TRANSNET freight rail

A Division of Transnet Limited

TECHNOLOGY MANAGEMENT SPECIFICATION

INSTALLATION OF EARTHING AND LIGHTNING PROTECTION OF SIGNAL RELAY ROOMS AND SIGNAL EQUIPMENT ENCLOSURES

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1 Scope

1.1 This specification contains the requirements and procedure to be followed for the earthing and lightning protection of signal relay rooms and other metallic and non-metallic enclosures where electric and electronic equipment are housed.

1.2 The aim of earthing and lightning protection is to protect personnel against hazardous working conditions, and equipment against damage caused by lightning and voltages surges.

1.3 This specification replaces the following specification: CSE-1155-515 CAT N48, “Installation of Earthing”.

2 Normative documents (Refer to latest version applicable)

2.1 SANS 10142, “The wiring of premises”.

2.2 BBB-1616, “450 Volt gas arrestor spark gap for traction supplies“.

2.3 Spoornet Electrical Safety instructions

2.4 IEC 1024-1, “Protection of structures against lightning, Part1: General principles“.

2.5 IEC 61663-1, “Lightning protection – Telecommunication lines – Part 1: Fibre optic installations”.

2.6 IEC 61663-2, “Lightning protection – Telecommunication lines – Part 1: Lines using metallic conductors”.

2.7 IEC 61312-1, “Protection against lightning electromagnetic impulse – Part 1: General principles”.

2.8 IEC 61312-2, “Protection against lightning electromagnetic impulse (LEMP)”

2.9 IEC 61312-3, “Requirements for surge protection devices”.

2.10 CEE 0059.84, “Earthing and Bonding 3kV DC Electrification”.

2.11 CEE 0060.84, “Earthing and Bonding 25kV and 50 kV AC Electrification”

2.12 CEE WPOL40/1/1, “Earthing of electric light and power (EL&P) equipment associated with 3 kilovolt DC electric traction.”

2.13 Drawing CSE-Z-462 CAT.N28. Typical relay room earth layout.

2.14 Drawing CSE-1155-515 CAT.N28 sheet 1-4.

2.15 CSE Z148 (Signalling standard series).

2.16 CSE-1155-515 Cat N28, “Main cable earthing arrangement”.

2.17 CSE-1164-006 CAT X47, “Stranded, bare copper or PVC insulated, outdoor or indoor cable for earth connections”.

3 Referenced documents (Refer to latest version applicable)

3.1 Investigation report CSE-1123-038 CAT.E97. Investigation report on earthing of relay rooms.

3.2 Grounding and Bonding, Volume 2, by Michel Mardiguian. This reference forms part of a series: “A Handbook Series on Electromagnetic Interference and Compatibility”

4 Terms and definitions

Air termination system

That part of an external lightning protection system, which is intended to intercept lightning flashes.

Bonding conductor

A conductor used for the equalisation of potentials.

Bonding bar

A bar on which metal installations, extraneous conductive parts, electrical power and telecommunication lines, other cables and lightning protection systems can be bonded.

Bonding network

Network of conductors bonding the exposed conductive parts of a system.

Earth termination system

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

Earth electrode

A part or group of parts of the earth termination system, which provides direct electrical contact with and disperses the lightning current to the earth.

Equipotential bonding bar (EBB)

A bonding bar to which equipotential bonding conductors are connected.

External lightning protection system

This system consists of an air-termination system, a down-conductor system and an earth termination system.

Housing

Any enclosure that houses electric or electronic equipment.

Impulse current (I_{imp})

Current defined by a current peak value I_{peak} and the charge Q_s and tested according to the test sequence of the operating duty test.

Lightning protection system

The complete system used to protect a space against the effects of lightning. It consists of both external and internal protection systems.

Classification of zones (see Appendix Q):

LPZ 0_A

Zone where items are subject to direct lightning strokes, and therefore may have to carry up to the full lightning current. The unattenuated electromagnetic field occurs here.

LPZ 0_B

Zone where items are not subject to direct lightning strokes, but the un-attenuated electromagnetic field occurs.

LPZ 1

Zone where items are not subject to direct lightning strokes and where currents on all conductive parts within this zone are further reduced compared with zone 0_B. In this zone the electromagnetic field may also be attenuated depending on the screening measures. If further reduction of conducted currents and/or electromagnetic field is required, subsequent zones shall be introduced. The requirement for those zones shall be selected according to the required environmental zones of the system to be protected.

Maximum discharge current (I_{max})

Crest value of a current through the SPD (surge protection device) having a 8/20 wave shape and magnitude according to the test procedure for the class II and 10/350 wave shape for class I operating duty test.

Ring earth electrode

An earth electrode that forms a closed loop around the structure below or on the surface of the earth.

Rated voltage (maximum continuous operating voltage) U_C

Maximum r.m.s. or DC voltage which may be continuously applied to SPD's mode of protection.

Surge protection devices (SPD)

Devices that are intended to limit transient over voltages and divert surge currents.

TT system earthing

When the consumer's electrical installation is connected directly to earth, independent of the earthing of the source of energy.

Signal relay rooms and enclosures make use of the TT system earthing as described by SANS 10142. The specification describes the TT system as follows: "All exposed conductive parts of the consumer's installation are connected to a consumer's earth electrode which is electrically independent of the source earth. This system relies on a low-impedance earth both at the source transformer and at every consumer's installation."

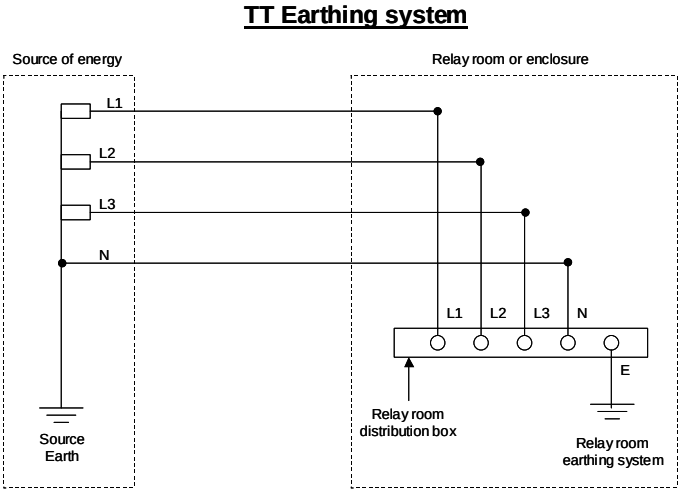


Figure 1: TT Earthing system

5 Earthing

5.1 General

5.1.1 The star-point of the transformer that supplies power to the relay room shall be earthed at the transformer as specified in **CEE WPOL40/1/1, "Earthing of electric light and power (EL&P) equipment associated with 3 kilovolt DC electric traction" for DC electrified areas and according to CEE 0060.84, "Earthing and Bonding 25kV and 50 kV AC Electrification"**, for AC electrified areas.

5.1.2 To prevent vandalism the earthing cable shall be installed into a galvanised pipe that is properly secured to the mast pole.

5.1.3 Connecting cables between the EBB and the earth termination system shall be installed in steel galvanized pipes / ducting or cemented in to prevent vandalism or theft.

5.1.4 For the purpose of earthing at signalling installations, a single integrated earth termination system shall be used (no separate earths).

5.1.5 This earth termination system shall be connected to an Equipotential Bonding Bar (EBB) (See section 6.2.2). The earth termination system shall be connected to the EBB. This point shall be where the earth cable from the surge protection, at the Distribution board, is connected to the EBB.

5.1.6 For lightning and voltage surge protection the armouring and earths of all cables entering the enclosure shall be connected to the EBB.

5.1.7 All incoming power cables shall be re-routed around the relay room or enclosure to the entering point that shall be at the E L & P distribution box. The E L & P distribution box shall be positioned inside the relay room or enclosure and not outside the building. The entering power cables shall not run underneath the floor of the enclosure to the E L & P distribution box.

5.1.8 Although a specific resistance to earth is not specified, the installer shall always strive to make the resistance to earth less than 10Ω.

5.1.9 All earth cables shall be as straight as possible. If bends are used, the radius shall be according to Table F.1 of SANS 10142 Part 1.

5.1.10 All earth connecting cables shall be as short as possible (no slack).

5.1.11 In the event of dissimilar metals, such as aluminium, which are used for lightning protection, the connection between the dissimilar metals shall be made above ground and all copper conductors shall be tinned, double riveted and rendered watertight.

5.2 Earth electrodes

5.2.1 Earth electrode shall never be in the same trench with other cables except with the approval from Technology Management.

5.2.2 One or a combination of the following earth electrodes shall be used to form an earth termination system:

- Vertical electrodes
- Trench electrodes
- Radial electrodes

5.2.3 Vertical earth electrode (Appendix A)

A vertical earth electrode is a Bimetallic copper/steel (copper cladded) rod that is driven vertically into the earth.

5.2.3.1 When multiple vertical earth electrodes are used in an earth termination system, refer to the sections on “Earth termination systems“ and “Bonding”.

5.2.3.2 Bimetallic copper/steel (copper cladded) rods shall be used as earth electrodes. The rods shall be constructed by a molten welded process resulting in the formation of a microscopic crystalline steel alloy between the two metals.

5.2.3.3 Electroplated rods shall not be used.

5.2.3.4 Every attempt shall be made to drive the vertical earth electrode to a minimum of 2m (preferably 4m) into the ground depending on the earth resistance.

5.2.3.5 Where mechanical hammers are used to drive the rods, a suitable adapter shall be used to ensure that the point of percussion is in a direct line with the central axis of the rod.

5.2.4 Trench earth electrode (Appendix B)

5.2.4.1 A trench earth electrode is a bare copper conductor that is laid in a horizontal trench.

5.2.4.2 Trench earth electrodes shall consist of a minimum of 50mm^2 bare copper cable and shall conform to specification CSE-1164- 006 CAT X47. The electrode is constructed as a closed loop (usually rectangular in shape) and the ends of the conductor shall be soldered, joined by a compression sleeve, exothermic welded or gas welded. The bonding cable connected to the electrode shall also be soldered, connected with a compression sleeve, exothermic welded or gas welded to the trench earth electrode.

5.2.4.3 The minimum depth at which the trench earth electrode shall be laid is 0,5m below normal ground level. The cable shall be surrounded by 0,05m of approved virgin soil. Thereafter normal backfill free of large stones may be used.

5.2.5 Radial earth electrode: (Appendix C)

5.2.5.1 A radial earth electrode is a bare copper conductor, which is laid horizontally in the earth and is connected to the earth termination system at one end.

5.2.5.2 If multiple radial earth electrodes are used, it shall be constructed as a radial earth termination system as explained in section 5.3.5. of this document.

5.2.5.3 The radial earth electrode shall consist of a minimum of 50mm^2 bare copper conductor laid in a horizontal trench. The minimum depth at which the radial earth electrode shall be laid is 0,5m below normal ground level. The cable shall be surrounded by 0,05m of approved virgin soil. Thereafter normal backfill free of large stones may be used.

5.2.5.4 The length of every radial electrode shall be more than 50m, but less than 80m.

5.3 Earth termination systems

The following earth termination systems can be used:

- Vertical earth electrode termination system
- Trench earth termination system
- Ring earth termination system
- Mat (mesh) earth termination system
- Radial earth termination system
- Combination earth termination system

5.3.1 Vertical earth electrode termination system (Appendix D)

5.3.1.1 A vertical earth termination system comprises of one or more vertical earth electrodes, a bonding cable and connecting cables.

5.3.1.2 Where the required earth resistance is not obtained, multiple vertical electrodes shall be used.

5.3.1.3 If multiple vertical electrodes are used, the distance between any two electrodes shall be greater than or equal to the driven depth of an electrode.

5.3.1.4 Multiple vertical electrodes shall be interconnected by horizontal connecting conductors not less than 0.5m below the surface. These conductors shall be 50mm^2 bare copper cable and shall conform to specification CSE-1164- 006 CAT X47. The cable shall be surrounded by 0,05m of approved virgin soil. Thereafter normal backfill free of large stones may be used.

5.3.1.5 All connections to the electrodes shall be made 0,5m under the ground surface.

5.3.1.6 A bonding cable shall be used to connect the vertical earth termination system to the EBB. See section 6.2.2 for bonding cable specification.

5.3.2 Trench earth termination system (Appendix E)

5.3.2.1 The trench earth termination system comprises of a trench earth electrode, vertical earth electrodes and a bonding cable.

5.3.2.2 If the desired earth resistance is not achieved, vertical earth electrodes can be added to the ends of the trench electrode.

5.3.2.3 The trench shall be at least 10m away from the centre of the closest railway track.

5.3.2.4 The length of the trench earth shall not be less than 50m, but not exceed 80m. The width of the trench shall be a minimum of 0.3 m.

5.3.2.5 The connection between the trench electrode and vertical electrodes shall be soldered, joined by a compression sleeve, exothermic welded or gas welded.

5.3.2.6 All connections to electrodes shall be made 0,5m under the ground surface using un-armoured insulated green and yellow 50mm^2 copper cable and shall conform to specification CSE-1164- 006 CAT X47. The size of the copper cable may be increased to overcome mechanical or corrosion problems.

5.3.2.7 A bonding cable shall be used to connect the trench earth termination system to the EBB. See section 6 of this document for a description of bonding.

5.3.3 Ring Earth termination system (Appendix F)

5.3.3.1 A ring earth termination system comprises of a trench earth electrode that forms a loop around the building or enclosure, vertical earth electrodes and a bonding cable.

5.3.3.2 Vertical earth electrodes shall form part of the ring earth termination system to decrease the resistance to earth. At least 4 vertical earth electrodes at relay rooms, 2 at apparatus rooms and 1 for apparatus cases shall be used.

5.3.3.3 Furthermore in the case of bigger buildings the distance between vertical rods shall not exceed 10 times the length of the vertical electrode.

5.3.3.4 The vertical earth electrodes shall be installed at the corners of the building or the enclosure and exothermic welded or gas welded to the ring earth termination system.

5.3.3.5 The trench electrode shall never be closer than 1m to any side or corner of the enclosure.

5.3.3.6 All connections at the ring earth termination system shall be made 0,5m below ground level.

5.3.3.7 At relay rooms there shall be at least 4 points where the ring earth termination system is connected to the equipotential bonding bar with bonding cables. The 4 connection points shall be evenly spread throughout the total length of the ring. For smaller enclosures less connections points may be used.

5.3.4 Mat (mesh) earth termination system (Appendix G)

5.3.4.1 A mat earth termination system comprises of a trench earth electrode (normally rectangular) with one or more horizontal cross conductors, vertical earth electrodes and a bonding conductor between the trench earth electrode and the EBB.

5.3.4.2 The size of the mat earth termination system may vary in size, but shall never be smaller than $8m^2$. Cross-bars that form the mat or mesh shall be exothermic welded or gas welded together and be 0.5m below ground level.

5.3.4.3 A vertical earth electrode shall be installed at every corner of the mat earth termination system. The length of the vertical earth electrode shall be at least 1m.

5.3.4.4 All connections at the mat earth termination system shall be made 0,5m below ground level. The connection shall be soldered, joined by a compression sleeve, exothermic welded or gas welded to the mat earth termination system.

5.3.4.5 A bonding cable shall be used to connect the mat (mesh) earth termination system to the EBB. See section 6 of this document for a description of bonding.

5.3.5 Radial earth termination system (Appendix H)

5.3.5.1 A radial earth termination system comprises of one or more radial earth electrodes, vertical electrodes and a bonding conductor.

5.3.5.2 The radial earth termination system shall consist of at least 5 radial earth electrodes for larger enclosures down to one radial electrode for apparatus cases.

5.3.5.3 The radial earth electrodes shall be combined at a central point. At the central point the ends of the conductors shall be soldered, joined by a compression sleeve, exothermic welded or gas welded together. The central point shall be 0.5m below ground level.

5.3.5.4 A vertical earth electrode shall be installed at the central point and at the far ends of the radial electrodes. The vertical earth electrode shall be at least 1m deep.

5.3.5.5 All connections at the radial earth termination system shall be made 0,5m below ground level. The connection shall be soldered, joined by a compression sleeve, exothermic welded or gas welded to the mat earth termination system.

5.3.5.6 A bonding cable shall be used to connect the radial earth termination system at the central point to the EBB. See section 6 of this document for a description of bonding.

5.3.6 Combination of earth termination systems (Appendix I)

A combination of the different earth electrodes can be used to form a combined earth termination system to lower the earth resistance. An example of a combination earth termination system can be seen in Appendix I.

5.4 Guideline to the type and position of the earth termination system used

5.4.1 At new installations and upgrading of earthing, ring earth termination systems shall always be used as a first option followed by a combination of termination systems.

5.4.2 If it is geographically not possible to install a ring earth termination system, a radial earth termination system shall be used.

5.4.3 Wherever other earth termination systems are used and the resistance to earth is low enough no changes need to be made. However when the earthing of an installation is upgraded sections 5.4.1. and 5.4.2 should be adhered to.

5.4.4 When the required resistance to earth is not met, every effort should be made to lower this resistance by adhering to section 5.3.6. It is important to note that a lower resistance to earth is achieved by increasing the contact area of the earth conductors to earth. It is thus better to spread out conductors over a bigger area such as explained in Appendix I rather than concentrating a large number of conductors in a small area.

5.4.5 The earth termination system shall always be as close as possible to the E L & P distribution box if any earth termination system is used other than a ring earth termination system.

5.4.6 If a ring earth termination system is used there shall be a bond from the ring earth electrode to the EBB at the position of the E L & P distribution box.

6 Bonding

The purpose of bonding is to reduce potential differences between metal parts and systems inside the volume to be protected against lightning and surges.

6.1 Bonding conductors

6.1.1 Bonding conductors shall be made of un-armoured insulated green and yellow 16mm^2 copper cable and shall conform to specification CSE-1164- 006 CAT X47.

6.1.2 Bonding conductors shall be terminated in appropriately sized lugs. An exception to this is bonding conductors used between the bonding bar and the earth termination system.

6.1.3 The end of the bonding cable between the EBB and the earth termination system shall be soldered, compress sleeved, exothermic welded or gas welded to the earth termination system while the other end shall be bolted to the EBB.

6.1.4 The connection between the EBB and the earth termination system shall be made 0,5m under the ground surface using un-armoured insulated green and yellow 50mm^2 copper cable and shall conform to specification CSE-1164- 006 CAT X47. The cable shall be surrounded by 0,05m of approved virgin soil. Thereafter normal backfill free of large stones may be used.

6.2 Bonding bars

6.2.1 General

6.2.1.1 Bonding bars shall be made of copper and shall have a minimum cross sectional area of 75 mm^2. Flat bar should be used instead of square or round bar. In areas where theft or vandalism is a problem galvanised mild steel can be used as an alternative for copper.

6.2.2 Equipotential bonding bar (EBB)

6.2.2.1 Every signal relay room or enclosure shall have an equipotential bonding bar (EBB) as shown in Appendix A to I. The equipotential bonding bar on new or upgraded systems shall be made of at least 25mm (75mm^2) galvanised mild steel angle iron. The EBB shall be bolted to the wall of the relay room or the sides of the enclosure.

6.2.2.2 All conductive parts (e.g. armouring, etc.), inside the signal relay room shall be bonded to the equipotential bonding bar via the shortest route. The colour of the insulation of the conductor used for wiring of the earth connections shall be green and yellow.

6.2.2.3 The equipotential bonding bar inside the signal relay room or enclosure shall be directly connected to the earth termination system (see section 6.1)

6.3 Internal bonding

6.3.1 Internal bonding can be described as the bonding used inside an enclosure.

6.3.2 Where shielded (armoured) cables from within the volume to be protected to external equipment are used, their shields (armours) shall be bonded at both ends in AC traction areas and in DC traction areas only one end of the shielded cable shall be bonded. The bonding shall always be done at the signal relay room end of the cable.

6.3.3 When the external conductive parts enter the signal relay room or enclosure at different locations, every entry location shall be connected to a bonding bar. See Appendix P for a description.

6.3.4 Where external conductive parts enter the signal relay room at one location all the conductive parts (e.g. armouring) shall be connected to a bonding bar and then to the EBB via the shortest possible route.

6.3.5 If the signal relay room is closer than 3m from the centre of the track in DC traction areas (Electrical Safety Instruction, par. 901.1.1), the signal relay room equipotential bonding bar (EBB) shall be bonded to the track via a surge arrestor spark gap. The surge arrestor spark gap shall conform to the requirements of Specification BBB-1616 Version 1. The bonding cables shall be 95mm^2 and conform to instruction CEE 0059.84, “Earthing and Bonding 3kV DC Electrification” and Engineering Instruction B028 Issue 1, “Replacement of traction return current copper bonds with steel equivalent”.

6.3.6 If the signal relay room is closer than 3m from the centre of the track in AC traction areas (Electrical Safety Instruction, par. 901.1.1), the signal relay room equipotential bonding bar (EBB) shall be connected directly to the track. The connection to the rail shall be made by approved methods such as exothermic-welding, gas welded or bolted to the rail. The bonding cables shall be 95mm^2 and conform to instruction CEE 0060.84, “Earthing and Bonding 25kV and 50 kV AC Electrification” and Engineering Instruction B028 Issue 1, “Replacement of traction return current copper bonds with steel equivalent”.

6.3.7 Although this is not required for signal relay rooms further than 3m from the track, it is desirable to bond the signal relay room at all times to the rail in AC traction areas and in DC areas via a surge arrestor spark gap.

6.4 External bonding

6.4.1 External bonding can be described as bonding that is used outside an enclosure.

6.4.2 All external bonding shall be via the shortest route.

6.4.3 If a connection point or points are available the ring earth electrode shall be connected to the reinforcing of the signal relay room by means of un-armoured green and yellow insulated copper cable of at least 50mm^2.

6.4.4 External conductive parts such as antenna mast poles, track side boxes and other termination points, shall be bonded in the appropriate way to the earth termination system.

7 Guideline for the earthing of specific enclosures and structures

The following types of enclosures are addressed in this section:

- Relay rooms
- Concrete enclosures (apparatus rooms) other than relay rooms
- Apparatus cases
- Metallic track side boxes
- Non-metallic track side boxes

7.1 General

7.1.1 Signal transformer cases housing equipment operating in excess of 150V shall be earthed. See page 75 of "Safety instructions: High Voltage Equipment 1992" as issued by the Chief Engineer (Electrical), Infrastructure, Spoornet (latest version applies). An earth value of less than 10Ω must be obtained.

7.1.2 Enclosures such as apparatus cases, potheads, hot box detector housings, etc. outside relay rooms next to the track, shall be earthed at ground level, NOT formation level.

7.1.3 Ducting (outside or in tunnels), trackside disconnection boxes, signal transformers, mounting posts and cases, which are used for housing equipment operating at less than 150 V shall not be deliberately earthed nor shall they be bonded to the return rail.

7.2 Relay rooms

7.2.1 Every relay room shall have an earth termination system. The earth termination system shall be as described in section 5.3 of this document.

7.2.2 Earthing of the framework in relay rooms

7.2.2.1 All framework sections of the relay racks or cabinet shall be connected together with an un-armoured insulated 16mm^2 copper cable and shall conform to specification CSE-1164- 006 CAT X47. Care should be taken that the connections between the sections of framework are continuous and at the same potential. See Figure 2.

7.2.2.2 Separate bonding cables shall be fitted from all relay racks and cabinets to the EBB for isolation and equipotential purposes. Both ends of the bonding cables shall be made off onto lugs and bolted to the framework or sections of the cabinets and the EBB. See appendix A. The cable from the EBB to the relay racks shall be installed in plastic conduit. The conduit shall run from the EBB to the specific rack or cabinet.

7.2.2.3 All cable trays shall be electrically isolated from the rack structures and separately connected to the equipotential bus bar by a removable earth bond.

7.2.2.4 Assembly of racks should be such that racks in the same row are permanently in good electrical contact with each other (Star washers, earth jumpers, pig tail connections, etc, etc.).

Interconnections on framework

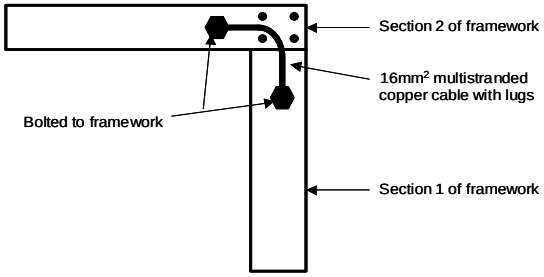


Figure 2 – Relay room racks

7.2.2.5 The sub-rack earth of any electronic/electrical equipment (PLC, Relay housings, Remote control, Axle counters etc.) shall be individually connected to its resident rack's metal structure.

7.2.2.6 The maximum resistance between the signal earth connection and any metal structure in the relay room not normally carrying current shall be less than 0.1Ω.

7.2.2.7 All earth connections shall have a minimum DC current carrying capability of 10 A.

7.2.3 Main cable earthing arrangement

Cable entry to relay rooms and apparatus cases

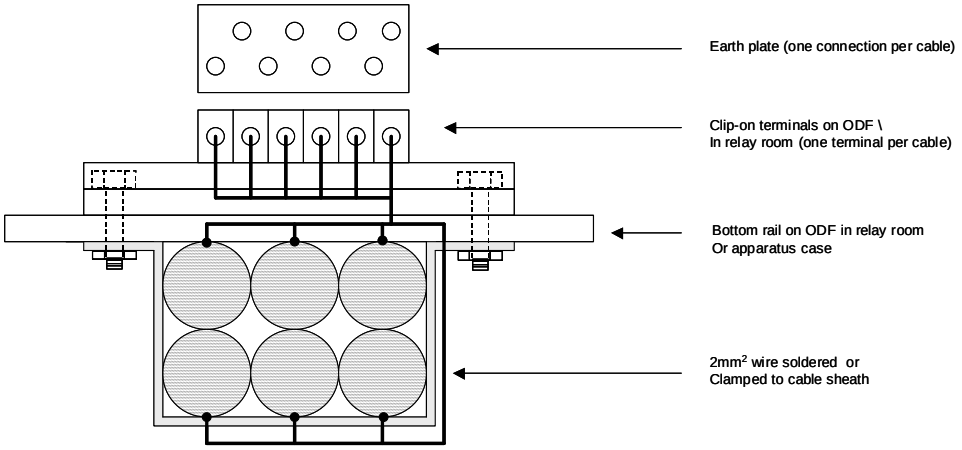


Figure 3 : Cable entry to relay rooms, apparatus cases and enclosures

The earthing arrangement of the main cables in a relay rooms shall be done as explained in CSE-1155-515 Cat. N28 sheet 4, “Main cable earthing arrangement”.

7.3 Concrete enclosures (apparatus rooms) other than relay rooms

7.3.1 Every concrete enclosure shall have an earth termination system. The earth termination system shall be as described in section 5.3 of this document.

7.3.2 An equipotential bonding bar (EBB) shall be installed inside the enclosure. The EBB shall be installed as described in section 6.2.2 of this document.

7.3.3 The re-enforcing of the concrete shall be connected to the equipotential bonding bar with an un-armoured insulated green and yellow 16mm^2 copper cable and shall conform to specification CSE-1164- 006 CAT X47. The bonding cable shall be bolted or welded to the reinforcing.

7.3.4 Any metal framework inside the concrete enclosure shall be connected to the equipotential bonding bar (EBB) with an un-armoured insulated green and yellow 16mm^2 copper cable and shall conform to specification CSE-1164- 006 CAT X47.

7.4 Metallic apparatus cases

7.4.1 Every apparatus case shall be earthed to a ring-, radial-, trench-,or a vertical earth termination system.

7.4.2 Any metal framework inside the apparatus case shall be bonded to the side of the apparatus case with a bonding cable that is made off into a lug and bolted to the side of the apparatus case. The bond shall be made up of an un-armoured insulated green and yellow 16mm^2 copper cable as described in specification CSE-1164-006 CAT X47.

7.4.3 A bonding cable shall be fitted from the earth of the 440v transformer to the framework of the apparatus. The bond shall be made up of an un-armoured insulated green and yellow 16mm^2 copper cable as described in specification CSE-1164-006 CAT X47. See Figure 4, 5 and 6 of this document.

7.4.4 The end of the bonding conductor between the earth termination system and the apparatus case, which is to be fixed to the apparatus, shall be compression crimped or soldered into a lug big enough to take all strands of the bonding cable. The lug shall be fixed to the framework inside the apparatus case with a bolt of non-corrosive material onto a clean metallic surface and sealed against corrosion.

7.4.5 Metallic apparatus case ring earth termination systems

7.4.5.1 Where possible the ring shall be constructed as shown in Figure 4. In all other case a vertical or trench earth electrode shall be used (Figure 5 and Figure 6).

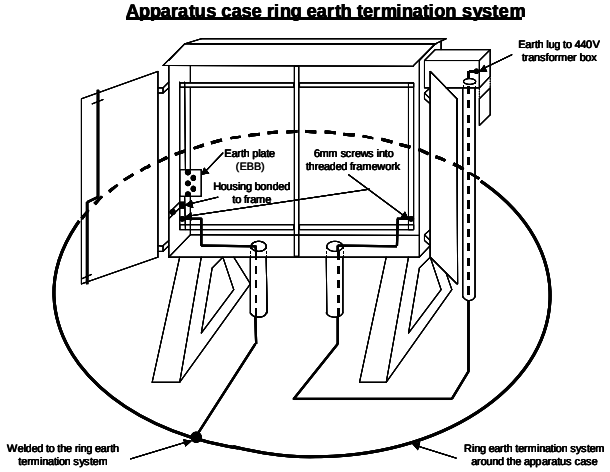


Figure 4 – Signal apparatus case ring earth termination system

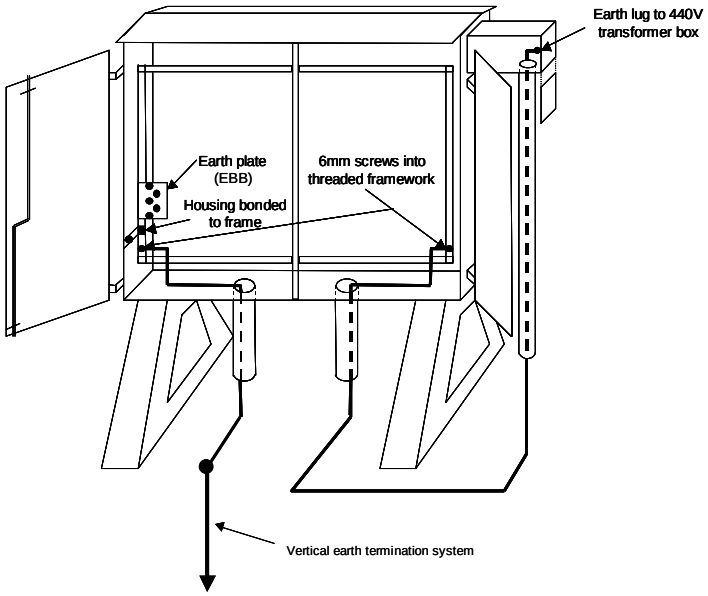


Figure 5 – Signal apparatus case vertical earth termination system

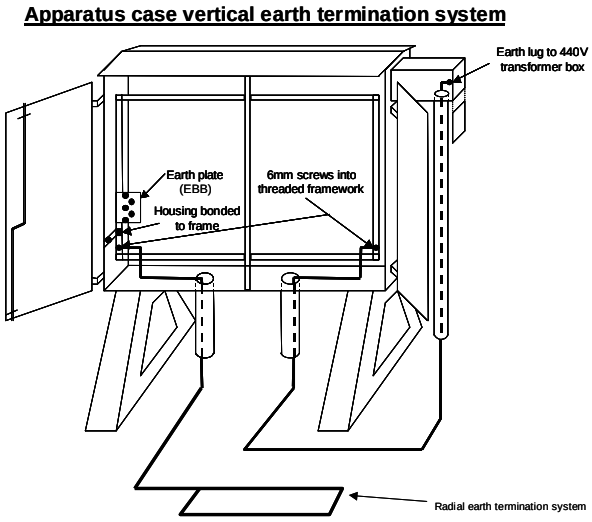


Figure 6 – Signal apparatus case trench earth termination system

7.5 Metallic trackside boxes

7.5.1 Every trackside box shall be earthed to a trench earth, a vertical earth or a ring earth termination system as described in section 5.3 of this document.

7.5.2 All metal framework inside the trackside box shall be connected to the trackside box with an un-armoured insulated green and yellow 16mm^2 copper cable as described in specification CSE-1164-006 CAT X47.

7.5.3 The end of the bonding conductor between the earth termination system and the metal track side box, which is to be fixed to the track side box, shall be compression crimped or soldered into a lug big enough to take all strands of the bonding cable. The lug shall be fixed to the side of the enclosure with a bolt of non-corrosive material onto a clean metallic surface and sealed against corrosion.

7.6 Non-Metallic trackside boxes / Apparatus cases

7.6.1 All non-metallic trackside boxes shall have an equipotential bonding bar (EBB). The EBB shall be constructed as described in section 6.2.2 of this document. In non-metallic enclosures the size of the EBB shall be at least 25mm x 3mm (75mm^2) galvanised mild steel angle iron. If copper is used for the EBB the cross sectional area of the EBB shall be at least 75mm^2.

7.6.2 Every EBB in the trackside box shall be earthed to a trench or a vertical earth termination system as described in section 5.3 of this document. In non metallic apparatus cases a ring earth termination system is preferable if possible.

7.6.3 Any metal framework inside the trackside box shall be connected to the EBB with an un-armoured insulated green and yellow 16mm^2 copper cable as described in specification CSE-1164-006 CAT X47.

7.6.4 The end of the bonding conductor between the earth termination system and the non-metal track side box, which is to be fixed to the EBB of the track side box, shall be compression crimped or soldered into a lug big enough to take all strands of the bonding cable. The lug shall be fixed to the EBB of the enclosure with a bolt of non-corrosive material onto a clean metallic surface and sealed against corrosion.

8 Lightning protection

8.1 General

8.1.1 All incoming and outgoing power cables crossing the boundaries of the relay room or enclosure shall be protected against lightning and voltage surges.

8.1.2 This specification covers lightning protection for the power supplied to the relay room or enclosure. All other cables to and from outside equipment shall have lightning protection, but will form part of the equipment documentation. However some recommendations are made in this regard.

8.1.3 All lightning protection shall be done according to SANS 10142 Part 1.

8.1.4 All lightning protection components must be SABS approved or if the product already has international approval from an accredited laboratory then

the National Regulator for Compulsory Specifications (NRCS) can issue a Regulatory Certificate of Compliance (RCC).

8.1.5 Lightning protection shall be done according to the lightning protection zone concept as explained in IEC 1312-1, Appendix L. (SANS 10142, Annex L)

8.1.6 Surge protection devices (SPD's) shall be chosen according to the requirements of the penetration point of the power and information networks. (SANS 10142, Annex L).

8.2 SPD performance requirements

8.2.1 The performance requirements of the individual SPD's shall be derived from the Lightning Protection Zone Concept (see Appendix P).

- Transition from (LPZ 0_A or LPZ 0_B) to LPZ 1
  Lightning strike characteristics to be used for the design of SPD's shall be equivalent to protection level I as defined in Table C1 of IEC 1312-1 and table L1 of SANS 10142 Annexe L
- Transition from LPZ 1 to LPZ 2
  At this interface Class II over voltage SPD's are required.

Note: If there is an external lightning protection system (e.g. electrical traction mast poles) LPZ 0_A and LPZ 0_B can be regarded as one zone with the requirement that Class I Lightning Current SPD's shall be used. Thus in the case of a signal relay room or any other enclosure within 3m of an electrified line, LPZ 0_B shall be assumed.

8.2.2 If surge protection devices (SPD's) with separate earth terminals are employed, a bonding bridge shall be employed to connect these earth terminals together.

8.2.3 The Surge Protection Device/s (Class I + Class II device) shall be installed next to the Electric Light and Power Distribution Box.

8.2.4 Incoming phase conductors to the Class I + Class II device and the outgoing phase conductors from the Class I + Class II device shall be separate and the earth conductor shall be directly connected via the shortest route to the EBB.

8.2.5 All earth connections from the SPD's shall be made of insulated green and yellow copper cable with a cross sectional area of at least $16mm^2$ and shall conform to specification CSE-1164- 006 CAT X47.

8.3 Incoming power

8.3.1 Lightning protection for incoming power shall be according to SANS 10142. These lines shall be regarded as entry from (LPZ 0_A or LPZ 0_B) to LPZ 1, which means that Class I + Class II lightning protection modules are required. Appendix J contains a graphical description of a lightning protection scheme for 3-phase power. Appendix K contains a graphical description of the preferred lightning protection scheme for 1-phase power. Alternative designs will be acceptable, but with the approval of Technology Management.

8.3.2 If used, the enclosure that houses inductors L1 to L4 (Appendix J) shall be installed next to the incoming distribution box. The cables connecting the inductors with the lightning protection modules shall be as short as possible.

8.3.3 Conductor phase-lines of the incoming electrical supply shall be separated from earth conductors connected to lightning protection devices. In cases where this is not possible, parallelism of these conductors shall be kept to a minimum. If the conductors do run parallel for lengths exceeding 0,2m, the conductors shall be mechanically secured (e.g. with cable ties or with cable saddles to the wall of the relay room or side of the enclosure).

8.3.4 In cases where the old type Class I protection modules is still in use, the L-Mov (Appendix J) shall be used for stage 2 protection. Where the new type Class I + Class II device is in use the L-MOV can be omitted, but if the L-MOV is already installed it shall be used with the Class I + Class II device and shall form part of the installation.

8.3.5 Where a L-MOV is used it shall be installed next to the lightning protection module at the Electric Light and Power Distribution Box.

8.4 Outgoing power

8.4.1 In cases where power is fed from inside the signal relay room or any other enclosure to outside equipment that falls outside the LPZ 0_B of the relay room or enclosure, lightning protection on these power lines shall be Class I + Class II. Appendix N contains a graphical description of the preferred lightning protection scheme. Alternative designs will be acceptable, but with the approval of Technology Management.

8.4.2 The 440 volt supply from the relay room to the apparatus cases shall be protected as explained in Appendix M.

8.5 Protection for installed electronic system components – Non power lines

8.5.1 Although lightning protection of installed equipment is the responsibility of the equipment supplier. The following minimum requirements for components of

these systems shall be adhere to:

8.5.1.1 Telephone lines

8.5.1.1.1 The incoming telephone line shall be protected against surges with a surge protection device that can withstand surges of up to 10kA (8/20). Technology Management approved devices must be used.

9 If a screened or armoured telecommunication cable is used, the screen shall be connected directly to the equipotential bonding bar at the point of entry to the signal relay room or any other enclosure. (Note, where the screen is not used as a conductor.)

9.1.1.1 Data lines

9.1.1.1.1 Incoming and outgoing data lines shall be protected against surge currents. Where shielded cables within the signal relay room or any other enclosure are used, their shields shall be bonded at both ends. Technology Management approved devices must be used.

9.1.1.2 Antennas

9.1.1.2.1 Antenna cables shall be protected against surge currents with a surge protection device that can withstand surges of up to 10kA (8/20). Technology Management approved devices must be used.

9.1.1.3 Fibre optic lines

9.1.1.3.1 The metallic elements of an optical fibre cable shall be continuous along the length of the cable. The metallic elements shall be connected to the equipotential bonding bar where the cable enters the signal relay room or enclosure.

9.1.1.4 Power fed to installed equipment

9.1.1.4.1 Lightning protection of other equipment inside or outside of the signal relay room or any other enclosure shall be the responsibility of the supplier of the equipment (only Technology Management approved products may be used). This specification only deals with the protection of the incoming power and equipment that is directly fed from the distribution box inside the

signal relay room or any other enclosure. The basic principles of this specification for the protection of equipment should however be used.

10 Documentation

10.1 The following as built plans, diagrams and documentation shall be completed for all signal relay room or any other enclosures that contain electronic, electrical or measurement equipment:

- A complete earthing diagram
- A complete lightning protection diagram
- A lightning protection component list

10.2 A copy of these as built plans, diagrams and documentation shall be kept on site inside the signal relay room or any other enclosure and a complete set of diagrams shall be kept at Documentation control.

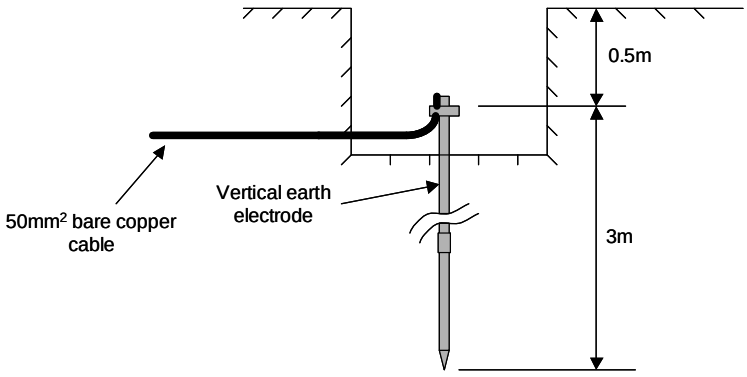
11 Quality assurance

11.1 Suppliers of all lightning protection equipment are required to submit proof of conformance to National and International specifications to Technology Management.

11.2 Transnet Freight Rail reserves the right to inspect the suppliers' premises for quality assurance purposes.

12 Appendix A – Installation o f a typical vertical earth electrode

Installation of a vertical earth electrode



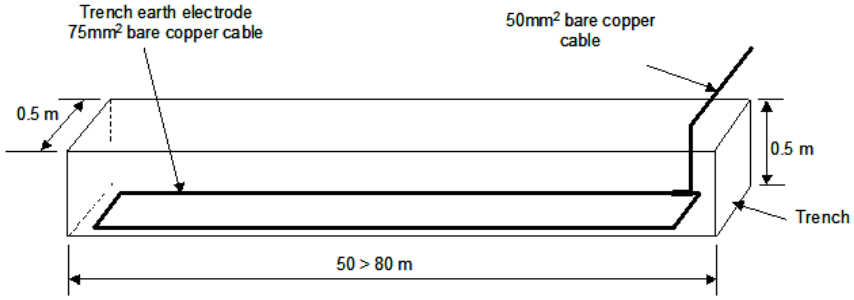
Notes:

1. The vertical earth electrode shall be at least 3m in length or multiples if 3m cannot be reached..
2. The vertical earth electrode shall be more than 10m away from the centre of the track.
3. All connections to the vertical earth electrode shall be made at least 0.5m below the ground level.
4. If multiple electrodes are used, the distance between the rods shall be greater or equal to the length of the rod.

Figure 7: Installation o f a typical vertical earth electrode

13 Appendix B – Installation of a typical trench earth electrode

Installation of a trench earth electrode



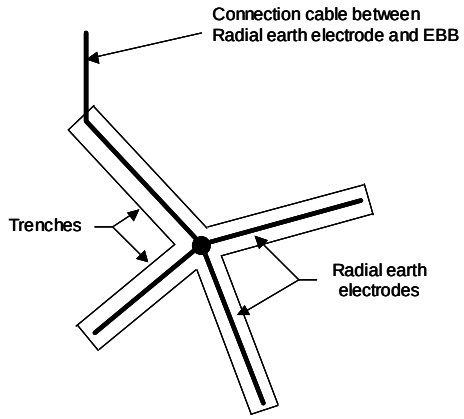
Note:

1. Total length of a ring earth must not be less than 50m, but not exceed 80m and must be at least 10m away from the center of the track in D.C. traction areas.
2. Ring earth shall be buried 0,5m deep and surrounded by 0,05m topsoil or other approved material.
3. The ring earth electrode shall be constructed of at least 75mm² bare copper cable.
4. The width of the ring earth shall be the width of the trench.
5. The width of the trench shall be at least 0.5m.

Figure 8: Installation of a typical trench earth electrode

14 Appendix C - Installation of a typical radial earth electrode

Installation of a radial earth electrode



Note:
1. The radial earth termination shall be constructed of at least system 75mm^2 bare copper cable.
2. Total length of a radial earth must not be less than 50m, but not exceed 80m and must be at least 10m away from the center of the track in D.C. traction areas.
3. The radial earth termination system shall be buried 0,5m deep and surrounded by 0,05m topsoil or other approved material.

Figure 9: Installation of a typical radial earth electrode

15 Appendix D - Installation of a typical vertical earth termination system

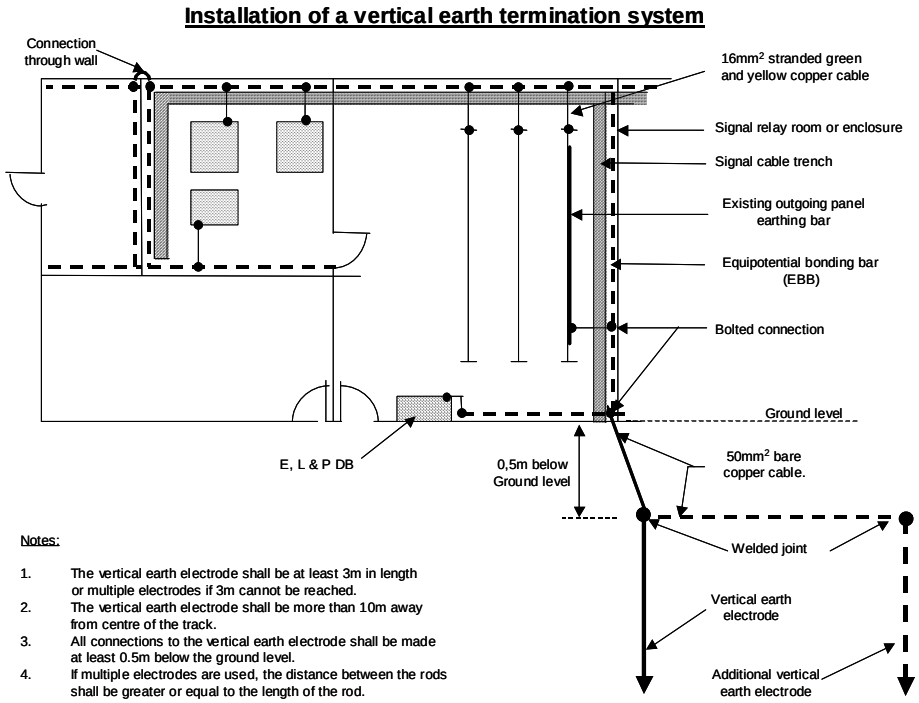


Figure 10: Installation of a typical vertical earth termination system

16 Appendix E - Installation of a typical trench earth termination system

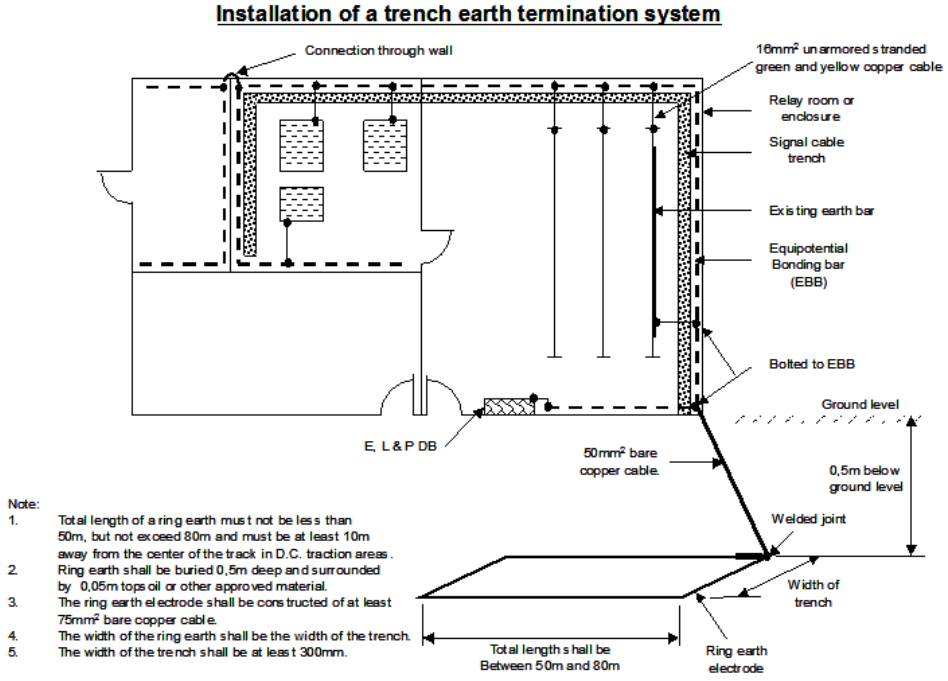


Figure 11: Installation of a typical trench earth termination system

17 Appendix F - Installation of a typical ring earth termination system

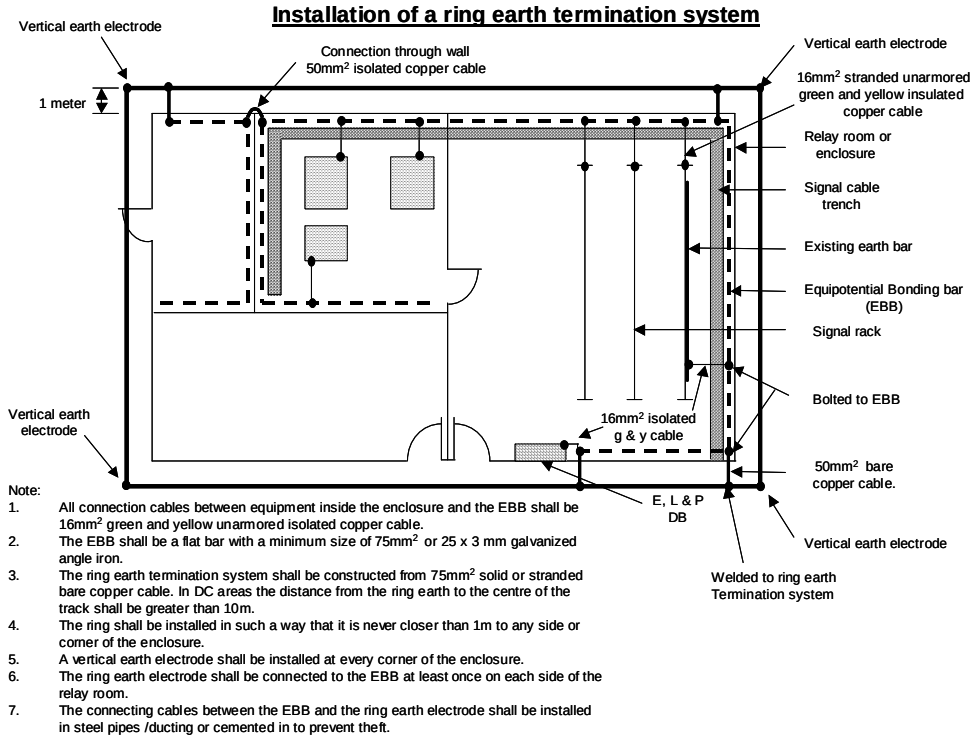


Figure 12: Installation of a typical ring earth termination system

18 Appendix G - Mat (mesh) earth termination system

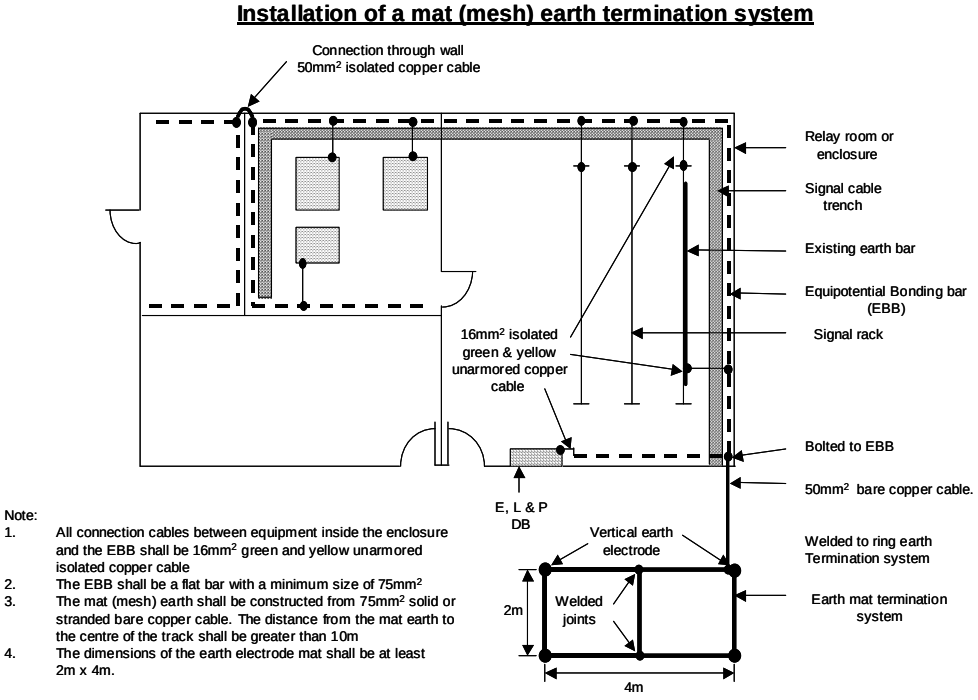


Figure 13: Mat (mesh) earth termination system

19 Appendix H - Radial earth termination system

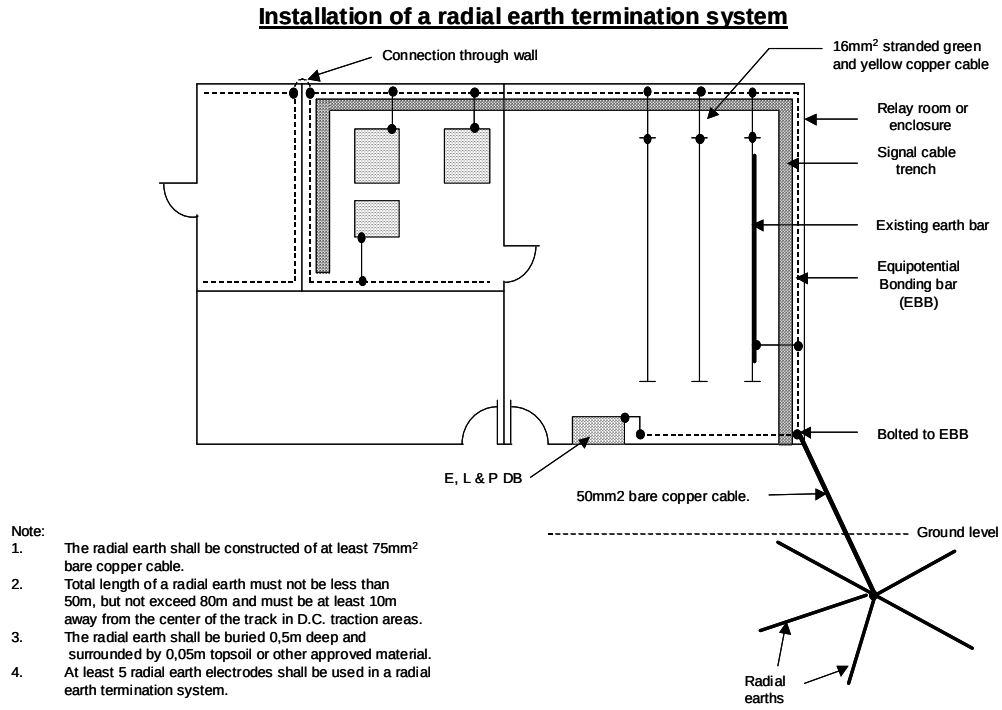


Figure 14: Radial earth termination system

20 Appendix I - Typical combination earth termination system

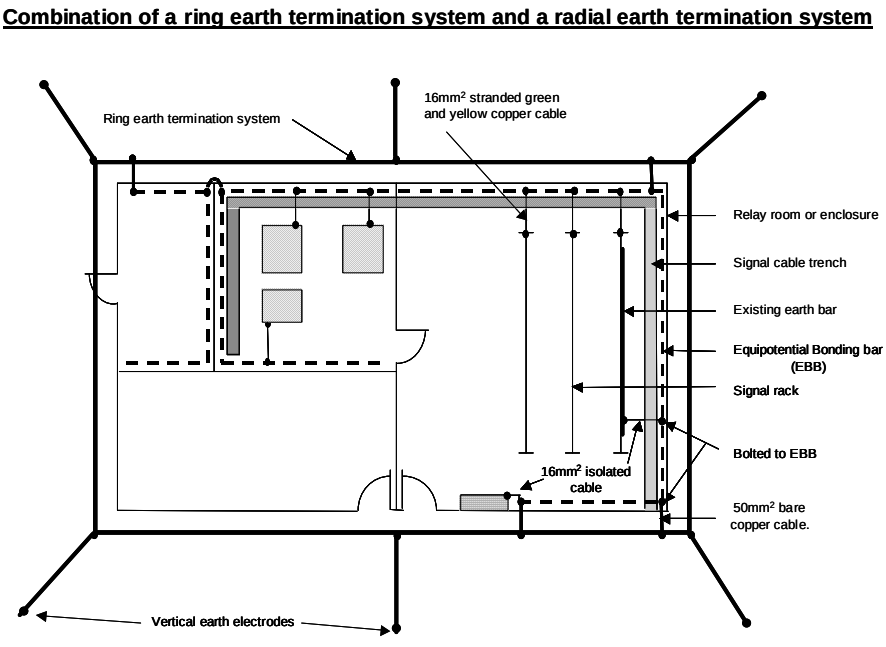


Figure 15: Typical combination earth termination system

21 Appendix J - Surge protection for incoming power (3-Phase)

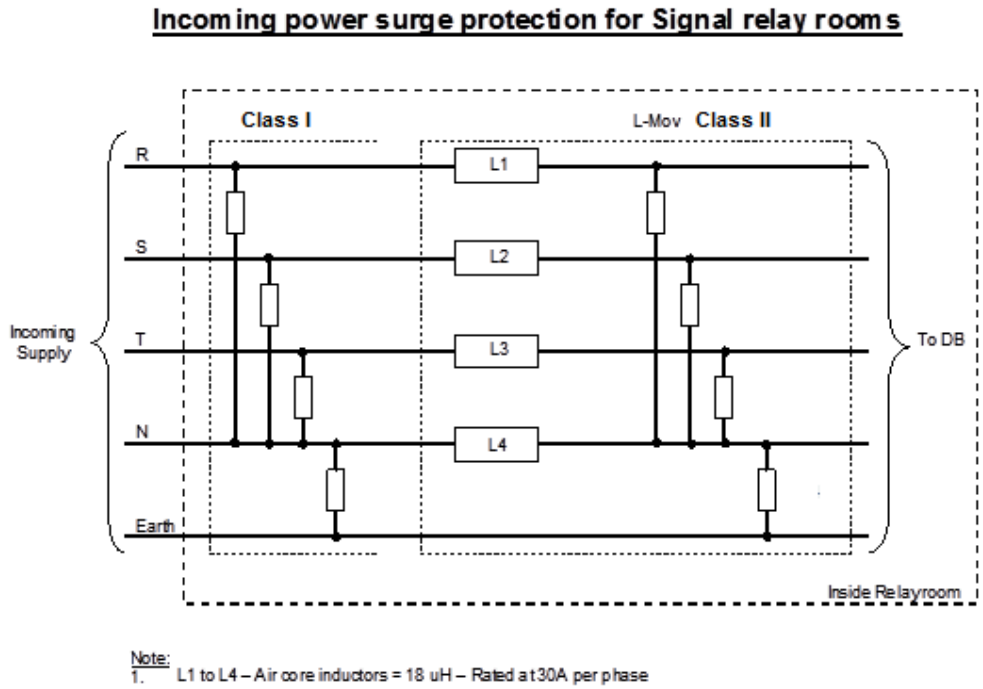


Figure 16: Surge protection for incoming power (3-Phase) using Class I and Class II devices

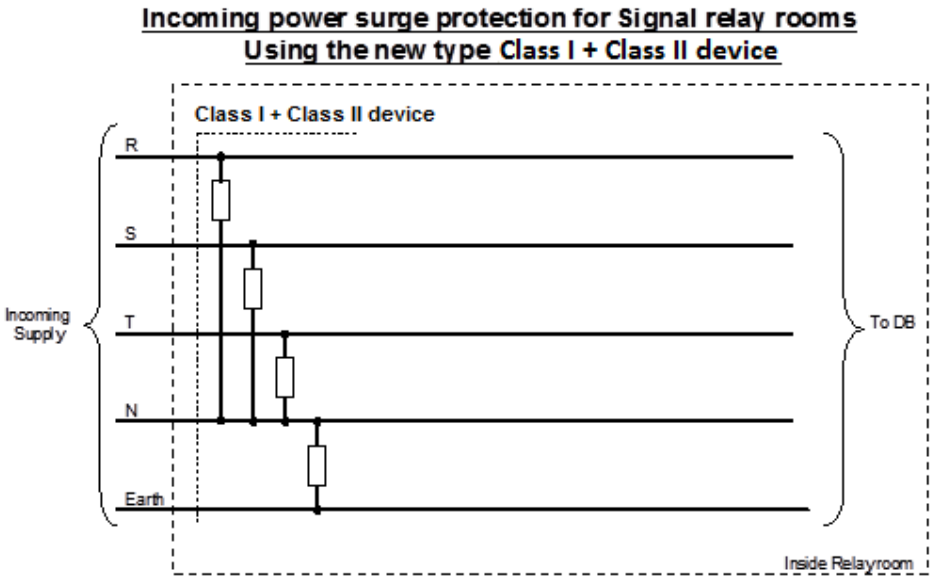


Figure 17: Surge protection for incoming power (3-Phase) using Class I + Class II device

22 Appendix K - Surge protection for incoming 220 volt power (1-Phase)

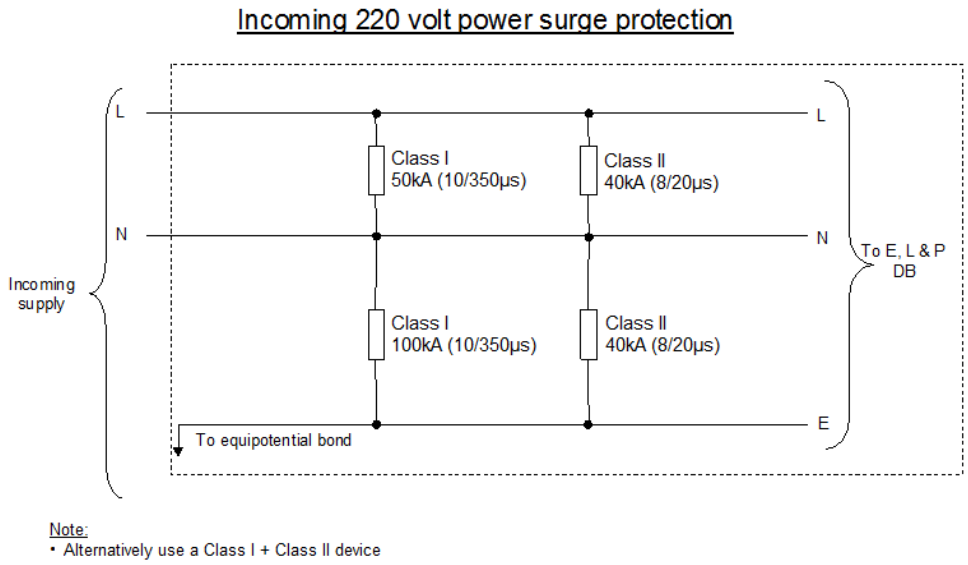


Figure 18: Surge protection for incoming 220 volt power (1-Phase)

23 Appendix L - Surge protection for outgoing power (220 &110 volt)

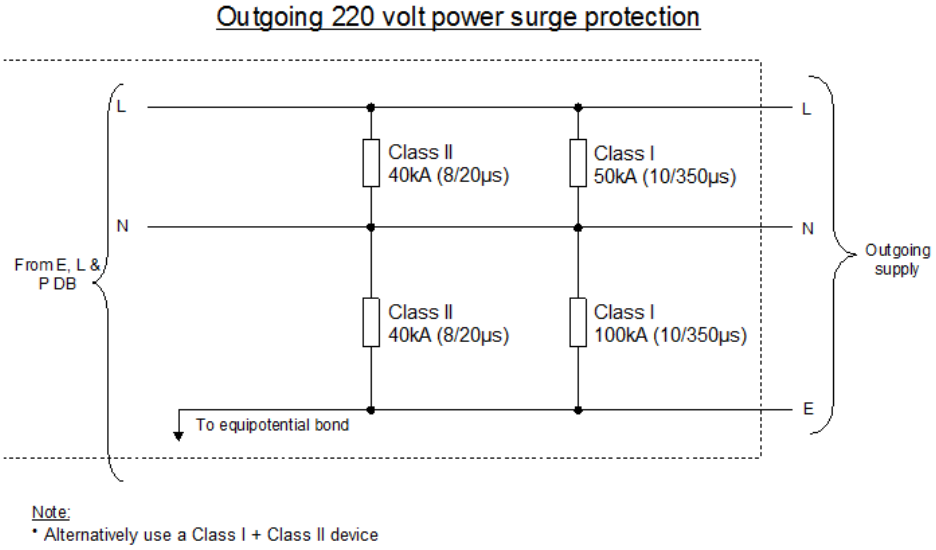


Figure 19: Surge protection for outgoing power (220 &110 volt)

24 Appendix M - Surge protection for outgoing 440 volt to apparatus cases

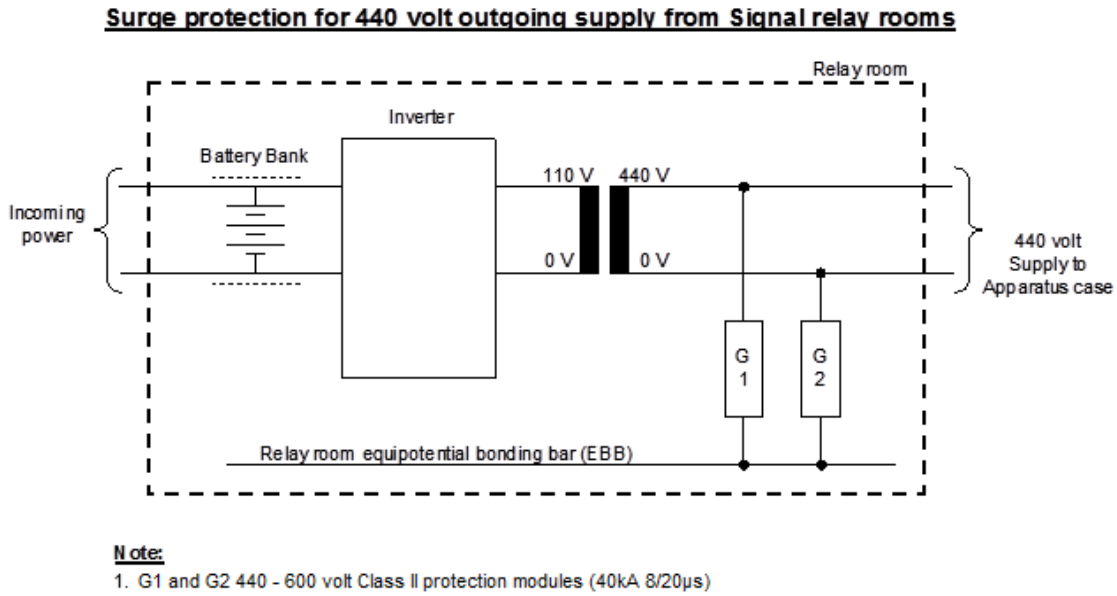


Figure 20: Surge protection for outgoing 440 volt to apparatus cases

25 Appendix N - Installation of Surge Protection Devices

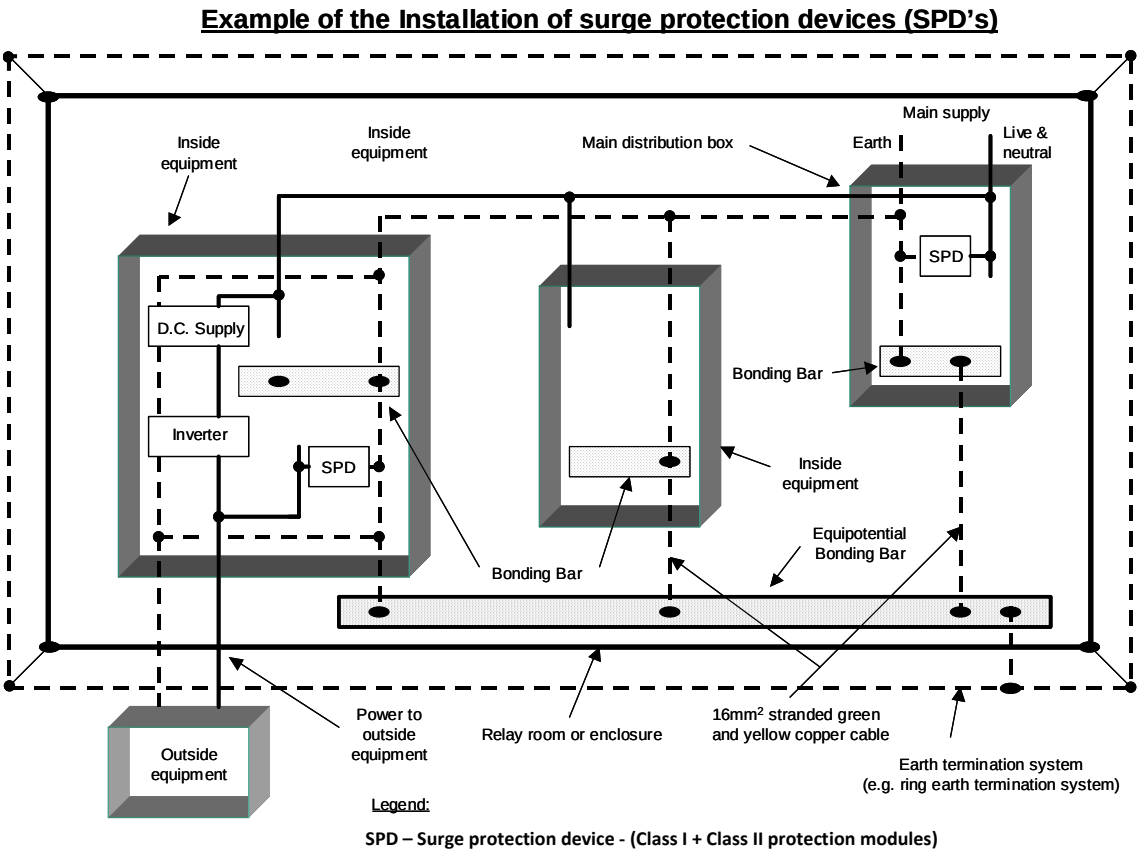


Figure 21: Installation of Surge Protection Devices.

Notes:

1. The bonding bar shall be located as close as possible to the SPD's. A Bonding Bridge that clamps directly into the SPD shall be used in preference to hard wiring. If hard wiring is to be used, the wire shall conform to specification CSE-1164- 006 CAT X47, and have a minimum size of 16mm^2.

2. The distance from the bonding bar to the earth equipotential bonding bar (EBB) terminal shall be via the shortest route and be as short as possible.

26 Appendix P - Multi point entry into the signal relay room / enclosure

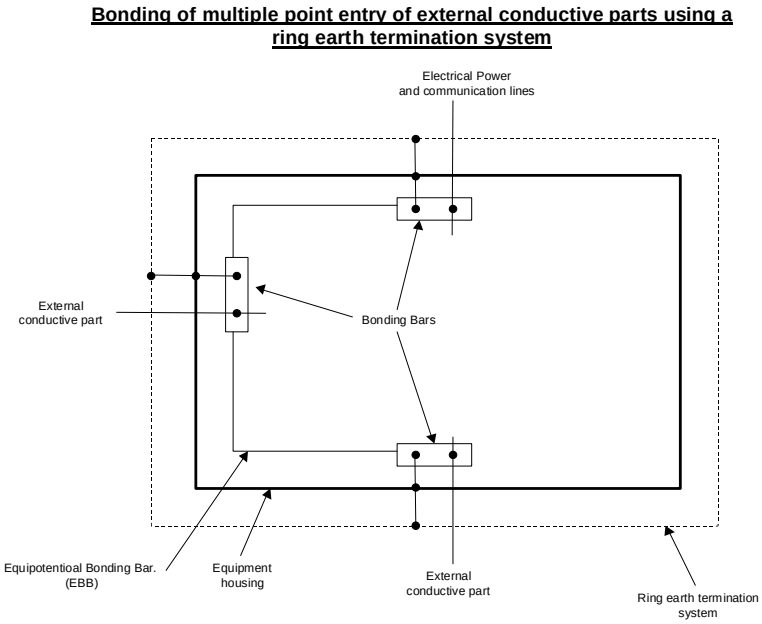


Figure 22: Multi point entry for conductive parts into the signal relay room or any other enclosure

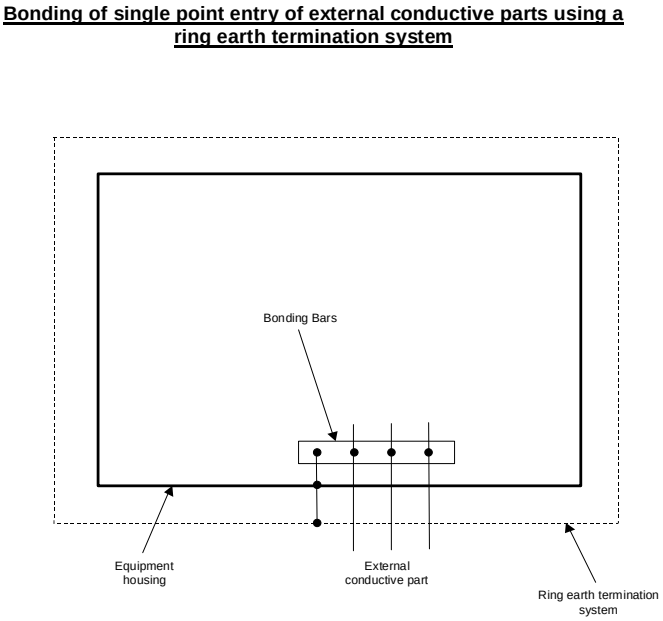


Figure 23: Single point entry for conductive parts into the signal relay room or any other enclosure

27 Appendix Q - Lightning protection zones (LPZ's)

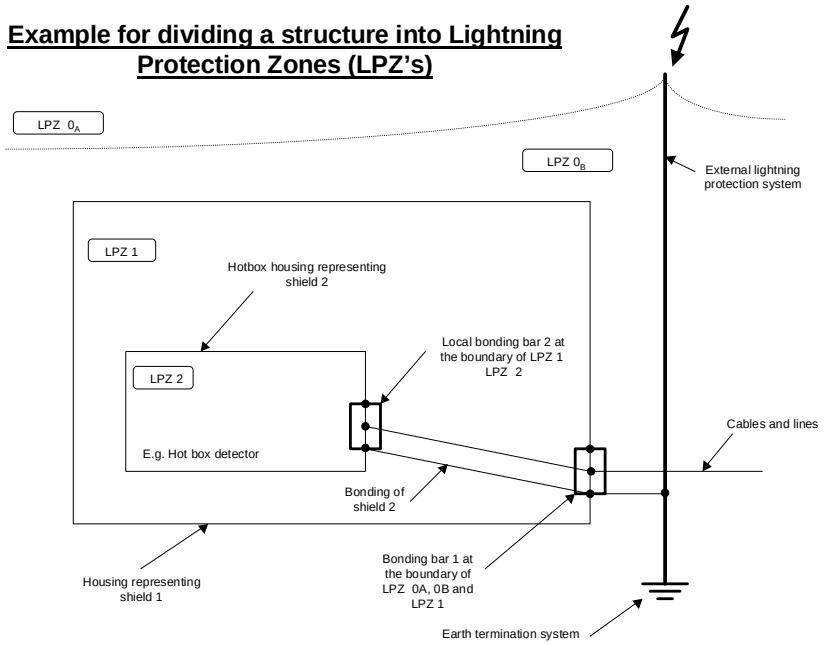


Figure 24: Lightning protection zones (LPZ's)