Earthing and equipotential bonding measures for the charging infrastructure of electric mobility

White Paper

Contents

Requirements for charging infrastructure

Public charging post with grid connection

Charging infrastructure in private and semi-public areas

Step and touch voltage

Requirements for equipotential bonding of metal structural components

Selection of materials

Documentation

Earthing and equipotential bonding measures for the charging infrastructure of electric mobility

White Paper

Safe operation of the overall electrotechnical system, and thus also the charging infrastructure of electric mobility, can only be ensured with a correctly installed earthing system and the integration of all necessary components in the earthing system. Lightning currents, fault currents and potential operating currents are discharged and spread over a large area through earthing measures. This ensures the safety of people, system reliability, operational safety, and the orderly functioning of the equipment.

Whether or not an earthing system is to be implemented and how is described based on the relevance of the topic in many different places:

- **IEC 60364-4-41:** Contains essential requirements for protection against electric shock, including basic protection and fault protection for people and livestock. It deals with the application and coordination of these requirements in relation to external influences.
- **IEC 60364-5-54:** This part of the IEC 60364 standard series applies to earthing systems and protective conductors, including protective bonding conductors. The objective is to make electrical systems safe. If an external lightning protection system is in place, IEC 62305-3 also applies to earthing systems.
- **VDE-AR-N 4100:** This VDE application rule that applies in Germany outlines the technical requirements that must be taken into account during the planning, set-up, connection and operation of customer systems on the low-voltage system of the grid operator. At which point in a TNC system PEN is split into N and PE is also described. It is to be used for systems which are being newly connected to the low-voltage system, as well as in the case of expansions or changes to existing systems.

The VDE-AR-N 4100 application rule also refers to the German DIN 18014

- **DIN 18014:** This standard applies in Germany to the planning and implementation of foundation earth electrodes. Foundation earth electrodes / ring earth electrodes as per this standard are used for the following measures, amongst others:
  - As a system earth electrode for connection with the protective equipotential bonding via the main earthing busbar IEC 60364-5-54;
  - For functional equipotential bonding and for functional earthing;
  - For potential control in buildings as per IEC 60364-4-44;
  - For the earthing of lightning protection systems and surge protective devices.

  The requirements for the implementation of the ring earth electrodes can also be applied to subsequent installations on existing buildings.

For strip steel, minimum dimensions of 30 mm x 3.5 mm and for round steel a minimum diameter of 10 mm is defined. Round steel and strip steel in the soil (ring earth electrodes) must be permanently corrosion-resistant; e.g. stainless steel with a composition: chrome > 16 %, nickel > 5 %, molybdenum > 2 %, carbon < 0.08 %; for example, material number 1.4571 or 1.4404. Due to the requirement, hot-dip galvanised material is not permitted!

If a lightning protection system is installed or if lightning discharge is anticipated based on a risk analysis, for example, then additional normative requirements apply:

- **IEC 62305-3:** This part of IEC 62305 contains requirements for the protection of a structure against physical damage with the aid of a lightning protection system (LPS) and for protection against injuries to living beings due to touch and step voltages near to lightning protection systems. This standard applies to:
  a) The planning, set-up, inspection and maintenance of lightning protection systems for structures without limits in terms of their height;
  b) Taking protective measures to prevent the injury of living beings due to touch and step voltages.

  These additional requirements for a lightning protection system are not addressed in this white paper.

Requirements for charging infrastructure

As a rule, the safety of people must always be ensured with respect to electrical hazards, irrespective of the topic of lightning and surge protection; i.e. in a TT system, for example, the relevant earth resistances are ensured so that the RCD / GFCI is always working.

Public charging posts with grid connection

If charging posts are installed with a grid connection in a public area, in Germany they fall under the scope of VDE-AR-N-4100, irrespective of which type of lightning and surge protection is installed. At the same time, this refers to DIN 18014. Based on this standard, the earthing system for charging posts irrespective of the system configuration is required in the form of a ring earth electrode; e.g. 10 mm round material or 30 mm x 3.5 mm flat material made of V4A stainless steel or equivalent.
The ring earth electrode must either be set up separately for an individual charging post or designed as an integrated ring earth electrode for a charging park to which the individual EB connections of the charging posts are connected.

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This link can also be implemented with a copper cable with a minimum cross-section of 16 mm² or equivalent, for example.
The ring earth electrode must be routed underneath the frost line. Any clamping points in the soil must be additionally wrapped up with an appropriate anti-corrosion tape (**Figure 1**).
Pursuant to DIN 18014 there are no required resistance values. According to lightning protection standard IEC 62305, a recommended earth resistance of 10 Ω must be aimed for.

Charging infrastructure in private and semi-public areas

If type-1 arresters are installed in charging posts, then, in accordance with IEC 60364-5-54, a separate equipotential bonding connection must always be provided for SPDs, which must be connected to the local earthing system. A connection to a PEN or PE conductor coming from the utility company alone will not suffice.
The local earthing system can be implemented either the same way as the public charging posts or alternatively as described in IEC 62305-3. For example, for class of LPS III, for each charging post, individual, local earth rods with a minimum length of 2.5 m can be installed below the frost line, or radial earth electrodes with a minimum length of 5 m below the frost line. The lengths are to be introduced until the recommended earth resistance of 10 Ω is achieved (**Figure 2 and 3**).
In a charging park, the introduction of a fully intermeshed, low-impedance earthing system is recommended. All components of the charging infrastructure – such as distribution cabinets or charging posts – must be connected in order to achieve the best-possible equipotential bonding.
Alternatively, the charging park can also be connected to an existing earthing system. This must be performed with interconnecting elements suitable and tested for the purpose. Permanent functioning must be ensured in this regard. If this cannot be proven beyond doubt by means of measurements, then a new earthing system must be set up as described.

Figure 1 Anti-corrosion tape fitted in a form-fitting manner around the clamp connection in the soil

Step and touch voltage

Depending on specific risk assessments, one must evaluate whether danger can be posed to people by step and touch voltages in the event of direct or nearby lightning discharges based on local existing conditions.
For example, this could be the case if a charging park roof is provided with a conventional external lightning protection system. If people are located in direct proximity to a conventional lightning protection system, step and touch voltages may occur.
Based on IEC 62305, the following approaches are possible for preventing this hazard:

- Replace the conventional down-conductor system (uninsulated round material) of the external lightning protection with a high-voltage-resistant, insulated CUI conductor (part. no. 830 208) for the prevention of touch voltages.
- Install potential control in areas where people are located using mesh mats tested with lightning currents to prevent step voltages (**Figure 4**).

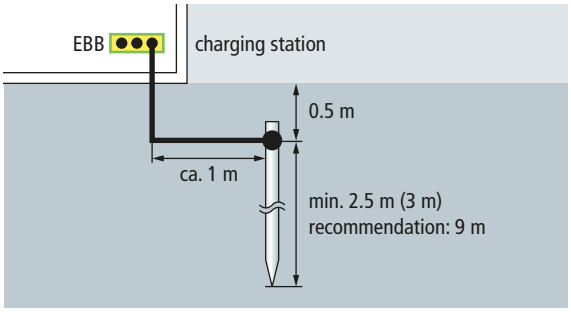

Figure 2 Radial earth electrode, e.g. with earth rod, 20 mm, V4A stainless steel

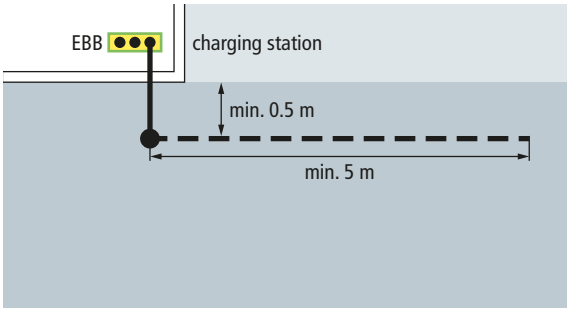

Figure 3 Horizontal earth electrode, e.g. with strip steel, 30 mm x 3.5 mm, V4A stainless steel

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Figure 4 Fully intermeshed earthing system, including potential control where people are located for the prevention of step voltage

Putting up information signs is another measure for the prevention of hazards.

Requirements for equipotential bonding of metal structural components

When using metallic structures for cable routing, all components must be interconnected so as to be capable of carrying lightning currents for the purpose of equipotential bonding.

For the linking of pipe systems, pipe clamps tested with lightning currents (e.g. part no. 540 104) are suitable for example (**Figure 5**).

Selection of materials

It must always be ensured that the earthing system is permanently functional. In order to achieve this and set up an earthing system that is as low maintenance as possible, using permanently corrosion-resistant material is recommended.

Minimum dimensions of 10 mm round material or 30 mm x 3.5 mm strip steel or larger must be chosen for earthing materials.

The minimum dimensions of conductors that connect different equipotential bonding busbars with each other or with the earthing system are 16 mm^2 for copper, 25 mm^2 for aluminium or 50 mm^2 for steel.

- **Ring earth electrode:** According to DIN 18014, round and strip steels must be permanently corrosion-resistant in the soil; e.g. stainless steel with a composition: chrome > 16 %, nickel > 5 %, molybdenum > 2 %, carbon < 0.08 % (for example material number 1.4571 or 1.4404). Due to

Figure 5 Equipotential bonding of metallic structural components by means of pipe clamps tested with lightning currents

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this requirement, hot-dip galvanised material is not permitted.
As an alternative to the round and strip steels mentioned, stranded copper cables (uninsulated or tin-plated) of at least 50 mm² can also be used.

➡ **As a rule:** If direct or nearby lightning loads are anticipated according to the risk assessment, then the connecting clamps must be checked and designated for lightning current carrying capability as per IEC 62561-1.

Documentation

When setting up an earthing system, complete documentation must be produced, including image documentation in accordance with DIN 18014.

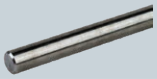
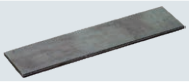
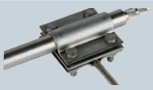
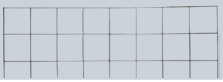
Part	Material	Application	Part no.	
Hammer inserts for vibration hammers	St	For BOSCH / HILTI / Millwaukee for the correct driving-in of earth rods, 20 mm	620 029	
Round wire 10 mm	StSt (V4A)	Ring earth electrode	860 010	
Strip steel 30 x 3.5 mm	StSt (V4A)	Ring earth electrode	860 325	
Earth rod	StSt (V4A)	Rod length 1,500 mm, Diameter 20 mm	620 902	
Impact tip for earth rods	TG/tZn	For easy driving-in	620 001	
Connecting clamp for earth rods, 20 mm	StSt (V4A)	Connection of earth rods to round (10 mm) or flat material (30 x 3.5 mm); e.g. to ring earth electrodes	610 020	
Connecting clamp for earth rods, 20–25 mm	StSt (V4A)	Connection of earth rods to round materials, 8–10 mm, or connection lines (solid or stranded, 4–50 mm²)	540 121	
Anti-corrosion tape	Petrolatum	Protection of connecting components	556 125	
Equipotential bonding bar	Cu/gal Sn	Equipotential bonding	563 200	
Mesh mat	StSt (V4A)	For potential control	618 214	
Connecting clamp for mesh mat	StSt (V4A)	Clamping range Rd / Rd 8–10 / 3–5 mm	540 271	
Pipe clamp	StSt	Equipotential bonding	540 200	
Connection clamp for steel girders	StSt	Equipotential bonding	372 129	
CUI conductor	Cu/PU	Protection from touch voltage	830 208	

Table 1 Example selection chart of earthing and equipotential bonding materials

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Services by DEHN

DEHN offers the following components for a complete lightning protection and earthing concept:

- Risk analyses in accordance with IEC 62305
- Planning the external lightning protection system
- Planning earthing systems for new and existing structures
- Creation of a surge protection concept
- Digitisation of existing systems using laser scanning
- Dimensioning the earthing conductor cross-section to transformer stations
- Simulation of step and touch voltage in transformer stations
- Inspections and project discussions on site

DEHNconcept: *https://www.dehn-international.com/en/dehnconcept-planning-lightning-protection-systems*

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Lightning Protection
Safety Equipment
DEHN protects.

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