Excellence in Electrotechnical & Engineering Services

GUIDANCE Note

Electric Vehicle Charging

1.0 Introduction

Amendment 1 to BS 7671:2018 has made significant changes to Section 722 regarding installations of electric vehicle charging equipment (EVCE). These changes allow additional methods of connection of EVCE particularly with regard to charging points installed at a dwelling, outside a building or on a TN-C-S earthing system (PME).

This guidance note details the considerations an electrical designer and installer need to take into account, when planning the installation of an Electric Vehicle Charge Point (EVCP) as well as generic information regarding Electric Vehicles.

Key information

- New method of installation of EVCE now permitted within BS:7671:2018 Amendment 1

2.0 Electric vehicles

EVs are gaining an increasing market share of new vehicle sales month on month as barriers to adoption are being addressed, such as cost, range, availability of Electric Vehicle Charge Points (EVCP) and performance. It is without doubt that this new form of transport presents significant new workstreams to the electrical industry. This move has been pushed with the UK Government's intent to ban petrol and diesel car sales by 2040 (if not before) and also their Net Zero Carbon 2050 commitment.

3.0 Initial Considerations – Vehicle Owner

Despite their falling prices, any electric vehicle will continue to be a significant financial investment for its owner, with many considerations needed before a purchase is finalised. Many of these will be related to the ability to charge the vehicle, and it is for this reason, sometimes the electrical implications ideally need considering at an early stage of the decision-making process.

Typical charging related factors that a potential owner will need to consider may include:

- Type of journeys the intended vehicle will need to make – particularly journey distance
- The true 'real world' mileage range of the vehicle's battery between charges
- The ability to charge the vehicle at suitable locations in relation journeys undertaken
- The speed at which the vehicle's battery can be charged
- The maximum electrical demand required of the charging facility to charge the vehicle
- The location of the vehicle whilst being charged – within or outside a dwelling or place of work, at a road-side charger provision, etc.

• Favourable electricity supply tariffs that may be available at charge locations, including time-of-use (ToU) tariffs which are now offered by an increasing number of suppliers.

It is for these reasons, that if possible, the parties with the responsibility for providing the charging facility should be involved right from the outset, although in practice this might not always be the case. It may however, be seen as a significant marketing tool for future work and business development if electrical contractors can make their knowledge and expertise in this specialist area widely known.

There are of course the usual other areas associated with any vehicle that would need careful consideration by the owner before committing to a purchase, including but not limited to:

• Initial cost and financing arrangements – particularly as EV purchase may be eligible to many, continually changing, cost incentives. (Note: due to high residual values, EVs make compelling lease-hire propositions)

• Warrantee – particularly any specific terms and conditions regarding servicing, mileage limits and time limits. *How these terms and conditions relate to the battery will also need careful attention*

• Type of usage vehicle is to be needed for – particularly regards size, passenger capacity, etc.

• Running costs – *particularly regards battery charging costs at different locations*

• Depreciation

• Servicing requirements

• Insurance costs

4.0 Initial Considerations – Vehicle Charging Installation

The sheer amount of energy that a relatively small volume of either petrol or diesel fuel can provide, is so often under-estimated – and it is only when considering this and assessing how similar amounts of energy can be sourced from an electricity supply and stored, that issues become evident.

In essence, charging an EV will usually demand a significant electrical load, often for a considerable time – a factor often overlooked by many, particularly when many EVs are provided with a charging lead terminating at an innocent-looking domestic type 13 A plug!

Note: ECA urge members to advise clients that these chargers are only ever used as a last resort and not for main-stream, regular charging.

As with any new electrical work, alteration or addition, BS 7671 in its sections 132 and 133 sets out fundamental requirements, all of which need to be considered and verified before the work proceeds.

These will include:

• Supply characteristics – voltage, frequency, number of phases, max demand

• Adequacy of existing supply to supply the load

• Adequacy of any existing switchgear and cabling to supply the load and provide safety

• Adequacy of existing earthing and bonding arrangements to ensure safety

• Adequacy of existing supply intake equipment such as Distribution Network Operator's (DNO's) cut out, metering, meter tails, etc.

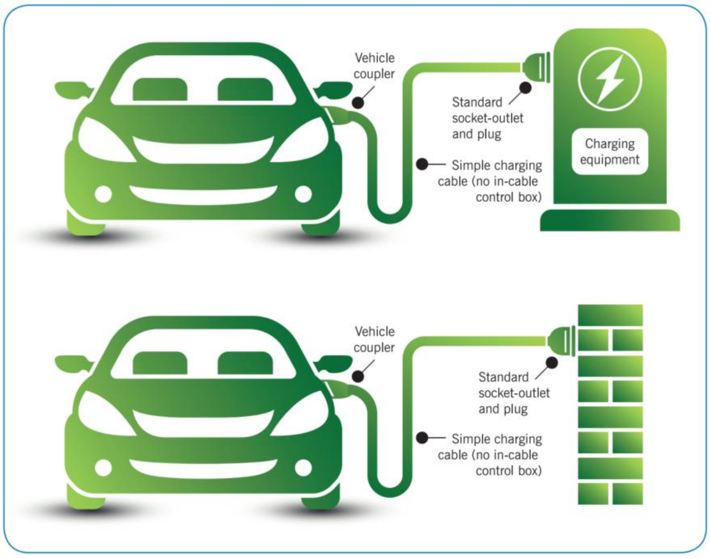
It is for these reasons that ideally the exact details of the proposed EV and its charging requirements are established before any design and installation of the charging provision commence.

Conversely, it may be in some instances, that the characteristics of the available supply at a

charging location being considered may influence the choice of EV.
Either way, the owner of the proposed vehicle and the party responsible for the provision of the charging solution at the address concerned need to talk at an early stage!

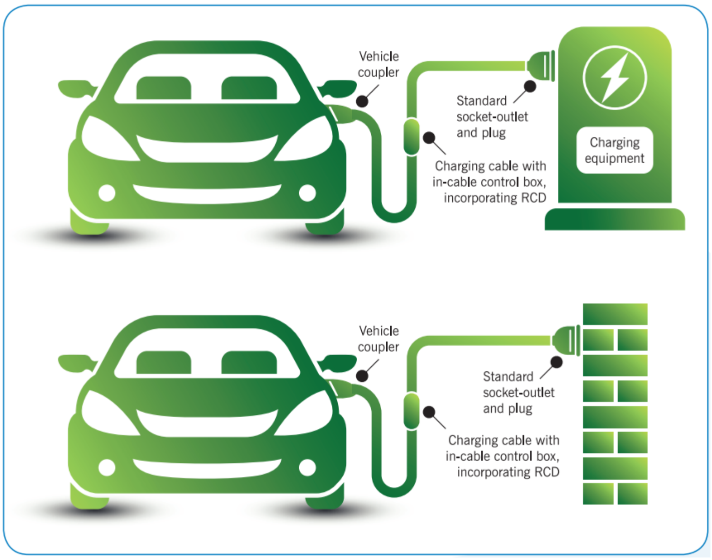
5.0 EV Charging Modes

In its simplest form, one method of charging an EV may be via a common 13 A socket outlet. At the other extreme the vehicle charge may be via a high capacity bespoke charging unit, generating its own DC charge current, and incorporating intelligent controls and monitoring. At the time of writing, there are four commonly adopted charging methods, referred to as charging 'modes'.



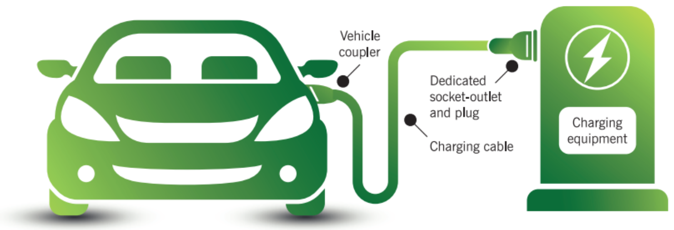
5.1 Mode 1 Charging

This system is the simplest and uses
standard socket outlets not exceeding 16 A (single or three phase) and uses the power and protective earth conductors between the AC supply and the vehicle. This system is no longer considered a 'mainstream charging technology', however.

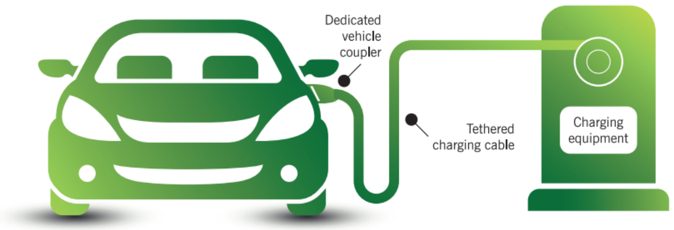


5.2 Mode 2 Charging

This system is similar to Mode 1 charging, in that it uses an AC connection, providing charging currents of 10 A or less, using power and protective earth conductors between the AC supply and the vehicle, **but in addition with a control pilot function and system of protection against electric shock.** This system is presently considered as the 'entry level' charging solution for single phase domestic applications.



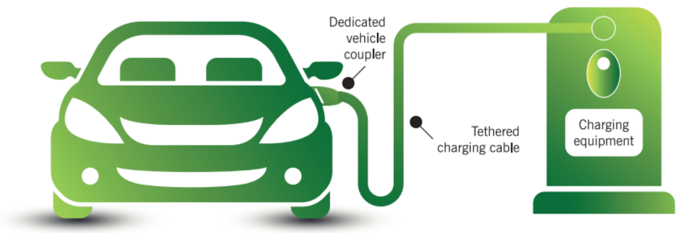
Mode 3 charging using a dedicated socket outlet



Mode 3 charging using tethered lead charging

5.3 Mode 3 Charging

This system **uses a dedicated charger unit** or to give it its proper term 'electric vehicle supply equipment' (EVSE), with control and monitoring as well as an AC charge supply to the vehicle being provided. Such units often have charge leads tethered to the EVSE or special BS 62196-2 'type 2' plugs. The EVSE, often being of larger charging capacity, may require a 3 phase supply.



5.4 Mode 4 Charging

This system is similar to Mode 3 charging above, with **the difference that the EVSE provides a DC charge current to the vehicle,** via a tethered cable. Such EVSEs are usually considerably more complex and expensive and are thus bigger and usually floor mounted. They can, however, offer more rapid charging and are thus more likely to be found in specific car charging provisions at **service stations, public car parks** and the like.

As can be seen from the preceding paragraphs, it will be beneficial to ascertain from the vehicle owner exactly what Charging Mode will be required for the vehicle in question, as well as the charger supply capacity and electrical supply requirements, before a design solution can be considered.

6.0 Design Considerations

6.1 Electrical Fundamentals

Only once the vehicle and it associated charger requirements are confirmed can detailed design commence for the associated electricity supply.

It is assumed at this stage also that the 'fundamental' requirements of BS 7671, covered in section 4 of this guide have also been thoroughly checked and found adequate, i.e.

- Supply characteristics required by charge facility are available at the proposed location
- Existing supply and DNO equipment – including earthing and bonding are all adequate
- Existing switchgear (and any existing circuit wiring) are all adequate

6.2 Additional Electrical Considerations

6.2.1 Liaison with Local Distribution Network Operator (DNO)

There are two options for DNO notification of the installation of EVCE.
Where the **maximum demand** (load) including the new EV charging equipment of a property, is:

a) less than or equal to 13.8 kVA, the DNO must be notified within 28 days of the installation. (addresses can be found for the relevant DNO here: http://www.energynetworks.org/electricity/futures/electric-vehicle-and-heat-pumps.html)
b) greater than 13.8 kVA or where an issue is identified with the adequacy of supply or safety of the existing service equipment, the DNO must be contacted prior to installation to establish the supply capacity.

6.2.2 Metering of Supply

Depending on the source of supply, metering of the charger may be required or desired.
If a charger is being fed directly from a public supply, it will be necessary for the client to contact the local DNO and an energy supplier to set this up.
If the charger is being located perhaps in a communal car park, it may be necessary to connect to a local landlord's supply. Again suitable permissions will need to be granted and metering discussed.
Even if the charger is being connected to a private supply, such as an office or dwelling, metering although not essential may be required for energy monitoring requirements by the client, or if nothing else to see how much running the vehicle is actually costing.

6.2.3 Location of Charger Point in Relation to Parking Space

Often overlooked, this would concern the length of any charge lead (tethered or not) and the ability to reach the connection on the vehicle – taking into account the usual parking position and vehicle connection arrangements. Trip hazards associated with trailing leads will need to be considered.

6.2.4 Physical Protection of the Charging Equipment

The charging equipment will need to be located where it is protected from the likelihood of physical impact from vehicles as well as weather, any unauthorised use, tampering or vandalism.
This may involve additional measures such as bollards, guard rails as well as physically robust, corrosion resistant and lockable enclosures – depending on the local environment.
It should be noted that BS 7671 in its regulation 722.55.101.5 requires the lowest part of any socket outlet associated with vehicle charging to be located between 0.5 m and 1.5 m from the ground. Additionally, where applicable, the requirements of Approved Document M of the statutory Building Regulations should also be considered.

6.2.5 Accessibility to the Charger Equipment

Charging equipment and provisions, as with any electrical equipment needs physical space to be installed, worked upon, maintained and replaced safely. Where applicable any specific ventilation requirements will also need to be provided.

6.2.6 Potentially Explosive Atmospheres

Charging equipment and provisions should not be installed where potentially explosive atmospheres may be present, such as petrol vapour or other gases.

If such is to be installed at fuel filling station locations, specialist guidance given by the Association for Petroleum and Explosive Administration (APEA) should be followed.

6.2.7 Socket Outlets and their Labelling

Where a Mode 1 or Mode 2 charging installation is to incorporate a 13 A socket outlet to BS 1363 gauge, such socket-outlets shall comply with BS 1363-2:2016, which are marked 'EV' on their rear. This is a new requirement brought in by BS 7671: 2018, and at the time of writing, very few such sockets are on the UK market.

Socket-outlets made to this product standard, and marked as such, are tested to more onerous duty and loading parameters than their everyday counterparts, despite looking visually similar.

Regulation 722.55.101.0.201.1 also lists other suitable types of socket outlet that may be used, depending on the vehicle and charging equipment in question.

Adjacent to each such socket, to differentiate it from sockets intended for general purpose use, good practice is to fit a warning label stating **'Electric Vehicle Charging Point'**

6.3 Earthing & Bonding

As electric vehicles may be expected to be charged often outside or away from existing buildings, and hence be outside the normal 'equipotential zone' required and created by normal earthing and bonding practice, as might be expected BS 7671:2018 sets stringent additional requirements.

Key regulations to consider in this respect, regardless of earthing systems adopted, include:

411.3.1.1	requires simultaneously accessible exposed conductive parts to be connected to the same earthing system.
542.1.3.3	requires consideration of protective conductive paths between installations fed by separate earthing arrangements and suitable protective steps taken to avoid problems. which covers earthing and bonding generally.
Chapter 54	which covers earthing and bonding generally

6.4 Shock Protection

As common to other special locations covered by BS 7671, certain basic prohibitions exist, regarding shock protection, in the following regulations:

722.312.2.1	Final circuit(s) of a TN supply serving an EV charging point shall not include a combined neutral and protective (PEN) conductor.
722.410.3.5	Protective measures of 'obstacles' and 'placing out of reach' shall not be used.
722.410.3.6	Protective measures of 'non-conducting location' and 'earth-free local equipotential bonding' shall not be used.

6.5 Earthing Systems

6.5.1 TT Systems

These systems are suitable for EV charging supplies, especially if the whole installation is connected to such a system.

If it is considered to use a TT system just for the EV supply however, then the requirements of BS 7671 regulation 411.3.1.1 need careful consideration – regards any simultaneously exposed conductive parts in the vicinity of the associated circuit wiring system(s), charger, and EV itself.

6.5.2 TN-C Systems

By definition, such systems would include a PEN conductor, so thus prohibited by regulation 722.312.2.1.

Additionally, in Great Britain, Regulation 8(4) of the Electricity Safety, Quality & Continuity Regulations prohibit PEN conductors within consumers' installations.

6.5.3 TN-S Systems

If a guaranteed TN-S system can be assured, such as may be the case with a privately owned transformer and TN-S configuration is provided throughout, such a system can be used to charge an electric vehicle either within a building or outside, provided that the existing usual BS 7671 requirements for earthing and bonding are met.

In the case of a public supply network, such as provided by a DNO, it is now viewed by many parties that not many of these systems can now be guaranteed to be true TN-S systems back to the source of supply, due to ongoing network changes, repairs and modifications.

As such, in these instances, it is suggested that such DNO networks are regarded as TN-C-S systems, for the purposes of EV charging.

6.5.4 TN-C-S Systems (PME Supply)

6.5.4.1 The Potential Dangers Associated with TN-C-S Earthing (PME)

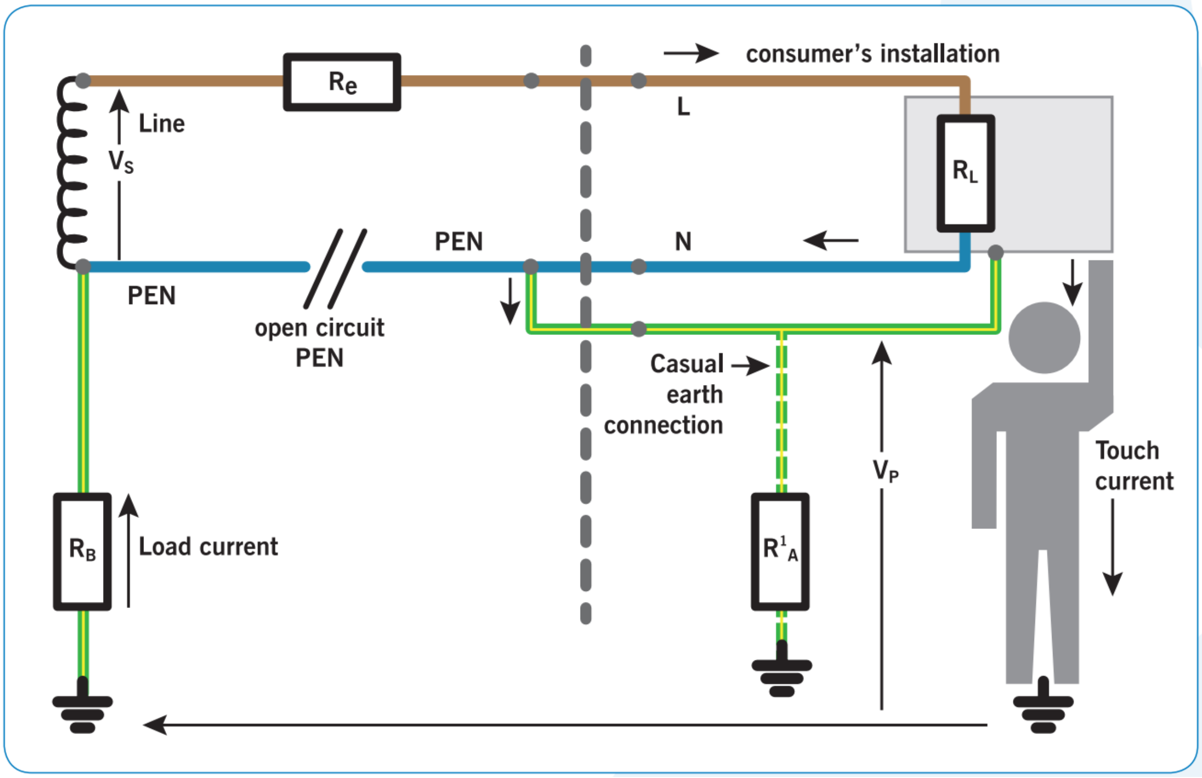
Ordinarily, TN-C-S earthing offers a reliable way in providing installations with an earthing facility, usually by the provision of a consumer's earthing terminal taken from the neutral conductor at the supply intake position.

However, on the rare occurrence of an open circuit fault on the PEN conductor serving the installation, dangerous voltages above true earth potential can appear on all conductive parts of the installation, and other installations, connected to the same source of supply, giving rise to potential shock hazards.

Additionally 'diverted neutral' currents can endeavour to return to the origin of the supply, via protective conductors, which may in some instances give rise to overheating and fire risks.

Conventional circuit protective devices such as fuses, circuit breakers and RCDs cannot protect against these occurrences, and it is for reason that BS 7671 has for many years prohibited use of TN-C-S earthing on many 'special installations' (usually where earthing and bonding may be incomplete, or for installations considered being outside the equipotential zone, created by earthing and bonding).

The diagram below shows the perceived problem:



6.5.4.2 BS 7671:2018 Requirements for EV Charging if using TN-C-S Earthing (PME)

BS 7671:2018 prescribed stringent requirements, if considering PME earthing for an external EV charging installation. As the system is one of the most commonly used in the UK for all LV DNO networks, these changes impacted many installations, leading to many installations requiring adoption of a TT system.

Amendment 1 has made a significant change to regulation 722.411.4.1, (points iv and v) permitting a new technology which wasn't available at the time of the publication of BS 7671:2018, thereby aiding in the installation of EVCPs for TN-C-S earthing systems

Regulation 722.411.4.1

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.*

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.

Option (i) above, relies on the principle, that in balanced three phase systems, the current balance will 'hold the neutral' in place, with respect to reference earth, provided that certain issues such as power factor and harmonics are considered.
Annexe clauses A722.1 and 722.2 give useful equations that may be used in this respect. The equation in A722.1 has been reformatted from previous editions to better reflect taught formulae.
The designer will have to consider these values in detail, especially the likelihood of the load balance being sustained during the usage and life of the installation. Obviously, this option will not be available on single phase supplies - such as often provided in dwellings or smaller commercial installations.

Option (ii) above, relies on the principle of an additional earth electrode – supplementing the TN-C-S earthing facility, and providing sufficiently low earth loop impedance at all material times to limit shock voltages, especially should the main PME pen conductor fail to open circuit..
Annexe clause 722.3 gives a useful equation that may be used in this respect.
The designer will however have to ascertain the maximum demand current of the whole installation if single phase, or the maximum neutral current for the whole installation if three-phase. This in itself, may prove problematic. Once this has been assessed and the equation applied, suitable maximum earth impedance for the supplementary electrode(s) can be arrived at. It will be found however, that this electrode impedance will be very low – typically in the order of 10 ohms or less, which may be impracticable, or often impossible to achieve - even with multiple electrodes.

Option (iii) above relies on a special type of circuit breaker, which monitors the voltage between the installation earth connection and a reference true earth taken at a sampling electrode. Should a dangerous touch voltage occur between these two references, exceeding a specified time, the device trips out –disconnecting the live conductors and the source earth connection – in a predetermined time sequence.
These were commonly known as the 'unicorn device' as they were often sought but never found- i.e. were not available. However, they are now available in the UK, but do still require the installation of an earth electrode to monitor the true voltage differential between the installation earth and true earth (this of course would not need to be sized to 'shunt' any fault current as would be the case with a TT Earth electrode).

Option (iv) is an important change with amendment 1. This now permits the use of a device which provides protection by monitoring the utilisation voltage at the chargepoint and disconnecting all conductors (line, neutral and earth), should the utilisation voltage **at the charging point** go above or below 10% of the nominal voltage (207V -253V). It will be common place for this device to be built into the EVCE but could also be employed in series with the EVCP.

Note: when an installation is deemed single phase, it is important to use a single phase protective device satisfying 722.411.4.1(iv) and where deemed three phase to use a three phase device satisfying 722.411.4.1(iv).
If the situation is ambiguous for any reason, (such as a lack of access), the advice is to speak to the open PEN device manufacturer for clarification on the particular case at

hand. (For example- an industrial unit with a single-phase supply, being taken from a three-phase main supply).

Option (v) this is an important change in that it will prevent another amendment being required, should newer technology come to market that can provide protection to EVCPs that is no less safe than those permitted in BS 7671:2018 amendment 1.

6.6 Other Methods of Compliance

If none the options of regulation 722.411.4.1 can be practically achieved, and where external vehicle charging is required from a TN-C-S sourced electrical installation, the electrical designer may consider the following further three options:

6.6.1 Provide TT Earthing for the Charger Circuit Only

This would follow the solution widely used for taking supplies to remote outbuildings, where the TN-C-S sourced earth from the origin ceases and is isolated at the point of the remote location and the load then earthed at that point directly onto a TT earth electrode.
With this option, it is essential that consideration and risk assessment is made of the likelihood of simultaneous contact between those exposed or extraneous conductive parts connected to the TT system and those connected to the TN-C-S main installation.
The earth electrode will also need to be located at sufficient distance away from any extraneous parts connected to the main installation, or the benefit of the separated earthing system will not be gained. The electrode itself, following BS 7671 guidance under Table 41.5, should have a resistance to earth not exceeding 200 ohms.
Suitable RCD protection on the TT supply will also be needed for shock protection.

6.6.2 Convert Whole Installation to TT System

This option is only likely to be suitable for smaller installations – typically domestic and even then, further unforeseen issues should be given consideration by the designer.
To be effective, the TN-C-S earthing provision must be completely isolated at source and replaced with a suitable earth electrode system. Necessary steps will then be needed to ensure that all existing circuits are adequately protected against earth fault currents, and this may require the fitment of additional RCDs, RCBOs etc. This in turn may pick up dormant faults in existing circuits which will require rectification.
As well as these issues, the subject of RCD selectivity (formerly known as discrimination) will also require full consideration – especially on such installations incorporating distribution circuits and other more elaborate system layouts. Cost will also be a factor – especially on larger installations, or existing installations where dormant faults end up having to be rectified.

6.6.3 Use of an Isolating Transformer

The use of an isolation transformer to serve just the electric vehicle charging equipment will overcome the issues posed by open circuit faults in the PEN conductor of the supply; its basic principle being as shown below:

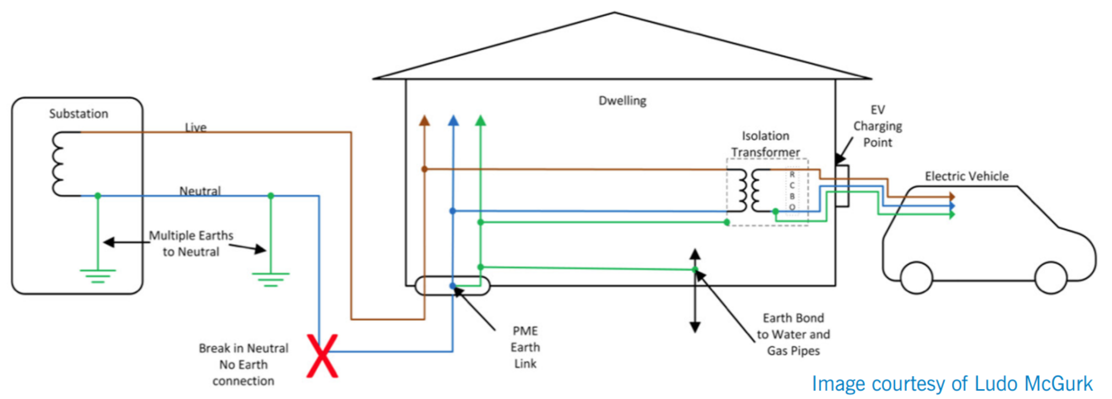


Image courtesy of Ludo McGurk

If considering this option, it is essential that the designer considers the isolation provided between the protective conductor on the output of the transformer, and any possible likelihood of accidental or fortuitous contact between it and extraneous conductive parts connected to the rest of the installation.
In reality this will involve the use of all-insulated wiring accessories and wiring systems on the connection between the transformer and the electric vehicle.
Other considerations for the designer will obviously include the electrical rating of the transformer, physical size of the transformer, any ventilation requirements, possible consideration for its suitability for different vehicles at a later date (loading) and of course - cost.
Again, as with other solutions to the 'TN-C-S problem' it might be that suitable isolation is provided within or part of bespoke charge equipment – particularly for Mode 3 and Mode 4 charging systems. These avenues need thorough checking by the designer before committing to a solution.

7.0 Overcurrent Protection

Regulation 722.533.101 states that: *Each charging point shall be supplied individually by a final circuit protected by an overcurrent protective device* which we detail below. Its important to note that the '*dedicated final circuit´* is be between each EVCP and its origin of supply- which could be within an EVCE which has multiple charging points.

This regulations also specifies the following as acceptable types of overcurrent protective device:

- Low voltage circuit breakers – to BS EN 60947-2 (2017)
- Low voltage control & protective switching devices - to BS EN 60947-6-2 (2003)
- RCBOs to BS EN 61009-1 (2016)
- Circuit breakers for household and similar installations – to BS EN 60898 (2012)
- Low voltage fuses – to BS EN 60269-1 (2014)

Whatever device is selected, it is essential that its rating and operating characteristic are suited to the load connected. Parameters to consider in this respect would include maximum loading and any transient characteristics, such as inrush, at either switch on or switch off.
In all cases, it is essential that the designer consults fully the manufacturer's instructions particular to the charging equipment – as parameters will differ considerably between charge solutions. It is important to re-iterate that EVCE may have multiple charging points and each charging point must be protected accordingly.

8.0 RCD Protection & Usage of Type A, Type B and Type F RCDs

Section 722.531.3 of BS 7671: 2018 covers very specific requirements for RCDs, in its regulation

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.

Regulation 722.531.3.1 stipulates that RCDs shall disconnect all live conductors – which effectively rules out many types of RCBO, which only interrupt one pole.

It is important that the designer recognises and understands the differing types of RCDs, and why they are required for certain applications such as electric vehicles charging. The concept is concerned with how the RCD operates correctly should there be components of direct current or distorted waveforms present on the circuit being thus protected.
More information outlining RCD types is available in separate ECA guidance, as well as from reputable organisations such as BEAMA.
It is vital that RCD types are not confused with the more commonly used similar descriptions associated with circuit breakers or RCBOs, where the ‘type’ referred to in those cases is a completely different concept –that of the operating time/current curve characteristic, and nothing to do with distorted, or non AC waveforms!

8.1 Testing of Type A, Type B and Type F RCDs

Regulation 722.531.2.101 requires each charging point to incorporate its own RCD of residual operating current not exceeding 30 mA. To meet the relevant RCD product standard, such devices should trip within 40 mS when tested at a residual current of (x5) their residual current rating.
It should be borne in mind that Type A, Type B and Type F RCDs sometimes require specific test instrumentation to undertake trip tests correctly, and often older designs of test equipment may not be suitable.
In all cases the party responsible for verification of the electrical installation associated with the electric vehicle charging facility should ensure that the test instrument being used is able to correctly test Type A and particularly Type B RCDs.

(Note: Specific EVCE testing equipment is available which will carry out the fully suite of tests required. If EVCP installation is likely to be a commonly undertaken task within your business, this is a sensible piece of equipment to invest in.)

9.0 Protection Against Transient Overvoltage Considerations

Although not a specific requirement under the revised section 722, BS 7671:2018 has introduced elsewhere revised guidance and considerations to be made regards surge protection and the use of surge protection devices (SPDs).

Regulations in this respect include 443.4 and 443.5, where it can be seen that a risk assessment on the need for such be completed.
This would be a relevant consideration for any designer to undertake together with the client, considering the not insignificant financial investment associated with an electric vehicle and its charging solution.
More information on SPDs types is available in separate ECA guidance, as well as from reputable organisations such as BEAMA.

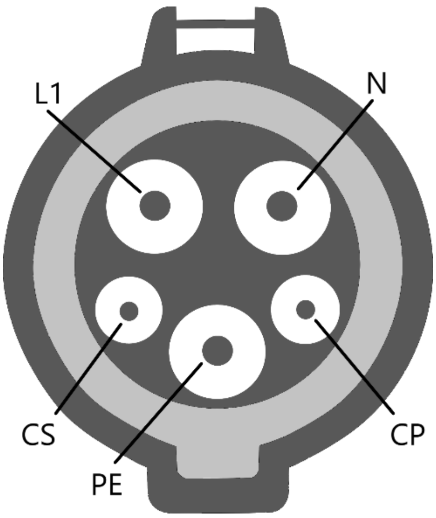
10.0 Protection Against Arc Faults

Although not a specific requirement under the revised section 722, BS 7671:2018 has introduced elsewhere new requirements for the consideration of arc fault protection devices (AFFDs).
The regulations in this respect include 421.1.7 and 532.6, where it can that such devices may be appropriate if the electric vehicle charging process is:
• Within a premises that also contains sleeping accommodation
• In a location where nature of process or stored materials pose a high risk – such as barns
• In a building constructed from combustible materials – such as a timber framed or clad garage
More information on AFDDs is available in separate ECA guidance, as well as from reputable organisations such as BEAMA.

11.0 Electric Vehicle Common Connector Types

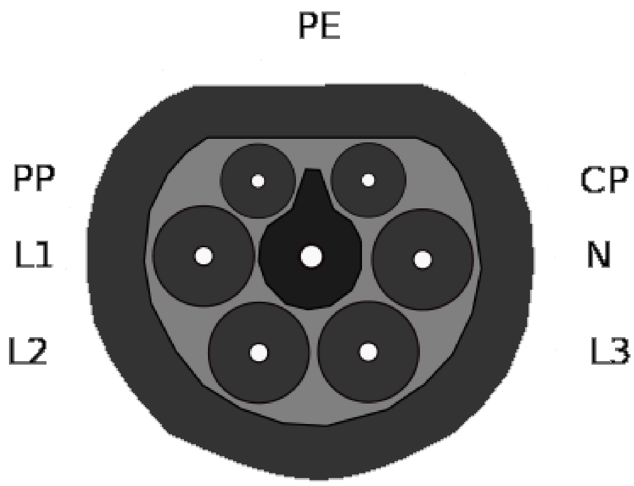
A few variations on connectors for electric vehicles exist.

11.1 AC Connectors



Type 1 connector (SAE J1772)

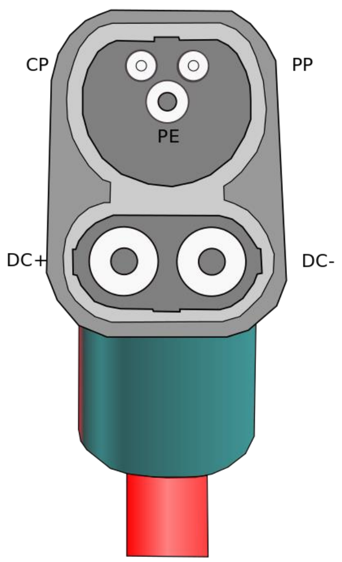
5 pin plug, common in North America, but also found on older versions of the Nissan Leaf and Kia Soul EVs. (also on the current Mitsubishi Outlander). The upper 2 pins are the line conductors (L1 and N), the lower centre pin is the protective Earth, CP is the 'connected fully' pin and CS 'partially connected' pin. The arrangement of these two pins ensures that the EVCE stops delivering power before the plug is fully disconnected. Type 1 EVCPs are uncommon in the UK and vehicles with Type 1 sockets can utilise Type 2 sockets through a common type1- type 2 cable, commonly supplied with the vehicle.

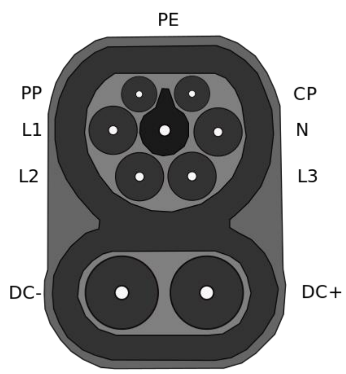


Type 2 Connector

Type 2 connectors are the common standard for EVs throughout Europe. The PP pin tells the EVSE that an EV is plugged in, the CP pin tells the EV what current the EVSE can supply, the central pin provides the protective Earth connection and the four remaining pins around the periphery provide three phase AC and neutral connections.

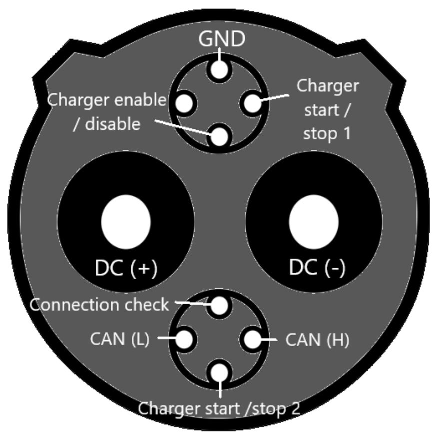
11.2 DC and combined Connectors





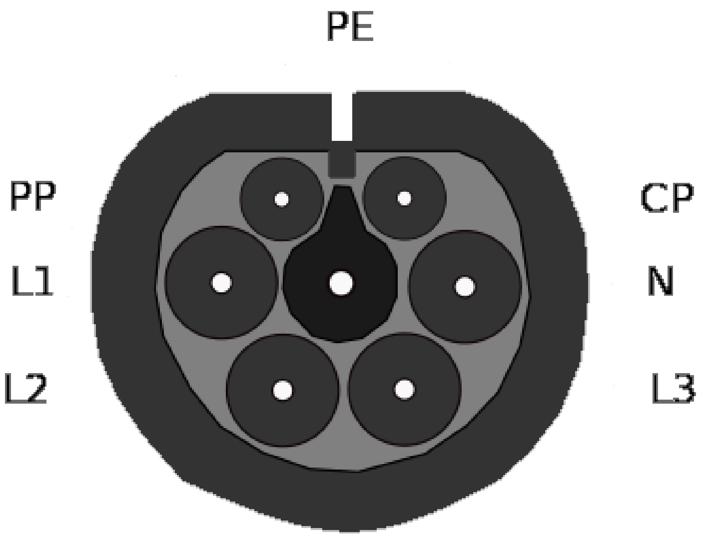
Combined Charging System (CCS) connector

The CCS connector is effectively, the type 2 with the addition of 2 large DC pins in the lower section as shown. During AC charging, the upper section is used. When the Vehicle is using a CCS connector from a Mode 4 DC charger, the lower DC pins, protective earth (PE) and the control / pilot pins are used.



CHAdeMO Connector

The CHAdeMO charging connector provides fast DC charging. It is a system favoured by South East Asian Vehicle manufacturers (Nissan, Mitsubishi et al) and provides advanced communication between the EVCE and the vehicle. CHAdeMO is also currently the only connection type to facilitate V2G capabilities (although TESLA EVs are able to utilise this through the Tesla CHAdeMO adapter)



TESLA

The TESLA connector is a variation of the Type 2 connector, with an additional notch and cut out at the top. During AC charging this operates in the same manner as the Type 2. However, when connected to the TESLA DC Supercharger, the EVCP informs the EV that it is DC connected and DC is delivered via the L1, L2, L3 & N. (Note: this is only for Models ‘S’ and ‘X’ and the new model ‘3’ and ‘Y’ have adopted the CCS system.)

Note: It is common for newer South East Asia vehicles employing the CHAdeMo DC charging system to also have the Type 2 connector for AC charging.

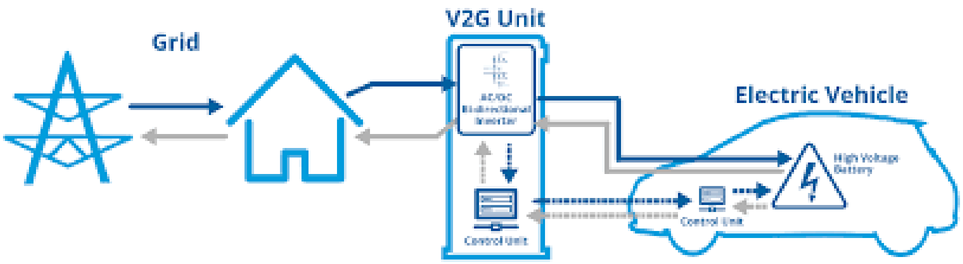
12.0 Vehicle to Grid (V2G) and Vehicle to Building (V2B)

Vehicle to Grid (V2G) is a concept undergoing extensive trials throughout the world. Essentially it is the bi-directional flow of energy to and from the vehicle, with the stored energy within the vehicle made available on demand for utilisation by the electricity grid (V2G) or the building (V2B). This has the potential to assist the energy networks in the following instances:

- Frequency response
- Time shifting of demand
- Increased storage for renewable energy generation
- Reduction of expensive grid upgrades

Trials include offering users of V2G ‘free mileage’, i.e. not charging the user for any kWh used whilst driving (Denmark 2017), to paying them up to double the purchase price of kWh supplied back to the grid (30 ppkWh- Ovo UK).

DC V2g charging is currently dominating the trials, although AC V2G charging is also being conducted.



(Image courtesy of CENEX)

13.0 Further reading

Electric vehicles and their charging solutions, as with any field linked with new technology and Governmental policies, will be ever changing.

At the time of writing, further information, such as grant eligibility, opportunities for installers, energy supply tariffs, etc. on this continually developing technology can be found at:

https://www.gov.uk/government/organisations/office-for-low-emission-vehicles
http://www.energysavingtrust.org.uk/transport-travel/electric-vehicles
https://www.v2g-hub.com/Final-Report-UKPN001-S-01-I-V2G-global-review.pdf
https://shop.theiet.org/code-of-practice-for-electric-vehicle-charging-equipment-installation-4th-edition
https://www.chademo.com/

ECA also provide guidance on the process of navigating OLEV funding through their Workplace Charging Scheme (WPS) and Electric Vehicle Homecharge Scheme (EVHS).

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