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HIGH PRESSURE (HP) TRANSMISSION SYSTEMS

EXTERNAL LIGHTNING PROTECTION

QUALITY ASSURANCE PAGE

CHANGES LOG

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CONTENTS

REFERENCE DOCUMENTS

Job Specification 700/5
[General Electrical Works]

Job Specification 700/6
[Electrical Installation in Civil Building]

ELOT EN 50164-1
[Lightning Protection Components (LPC) - Part 1: Requirements for connection components]

ELOT EN 50164-2
[Lightning protection components (LPC) - Part 2: Requirements for conductors and earth electrodes]

ELOT EN 60079-10
[Electrical apparatus for explosive gas atmospheres - Part 10: Classification of hazardous areas]

ELOT EN 60079-14
[Electrical apparatus for explosive gas atmospheres - Part 14: Electrical installations in hazardous areas (other than mines)]

ELOT EN 62305-1
[Protection against lightning - Part 1: General principles]

ELOT EN 62305-2
[Protection against lightning - Part 2: Risk management]

ELOT EN 62305-3
[Protection against lightning - Part 3: Physical damage to structures and life hazard]

ELOT EN 62305-4
[Protection against lightning - Part 4: Electrical and electronic systems within structures]

ELOT HD 60364-5-54
[Low-voltage electrical installations - Part 5-54: Selection and erection of electrical equipment - Earthing arrangements, protective conductors and protective bonding conductors]

Υ.Α. Φ.7.5/1816/88 ΦΕΚ 470Β/05.03.2004
[Αντικατάσταση του ισχύοντος Κανονισμού Εσωτερικών Ηλεκτρικών Εγκαταστάσεων (Κ.Ε.Η.Ε) με το Πρότυπο ΕΛΟΤ HD 384 και άλλες σχετικές διατάξεις]

1.0 SCOPE - APPLICABLE STANDARDS

This Specification deals with general criteria which must be used for design, selection of materials and construction of an External Lightning Protection System. It is applicable to civil and industrial buildings, factories, process and storage installations.

This Specification is based on the following standards:

- ELOT EN 50164-1
  [Lightning Protection Components (LPC) - Part 1: Requirements for connection components]
- ELOT EN 50164-2
  [Lightning protection components (LPC) - Part 2: Requirements for conductors and earth electrodes]
- ELOT EN 62305-1
  [Protection against lightning - Part 1: General principles]
- ELOT EN 62305-2
  [Protection against lightning - Part 2: Risk management]
- ELOT EN 62305-3
  [Protection against lightning - Part 3: Physical damage to structures and life hazard]
- ELOT EN 62305-4
  [Protection against lightning - Part 4: Electrical and electronic systems within structures]
- ELOT HD 60364-5-54
  [Low-voltage electrical installations - Part 5-54: Selection and erection of electrical equipment - Earthing arrangements, protective conductors and protective bonding conductors]

2.0 GENERAL

This General Specification shall be read in conjunction with the Specification **Job Specification 700/5** and with **Job Specification 700/6,** for what concerns coordination with the general earthing electrode and with bonding.

3.0 TERMS AND DEFINITIONS

3.1 LIGHTNING PROTECTION SYSTEMS (LPS)

The complete system used to protect building or premises and installations contained in it against the effects of lightning. It consists of both external and internal lightning protection systems.
An external lighting protection system consists of an air-termination system, a down-conductor system and an earth termination system.
An internal lighting protection system consists of all those additional measures which would reduce the electromagnetic effects of lighting current within the space to be protected.

3.2 AIR TERMINATIONS

The metallic parts of the lightning protection system having the purpose to intercept lightning flashes.

The air terminations may consist of "normal" and "natural" elements; the first are specifically installed for the purpose of lightning protection; the second ones are metallic parts performing a lightning protection function but which are not installed specifically for that purpose.

3.3 DOWN CONDUCTORS

Part of the LPS which is intended to conduct the lightning current from the air terminations to the earth-termination system. Down conductors may also be normal or natural.

3.4 EARTH TERMINATION SYSTEM

That part of an external LPS which is intended to conduct and disperse lightning current to the earth.

3.5 EARTH ELECTRODE

Earth electrode (part of the earth-termination system) consist of metallic part assemblies in direct electrical contact with the soil, provided or used to disperse the lightning current to the earth; also earth electrodes may be normal and natural.
Components of the earth electrode such as wires, rods, plates, etc. are called elements of the electrode.

3.6 EARTHING LEADS

Conductors downstream of the test joints having the following functions:

- Connect the earthing electrodes between them.
- Collect the lightning currents from the down conductors and convey them to the earth electrodes.

Parts of such conductors directly in contact with the soil are regarded as parts of the earth electrode.

3.7 TEST JOINT

A joint which is designed and situated to facilitate electrical testing and measurement of LPS components. It is provided for the connection between down conductors and earthing leads; this terminal is of loosening type in order to permit measuring and test of the installation. The connection at the earthing lead side is called earth terminal.

3.8 SURGE PROTECTION DEVICE (SPD)

A device intended to limit transient overvoltages and direct surge currents, such as spark gaps, surge diverters or semiconductor devices.

3.9 DANGEROUS SPARKING

An unacceptable electrical discharge caused by lightning current inside the space to be protected.

3.10 ZONE OF PROTECTION

The volume within which a LPS gives protection against a direct lightning stroke by directing the stroke to itself.

3.11 STRUCTURE

In this General Specification structure means buildings or premises of any nature for which protection against the effects of lightning is required.

4.0 LIGHTNING PROTECTION SYSTEM - CHARACTERISTICS OF THE INSTALLATION

4.1 FUNCTION

The lightning protection system shall be made in such a way that the lightning current to earth and its dispersion shall be as much direct as possible, through a low impedance way, in order to avoid damages due to the current, dangerous voltage for the equipment, human beings or livestock and dangerous sparking capable to ignite fire or destroy materials.
A lightning protection system reduces the risk of lightning damage but can not guarantee absolute protection.

4.2 CONSTRUCTION

The external lightning protection installation consists of:

- air terminations,
- down conductors,
- earthing leads,
- earthing electrodes,
- earthing conductors,
- test joints,
- accessories such as joints, supports, terminals etc,

which are assembled in a system forming a protective conductor mesh enclosing the construction to be protected.

4.3 SIZING AND DURATION

The lightning protection installation shall be suitably sized for thermal and dynamic stresses due to the lightning current.
The duration of the installation shall not be less than that of other installation.
For the LPS materials and requirements for operation (corrosion etc.) refer to **ELOT EN 62305 series.**

4.4 ZONE OF PROTECTION

The extension of the protected zone depends on the air termination type, (rods, conductor etc), the height of the structures, the protection level requested and the code to be applied.
To determine the extension of the zone of protection refer to **ELOT EN 62305 series**.

4.4.1 CLASSIFICATION OF DEGREES OF PROTECTION OF A LPS

According to the required LPS efficiency the system shall be designed to meet the requirements of the protection level degrees according to **ELOT EN 62305-1 para 8.1**, as these are given on **TABLE 1**.

TABLE 1

PROTECTION LEVEL DEGREE OF A LPS	SYSTEM EFFICIENCY E %
I	98
II	95
III	88
IV	81

4.4.2 LIGHTNING CURRENT PARAMETERS - RELATION TO PROTECTION LEVELS

Lightning system shall be adequate designed to withstand expected direct lightning strokes with parameters according to **ELOT EN 62305-1**, as shown on **TABLE 2**.

TABLE 2

LIGHTNING PARAMETERS OF FIRST STROKE	PROTECTION LEVEL TO LPS		
	I	II	III-IV
Peak current I (kA)	200	150	100
Short stroke charge Q_{short} (C)	100	75	50
Specific energy W/R (MJ/Ω)	10	5,6	2,5
Time parameters T_1/T_2 (μs /μs)	10 / 350		

4.5 INDIRECT PROTECTION

Construction for which there are no special protection requirements (e.g. **ELOT EN 60079-10, ELOT EN 60079-14** for hazardous areas), which are within the protection zone as specified in **para 4.4** may be considered as protected:

- If they are protected with a conductive loop preferably embedded in the soil, made in accordance with **para 5.3.**

- The earthing loop of the construction must be connected to other earth electrodes. Connection shall be made by means of at least two opposite side short jumpers.
- If all metallic parts incoming to and outgoing from the construction, are connected to the loop directly or eventually through an overvoltage limiter with provision for inspection.
- In case the protection is by means of horizontal air terminations suspended at their extremities, if the minimum vertical distance H between the conductor and the construction is not less than that specified in the relevant Standard (see **figure 1**).
- The indirect protected constructions do not require individual air terminations and down conductors.

4.6 REINFORCED CONCRETE STRUCTURE

The reinforced concrete structures may be considered as natural elements and therefore they are considered parts of the lightning protection installation only if the following requirements are fulfilled:

a) For cast in place structures: The reinforcing bars are connected to provide electrical continuity. A suitable system of electrical connection may be as follows:

- Steel wire wrapping as shown on **Figure 2** or
- Welding of bars as per **Figure E5 of ELOT EN 62305-3.**
- Clamping of bars (rods) (see **Figure 2A**), according to **ELOT EN 62305-3.**

b) For prefabricated structures: Provisions are taken during prefabrication of the structures to permit the electrical connection of the reinforcing bars of individual separated reinforced concrete structures at the field (**Figures 3 and 4**).

5.0 LIGHTNING PROTECTION INSTALLATION

5.1 AIR TERMINATIONS

5.1.1 Reinforced concrete structures shall not be considered suitable as components of air-termination systems and they shall be protected as specified in the **para 5.1.4.**

5.1.2 Metal covering of non metallic roofs may be considered as natural air-termination components if:

a) The electrical continuity between parts is assured in permanent manner by means of welding, riveting or folded seam.

b) Thickness of metal sheet is not less than the value specified in **ELOT EN 62305 series.**

c) They are not clad in insulating material.

5.1.3 Metallic parts of roofs may be considered as natural air-termination components if their cross-sectional area is not less than that required for normal air terminations

(**para 8.2**); for pipes and tanks the thickness shall be not less than 5 mm and the temperature rise of the inner surface at the point of strike should not constitute a danger.

Such parts shall be connected together and with other parts of the lightning protection installation, complying with all requirements stated for them.

Metallic parts not complying with above requirements shall be bonded to air terminations (**para 7.1**).

5.1.4 Construction made of non conductive materials, such as reinforced concrete, tiles, slating and other constructions not falling under **para 5.1.2**, shall be provided with air-termination conductors laid along the uppermost parts and edges of the construction, in order to form a mesh in which any point of the construction is included.

The mesh width shall be not higher than those specified in **ELOT EN 62305 series** and the connection with the earth electrode is at least by means of two separate down conductors on opposite side of the construction. The ridges of the roof shall be provided with proper air termination conductors if are higher than 1/10 of their horizontal distances from the air termination conductor (**Figure 7**).

5.1.5 The air termination conductors shall be laid in such a manner in order to obtain short and straight runs.

Loops shall be avoided as far as possible; if such loops can not be avoided, they shall be made as per **ELOT EN 62305 series.**

To avoid excessive loop lengths, the solution shown on **Figure 5** may be adopted.

5.1.6 Material and minimum size of air terminal elements are given in **para 8.1.**

5.2 DOWN CONDUCTORS

Down conductors to connect the air terminations to the earth electrodes shall be provided. They shall not be less than two or in such a number that the average distance between them does not exceed the value specified by **ELOT EN 62305 series.**

Distance between down conductors shall be uniform as far as possible.

A down conductor should be near to each corner of the structure.

Down conductors shall preferably be laid on the outer surfaces of outside walls of the construction. Where for civil buildings it is not practical to lay down conductors outside of external walls because of esthetical reasons, partial or total installation into ducts is allowed, provided that:

- Ducts are made of non combustible materials.
- Ducts do not contain combustible materials.
- Metallic ducts are suitably bonded.
- Ducts are not used for other electrical circuits unless they are adequately shielded.
- Ducts permit inspection and maintenance of down conductors.

Down conductors may also be installed on the inner surface of the walls, if normally not occupied by personnel.
For construction with the top edge higher than 20 m, down conductors shall be bonded together with one or more horizontal jumpers equally spaced, in such a way that the distances between them, the air terminals and soil shall not exceed 20 m.

Normal down conductors shall be laid in the same manner as specified for air termination conductors, in particular, non-straight runs shall be avoided, where the human body nay complete a loop for the lightning current **(figure 8).**

Metal installations, metal framework of the structure, the interconnected steel of the structure, facade elements etc. may be used as natural down-conductors provided that they comply with **ELOT EN 62305 series.**

Water and fuel gas piping should not be used as down conductors.
Reinforced concrete columns and beams may be used as down-conductors only if the electrical continuity of the reinforcing bars are assured as specified in **para 4.6.**

Metallic parts which may not be considered and used as natural down-conductors shall be bonded to the lightning protection installation.

Internal metallic bodies near to the external walls shall be bonded as specified in **para 7.1.**

5.3 EARTH ELECTRODES

5.3.1 Earth electrodes for the lightning protection system shall be capable to disperse the lightning current in a satisfactory manner, as specified in **para 4.1.** For this purpose it is not necessary the earth-termination system to have a specific earth resistance, but rather to have adequate shape and dimensions. In any case a low earth resistance is recommended to increase the protection effectiveness.

The earthing electrodes shall have shape and arrangement conforming to the geoelectric characteristics of the soil, and be installed as far as possible along the perimeter of the construction to be protected.

The minimum length of the earth electrodes shall not be lower than the values specified in **ELOT EN 62305 series.**

5.3.2 FOUNDATION EARTH ELECTRODES

Foundation earth electrodes shall be according to **ELOT EN 62305-3 para E.5.4.3.2, EN 50164 series, ELOT HD 60364-5-54 and Y.A. Φ.7.5/1816/88 ΦΕΚ 470Β/05.03.2004**.

A foundation earth electrode comprises conductors, which are installed in the foundation of the structure below ground. The length of additional earth electrodes should be determined using the diagram in Figure 2 of **ELOT EN 62305-3**.

Foundation earth electrodes are installed in the reinforced concrete foundation.

5.3.3 RING TYPE EARTH ELECTRODES

Ring type earth electrode (type B according to **ELOT EN 62305 series**) shall be additionally installed where applicable according to the requirements of **ELOT EN 62305 series**. The ring type earth electrode consists of a bare conductor laid in the

soil, at a depth of 0,5 to 2 m, outside the construction perimeter, preferably in wet soil, not subject to landslip.

The laying depth shall be not less than 0,5 m and not closer than 1 m to the wall.

Mechanical stresses due to traffic, soil movement, excavations and similar damages shall be considered.

5.3.4 MESH TYPE EARTHING ELECTRODES

Within industrial installations the earth electrodes for lightning protection system are generally integral part of the general earth electrode provided for operational and safety reasons with respect to the electrical installations.

In this case the general earth electrode shall comply also with the requirements proper of the lightning protection.

The following points shall be considered:

- The loop electrode around the construction shall be laid at a depth not less than 0,5 m.
- The connections between the lightning protection electrodes and the ones provided for the operational and safety earthing shall be as short and straight as possible.

5.3.5 NATURAL EARTH ELECTRODES

a. Except for steam, gas, flammable liquids and similar piping, underground metal structures may be used as natural earth electrodes, provided that their characteristics comply with the requirements of **ELOT EN 62305 series.**

b. If the above metallic parts are installed in ducts (stone-ware, cement and similar), they may be used as earthing leads only.

c. All the other metallic parts in direct contact with the soil shall always be connected to earth electrode as near to the point of entry into the structure as possible. The connection shall be by means of links suitable to be opened and inspected (bonding bar).

d. Where a permanent connection with the earth electrode is not possible, a surge protection device, having striking voltage not higher than 2 kV at 50 Hz shall be installed, in order to permit to make a temporary connection of pipes or other structures during the lightning stoke.

e. In the case of an isolated construction with earth electrode separated from the general plant earth electrode, all metallic parts buried in the soil, outside the construction perimeter, but within a minimum distance from the earthing electrode (as per applicable standard) or metallic parts connected to them, shall be connected to the earthing electrode directly or by means of a lightning arrester as above specified.
The earth electrodes of two adjacent constructions, both protected in accordance with this specification, shall be connected and considered as a single electrode; the conductors connecting the two electrodes shall be sized as per **ELOT EN 62305 series** and **ELOT EN 50164-2.**

f. The reinforced concrete foundations complying with requirements in **para 4.6,** may be considered as a natural earth electrode. To increase the electric continuity with the soil some hot dip galvanized steel bars of suitable lengths, should be brought out from the reinforced concrete foundation. Such galvanized steel bars may also be used to bond this natural earth electrode to the other earth electrode elements (**Figure 10**).

5.4 CONNECTIONS BETWEEN DOWN CONDUCTORS & EARTH ELECTRODE

Each down-conductor (except in the case of natural down conductors), shall be connected to the earth termination system through a test joint.
The connection up to the earth electrode shall be as short as possible.
For down conductors made of aluminum or aluminium alloy the measuring terminal shall be installed at least 0,3 m above grade.

6.0 JOINTS AND CLAMPING

6.1 JOINTS

Joints along conductors shall be as minimum as possible, in order to ensure good electrical continuity. Joints shall be made by welding, brazing or autogenous welding and if inspection able, may be made by riveting or by bolted terminals with an overlapping of 20 mm minimum and with surface contact of at least 200 mm^2. Connections between pipes may be made by threading with or without unions. Junctions shall be properly protected against corrosion.

6.2 CLAMPING AND FASTENING

Elements forming part of air terminations and of down conductors shall be properly fastened to the protected construction, in order to prevent rupture or loosening due to electrodynamic or other accidental mechanical stresses.

Isolating material shall never be interposed between conductor and fastener.
For the conductors laid on flammable surfaces, fasteners shall be made in a manner to keep conductors at least 0,1 m apart from the flammable surface.
Types of fasteners and joints are shown on **Figures 11, 12** and **13.**

7.0 BONDING

7.1 GENERAL

All metallic parts of big dimensions, which are inside or outside of the protected construction, shall be bonded to the nearest point of the lightning protection installation by means of one or more jumpers.

Where the metallic parts run parallel to protection conductors for a length "l" which is more than five times the distance "d" between them, they shall be bonded at least at two extreme points, so that connections are not spaced more than 5 d.
Bonding connections shall be made by means of connectors having the same characteristics and sizing as protection conductors.

The bonding connections shall correspond to the nearest points between the metallic parts and the protection conductors and shall be as short and straight as possible. Parts to be bonded are e.g.: piping systems for water, air, gas, frames of hoists, rain water canalization, ornamentals, hand rails, reservoirs, machine frames etc. Bonding shall be provided between conductors of the lightning protection installation and conductors of the general earthing and protection system. Bonding jumpers shall always be as short and as straight as possible.

7.2 EXTERNAL PROJECTING METALLIC PARTS

- Metallic projections, parts on top, and projections from side walls of the construction shall be bonded to the lightning protection installation even if not used as air terminals.
- The metallic supports for broadcasting or television antennas shall always be bonded to the protection installation by means of the same conductors used for the normal air terminal. The metal shield if any, of the antenna down cables shall also be bonded at the highest possible point by a conductor with a cross sectional area not less than the shield one.
- Metallic parts of non negligible dimensions, including also protection conductors of the electrical installation running inside the construction within 2 m from the lightning protection system or metallic parts connected to it, shall be bonded to the protection system directly or through metallic parts bonded to it.

7.3 ELECTRICAL CABLES

Electrical cables (power, control, signaling, communication and other) entering the construction shall be protected against damaging by side flashes. The following provisions shall be taken depending on the characteristics of the installation:

- Installation of cables in the continuous metallic ducts, trucking or conduits.
- Use of continuously shielded cables.
- Insertion of surge protection devices with adequate characteristics in suitable points.
- By distancing the cable from the metallic parts connected to the lightning protection system or by adopting adequate insulation levels.

Metallic ducts, cable shields etc. shall in any case be connected to the protection system at the entrance to the construction.
Where cable metallic shields, ducts or similar run parallel to protection conductors, bonding shall be provided completely in accordance with **para 7.1,** by means of conductors having at least the same cross sectional area as the metallic shield or ducts, which shall be equivalent to figures shown in **Table 1.**

The above shall not apply if contradict with the specific rules stated for the installations to which pertain the said cables.

7.4 FENCES

The following recommendations are to be made for the safety of personnel and livestock, where fences are made of electrically continuous metal extending for a long distance:

- The metal shall be earthed at intervals to the common mesh or to separate earth electrodes. The intervals shall not be more than 75m. The intervals may be extended to 150 m if the soil is permanently damp and the location surrounded by the fence is not hazardous.
- The continuity of the metal shall be broken at intervals not exceeding 300 m by non conductive gates or by gaps at least 60 cm wide, closed by sections constructed of non-conductive material.
- The earth termination of the fence at such gap shall be at least 8m away from either side of the gap.
- The test joint required for the down conductors may be omitted.

8.0 MATERIAL

8.1 GENERAL

Material to be used for lightning protection installations shall be properly selected, with proper mechanical and chemical resistance. Material shall be protected against corrosion. Electrolytic corrosion shall be prevented by avoiding surface contact between -different metals. Material to be used shall be preferably the same adopted for the general earth electrode and for aboveground protective conductors. Suitable material are: copper, hot dip galvanized iron, stainless steel, aluminium, lead clad iron.

Conditions of use shall be according to **ELOT EN 62305 series.**

Minimum sizes shall comply with **ELOT EN 50164-2.**

8.2 MATERIAL FOR AIR TERMINATIONS AND FOR CONDUCTORS

Generally all material listed in **para 8.1** may be used.

Aluminium and stainless steel cannot be used for installation in concrete.

8.3 MATERIAL FOR EARTH ELECTRODE

Material to be used for earth electrodes shall be as specified in **para 8.1**, with the exception of aluminium.

9.0 ADDITIONAL REQUIREMENTS FOR LIGHTNING PROTECTION INSTALLATION IN HAZARDOUS LOCATIONS

In addition to what specified in **para 4.0** to **8.0,** the requirements specified in the following paragraphs shall be complied for lightning protection installation within hazardous locations.

9.1 ZONE OF PROTECTION

The protective angle given by a vertical or horizontal conductor shall be limited to a 30° angle. If two or more vertical or parallel horizontal conductors are installed, the protective angle to be applied may be 45° within the space bounded by the conductors, but it should not exceed 30° outside that space.

9.2 AIR TERMINATIONS

- Where no risk is involved in discharging the lightning current over the surface of the structure to be protected, a network of horizontal conductors with a mesh between 3 m and 7,5 m according to the risk, should be fixed on the roof of the structure. Metallic parts on the roof may be considered as integral parts of the mesh.
- A structure which is wholly below ground and which is not connected to any services aboveground can be protected by a suspended air terminal considering its protected zone as specified in **para 9.1.**
  Where the depth of burying is adequate, the air terminal may be replaced by a network of earthing strips arranged on the surface.

9.3 DOWN CONDUCTORS

The normal down conductors for non conductive construction shall be at least 2 or in such a number that the distance between two down conductors does not exceed 15 m measured along the construction perimeter.

The metallic structures and equipment such as tanks, metallic chimney etc. in which the walls are considered as natural down conductors shall have at least two connection to the earthing electrode if the diameter or width is ≤ 30 m.

For those exceeding 30 m in diameter or width the connection to the earthing electrode shall be 3 at least.

9.4 EARTHING ELECTRODES

A mesh to improve the earthing ring type electrodes shall always be installed for the installation in which the earth resistance exceeds 300 Ω/m. This electrode may also be integral part of the general earthing electrode provided for operational and safety reasons with respect to the electrical installations.

Where possible the values of the total earthing resistance below indicated, depending from the size of the protected installation shall be considered:

- For building and structures:

Surface S to be protected (m^2)	Maximum value of the earthing resistance (ohm)
S ≤ 50	25
50 < S ≤ 300	12,5
300 < S ≤ 500	8
500 < S ≤ 650	7
650 < S ≤ 800	6
800 < S ≤ 950	5

- For metallic tanks: 7 ohm

9.5 BONDING

- All underground metallic parts not entering or leaving the construction but laid within the distance D indicated below from the earthed construction or metallic parts bonded to it, shall be bonded to that metallic elements. The distance D in meters is determined by:

$$D = 0,8\ R,$$

in which R is the total earthing resistance.

In any case the distance D shall not be less than 2 m.

- Metallic pipes, electrical conductor sheaths, steel ropes, rails not in continuous electrical contact with the earth, which enter in a structure, shall be bonded to the lightning protective system.
  They shall be earthed at the point of entry outside the structure and at two points, one about 75 m away and one at further 75 m away (see **Figure 14**).

- The metal uprights, components and wires of all fences and of retaining wails shall be connected in such a way to provide continuous metallic connection between themselves and the lightning protection system. Discontinuous metal wire fencing on non-conductive supports or wire coated with insulating material shall not be employed.

10.0 ATTACHED DOCUMENTS

1. **Table 1**
   [Minimum Dimensions of LPS Materials]
2. **Figure 1**
   [Indirect Protection (paragraph 4.5)]
3. **Figure 2**
   [Electrical Connection between Two Concrete Reinforcing Bars (paragraph 4.6)]
4. **Figure 2A**
   [Example of clamps used as joints between reinforcing rods and conductors]
5. **Figure 3**
   [Electrical Connections of Prefabricated Reinforced Concrete Elements used as Natural Down Conductors]
6. **Figure 4**
   [Electrical Connections of Prefabricated Reinforced Concrete Elements (with cast in place joint) used as Natural Down Conductors]
7. **Figure 5**
   [Avoiding a Loop by taking the Protective Conductor through a Parapet Wall]
8. **Figure 6**
   [Typical Positioning of Air Terminals]
9. **Figure 7**
   [Condition for Positioning of Air Terminal Conductors on the Roof Ridges]
10. **Figure 8**
    [Routes for Down Conductors in a Building with Cantilevered Upper Floors]
11. **Figure 9**
    [Electrical Continuity between the Steel Structure and Reinforced Concrete Foundation]
12. **Figure 10**
    [Increasing of the Electrical Continuity between Reinforced Concrete Foundation and Soil: Bonding with Other Earth Electrode]
13. **Figure 11**
    [Typical Fasteners for Air Terminal Conductors]
14. **Figure 12**
    [Typical Fasteners for Air Terminals and Down Conductors]
15. **Figure 13**
    [Typical Accessories for Air Terminals and Down Conductors]
16. **Figure 14**
    [Bonding of Metallic Parts having a Long Extension, Entering in a Structure]

TABLE 1

MINIMUM DIMENSIONS OF LPS MATERIALS

Material	Air-termination (mm^2)	Down-conductor (mm^2)	Earth termination (mm^2)
Cu	50	50	50
Al	50	50	-
St-Fe hot dip	50	50 (*)	80

(*) 80mm^2 when installed in concrete

The above dimensions shall be considered as a minimum and to be applied for the construction not higher than 30 m.

For the construction higher than 30 m the above dimensions shall be increased by 25%.

FIGURE 1

INDIRECT PROTECTION
(paragraph 4.5)

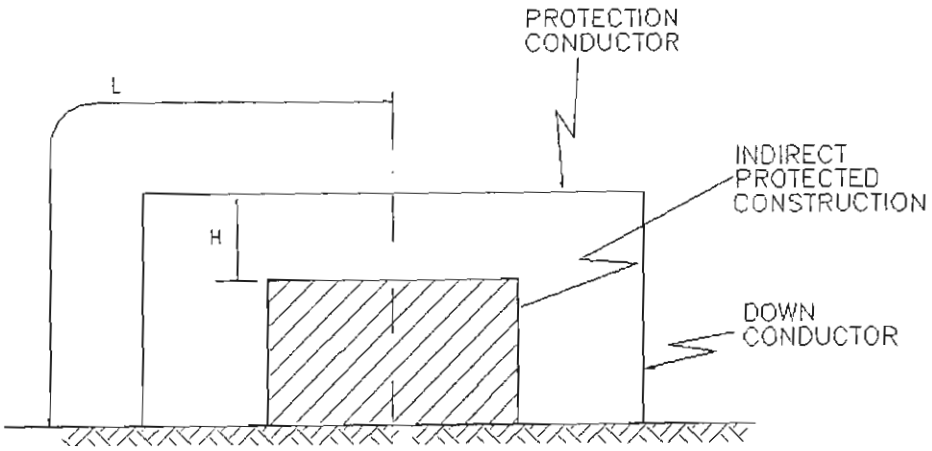


FIGURE 2

ELECTRICAL CONNECTION BETWEEN TWO CONCRETE REINFORCING BARS
(paragraph 4.6)

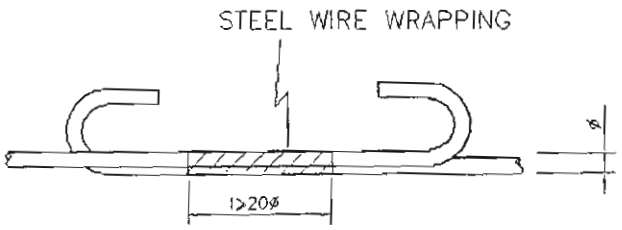
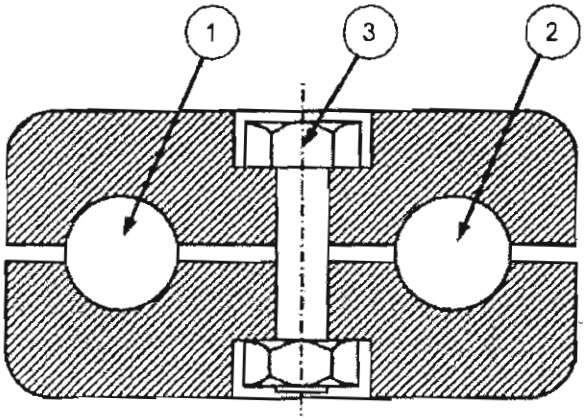
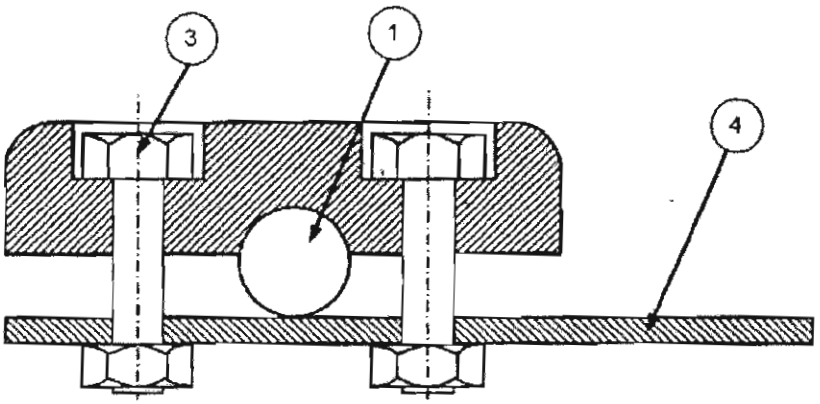


FIGURE 2A

EXAMPLE OF CLAMPS USED AS JOINTS BETWEEN REINFORCING RODS AND CONDUCTORS



a. Circular conductor to a reinforcing rod

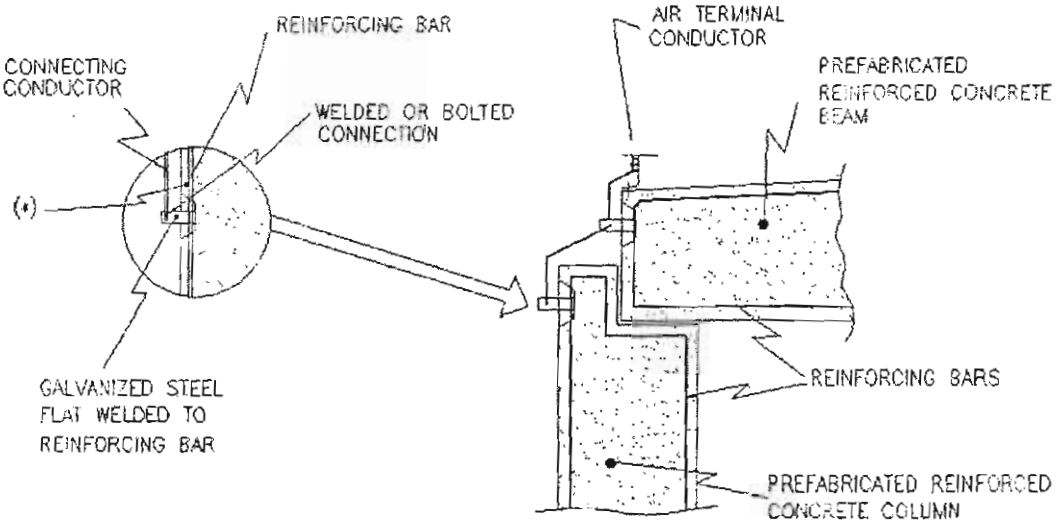


b. Solid tape conductor to a reinforcing rod

Key
1. Reinforcing rod
2. Circular conductor
3. Screw
4. Tape conductor

FIGURE 3

ELECTRICAL CONNECTIONS OF PREFABRICATED REINFORCED CONCRETE ELEMENTS USED AS NATURAL DOWN CONDUCTORS



(*) WELDING PIT TO BE CONCRETE POURED AFTER WELDING

FIGURE 4

ELECTRICAL CONNECTIONS OF PREFABRICATED REINFORCED CONCRETE ELEMENTS (WITH CAST IN PLACE JOINT) USED AS NATURAL DOWN CONDUCTORS

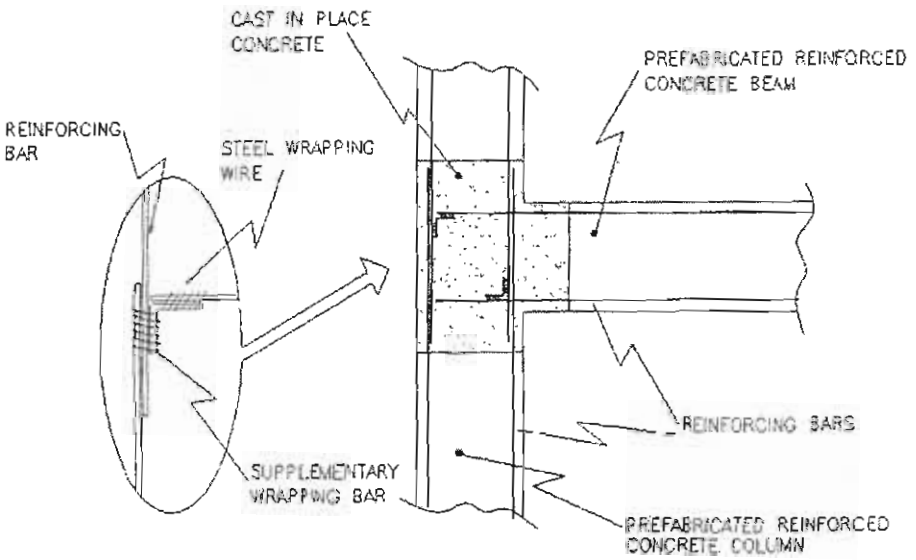


FIGURE 5

AVOIDING A LOOP BY TAKING THE PROTECTIVE CONDUCTOR THROUGH A PARAPET WALL

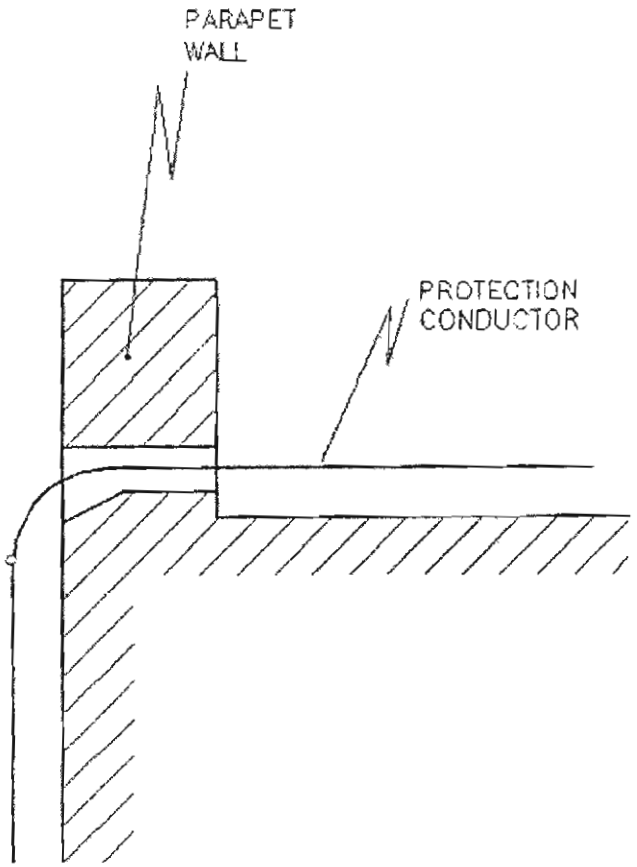


FIGURE 6

TYPICAL POSITIONING OF AIR TERMINALS

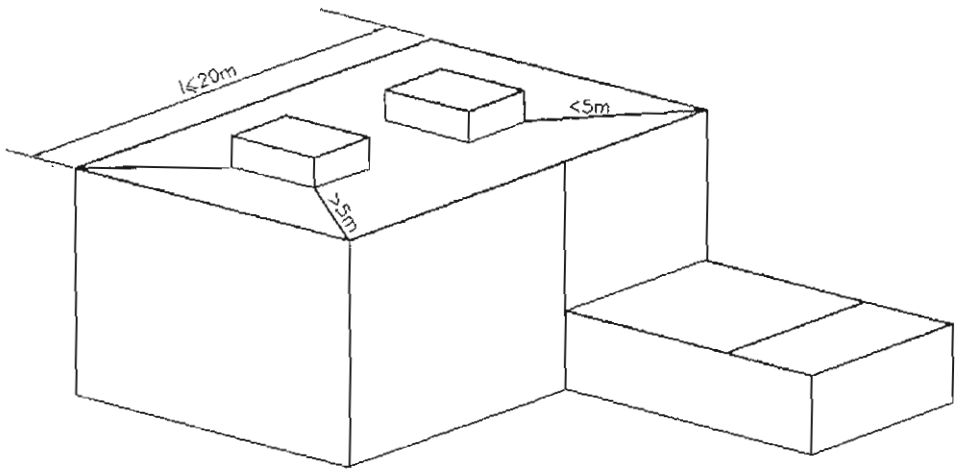


FIGURE 7

CONDITION FOR POSITIONING OF AIR TERMINAL CONDUCTORS ON THE ROOF RIDGES

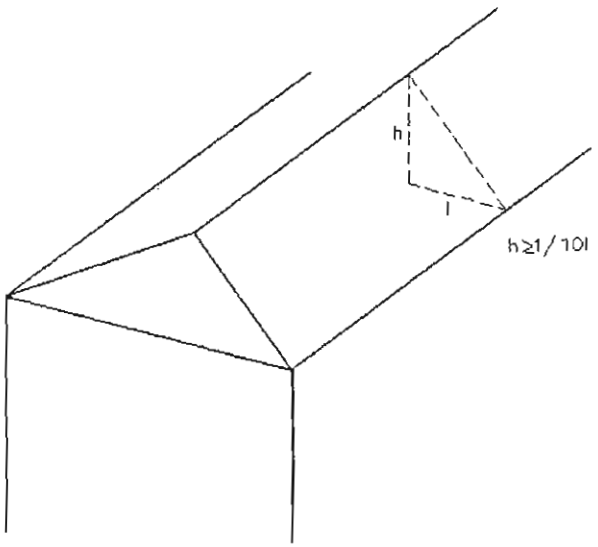


FIGURE 8

ROUTES FOR DOWN CONDUCTORS IN A BUILDING WITH CANTILEVERED UPPER FLOORS

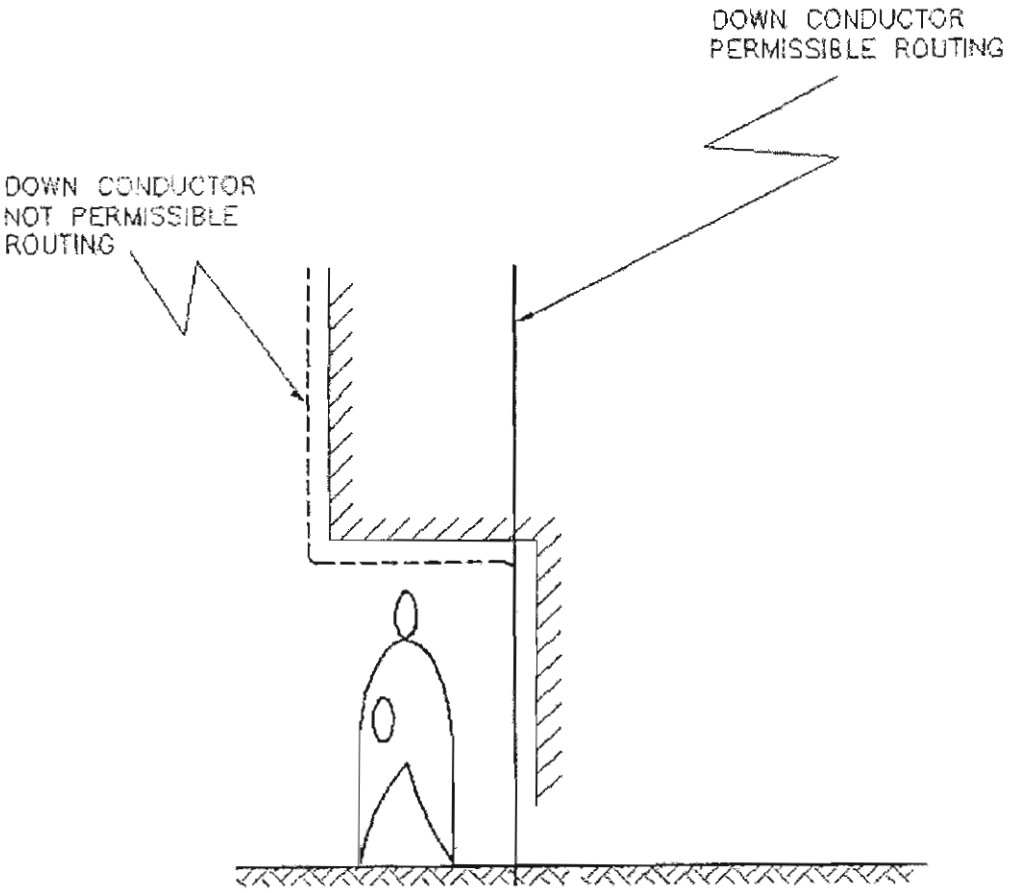


FIGURE 9

ELECTRICAL CONTINUITY BETWEEN THE STEEL STRUCTURE AND REINFORCED CONCRETE FOUNDATION

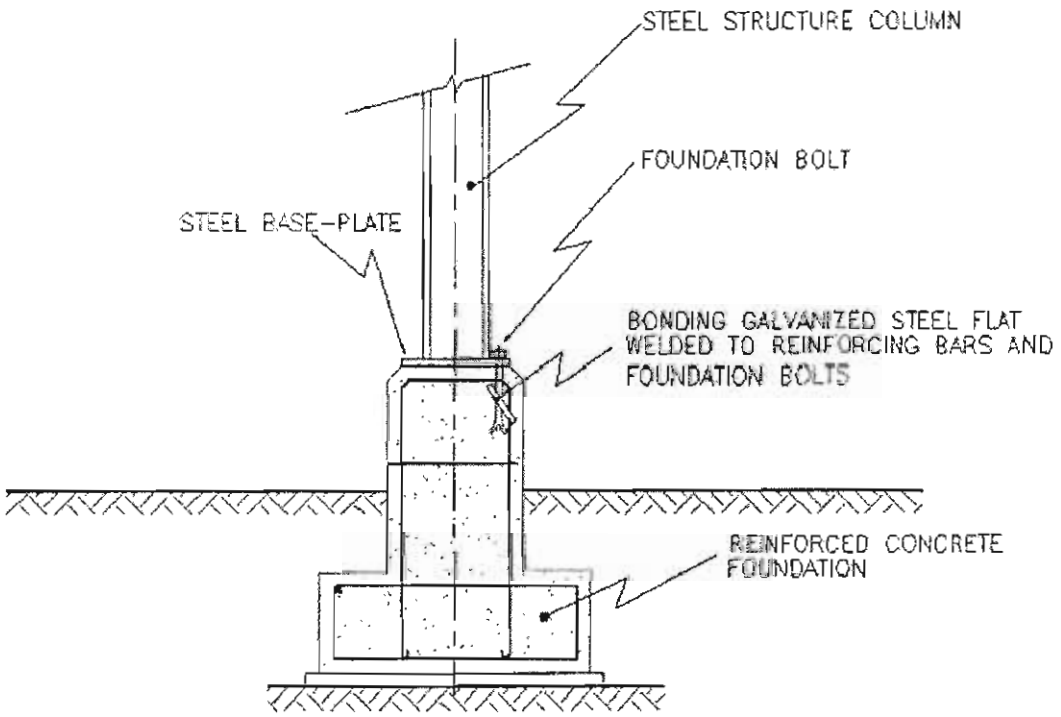


FIGURE 10

INCREASING OF THE ELECTRICAL CONTINUITY BETWEEN REINFORCED CONCRETE FOUNDATION AND SOIL : BONDING WITH OTHER EARTH ELECTRODE

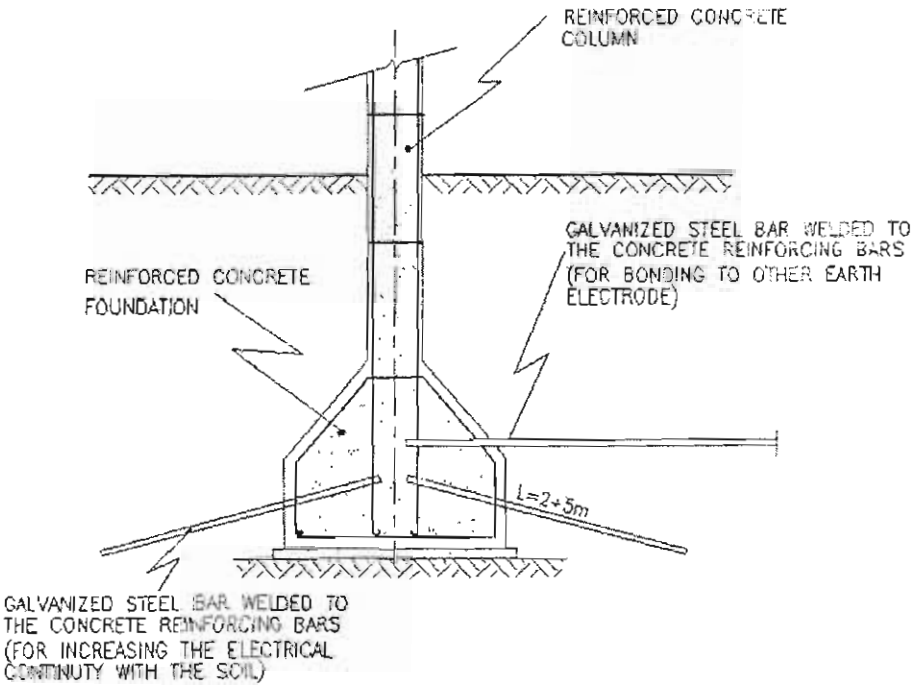
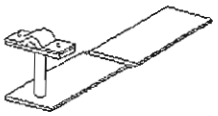


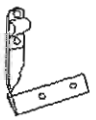
FIGURE 11

TYPICAL FASTENERS FOR AIR TERMINAL CONDUCTORS

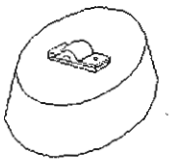
a)Air terminal rod



b)Round conductor parallel type bracket fastener



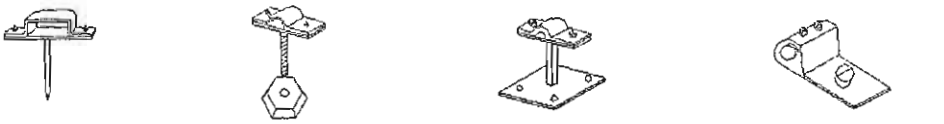
c)Round conductor perpendicular type bracket fastener



d)Round conductor rising stone fastener

FIGURE 12

TYPICAL FASTENERS FOR AIR TERMINALS AND DOWN CONDUCTORS



a)Flat conductor nail type

b)Round conductor bolted type fastener

c)Round conductor plate type fastener

d)Round conducto clamping type fastener

FIGURE 13

TYPICAL ACCESSORIES FOR AIR TERMINALS AND DOWN CONDUCTORS

a)Round conductor termination joint

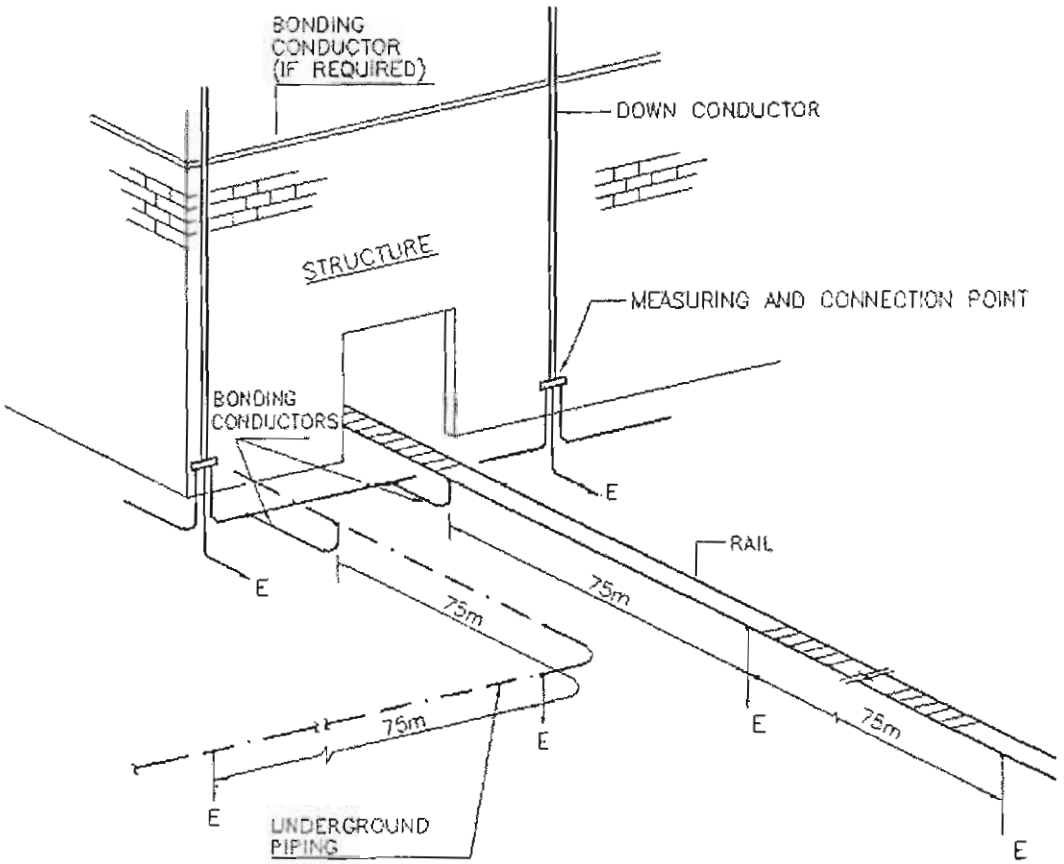
b)Round conductor crossing joint

c)Flat conductor crossing joint

d)Connecting lug for piping

FIGURE 14

BONDING OF METALLIC PARTS HAVING A LONG EXTENSION, ENTERING IN A STRUCTURE



E=CONNECTION TO EARTHING ELECTRODES