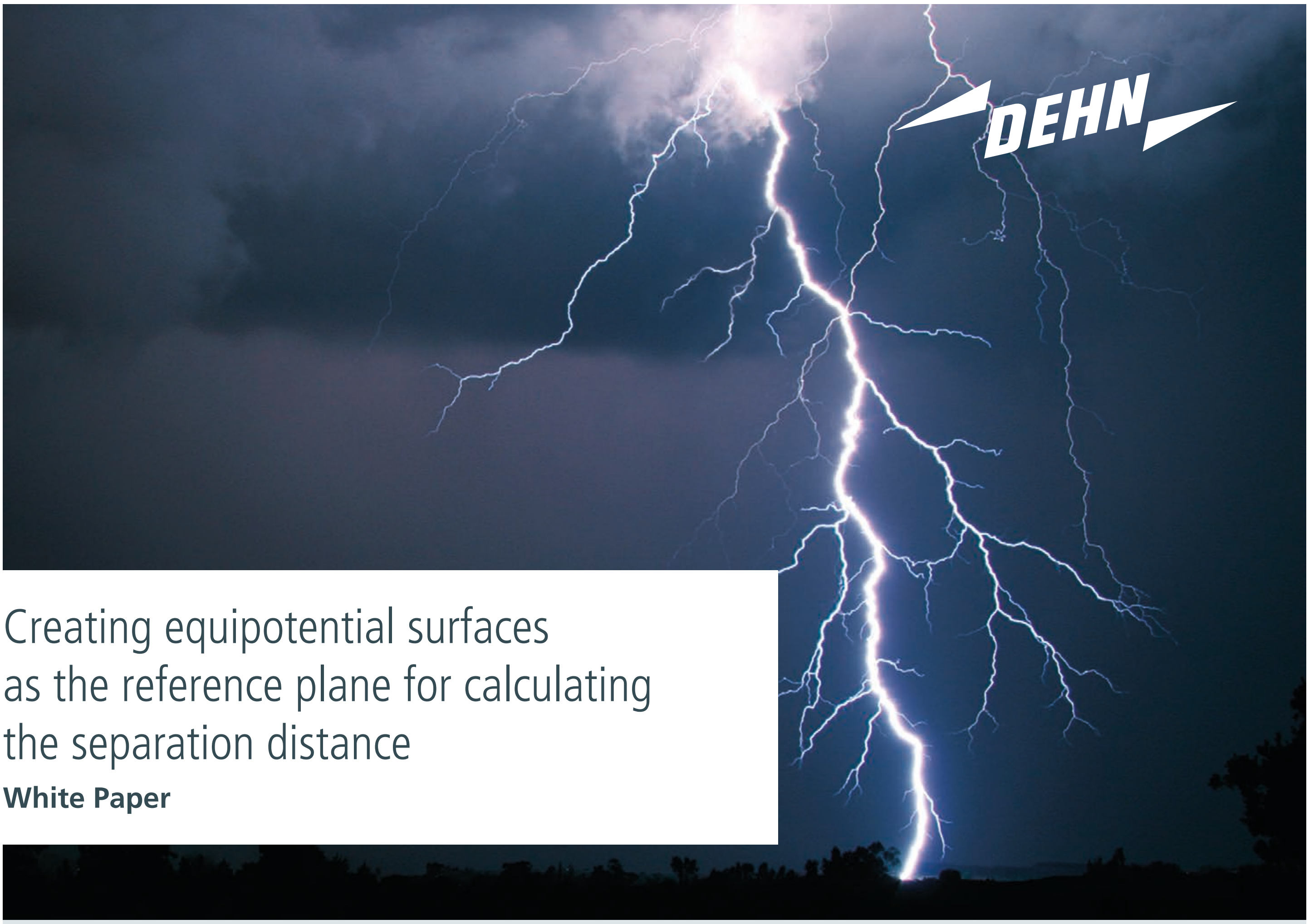
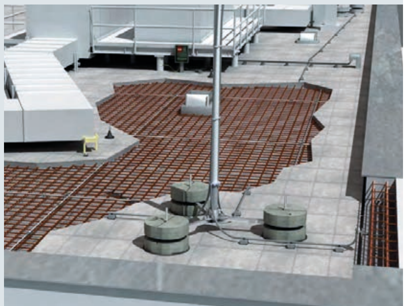


Creating equipotential surfaces as the reference plane for calculating the separation distance

White Paper



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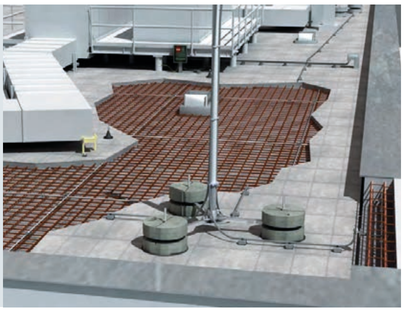


For many decades now, lightning protection systems have been installed as a preventative fire protection measure. The basis for planning and execution is the lightning protection standard IEC 62305 Parts 1-4. Whilst the primary objective is personal protection, the aim is also to prevent uncontrolled flashover as a result of impulse voltage which may damage the structure, installed electrical (wiring) systems or cause a fire.

There is a risk of uncontrolled flashover between parts of the external lightning protection and metal building structures, rooftop installations, and electrical installations inside the building. This is the case if there is insufficient space between the air-termination system/down conductor and metal/electrical installations inside the structure to be protected. This is generally referred to as the required separation distance. The formula is:

$$s = k_i \frac{k_c}{k_m} \cdot l \ \ [m]$$

where

- k_i depends on the class of LPS selected (induction factor),
- k_c depends on the geometric arrangement (partitioning coefficient),
- k_m depends on the material used at the point of proximity (material factor) and
- l [m] is the length along the air-termination system or down conductor from the point where the separation distance is to be determined to the next equipotential bonding or (e.g. equipotential surface) or earthing point.

In the case of buildings with foundation earth electrodes or combined earth-termination systems, these, in combination with consistently implemented lightning equipotential bonding, form a so-called equipotential surface at ground level. By creating additional equipotential surfaces in further parts of the building, the real length l of the air-termination system (required to calculate the separation distance in the above calculation) can be reduced.

Utilising the natural building substance as part of the lightning protection system (**Figure 1**) makes economic sense. If one wishes to create an equipotential surface as a reference plane in a high building, certain prerequisites must be given on the building site.

One of these is the calculation of the separation distance on the relevant reference plane (see definition of length l). As a rule, this is the earth-termination system or the closest equipotential bonding point. The conductor loop of installations within the building to air-termination systems outside the buildings and structures is considered in detail here (**Figure 2**).

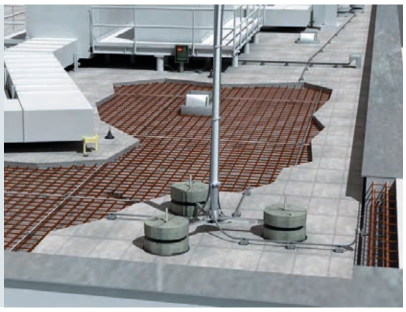
The note in IEC 62305-3 that no separation distance is necessary in structures with metallic or electrically interconnected reinforcement steel applies exclusively to those buildings which have complete shielding in line with IEC 62305-4.

If one uses steel or reinforced concrete supports as natural conductors (**Figure 1**), separation distances must be considered. The background being that such conductors have a large cross-section in comparison to a wire D = 8 mm which reduces the magnetic field and the induced voltage in installed conductor loops but does not entirely prevent it. Different cross-sections are not considered in the standards.

A reinforced concrete ceiling or a metal roof can, in combination with steel girders and reinforced steel supports, form a reference plane or also an equipotential surface for calculating the separation distance. Metal conduits or electrical cables which penetrate the equipotential surface must be connected to the same either directly or indirectly by way of surge protective devices.

An equipotential surface can be created at different levels (e.g. on different floors) of a structure. For this purpose, meshes measuring 5 x 5 m

Figure 1 Reinforced steel supports as natural down conductors



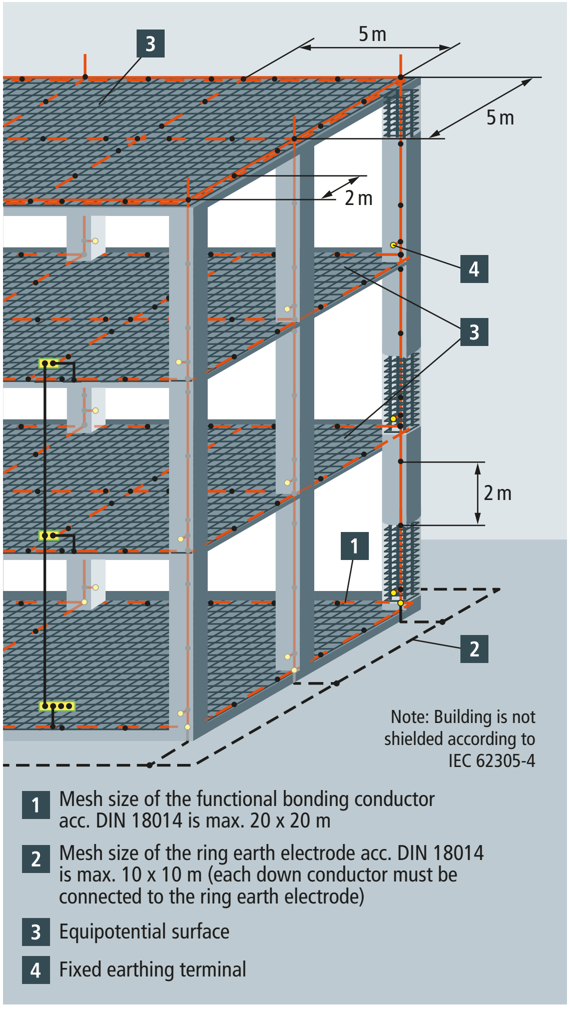


Figure 2 Building with equipotential surfaces and air-termination system (optional e.g. for curtain wall)

should be installed in the reinforcement (clamped every 2.0 m to reinforcement steel) on the designated levels. The following describes different building situations and the profile of requirements.

Equipotential surfaces in single and multi-storey buildings using the reinforcement steel

In buildings made up of reinforced concrete supports bearing a reinforced concrete ceiling, the steel contained within can be used as a natural down conductor. Here, it is important to remember that the conductors/down conductors laid in the reinforcement must be connected to the reinforcement at intervals of 2.0 m.

It is also possible to use the reinforcement in the ceiling to create a reference plane/equipotential plane which can then be used to calculate the separation distance. A basic prerequisite is that the structure has reinforced concrete supports, the foot of which must be connected to the earth-termination system/functional bonding conductor and the top to the mesh of the equipotential plane. The creation of the equipotential surface consists of the reinforcement in the ceiling in which a 5.0 x 5.0 m mesh must be installed and clamped to the reinforcement steel every 2.0 m. The applicable standard here is the IEC 62305-4. The aim is to interconnect all metal components as well as possible to avoid differences in potential.

Equipment (e.g. air-conditioning, PV systems, roof ventilators) should also be connected to the reference plane using equipotential bonding (EB) conductors. Minimum cross-sections in accordance with table 8, IEC 62305-3 must be observed here (**Table 1**).

If the equipment is installed within the protected volume, reduced cross-sections are sufficient in compliance with table 9 of IEC 62305-3.

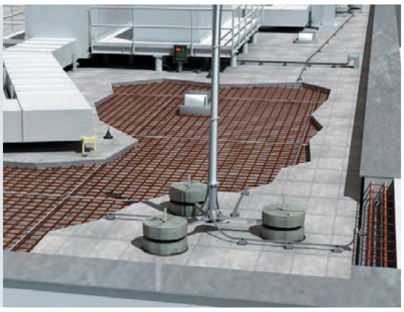
Beside reinforced concrete ceilings, in practice metal roofs are often used as roof coverings. These can be used to create an equipotential surface. A basic prerequisite is the lightning current carrying connection of the metal roofing sections with each other.

In practice, insulation and sealing measures (roof sheeting) are often installed on rooftops. The connection of the air-termination system to the roof is generally in the parapet area and through roof bushings to the equipotential surface. Due to the cable routing on the roof, separation distances must be observed, despite the equipotential surface. These can, for example, be kept by installing a separate air-termination system (e.g. HVI light system or roof conductor holder DEHNiso) (**Figure 3**). This eliminates the possibility of uncontrolled flashover through the roof insulation to ceiling reinforcements or metal roofs.

If the rooftop installations are within the protected volume (LPZ 0_B), all their supply lines must be included in the equipotential bonding at the transition LPZ 0_B/1. If no lightning currents are anticipated in the supply lines, type 2 arresters are recommended (**Table 2**). If the rooftop installations are not within the protected volume, the supply lines must be connected to type 1 lightning current arresters. Equipotential sur-

Protection class of LPS	Material	Cross-section
I to IV	Copper	16 mm^2
	Aluminium	25 mm^2
	Steel	50 mm^2

Table 1 Minimum cross-section of EB conductors



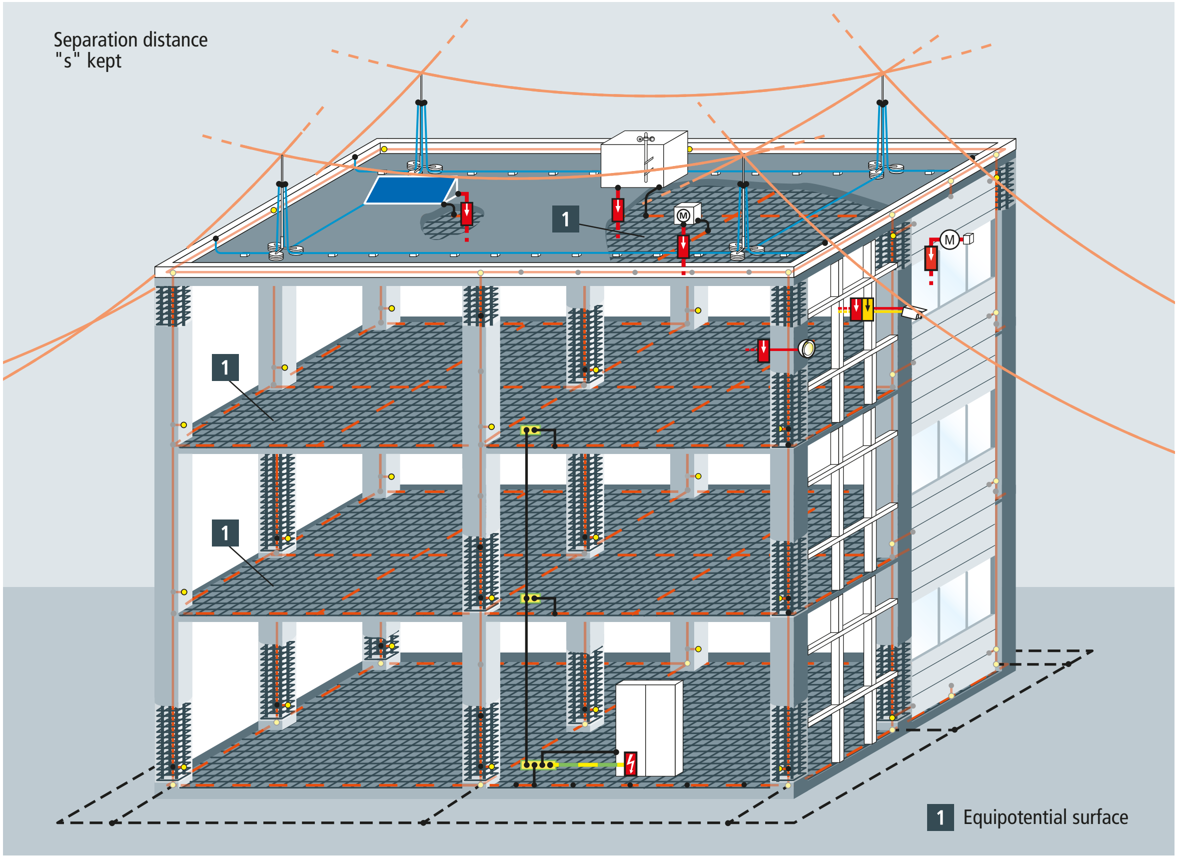


Figure 3 Multi-storey building with equipotential surfaces including air-termination system

LPL	Recommendation type 2 SPD	Recommendation type 2 SPD
LPL I	Nominal discharge current I_n 20 kA (8/20 µs)/pole	Nominal discharge current I_n 10 kA (8/20 µs)/wire
LPL II	Nominal discharge current I_n 15 kA (8/20 µs)/pole	Nominal discharge current I_n 10 kA (8/20 µs)/wire
LPL III/IV	Nominal discharge current I_n 10 kA (8/20 µs)/pole	Nominal discharge current I_n 10 kA (8/20 µs)/wire

Table 2 Recommendation type 2 SPD

faces can also be created in the ceilings of the different floors in a multi-storey building (**Figure 2**).
When creating equipotential surfaces, e.g. on each floor, one must remember to connect the functional equipotential bonding to this floor level of equipotential bonding (**Figure 4**). This also involves bringing all power and information technology systems to this potential using SPDs. As a rule, it is not imperative to create an equipotential surface on every floor. In higher buildings, it may suffice to create an equipotential surface every two or three floors (depending on the individual situation), provided that the separation distance can be observed in the floors without equipotential surface. The overall protection target for the structure is decisive here.

Steel halls with metal cladding (shielding)

In halls which have a steel framework and continuously, electrically through-connected metal cladding, in line with the provisions in the standard, there is no need to observe separation distances (**Figure 4**).

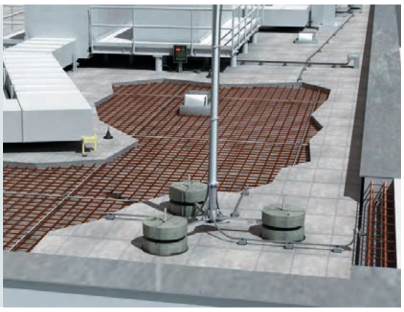


Figure 4 Steel hall with metal cladding

According to IEC 62305-4 every support must be used as a natural conductor. The foot of each support must be connected to the earth-termination system (regardless of the distance between the supports). The metal façade must also be connected to the earthing system at regular intervals if it is not already in contact via the steel supports. Additional connections must be provided if the distance between the supports > 5.0 m (**Figure 5**).

Steel halls – metal roof with insulation/foil roofing/metal façade

In practice, most metal building constructions are not completely closed. One usually has sheet metal roofing with additional insulation (**Figure 6**).

In addition, plastic sheeting, sealing strips or flat roof sealing is mounted for sealing purposes. In practice the air-termination system forms a mesh on the surface of the roof. If the connection of the air-termination system to the steel construction with metal cladding is at the height of the eaves, the eaves edge can be taken as the reference point for calculating the separation distance (equipotential surface). Roof penetrations at the nodes between the air-termination mesh and the steel construction can considerably reduce the separation distance. One way of observing the separation distance on the roof surface is to use roof conductor holder DEHNiso with spacer bars (**Figure 6**).

In the case of steel supports used as natural down conductors on the other hand, separation distances must be taken into account. The base of each support must be connected to the earth-termination system.

In general, it is important to comply with the requirements of IEC 62305-3. The DEHN Distance Tool in the DEHNsupport software provides a simple way of calculating the separation distance (**www.de.hn/bp18dst-en**). The calculation is based on nodal analysis, as described in chapter 3.3.2.1 of our Lightning Protection Guide.

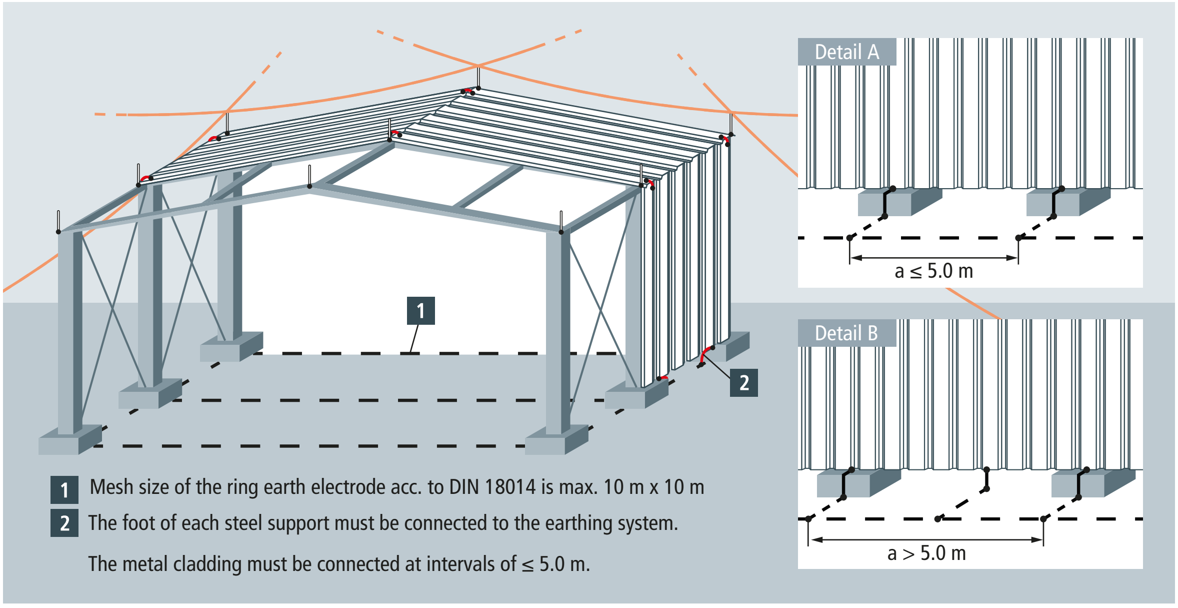
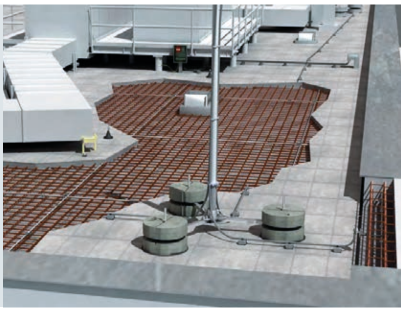


Figure 5 Steel hall with continuous metal cladding



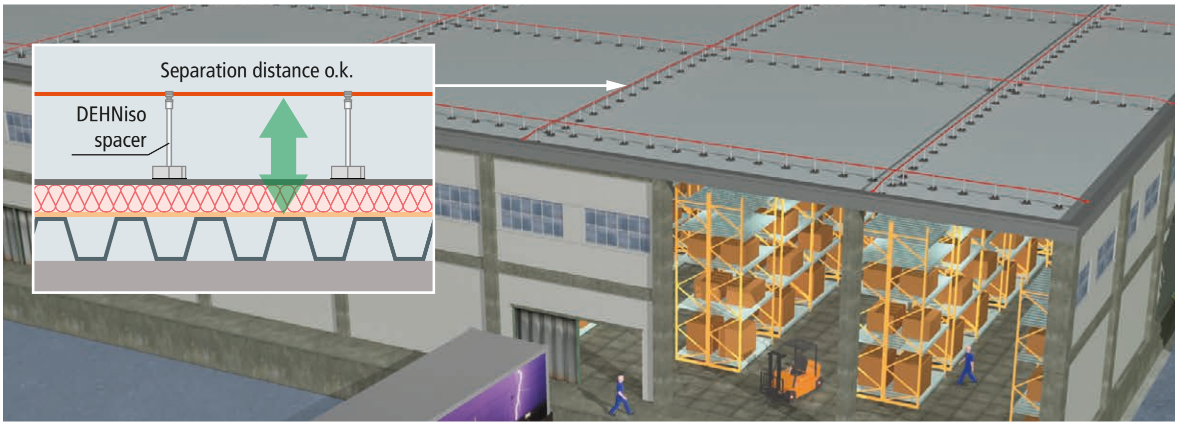


Figure 6 Elevated air-termination system to observe the separation distance

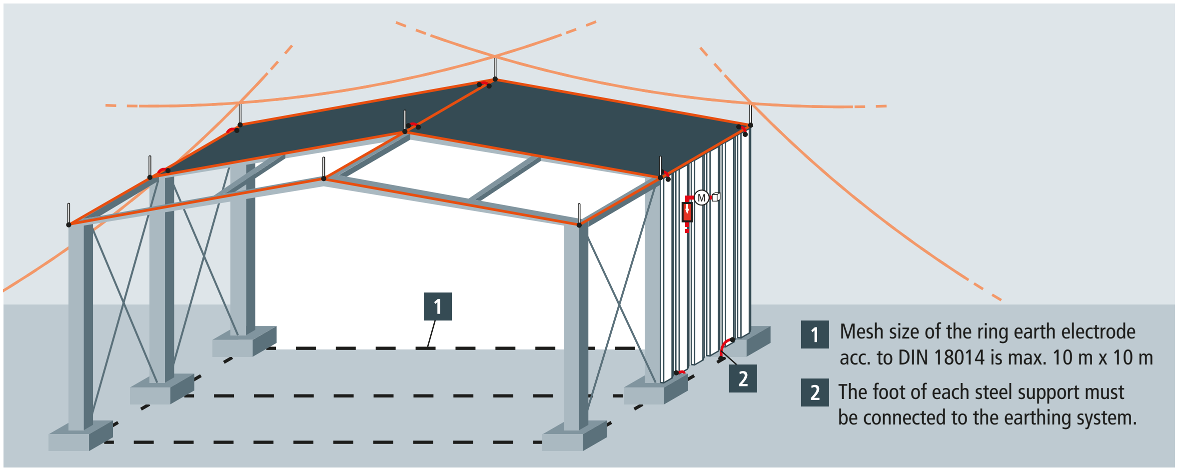


Figure 7 Steel hall with metal cladding and air-termination installed on the foot roof

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