



An electric car charges up. [Reproduced with kind permission of future transport systems and Mitsubishi UK Ltd]

Supplies to electric vehicles for charging purposes

A brief overview

By Geoff Cronshaw

This is the second of two articles concerning the basic requirements for the connection of an electric vehicle to the fixed electrical installation.

In this article we take a closer look at the power requirements for charging electric vehicles, the types of electric vehicles, the existing standards relating to equipment for charging electric road vehicles, connections to the vehicles, and the requirements

for the electrical installation supporting the connection of an electric vehicle to the fixed electrical installation.

More and more electric vehicles and hybrid vehicles are on the market or being developed. The charging requirements vary considerably. Some electric vehicles are equipped with an on board charger and require a 230 V 3kW supply for up to 8 hours to ensure proper

charging of the electric vehicle traction battery, while others may require a smaller charge. Others require a three-phase supply. Vehicles may have a dedicated off-board charger designed to be used only with a specific type of electric vehicle, where the charger would provide a dc supply to the vehicle.

BS EN 61851 series

At present BS EN 61851 Electric vehicle conductive charging system series of standards applies to equipment for charging electric road vehicles at standard a.c. supply voltages up to 690 V and at d.c. voltages up to 1000 V, when connected to the supply network.

BS EN 61851-1 2001 recognises a number of options for electric vehicle (EV) charging. One method is to connect the a.c. supply network (mains) to an on-board charger. The alternative method is to use an off-board charger for delivering direct current to the vehicle. In addition, the standard recognises that for charging in a short period of time special charging facilities operating at high power levels could be utilized.

BS EN 61851-1 2001 includes requirements for:

- EV charging modes,
- types of EV connection,
- functions provided in each mode of charging,
- serial data communication,
- protection against electric shock,
- protection against direct contact (basic protection),
- protection against indirect contact (fault protection),
- supplementary measures,
- provision for the traction battery,
- additional requirements,
- connection between the power supply and the EV,
- specific inlet, connector, plug and socket-outlet requirements (on vehicle) and the charging cable.

In addition, Part 1 includes a normative Annex giving the Charging cable assembly requirements and three informative Annexes giving details for a PWM control pilot circuit, control pilot circuit and coding tables for power indicator.

BS EN 61851-21: 2002 appears to supplement Part 1 and includes requirements for: electrical safety (earthing connection and electric vehicle continuity and detection of the electrical continuity of the protective conductor), electrical characteristics of the vehicle, electromagnetic compatibility, functional requirements (includes requirements for cable housing in the electric vehicle), electric vehicle inlet or plug requirements, and marking and instructions.

BS EN 61851-22: 2002 appears to supplement Part 1 and includes requirements for electric vehicle charging stations. However, the standard does not cover box type assemblies with socket-outlets, installed for the purpose of delivering energy to the vehicle, which have no charging control functions.

BS EN 61851-22 2002 includes requirements for functional and constructional requirements for the charging station - such as the minimum degree of IP protection for the charging station, the means of storage for the cable assembly, metering requirements, etc. Also, Electrical safety is covered including protection against indirect contact (fault protection), such as detection of the electrical continuity of the protective conductor. Finally a wide range of testing requirements is included.

Therefore, the requirements for electric vehicle charge points appear to be reasonably well catered for by BS EN 61851 series of standards. This article attempts to clarify the requirements for the electrical installation supporting the connection



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of an electrical vehicle to the fixed electrical installation.

IEE Wiring Regulations (BS 7671:2008)

The IEE Wiring Regulations (BS 7671:2008) is the national standard for electrical installations in the UK up to 1000V a.c. and 1500V d.c.

BS 7671:2008 does not include a specific section giving requirements for the connection of an electric vehicle to the fixed electrical installation.

However, many of the requirements (such as: circuit design, RCD protection, measures of protection against electric shock, IP rating of equipment, impact protection against mechanical damage, isolation and switching, etc.) for the electrical installation associated with the power supply for the charging of an electric vehicle are covered in the general rules of BS 7671:2008; examples of the general rules are given below. It is important to point out that systems for the distribution

of electricity to the public are outside the scope of BS 7671, therefore, these requirements apply to private supplies such as those from dwellings and private commercial and industrial establishments, when charging the vehicle at home and at work.

Circuit design

A circuit intended to supply an electric vehicle must fit for purpose and suitable for the load. It should be correctly designed in accordance with BS 7671:2008. Chapter 43 deals with protection

against overcurrent and also thermal constraints, Chapter 41 deals with protection against electric shock and gives the disconnection times that must be met whilst Section 525 deals with voltage drop. Appendix 4 gives current carrying capacity and voltage drop for cables. All these areas need to be taken into account when determining the cable size for a particular circuit.

RCD protection

Regulation 411.3.3 requires



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that an RCD be used as additional protection for socket-outlets with a rated current not exceeding 20A which are for use by ordinary persons and are intended for general use. Regulation 415.1 requires that an RCD be used as additional protection for mobile equipment with a rated current not exceeding 32A for use outdoors. As indicated in the Regulations, the RCD has then to have a rated residual operating current not exceeding 30 mA and an operating time not exceeding 40 ms at a residual current of $5 I_{\Delta n}$. This requirement is met by general type devices complying with BS EN 61008 or BS EN 61009 (or BS 4293).

Protection against electric shock

There are four protective measures generally permitted by BS 7671:2008, given in Regulation 410.3.3: (i) Automatic disconnection of supply (Section 411) (ii) Double or reinforced insulation (Section 412) (iii) Electrical separation for the supply to one item of current-using equipment (Section 413) (iv) Extra-low voltage (SELV and PELV) (Section 414).

A note at the end of this Regulation acknowledges that, in electrical installations, the most commonly used protective measure is automatic disconnection of supply.

IP rating of equipment (External influences, presence of water (AD) or high humidity) (AB)

Regulation 522.3 requires that any wiring system or equipment selected and installed must be suitable for its location and able to operate satisfactorily without deterioration during its working life. The presence of water can occur in several ways, e.g. rain, splashing, steam/humidity, condensation and at each location where it is expected to be present its effects must be considered. Suitable protec-

tion must be provided, both during construction and for the completed installation. The IP classification code, BS EN 60529:2004, describes a system for classifying the degrees of protection by the enclosures of electrical equipment.

Impact protection against mechanical damage

Regulation 512.2 requires equipment to be of a design appropriate to the situation in which it is to be used. The effect of environmental conditions and general characteristics around an installation should always be assessed to enable suitable electrical equipment to be specified. All electrical equipment selected must be suitable for its location, use and method of installation. The IK classification standard BS EN 62262 describes a system for classifying the degrees of protection provided by enclosures for electrical equipment against external mechanical impacts. The letters IK are followed by two numerals which identify a specific impact energy.

Isolation and switching.

Chapter 53 recognises four distinct types of isolation and switching operation: (i) isolation (ii) switching off for mechanical maintenance (iii) emergency switching (iv) functional switching.

Some key regulations which must be considered include:

537.2.1.1 Every circuit shall be capable of being isolated from each of the live supply conductors. In a TN-S or TN-C-S system, it is not necessary to isolate or switch the neutral conductor where it is regarded as being reliably connected to Earth by a suitably low impedance.

Provision may be made for isolation of a group of circuits by a common means, if the service conditions allow this. 537.3.1.1 Means of switching off for mechanical maintenance shall be provided where



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mechanical maintenance may involve risk of physical injury.

537.3.1.2 Suitable means shall be provided to prevent electrically powered equipment from becoming unintentionally reactivated during mechanical maintenance, unless the means of switching off is continuously under the control of any person performing such maintenance.

537.3.2.3 A device for switching off for mechanical maintenance shall be designed and/or installed so as to prevent inadvertent or unintentional switching on.

537.3.2.4 A device for switching off for mechanical maintenance shall be so placed and durably marked so as to be readily identifiable and convenient for the intended use.

537.4.1.1 Means shall be provided for emergency switching of any part of an installation where it may be necessary to control the supply to remove an unexpected danger.

Socket-outlets

Socket outlets must be fit for purpose. They must be suitable for the load, and for the external influences such as protection against mechanical damage

and ingress of water. Section 553 deals with accessories such as plugs and socket outlets. However, Annex D of BS EN 61851-1 2001 (charging electric vehicles) recommends an industrial type socket-outlet to IEC 60309-2 which is a similar requirement to caravan sites in BS 7671 and would be suitable for non domestic installations in the UK. This is because Regulation 553.1.4 requires shuttered type socket outlets for household and similar.

ESQCR - Electricity Safety, Quality and Continuity Regulations 2002 (as amended).

Precautions to prevent the electric vehicle supplying the fixed installation.

There are mandatory requirements concerning the parallel connection of generators with the supply network, and the permission of the distributor must be obtained before a connection is made. Persons involved in this work are recommended to consult The Electricity Safety, Quality and Continuity Regulations 2002 (as amended). Section 551 of BS 7671:2008 gives requirements for the installation of generators.

It may be worth consulting the engineering recommendations

of the ENA. G83/1 published by the Energy Networks Association gives recommendations for the connection of small-scale embedded generators (Up to 16A per phase) in parallel with public low-voltage distribution networks. For larger generating plant Engineering Recommendations G59/1 also published by the Energy Networks Association gives recommendations for the connection of embedded generating plant to the public electricity supplier's distribution systems.

Protective multiple earthing.

The Electricity Safety, Quality and Continuity Regulations 2002 (as amended) permit the distributor to combine neutral and protective functions in a single conductor provided that, in addition to the neutral to Earth connection at the supply transformer, there are one or more other connections with Earth.

The supply neutral may then be used to connect circuit protective conductors of the customer's installation with Earth if the customer's installation meets the requirements of BS 7671. This protective multiple earthing (PME) has been almost universally adopted by distributors in the UK as an effective and reliable method of providing their customers with an earth connection. Such a supply system is described in BS 7671 as TN-C-S.

Whilst a protective multiple earthing terminal provides an effective and reliable facility for the majority of installations, under certain supply system fault conditions (external to the installation) a potential can develop between the conductive parts connected to the PME earth terminal and the general mass of Earth. The potential difference between true Earth and the PME earth terminal is of importance when:

i.) body contact resistance is low (little clothing, damp/wet

conditions), and/or ii.) there is relatively good contact with true Earth.

Contact with Earth is always possible outside a building and, if exposed-conductive parts and/or extraneous-conductive-parts connected to the PME earth terminal are accessible outside the building, people may be subjected to a voltage difference appearing between these parts and Earth.

For this reason Regulation 9(4) of the The Electricity Safety, Quality and Continuity Regulations 2002 (as amended). does not allow a combined neutral and protective conductor to be connected to any metalwork in a caravan or boat.

It is not clear at this stage the effect of the Electricity Safety, Quality and Continuity Regulations on supplies to electric vehicles; however, it seems reasonable to assume the same requirements would apply to a vehicle as a caravan. If this was the case one option would be to convert the PME system to a TT system at the charge point for the vehicle. Persons involved in this work are advised to seek advice from HSE.

Conclusion

This article gives a brief overview of the requirements of BS 7671:2008 for the electrical installation supporting the connection of an electrical vehicle to the fixed electrical installation.

For further information refer to:

- BS 7671:2008, Requirements for electrical installations
- Engineering Recommendations G83/1 and G59/1 published by the Energy Networks Association
- The Electricity Safety, Quality and Continuity Regulations 2002 (as amended). published by the Department of Energy and Climate Change.
- BS EN 61851 series

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