

# DESIGN CRITERIA AND STANDARDS

Civil DCS

Earthing and Grounding

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## 1 Introduction

- a) This document is the Design Criteria and Standard for the Earthing and Grounding for the Works.
- b) The requirements in the Particular Design Criteria and Standards overrule the general requirements of the Design Criteria and Standards, in case of discrepancies.

## 2 Definitions

The following words and expressions shall have the meanings hereby assigned to them:

Term	Explanation
Contractor	Means the entity named as contractor or Seller in the main contract.
Employer	Means the entity named as employer or Buyer in the main contract.
DCS	Or “ <b>Design Criteria and Standards</b> ” means the documents as referred to in Annex 5 or the Employer requirements hereof, and including any specifications and other Employer requirements in respect of the Works to be carried out by the Contractor, if any, and any Variation to such document.
PDCS	Or “ <b>Particular Design Criteria and Standards</b> ” means the documents as referred to in Annex 4 or the Employer requirements hereof, and including any specifications and other Employer requirements in respect of the Works to be carried out by the Contractor, if any, and any Variation to such document.
Site	Means the location as identified in the main contract where the Permanent Works are to be delivered or executed.
Works	Means all the work and design to be performed by the Contractor including temporary work and any Variation as specified in the Contract and the Employers Requirements.
MV / LV	Medium Voltage / Low Voltage
PE	Potential Earth

Table 1: Definitions

## 3 Codes and Standards

- a) The design, manufacturing, provisions, installation and construction of all works, shall conform to the local Codes and Standards of the country of the Works and shall conform to the Codes and Standards mentioned in the DCS.
- b) The design and construction of the Works shall be carried out in accordance with the regulations and requirements of all relevant legal authorities.
- c) Basic norms and regulations are DIN EN 62305 (VDE 0185-305) lightning protection and DIN 18014 foundation earth.

- d) If there is any specification in this document which is against local or European Codes and Standards, the Contractor shall provide to the Employer for approval a similar solution which is in line with local and Standards.
- e) For areas, which are not regulated by local or European Codes and Standards, the design shall be in accordance with the Codes and Standards of the International Electric Commission (IEC).

### **3.1 Design and Installation Rules**

- a) All connections to the earthing wires and splices shall be welded. Bolted connection shall be used where it is impractical to weld.
- b) Lightning protection shall be provided for all tall structures built of non-conducting materials.
- c) The power distribution and earthing system shall be designed with the latest technological methods of "Transient Absorption Technology" for optimum protection against power-line transients.
- d) All motors, Low and Medium voltage, shall be earthed utilizing a separate earth wire that runs to each motor from a common earth bar.
- e) In general, all equipment containing connected electrical apparatus and wiring devices, and metallic cable routes shall be earthed. A separate earth wire shall be run to each of these devices from a common earth bar. Series connections from one device through another are not acceptable. In all electric rooms, a common earth bus shall be installed for the connection of all equipment.
- f) The neutral earthing point shall be accessible for further use.
- g) The Earthing resistance shall be not more than 4 ohms throughout the plant.
- h) The resistance of the lightning installation shall be lower than 10 ohms.
- i) Before fitting an earth cable connection, the contact surfaces shall be cleaned to smooth bright metal, the bolts shall be drawn tight and the connections shall be coated with a corrosion-resistant paint.

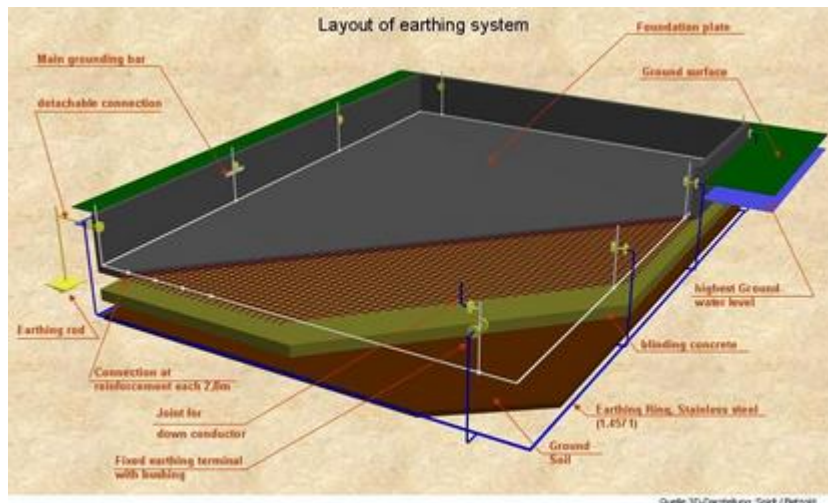
## **4 Perimeter Ground**

- a) An adequately sized bare perimeter ground grid, made from galvanized steel bar, shall be installed around each process area forming a ring type of network.
- b) At main junction points, ground rods shall be driven into the ground and connected to the ring if required.
- c) A colored warning tape shall be used to mark the position of the underground Perimeter Ground for future excavations.

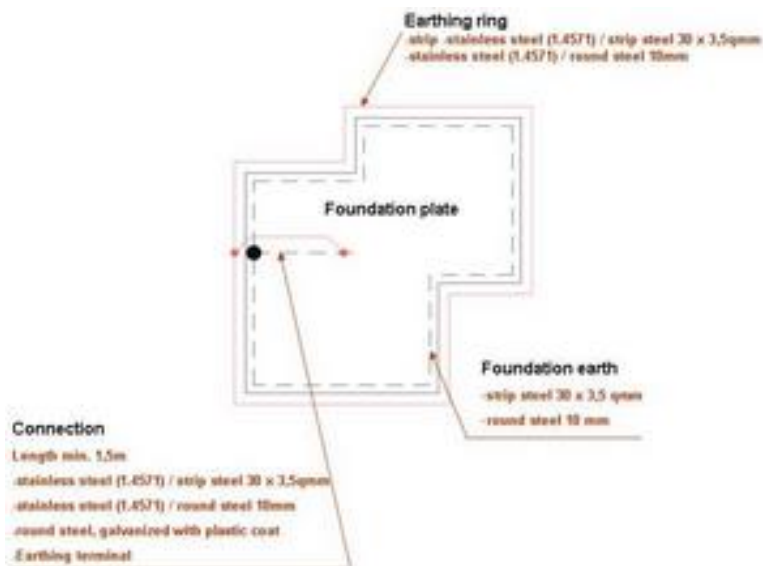
## **5 Earthing Ring**

- a) An earth ring structure shall be installed around buildings or its sections (e.g. around main substation).
- b) All elements of the earthing system, which have direct contact with the ground soil shall be installed of stainless steel (type 1.4571 / Grade 316).

- c) For the earthing ring a flat bus-bar of stainless steel (type 1.4571 / Grade 316) with the minimum of 30 x 3,5 mm<sup>2</sup> shall be used. The bus-bar shall be laid directly into the ground soil with physical connection of it. The foundation earthing is embedded into the concrete, which will protect it against corrosion.
- d) For more complex shapes more earth rings are necessary. If a building can be divided into sections then each section shall have a separate earthing ring.
- e) The earth rings will be used as a common protection for electrical shock as well as for the lightning protection.



**Figure 1: Example layout of earthing system**



**Figure 2: Earthing ring example shape**

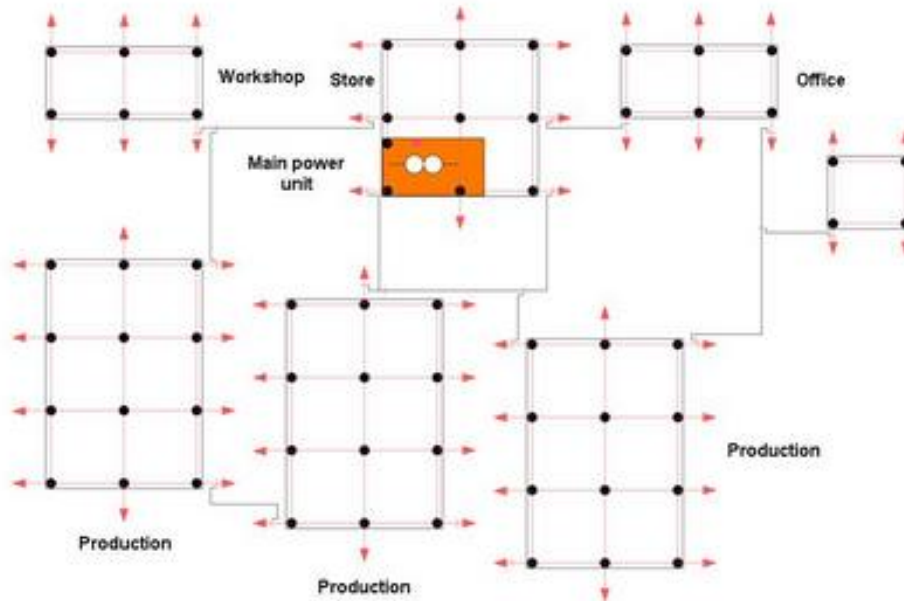


Figure 3: Earthing ring example shape

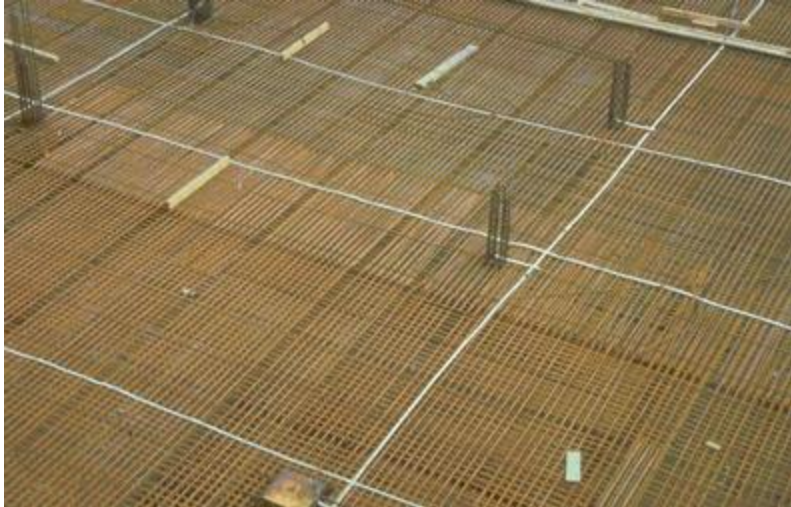
- f) If the area inside the “ring” is more than 20x20m a cross connection has to be made.
- g) If a lightning protection system is required, the Contractor shall prepare a 10m x 10m cross connection.

## 6 Foundation Earthing and Earth rods

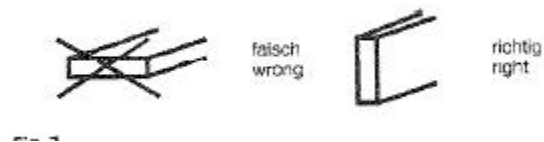
- a) Best practice is to install galvanized bands in the foundations of civil structures to form a good and reliable earthing connection.
- b) Ground rods shall be installed so that the total calculated resistance of the ground system to earth is not higher than 4 ohms, as measured by the “fall of potential” method.

## 7 Installation in Foundations of Building(s)

- a) The closed earth ring shall be installed inside the foundation reinforcement as it is shown in photo 1.



**Photo 1: Ring bus-bar example.**



**Figure 4: Bus bar configuration**

- b) Bus bars shall be installed vertically as concrete may not contact the lower side if installed flat.
- c) No insulation (like asphalt plastic foil, etc) shall be installed under the foundation. (Can create high electrical insulation between the foundation earth and the outside.) Special situations that require water proof isolation shall be discussed with Employer.
- d) The bus-bar shall be surrounded by at least 5 cm of concrete.
- e) The bus-bar shall be fixed to the reinforcement every 2 m or less. For the connection special clamps may be used only. Welding to the reinforcement is possible as well, however in order to ensure a good connection quality, welding may be performed by person only, who is in possession of welding certificate.
- f) Foundations without reinforcement require special bar holders to be used as shown in photos 2 and 3.



Photo 2: Earth rods



Photo 3: Earth Ring holders.

## 8 Earth Rods

- a) In order to reduce the total earthing resistance, earthing rods connected to the earthing ring shall be used.
- b) The distance between rods depends on the local soil condition however a typical value is every 4-5 meters around the external walls of buildings.
- c) It is advisably to keep a distance between building and rods not less than 2 times the rods length.
- d) Insulated cables for connections between a rod and earthing ring bar shall be used. The cable at the connection point with the rod shall be connected with a cable end and covered isolated with asphalt.

## 9 Connection of Closed Earth Rings

- a) Earthing rings of the same objects (equipment or buildings) shall be connected together.
- b) If an extension gap between two foundation plates exists then the solution shown in photo 4 shall be used.



Photo 4: Extension gap

- c) If foundation plates or sections are fixed then a connection shall be done as it is shown in Figure 5.



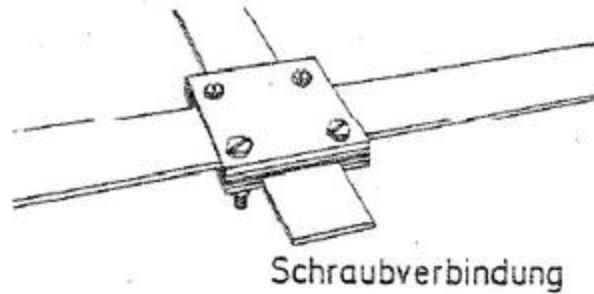


Figure 5: Connection plate



Photo 5: Connection example to rebar



Photo 6: Connection example to rebar

## 10 Lightning Protection System

- a) Earthing rings have to be connected with down conductors of the lightning protection system by means of special clamps, which can be disconnected for resistance testing.
- b) The quantity of down conductors depends on building's shape and it shall comply with local codes and standards. However the distance between down conductors shall not exceed 20 m.

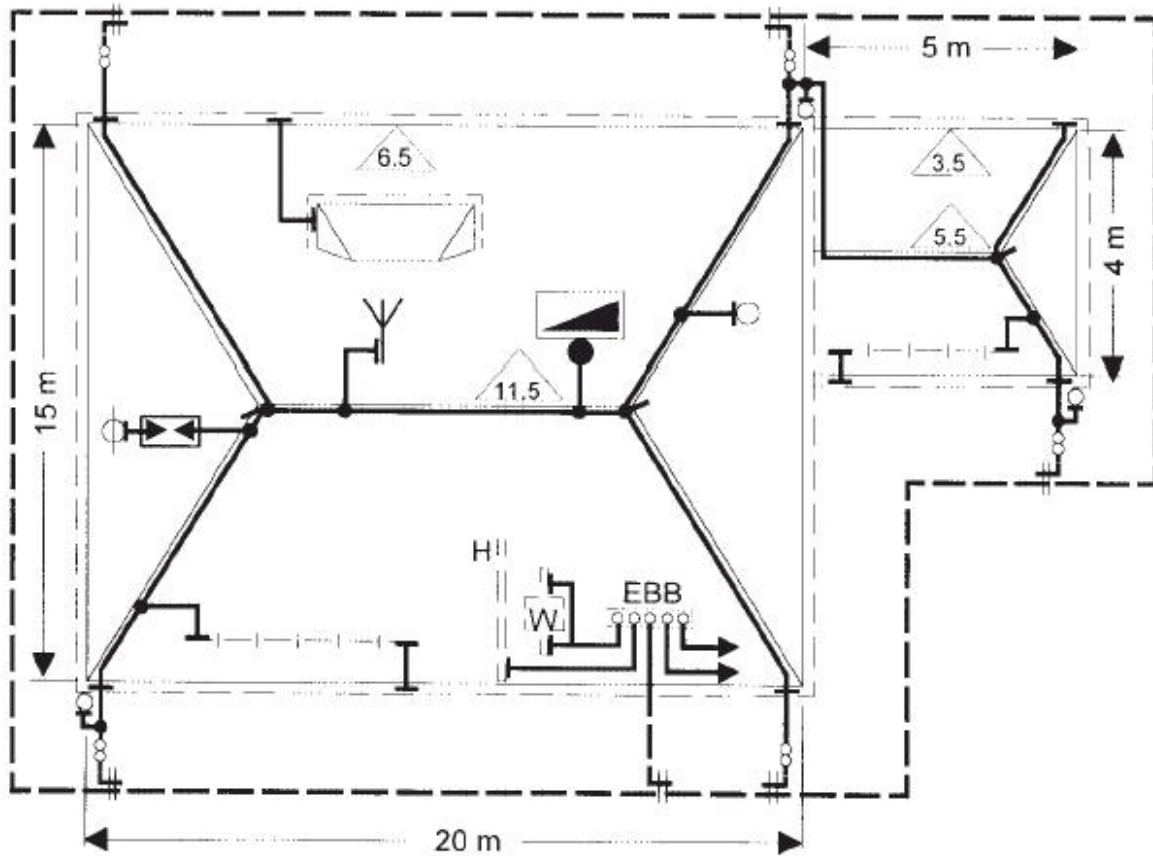


Figure 6: Example lightning protection system

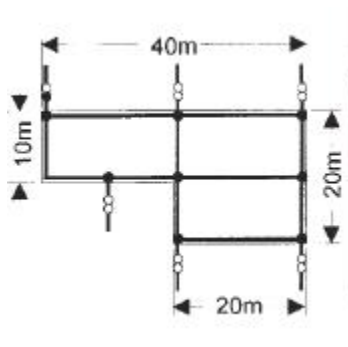
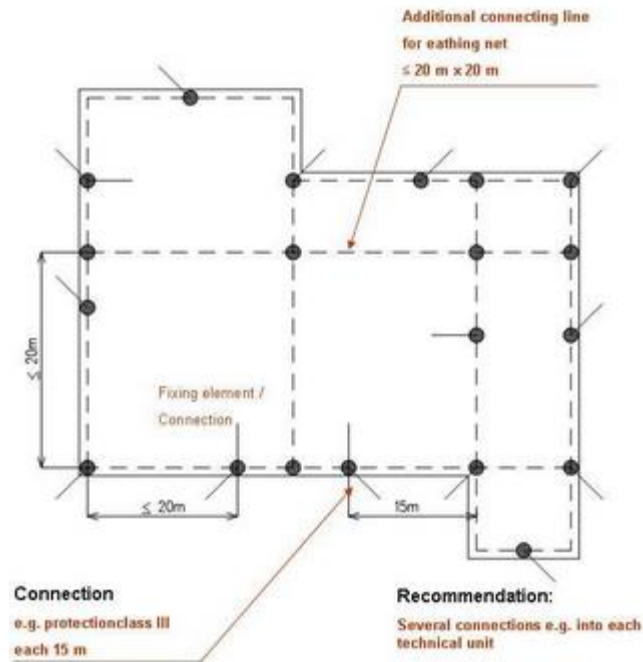


Figure 7: Lightning down roads arrangement

## 10.1 Handling of the Earth-Lightning Connections

- a) A proper connection between lightning down conductor and earthing ring shall not have a direct contact with the ground. This can be solved if a connecting bar is installed in a concrete (wall) or an insulated cable used. See Figure 8 below.



**Figure 8: Earth Lightning Connectors**

- b) In figure 8 the connection is made above ground level and the related connecting bar has been installed in the wall for corrosion protection.

## 10.2 Test Points

- a) Down conductors shall contain “test points”, which are necessary to carry out measurements of connection resistance to the ground. For this reason every single component of the lightning protection system shall be easily accessible.
- b) The test points shall be positioned above ground level.



**Photo 7: Test point**

## **11 Equipotential Bus-Bars in Electrical Rooms**

- a) Separate connections with the lightning protection system and the earthing ring shall be connected to a common equipotential bus-bar that is installed in every electrical room.
- b) All PE bus bars at distribution switchgear in the electrical room (i.e. MCC infeed field) shall be connected to the equipotential bus-bar.

### **11.1 Connections between Buildings**

- a) Separate buildings containing switchgear and electronic equipment shall have a potential bonding system between buildings.
- b) A hot-galvanized steel strip 4x50 mm shall be laid as an equipotential bonding line.