, injury to him/herself and others.
Electric vehicle charging point	The point where the EV is connected to the fixed installation. Note NOTE: The charging point is a socket-outlet where the charging cable belongs to the vehicle, or a connector where the charging cable is a fixed part of the EV supply equipment. See BS 7671.
Exposed-conductive-part	Conductive part of equipment that can be touched and that is not normally live, but can become live under fault conditions. For further guidance, refer to BS 7671 and IET Guidance Notes 1, 3, 5 and 8.
Extraneous-conductive-part	Conductive part liable to introduce a potential, generally Earth potential, and not forming part of the electrical installation. For further guidance, refer to BS 7671 and IET Guidance Notes 1, 3, 5 and 8.
DNO	Distribution network operator
Electric Vehicle (EV)	In the context of this Code of Practice, EV covers all electrically propelled road vehicles with four or more wheels that are capable of accepting electrical charge from a source external to the vehicle, including plug-in vehicles (PiVs), full battery electric vehicles (BEVs), plug-in hybrid electric vehicles (PHEVs) and range-extended hybrid electric vehicles/extended-range hybrid electric vehicles (REHEVs/ERHEVs).
EV	Electric vehicle
E-REV	Extended range electric vehicle
EVSE	Electric vehicle supply equipment
ICCB	In-cable control box for Mode 2 charging.
IK	Mechanical impact protection code according to BS EN 62262

IP	Ingress protection code according to BS EN 60529.
Island mode	Operating mode in which the PEI is disconnected from the public distribution system, but remains energized. An operating state of an electrical system that is normally connected to the grid, but is operating in a mode where some or all of the installation is isolated from the grid and is operating solely from local generation sources. See BS HD 60364-8-2 BS 7671.
Load curtailment	Load reduction in an electrical installation, including disconnection, either automatically or manually.
MF-WPT	Inductive (magnetic field) wireless charging
Open-PEN	Open-circuit combined protective earth and neutral conductor fault
OPDD	Open-circuit PEN fault disconnection device
PEI	Prosumer's electrical installation
PEN	Combined protective earth and neutral conductor
PHEV	Plug-in hybrid electric vehicle
PME	Protective multiple earthing
Presuming Prosumer's electrical installation	Low voltage electrical installations connected or not to a public distribution network able to operate: - with local power supplies, and/or - with local storage units, and that monitor and control the energy from the connected sources delivering it to: - current-using equipment, and/or - local storage units, and/or - public distribution network. See BS 7671. An electrical installation that incorporates sources of electrical energy, such as solar photovoltaic and electrical energy storage systems, in addition to current using equipment. See BS HD 60364-8-2.
V2G	Vehicle to grid
V2H	Vehicle to home
V2X	Generic term for grid-connected vehicle as storage, encompassing vehicle to grid, vehicle to home, and/or other grid-connected storage applications
WPT	Wireless power transfer (wireless charging)

Appendix NAppendix O References

The following regulations, standards and guidance are referenced within this Code of Practice:

The Electricity Safety, Quality and Continuity Regulations 2002 (as amended)

The Electromagnetic Compatibility Regulations 2016 [\(as amended\)](#)

The Electrical Equipment (Safety) Regulations 2016 [\(as amended\)](#)

The Building Regulations 2010: [Part Approved Document P](#) (Electrical safety – Dwellings), 2013 Edition

[The Building Regulations 2010: Approved Document S \(Infrastructure for the charging of electric vehicles\), 2021 Edition](#)

IET Designer's Guide to Energy Efficient Electrical Installations

[IET/APEA Electric Vehicle Charging Installations at Filling stations \(A supplement to the Code of Practice for Electric Vehicle Charging Equipment Installation\)](#)

BS 1363 series:

BS 1363-1:2016+A1:2018 – 13A plugs, socket-outlets, adaptors and connection units. Specification for rewirable and non-rewirable 13A fused plugs

BS 1363-2:2016+A1:2018 – 13A plugs, socket-outlets, adaptors and connection units. Specification for 13A switched and unswitched socket-outlets

BS 4662:2006+A1:2009 – Boxes for flush mounting of electrical accessories. Requirements, test methods and dimensions

[BS 5467:2016 – Electric cables. Thermosetting insulated, armoured cables of rated voltages of 600/1 000 V and 1 900/3 300 V for fixed installations. Specification](#)

[BS 6701:2016+A1:2017 – Telecommunications equipment and telecommunications cabling. Specification for installation, operation and maintenance. Specification for installation, operation and maintenance](#)

BS 7430:2011+A1:2015 – Code of practice for protective earthing of electrical installations

[BS 7645:1993, IEC 60757:1983 – Code for designation of colours](#)

BS 7671:2018+~~A2:2022~~[A1:2020](#) – Requirements for Electrical Installations, IET Wiring Regulations, Eighteenth Edition

BS 8300 series:

BS 8300-1:2018 – Design of an accessible and inclusive built environment. Part 1: External environment – Code of practice

BS 8300-2:2018 – Design of an accessible and inclusive built environment. Part 2: Buildings – Code of practice

4947 [BS EN ISO 19363:2021 – Electrically propelled road vehicles. Magnetic field wireless power](#)
4948 [transfer. Safety and interoperability requirements](#)

4949 BS EN 50174 series:

4950 BS EN 50174-1:2018+A1:2020 – Information technology. Cabling installation.
4951 Installation specification and quality assurance

4952 BS EN 50174-2:2018 – Information technology. ~~Cabling~~ ~~installation~~ [Cabling](#)
4953 [installation](#). Installation planning and practices inside buildings

4954 BS EN 50174-3:2013+A1:2017 – Information technology. Cabling installation.
4955 Installation planning and practices outside buildings

4956 BS EN 50413:2008+A1:20132019 – Basic standard on measurement and calculation
4957 procedures for human exposure to electric, magnetic and electromagnetic fields (0 Hz - 300
4958 GHz)

4959 BS EN 50491-11:2015+A1:2020 – General requirements for Home and Building Electronic
4960 Systems (HBES) and Building Automation and Control Systems (BACS). Smart Metering.
4961 Application Specifications. Simple External Consumer Display

4962 BS EN 50499:2019 – Procedure for the assessment of the exposure of workers to
4963 electromagnetic fields

4964 BS EN 50500:2008+A1:2015 – Measurement procedures of magnetic field levels generated
4965 by electronic and electrical apparatus in the railway environment with respect to human
4966 exposure

4967 BS EN 50522:2010 – Earthing of power installations exceeding 1 kV a.c.

4968 BS EN 50664:2017 – Generic standard to demonstrate the compliance of equipment used by
4969 workers with limits on exposure to electromagnetic fields (0 Hz - 300 GHz), when put into
4970 service or in situ

4971 BS EN 50665:2017 – Generic standard for assessment of electronic and electrical equipment
4972 related to human exposure restrictions for electromagnetic fields (0 Hz - 300 GHz)

4973 [BS EN 60228:2005 – Conductors of insulated cables](#)

4974 BS EN 60255-series:

4975 BS EN 60255-1:2010-2022 – Measuring relays and protection equipment. Common
4976 requirements

4977 BS EN 60255-21-1:1996 – Electrical relays. Vibration, shock, bump and seismic tests
4978 on measuring relays and protection equipment. Vibration tests (sinusoidal)

4979 BS EN 60255-21-2:1996 – IEC 60255-21-2:1988 – ~~Electrical relays~~. Vibration, shock,
4980 bump and seismic tests on measuring relays and protection equipment. Shock and
4981 bump tests

4982 BS EN 60255-21-3:1995 – *Electrical relays. Vibration, shock, bump and seismic tests*
4983 *on measuring relays and protection equipment. Seismic tests*

4984 BS EN 60255-26:2013 – *Measuring relays and protection equipment. Electromagnetic*
4985 *compatibility requirements*

4986 BS EN 60255-27:2014 – *Measuring relays and protection equipment. Product safety*
4987 *requirements*

4988 BS EN 60255-127:2014 – *Measuring relays and protection equipment. Functional*
4989 *requirements for over/under voltage protection*

4990 ~~BS EN 60309~~ [BS EN IEC 60309](#) series:

4991 ~~BS EN 60309~~ [BS EN IEC 60309-1:1999+A2:20122022](#) – *Plugs, socket-outlets and*
4992 *couplers for industrial purposes. General requirements*

4993 ~~BS EN 60309~~ [BS EN IEC 60309-2:1999+A2:20122022](#) – *Plugs, socket-outlets and*
4994 *couplers for industrial purposes. Dimensional interchangeability requirements for pin*
4995 *and contact-tube accessories*

4996 ~~BS EN 60309~~ [BS EN IEC 60309-4:2007+A1:20122022](#) – *Plugs, socket-outlets and*
4997 *couplers for industrial purposes. Switched socket-outlets and connectors with or*
4998 *without interlock*

4999 BS EN 60529:1992+A2:2013 – *Degrees of protection provided by enclosures (IP code)*

5000 BS EN 60670-1:2005+A1:20132021+A11:2021 – *Boxes and enclosures for electrical*
5001 *accessories for household and similar fixed electrical installations. General requirements*

5002 BS EN 60947-2:2017 [+A1:2020](#) – *Low voltage switchgear and controlgear. Circuit-breakers*

5003 BS EN 61000-6- and BS IEC 61000-6 series:

5004 BS EN 61000-6-1:2019 – *Electromagnetic compatibility (EMC). Generic standards.*
5005 *Immunity for residential, commercial and light-industrial environments*

5006 BS EN 61000-6-2:2019 – *Electromagnetic compatibility (EMC). Generic standards*

5007 BS EN 61000-6-3:2007+A1:20112021 – *Electromagnetic compatibility (EMC). Generic*
5008 *standards. Emission standard for residential, commercial and light-industrial*
5009 *environments*

5010 BS EN 61000-6-4:2019 – *Electromagnetic compatibility (EMC). Generic standards.*
5011 *Emission standard for industrial environments*

5012 BS EN 61000-6-5:2015 – *Electromagnetic compatibility (EMC). Generic standards.*
5013 *Immunity for equipment used in power station and substation environment*

5014 BS IEC 61000-6-6:20038:2020 – *Electromagnetic compatibility (EMC). Generic*
5015 *standards. [Emission standard for professional equipment in commercial and light-](#)*
5016 *[industrial locations](#)*

5017 BS EN 61008-1:2012+A12:2017 – *Residual current operated circuit-breakers without integral*
5018 *overcurrent protection for household and similar uses (RCCBs) – General rules*

5019 BS EN 61009-1:2012+A12:2016+A13:2021 – *Residual current operated circuit-breakers with*
5020 *integral overcurrent protection for household and similar uses (RCBOs). General rules*

5021 [BS EN IEC 61439-7:2020 – Low-voltage switchgear and controlgear assemblies. Assemblies](#)
5022 [for specific applications such as marinas, camping sites, market squares, electric vehicle](#)
5023 [charging stations](#)

5024 BS EN 61557-8:2015 – *Electrical safety in low voltage distribution systems up to 1 000 V a.c.*
5025 *and 1 500 V d.c. Equipment for testing, measuring or monitoring of protective measures.*
5026 *Insulation monitoring devices for IT systems-*

5027 BS EN 61558-2-4:2009-2021 – [Safety of transformers, reactors, power supply units and](#)
5028 [combinations thereof. Part 2-4: Particular requirements and tests for isolating transformers](#)
5029 [and power supply units incorporating isolating transformers for general applications](#)~~Safety of~~
5030 ~~transformers, reactors, power supply units and similar products for supply voltages up to 1100~~
5031 ~~V. Particular requirements and tests for isolating transformers and power supply units~~
5032 ~~incorporating isolating transformers~~

5033 BS EN IEC 61851/BS EN 61851 series:

5034 BS EN IEC 61851-1:2019 – *Electric vehicle conductive charging system. General*
5035 *requirements*

5036 BS EN 61851-21:2002 – *Electric vehicle conductive charging system. Electric vehicle*
5037 *requirements for conductive connection to an AC/DC supply*

5038 [BS EN IEC 61851-21-2:2021 – Electric vehicle conductive charging system. Electric](#)
5039 [vehicle requirements for conductive connection to an AC/DC supply. EMC](#)
5040 [requirements for off board electric vehicle charging systems](#)

5041 BS EN 61851-22:2002 – *Electric vehicle conductive charging system. AC electric*
5042 *vehicle charging station*

5043 BS EN 61851-23:2014 – *Electric vehicle conductive charging system. DC electric*
5044 *vehicle charging station*

5045 [BS EN 61851-23-1 \(proposed\) – Electric vehicle conductive charging system. Part 23-](#)
5046 [1. DC electric vehicle charging station with an automated connection device](#)

5047 BS EN 61851-24:2014 – *Electric vehicle conductive charging system. Digital*
5048 *communication between a d.c. EV charging station and an electric vehicle for control*
5049 *of d.c. charging*

5050 [BS EN IEC 61851-25:2021 – Electric vehicle conductive charging system. DC EV](#)
5051 [supply equipment where protection relies on electrical separation](#)

5052 [BS EN 61936-1:2021 – Power installations exceeding 1 kV AC and 1,5 kV DC. Part 1 – AC](#)

5053 BS EN 61968-9:2014 – *Application integration at electric utilities. System interfaces for*
5054 *distribution management. Interfaces for meter reading and control*

5055 BS EN [IEC](#) 61980-series:

5056 BS [EN](#) IEC 61980-1:[2021](#) ~~(proposed)~~ – *Electric vehicle wireless power transfer (WPT)*
5057 *systems. Part 1. General requirements*

5058 [BS EN IEC 61980-2 \(proposed\) – Electric vehicle wireless power transfer \(WPT\)](#)
5059 [systems. Part 2. Specific requirements for communication between electric road](#)
5060 [vehicle \(EV\) and infrastructure](#)

5061 [BS EN IEC 61980-3 \(proposed\) – Electric vehicle wireless power transfer \(WPT\)](#)
5062 [systems. Part 3. Specific requirements for the magnetic field wireless power transfer](#)
5063 [systems](#)

5064 PD IEC ~~TS~~ 61980-2:[2020](#)~~2019~~ – *Electric vehicle wireless power transfer (WPT)*
5065 *systems. Specific requirements for communication between electric road vehicle (EV)*
5066 *and infrastructure*

5067 PD IEC ~~TS~~ 61980-3:[2019](#)–[2020](#) – *Electric vehicle wireless power transfer (WPT)*
5068 *systems. Specific requirements for the magnetic field wireless power transfer systems*

5069 BS EN 62056 series *Electricity metering data exchange*

5070 BS EN 62196 series:

5071 BS EN 62196-1:2014 – *Plugs, socket-outlets, vehicle connectors and vehicle inlets.*
5072 *Conductive charging of electric vehicles. General requirements*

5073 BS EN 62196-2:2017 – *Plugs, socket-outlets, vehicle couplers and vehicle inlets.*
5074 *Conductive charging of electric vehicles. Dimensional compatibility and*
5075 *interchangeability requirements for ~~a.c.~~AC pin and contact-tube accessories*

5076 BS EN 62196-3:2014 – *Plugs, socket-outlets and vehicle couplers. Conductive*
5077 *charging of electric vehicles. Dimensional compatibility and interchangeability*
5078 *requirements for d.c. and a.c./d.c. pin and tube-type contact vehicle couplers*

5079 [BS EN IEC 62196-6:2022 – Plugs, socket-outlets, vehicle connectors and vehicle](#)
5080 [inlets. Conductive charging of electric vehicles. Dimensional compatibility](#)
5081 [requirements for DC pin and contact-tube vehicle couplers intended to be used for DC](#)
5082 [EV supply equipment where protection relies on electrical separation](#)

5083 [PD IEC TS 62196-3-1:2020 – Plugs, socket-outlets, vehicle connectors and vehicle](#)
5084 [inlets. Conductive charging of electric vehicles. Vehicle connector, vehicle inlet and](#)
5085 [cable assembly for DC charging intended to be used with a thermal management](#)
5086 [system](#)

5087 BS EN 62262:2002+[A1:2021](#) – *Degrees of protection provided by enclosures for electrical*
5088 *equipment against external mechanical impacts (IK code)*

5089 BS EN 62305 series – *Protection against lightning*

BS EN 62311:2008-2020 – Assessment of electronic and electrical equipment related to human exposure restrictions for electromagnetic fields (0 Hz - 300 GHz)

BS EN 62423:2012+A12:2022 – Type F and type B residual current operated circuit-breakers with and without integral overcurrent protection for household and similar uses

BS EN 62752:2016+A1:2020 – In-cable control and protection device for mode 2 charging of electric road vehicles (IC-CPD)

BS HD 60364-8-2:2011+A11:2019 – Low voltage electrical installations. Prosumer's low voltage electrical installations.

BS IEC 62955:2018 – Residual direct current detecting device (RDC-DD) to be used for mode 3 charging of electric vehicles

BS ISO/IEC/IEEE 8802-3:2017 – Information technology. Telecommunications and information exchange between systems. Local and metropolitan area networks. Specific requirements. Standard for Ethernet

[ETSI EN 303 645 v2.1.1 \(2020-06\) Cyber Security for Consumer Internet of Things: Baseline Requirements](#)

IEC TS 60479-5:2007 Ed 1 – Effects of current on human beings and livestock - Part 5: Touch voltage threshold values for physiological effects

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