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>
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>
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Preface

This Standard was prepared by the Signalling Earthing and Surge Protection Development Group, overseen by the ARISO Train Control Systems Standing Committee.

This document has been updated from the previous version, including;

(a) restructuring of requirements and transfer of explanatory material to informative appendices;

(b) updated alignment with AS 1768:2021 and current surge protective device standards;

(c) expanded functional-safety and failure-mode requirements for surge protection;

(d) revised AC traction, DC traction and multiple-earth interface requirements;

(e) revised earth-electrode, conductor, corrosion and earth-resistance requirements; and

(f) revised inspection, monitoring and testing provisions.

Objective

The objective of this Standard is to specify lifecycle requirements for the design, installation, testing and commissioning of signalling earthing and surge protection systems in Australia.

The main purpose of the requirements are to:

(g) provide a uniform basis to address all identified hazards associated with lightning and electrical surges in railway signalling equipment and railway signalling telecommunications equipment;

(h) clearly and accurately describe each of the essential requirements (functions, design considerations and constraints, performance, maintainability, monitoring and safety) of signalling earthing and SPDs for railway application, and

(i) promote a consistent or uniform management of signalling earthing and surge protection methods across the Australian railway networks.

Compliance

There are four types of provisions contained within Australian Standards developed by ARISO:

(a) Requirements.

(b) Recommendations.

(c) Permissions.

(d) Constraints.

Requirements – it is mandatory to follow all requirements to claim full compliance with the Standard. Requirements are identified within the text by the term ‘shall’.

Recommendations – do not mention or exclude other possibilities but do offer the one that is preferred. Recommendations are identified within the text by the term ‘should’.

Recommendations recognize that there could be limitations to the universal application of the control, i.e. the identified control is not able to be applied, or other controls are more appropriate or better.

Permissions – conveys consent by providing an allowable option. Permissions are identified within the text by the term ‘may’.

Constraints – provided by an external source such as legislation. Constraints are identified within the text by the term ‘must’.

Using this Standard

Appendices in ARISO Standards may be designated either “normative” or “informative”. A "normative" appendix is an integral part of a Standard and compliance with it is a requirement, whereas an "informative" appendix is only for information and guidance.

ARISO Standards identify known hazards relevant to the railway industry. Appendix A provides a non-exhaustive list of hazards relevant to the scope of this Standard.

> Commentary *C Preface*
>
> This Standard includes a commentary on some of the clauses. The commentary directly follows the relevant clause, is designated by ‘C’ preceding the clause number and is printed in italics in a box. The commentary is for information and guidance and does not form part of the Standard.

Table of Contents

Tables and Figures

Section 1 Scope and general

1.1 Scope

This document provides a whole-of-life cycle approach to safe application of signalling earthing and surge protection systems in Australian rail networks.

This document is intended to be used for signalling equipment earthing and surge protection, and where telecommunications or utility equipment earths (MEN earths) interface with signalling earths (IT earths).

This document does not cover earthing and surge protection systems for rolling stock, traction power systems or general building lightning protections except where there are interfaces to signalling systems.

The lightning protection system described in this document is based on the requirements of AS 1768. This document builds on AS 1768 by providing the additional requirements for integration of lightning protection with the railway signalling system.

The following are covered under this document for signalling installations:

(a) Lightning surges.

(b) Traction surges.

(c) Power surges.

(d) Earth potential rise from power system faults and cloud-to-ground lightning flashes.

(e) Signalling earthing requirements.

(f) Coordination between earthing systems and traction systems.

(g) Earth and bonding within location.

(h) Protection within the electric traction drop zone.

(i) Adjacent power lines.

(j) Product and application requirements for surge protective devices and earthing components.

(k) Multiple earthing situations.

This document applies to cane, heritage and light rail where signalling systems are installed.

1.2 Normative references

The following documents are referred to in the text in such a way that *some* or all of their content constitutes requirements of this document:

- AS 1768:2021, *Lightning protection*
- AS 7664:2020, *Railway signalling cable routes, cable pits, and foundations*
- AS 7702:2023, *Rail Equipment Type Approval*
- AS 7703:2020, *Railway Signalling – Power Supply Systems*
- AS 7717:2026, *Signal Testing and Commissioning Management Standard*
- AS/CA S009:2020, *Installation requirements for customer cabling* (the Wiring Rules)
- AS/NZS 3000:2018, *Electrical installations* (known as the Australian/New Zealand Wiring Rules)

- IEC 61643-21:2025, *Low voltage surge protective devices - Part 21: Surge protective devices connected to telecommunications and signalling networks - Requirements and test methods*
- IEC 60364-1:2025, *Low-voltage Electrical Installations - Part 1: Fundamental principles, assessment of general characteristics, and definitions*
- IEC 60364-5-54:2011, *Low-voltage electrical installations - Part 5-54: Selection and erection of electrical equipment - Earthing arrangements and protective conductors*
- IEC 62561-1:2023, *Lightning Protection System Components (LPSC) - Part 1: Requirements for connection components*
- IEC 62561-3:2023, *Lightning Protection System Components (LPSC) - Part 3: Requirements for isolating spark gaps (ISG)*

NOTE:

Documents for informative purposes are listed in a Bibliography at the back of the Standard.

1.3 Defined terms and abbreviations

For the purposes of this document, the following terms and definitions apply:

1.3.1
AC
alternating current

1.3.2
AEB
arrestor earth bar

1.3.3
clean wiring
protected wiring
wiring downstream of surge or transient protection devices where surge energy has been limited and segregated from dirty wiring (1.3.5) to prevent surge coupling

1.3.4
differential earth clamp
device that electrically connects two earthing systems under transient overvoltage conditions but remains electrically disconnected under normal operating conditions

1.3.5
dirty wiring
wiring upstream of surge or transient protection devices, or wiring not subject to surge energy limitation, including external field interfaces and associated earth conductors, which is capable of carrying surge energy

1.3.6
drop zone
overhead line contact zone
zone whose limits, in general, are not exceeded by a broken overhead contact line

1.3.7
earth
conductive mass of the ground in electrical contact with earth electrodes, used for protective or functional earthing and surge protection, and whose electric potential may differ from that of reference earth under normal, fault or transient conditions

1.3.8
earth leakage detector (ELD)
instrument intended to detect a leakage current to earth

1.3.9
earth potential rise (EPR)
rise in voltage of an earthing system and the surrounding soil with respect to a distant earth

Note 1 to entry: EPR can be caused by the flow of power system fault current to earth at an HV installation such as an electrical substation, lightning flashes, HV transformer or, commonly, an HV pole with a conductive element to earth.

1.3.10
earth rod
conductive rod driven or buried in the ground and forming part of an earth electrode system for protective, functional or lightning-protection purposes

1.3.11
earthing
process of intentionally connecting a point of an electrical system or a conductive part to earth for protective or functional purposes

Note 1 to entry: Signalling circuits are insulated/isolated from earth and the presence of any earth fault on wiring is a definite danger to signalling circuitry and calls for protective measures to be taken.

1.3.12
earthing conductor
final connection to an earth electrode

1.3.13
earthing electrodes
earth rods
ground rods
radials
those portions of the earth termination that make direct low resistance electrical contact with the earth

1.3.14
earthing resistance
resistance of the signalling earth to the general mass of earth, as measured from a test point

1.3.15
ELD
earth leakage detector

1.3.16
EMI
electromagnetic interference

1.3.17
EPR
earth potential rise

1.3.18
equipotential bonding
electrical connections intended to bring exposed conductive parts or extraneous conductive parts to the same or approximately the same potential, but not intended to carry current in normal service

1.3.19
high voltage (HV)
voltage exceeding low voltage limits

1.3.20
hazardous state
state that has the potential to cause harm to persons, significant material damage or other unacceptable consequences

1.3.21
immunity level
maximum level of a given electromagnetic disturbance incident on a particular device, equipment or system which it remains capable of operating at a required degree of performance

1.3.22
isolated terra (IT)
electrical earthing system where the power source is completely isolated from the earth, or connected to it through a deliberately high impedance, and exposed conductive parts are earthed

1.3.23
low frequency induction (LFI)
generation of currents in a telecommunications line due to inductive coupling with a power line carrying large, unbalanced currents

Note 1 to entry: For example, during a fault condition on a HV power system.

1.3.24
low voltage (LV)
voltage exceeding 50 V AC or 120 V DC but not exceeding 1,000 V AC or 1,500 V DC

1.3.25
LPS
lightning protection system

1.3.26
MEBS
main equipotential bonding strip

1.3.27
MEN
multiple earthed neutral

1.3.28
network service provider
entity authorised to provide electricity to the traction system

1.3.29
port
specific interface of equipment through which electrical, electromagnetic, or surge disturbances can enter or leave the equipment

1.3.30
potential earth clamp
device used to limit the potential difference between two separate earths

1.3.31
protection earth
earth provided for lightning and surge protection purposes

1.3.32
Rail Infrastructure Manager (RIM)
As defined in Rail Safety National Law.

1.3.33
RAMS
reliability, availability, maintainability and safety

1.3.34
self-restoring
ability to either recover completely or in a degraded state its insulating properties after a disruptive discharge caused by the application of an overvoltage

1.3.35
SER
signalling equipment room

1.3.36
SPM
surge protection measures

1.3.37
surge
transient voltage wave propagating along a line or a circuit and characterized by a rapid increase followed by a slower decrease of the voltage

1.3.38
surge protective device (SPD)
device that protects electrical equipment from damage caused by sudden increases in voltage

1.3.39
telecommunications functional earth electrode (TFEE)
electrode that provides a connection to the general mass of earth for functional earthing of telecommunications equipment and cabling

1.3.40
test earth
auxiliary ground connection used to verify the integrity, resistance, function, and safety of a permanent electrical grounding system

1.3.41
touch potential
voltage between simultaneously accessible conductive parts, or between an accessible conductive part and the surface on which a person stands, during an earth fault or transient even

1.3.42
traction sub-station
fixed installation that converts and/or switches electrical energy for supply to an electric traction system

1.3.43
transient
brief surge in the current or voltage in a circuit during a time interval short compared with the time-scale of interest

General rail industry terms and definitions are maintained in the ARISO Glossary. Refer to: https://www.ariso.org.au/glossary/

Section 2 General

2.1 Principles

As signalling power systems are typically IT (unearthed) systems, where referenced standards assume MEN arrangements, these shall be modified or interpreted to ensure compatibility with IT systems in accordance with AS 7703:2020.

Signalling earthing and surge protection systems shall be managed across the lifecycle in accordance with the RIM's safety management system.

NOTE 1: Compliance with this document does not remove responsibility for compliance with any Federal or State safety related legislation including Work Health and Safety, Electrical Safety and Rail Safety National Law.

NOTE 2: See Appendix B for general guidance information.

2.2 Type approval

All signalling earthing and SPDs shall be type approved in accordance with AS 7702:2023 and RIM requirements.

SPDs shall be compliant with the following standards unless otherwise specified by the RIM:

(a) AS/NZS 61643.11:2025 for low-voltage SPDs; or

(b) IEC 61643-21:2025 for telecommunications and signalling SPDs.

The manufacturer of signalling earthing and SPDs shall provide the performance criteria for the product and any specific requirements for installation as part of the type approval process.

2.3 Design life

The signalling earthing and surge protection system shall have a design life compatible with the required life of the signalling system and a maintenance cycle acceptable to the RIM.

2.4 Modification of earthing and surge protection systems

The RIM shall put in place a process to ensure relevant stakeholders, who can affect signalling earthing and surge protection, are aware that they need to notify signalling engineers of any changes which have the potential to affect the integrity of the signalling earth or the signalling equipment surge protection.

When notified of a proposed disturbance, the RIM shall assess the risk, define pre-work baseline tests and require post-work tests demonstrating that the earthing and surge protection integrity has not been degraded.

The integrity of the signalling earthing and surge protection equipment shall be assessed prior to carrying out any modification to the existing location that could affect the earthing and surge protection system.

Section 3 Design and development

3.1 General requirements

Inputs to the design shall be identified and documented, from which signalling earthing and surge protection design requirements can be derived.

Step, touch and transferred-potential hazards shall be assessed wherever persons can access conductive parts.

Permissible voltages and exposure durations shall comply with the applicable electrical-safety requirements for the hazard source.

NOTE: See Appendix C for general guidance information.

3.2 Interface co-ordination

An interface co-ordination plan with relevant stakeholders shall be developed to ensure the minimal interference by construction works to existing earthing and surge protection systems.

Co-ordination between disciplines shall be established to enable identification of adjacent conductive structures and any potential impacts on propagation of surges from the source over long distances to trackside signalling equipment.

RIMs shall assess all conductive structures and sources of electrical energy for their potential electrical effect on signalling systems in order to mitigate such effects.

Identified risks shall be referred back to the designer for resolution.

3.3 Installation design

Minimum safe separation distances shall be in accordance with Clause 4.2.3 of this document.

The installation design shall apply construction practices so that the effect of lightning electromagnetic impulses is controlled sufficiently to meet the RAMS requirements for the installation.

3.4 Functional safety

3.4.1 Failure modes and effects

The earthing and surge protection design, and SPD selection, shall identify, assess and control failure modes and effects of earthing and surge protection to assure that the functional safety of the system is protected.

3.4.2 Signalling systems

Surge protection measures shall be designed and implemented such that they do not adversely affect the fail-safe behaviour or functional safety of the signalling system under normal, fault or surge conditions.

NOTE: The inherent fail-safe principle should be used for the SPD so that when the SPD is used it does not compromise meeting the functional safety requirements of the protected function.

3.4.3 Signalling power supplies

Signalling AC supplies intended to operate as unearthed systems shall not have the output conductors intentionally connected to earth.

Signalling DC supplies intended to operate as unearthed systems shall have neither the positive nor the negative output conductor intentionally connected to earth.

3.5 Cables and wires

All earth wires shall be individually identified in the design.

All earth wires shall be clearly identifiable through colour coding, tagging or other methods in accordance with RIM specifications.

All earth wires to the protective earth shall be labelled as per design and in accordance with RIM specifications.

Cables shall not have joints unless justified, approved by the RIM, and controlled as part of the design.

3.6 Surge protection

3.6.1 General requirements

The signalling system design shall integrate surge protection measures identified by the design risk assessment to achieve the RAMS requirements for the expected life of the railway signalling system.

The design detail shall include sufficient information to communicate the correct construction and installation requirements of the surge protection measures to achieve the design performance.

3.6.2 Alignment with AS 1768

The surge protection system and surge protection measures shall be designed in accordance with AS 1768:2021.

Signalling site structures and property shall be protected against lightning strikes, using one of the two approaches in AS 1768:2021, namely no avoidable risk or assessment and management of risk.

The AS 1768:2021 no avoidable risk approach shall be applied for the protection of persons and equipment by application of the requirements defined in this document.

As railway signalling system safety is outside the scope of AS 1768, two additional risk areas shall be assessed and controls implemented:

(a) Lightning or surge damage causing a hazardous signalling state; and

(b) An SPD fault or failure adversely affecting the safety function.

The earthing arrangements in Clause 3.7 of this document shall take precedence over the AS 1768 requirements and recommendations for fences within or at the boundary of the rail corridor.

3.6.3 Protection

The required level of protection for people and equipment shall be assessed and documented.

The level of protection provided in the design shall limit touch, step and transferred potentials to safe values.

Protection shall provide equipment immunity commensurate with the expected surges and transients.

3.6.4 Surge protection measures

3.6.4.1 General requirements

SPM used as part of a railway signalling system shall meet the safety requirements detailed in Clause 3.4.

The SPM design shall protect persons from hazards due to EPR, LFI and electrostatic coupling, so far as is reasonably practicable.

The SPM shall be designed to protect the equipment (including SPDs) from damage due to EPR hazard zones, LFI and electrostatic coupling.

NOTE: The design of the SPM should apply the detailed concepts and arrangements provided in IEC 62305-4.

3.6.4.2 Co-ordinated surge protection measures

Co-ordinated SPM shall be provided to protect each applicable equipment port exposed to surge hazards to meet RAMS requirements.

The coordinated SPM shall limit the voltage at each protected equipment port, including SPD protection level and connection-lead voltage, to below the verified equipment immunity level with the design margin specified by the RIM.

3.6.4.3 Impulse voltages

Terminals, wiring, cables and miscellaneous items shall be selected to withstand the expected impulse voltage due to a lightning flash when used for the proposed application.

NOTE 1: Cables in external cable routes can be exposed to a lightning flash that exceeds their rated impulse voltage. In this case, these cables should be protected by either metallic shielding or supplementary insulation.

NOTE 2: Rated impulse voltages are defined for a range of pollution environments by IEC 60664-1 and IEC 62497-1. The rated impulse voltage should at least meet IEC 60664-1 category II in PD2 or IEC 62497-1 OV2 in PD3.

3.6.4.4 Errors and failure modes

The SPM shall identify and control human-error risks associated with installation and maintenance.

Failure modes, including open-circuit, short-circuit, resistive/high-leakage and cross-circuit faults for line-line, line-earth and input-output paths, including thermal runaway, disconnector operation and loss of indication, shall be assessed.

3.6.4.5 Trackside equipment locations

SPM for equipment shall comply with AS 1768:2021 to protect against:

(a) lightning flashes to the associated lightning protection level class;

(b) electrical traction related surges;

(c) 50 Hz EPR events; and

(d) LFI that could occur at the site.

The requirements of AS 1768:2021 shall be applicable to all externally installed signalling equipment and enclosures.

3.6.5 Surge protection device selection

SPD selection shall be based on assessment of the following:

(e) The safety and functional-safety requirements of the application in accordance with Clause 3.4 and Clause 3.7.

(f) The required lightning protection level, expected surge voltage and current and applicable EPR and LFI exposure, based on an assessment of site requirements.

(g) The equipment-port immunity level, acceptable let-through voltage, protection margin, SPD voltage-protection level and discharge-current rating.

(h) The protected circuit voltage, current, frequency, capacitance, insertion loss and voltage-drop requirements.

(i) Co-ordination with other SPDs and with any required disconnector, backup overcurrent protection or circuit-protection device.

(j) For AC IT power systems, the cumulative SPD capacitance and capacitance imbalance to earth shall be assessed to ensure that touch current, insulation monitoring, earth-fault detection and signalling functional safety are not adversely affected.

(k) For power SPDs, the prospective short-circuit current and the SPD short-circuit rating.

(l) Temporary overvoltage (TOV) performance for power SPDs.

(m) Follow-current interruption capability, where applicable.

(n) Provision of failure indication where loss of protection would not otherwise be self-revealing.

(o) Suitability for the environmental conditions, installation arrangement, design life and maintenance regime.

(p) Evidence that the selected SPD satisfies the equipment-port constraints when exposed to the assessed surge and fault conditions.

The SPD shall function in an impedance-neutral way in parallel with signal lines without drawing operational energy or interfering with signal status.

The SPD shall be designed to indicate failures so far as reasonably practicable.

The proposed SPD shall be assessed to satisfy the equipment port constraints defined in Clause 3.6.5(c) when exposed to the induced voltages and currents determined in Clause 3.6.5(b).

The proposed SPD shall be assessed to ensure the devices failure modes do not adversely affect any interface operational expectations or application safety requirements.

SPD capacitance to earth for AC IT arrangements shall be less than 10 ηF for each leg of the supply with no more than 50% variance between each leg. If more than ten (10) SPDs are to be used on the one ac power supply, then the electrical safety of the power supply shall be assessed for touch potential hazards.

NOTE 1: For all SPDs, 50 Hz EPR immunity rating should at least meet IEC 61643-21 AC durability test using the 20 A with 1 s duration and five (5) applications.

NOTE 2: The SPD should conform to the standardized terminal numbering of SPDs detailed in IEC 61643.

3.7 Earthing arrangement

3.7.1 General requirements

Different earthing arrangements within a location shall be either co-ordinated or effectively independent of each other and designed to limit impacts under fault conditions.

Independent earth systems shall be arranged so that a person is unable to contact conductive parts from each earth system at the same time without removal of protective provisions.

3.7.2 Functional earthing

Effectively independent earth systems shall manage potential for unintended connections between two earthing systems due to installation and earth bonding of equipment.

NOTE: Further information on achieving independent earthing systems is provided in Appendix C.7.9.

Functional earthing for surge protection purposes shall comply with AS 1768:2021 unless otherwise specified in this document.

The earthing arrangement provided for floating signalling power supplies shall comply with earthing for IT power distribution systems as defined in AS 7703:2020.

50Hz EPR shall be managed to ensure:

(a) protection of persons from hazardous touch and step voltages; and

(b) no adverse impact on the functional safety or operation of signalling systems.

3.7.3 Bonds

Each equipment earthing terminal shall be bonded to the applicable earthing system.

Earthing and bonding arrangements for structures and buildings shall be co-ordinated with the responsible party.

The following wiring shall have a low impedance:

(a) From the earth bar.

(b) On a rack.

(c) To an earth rod or from the earth terminal on a piece of equipment.

(d) To the earth bar.

To achieve a low impedance earth wiring shall, as a minimum:

(e) be as short and direct as possible;

(f) have no bends with a tighter radius than specified by the manufacturer;

(g) have no loops or coils of wire; and

(h) have no excess wire.

3.7.4 AC traction railway earthing arrangement

3.7.4.1 General requirements

All metal structures shall be bonded to either the traction return or to the traction earth system, depending on its proximity to the running rail, traction feeder station, or traction sub-station, unless assessed as not required by RIM.

Metallic signal structures, enclosures or buildings shall be bonded to the traction earthing system unless assessed as not required by RIM.

Equipment enclosures containing equipment connected to the traction system (e.g., track circuit equipment) shall be bonded to the traction earthing system regardless of proximity to overhead wire equipment.

3.7.4.2 Level crossings

Signal structures, including level crossing equipment, positioned outside of the overhead electrification drop zone at an active level crossing in an AC electrified line shall be bonded if a risk assessment identifies the potential for contact between the overhead wire and signalling structures following a de-wiring incident, including incidents caused by third-party vehicle impacts.

3.7.4.3 Track circuits

Bonding of signalling structures in track-circuited areas shall be in accordance with an approved bonding plan co-ordinated with the track-circuit, traction-return and earthing designs.

Direct bonding to a running rail shall not be used unless specifically approved.

For double-rail track circuits, bonding shall be connected to the impedance bond midpoint or neutral terminal, and the bonding conductor shall be rated for the applicable fault current and duration.

3.7.4.4 Aerial signalling circuit conductors

Aerial signalling circuit conductors shall not be used in electrified territory.

3.7.4.5 Network service provider supply

The network service provider supply installation shall comply with AS/NZS 3000:2018 up to the signalling power-system point of demarcation.

The downstream signalling supply shall use the IT earthing arrangement specified in AS 7703:2020.

Exposed conductive parts shall be bonded in accordance with the approved traction and signalling earthing design.

All earthing with respect to an isolation transformer shall be bonded on the load side of the isolation transformer to the AC traction earthing system, as specified by the approved earthing design.

3.7.5 DC traction railway earthing arrangement

3.7.5.1 General requirements

The signalling earthing arrangements for a DC traction railway shall be co-ordinated with telecommunications and electrical LV.

The signalling earth arrangements shall be designed to prevent a person from touching the signalling earth and a rail used for DC traction return at the same time.

NOTE: Co-ordination should be by provision of physically independent earthing arrangements connected by means of a potential earth clamp between the signals and electrical LV earth.

3.7.5.2 Independence

The signalling earthing arrangements for a DC traction railway shall be effectively independent of electrical HV earthing and traction earthing systems.

Any potential earth clamp used to connect otherwise independent earthing systems shall comply with IEC 62561-3:2023 and shall be selected for the assessed traction-interface conditions.

The following minimum ratings apply unless higher ratings are required by the traction-interface assessment:

(a) The rated power frequency withstand voltage shall be at least 300 V.

(b) Rated power frequency discharge current shall be at least 200 A for one 1 s.

(c) DC spark-overvoltage shall be less than 1,000 V.

(d) Failure mode due to overcurrent or long duration current shall be defined.

3.7.5.3 Electrolysis

The signalling earthing design and installation shall be coordinated with the RIM-approved DC stray-current and electrolysis-control design by:

(a) avoiding unintended paths for traction return current to earth;

(b) sectioning or insulating continuous conductive structures where required by the approved stray-current control design, with the locations, insulation performance and verification method specified in the design;

(c) ensuring circuits between locations with independent earthing systems remain electrically isolated from earth;

(d) applying AS/NZS 3000:2018 to public-supply installations up to the signalling power-system point of demarcation and AS 7703:2020 to downstream signalling IT systems; and

(e) coordinating signalling interfaces with any railway electrolysis-protection system.

3.7.6 Non-electrified railway earthing arrangement

3.7.6.1 General requirements

All distribution frames, communications pillars and communications equipment shall be earthed in accordance with the requirements of AS/CA S009:2020.

Earthing shall be installed at all communications equipment locations.

The communications earth system shall be bonded to any other earths via hard bond or a potential earth clamp as determined by the RIM.

The earthing systems shall be certified prior to being connected to the:

(a) computer-based interlocking system and its data communications system; and

(b) communication earth at the control room.

3.7.6.2 Low voltage power earth

Where the public-supply earth and signalling earth cannot be maintained as effectively independent, the connection method shall be defined by the approved earthing design.

The power utility earth (MEN) and the signalling earth (IT) shall be bonded by a potential earth clamp.

Direct bonding between the two earthing systems shall only be applied when justified by risk assessment. Any direct bonding conductor shall be rated for the applicable fault current and duration.

3.7.7 Earth system

3.7.7.1 General requirements

The earth terminations, earth electrodes and earth wiring shall comply with:

(a) AS 1768:2021 for lightning protection;

(b) IEC 60364-1:2025 for IT earthing arrangements;

(c) IEC 60364-5-54:2011 where conductor and electrode requirements are invoked; and

(d) AS/NZS 3000:2018 for MEN earthing arrangements.

Metallic items potentially exposed to corrosion shall be selected to meet the expected installation life with the planned maintenance arrangement.

A TFEE in accordance with AS/CA S009:2020 shall not be used as the lightning protection earth.

3.7.7.2 Earthing resistance

Test earths are not required to comply with this clause.

The design earth resistance shall be determined from the applicable lightning, surge, EPR, touch-voltage and equipment-performance requirements.

The RIM shall provide the maximum allowable earthing resistance as an input into the design. If a maximum resistance cannot be specified, a maximum allowable resistance of ten ohms shall apply.

3.7.7.3 Earth electrodes, conductors, connections and earth-enhancing compounds

Components used for the lightning protection earthing for railway signalling shall comply with IEC 62561-1:2023 requirements for LPS components.

Earth electrode materials and coatings shall be compatible with the soil, connected metals, expected stray currents, design life and maintenance regime. Hot dip galvanized electrodes shall not be used.

The earthing conductor from the MEBS to earth electrodes shall be sized according to the application.

Earthing conductors shall be sized for the applicable impulse and power-frequency current duty. Earthing conductors shall not be smaller than 16 mm^2.

Earth electrode inspection housings shall be provided.

NOTE: For installations requiring the use of earth enhancing compounds as a measure to reduce the earth resistance, the earth enhancing compounds to be used should meet the requirements of IEC62561-7 and be used in accordance with manufacturer's instructions.

3.7.8 Adjacent structures

The design of a signalling earthing and surge protection system shall assess the impact of conductive structures that could have potential impact on the propagation of surges from the source of the EPR over long distances to trackside signalling equipment.

3.7.9 Earth leakage detector

Earth leakage detectors (ELDs), where specified, shall be in accordance with AS 7703:2020.

An independent test earth shall be provided for locations where an ELD is specified by the RIM.

The independent test earth shall be electrically separate from the ELD detection earth. The independent test earth shall provide a test path for functional verification of the ELD.

NOTE: SPD connections that are not sealed should provide for maintenance testing at the connections using the typical test equipment.

3.8 Inspections and monitoring

3.8.1 Inspections

Inspections of the earthing system shall be performed in accordance with AS 1768:2021, or more frequently if required by the RIM.

Periodic examination intervals of the earthing system shall be adjusted based on the potential corrosion due to electrolytic hazards.

3.8.2 Performance monitoring

The RIM shall monitor the performance of surge protection, investigate inadequate performance, and take corrective action as required.

IT signalling power systems shall be continuously monitored for insulation faults in accordance with AS 7703:2020, with alarm thresholds, indication, testing and maintenance response specified by the RIM.

3.9 Records and documentation

Designers of signalling earthing and surge protection systems shall develop a technical report on the performance of the proposed surge protection.

The technical report shall include:

(a) design justifications;

(b) how interfaces will be managed;

(c) installation methods;

(d) maintenance requirements; and

(e) how the performance criteria will be met.

The technical report shall meet the RIM's requirements for each site or sites with the nominated equipment and installation practices.

The technical report shall assess any special needs for a particular installation due to:

(f) site aspects;

(g) equipment aspects; and

(h) any special training required for competent staff to carry out installation, testing and maintenance of equipment.

Section 4 Construction and implementation

4.1 General requirements

The construction of signalling earthing and surge protection shall be carried out in accordance with the design and this document.

Joints in cables and wiring shall not be introduced as part of construction and implementation without approval of the RIM. Approval shall only be granted in extenuating circumstances and only as a temporary arrangement.

NOTE: See Appendix D for general guidance information.

4.2 Factors to be reviewed

4.2.1 Safety integrity of inter-connections

Where an existing signalling earthing system is to be interfaced with a new installation, the following shall be confirmed:

(a) The safety integrity of inter-connections between components of the earthing system is achieved for all new and modified construction works; and

(b) there are no identified adverse impacts on the existing installation due to the new installation.

Non-compliances shall be brought to the attention of the designer for rectification.

4.2.2 Signalling system availability risk and possible controls

The integrity of any existing earthing systems that might be affected by the proposed works shall be maintained.

Procedures shall be in place to ensure that existing earthing systems are properly identified and protected during construction works.

Earth testing shall be carried out on existing equipment that could be affected before, during and after works to verify that the integrity of the earth system has not been compromised.

The RIM shall be notified if any earthing systems have been disturbed.

4.2.3 Wiring separation and cable routing

Surge protected wiring or clean wiring shall be physically separated from non-surge protected and dirty wiring.

NOTE: See Figure 1 and Figure 2 for the concept of separation.

Earth wires, including earth wires from surge protectors, shall be treated as non-surge protected wiring or dirty wiring.

Cable routing shall comply with AS 7664:2020.

If surge protected wiring crosses non-surge protected wiring, then it shall cross at right angles.

When segregating wiring, the parallelism between cables or wires occurs in the cable routes shall be assessed for suitability.

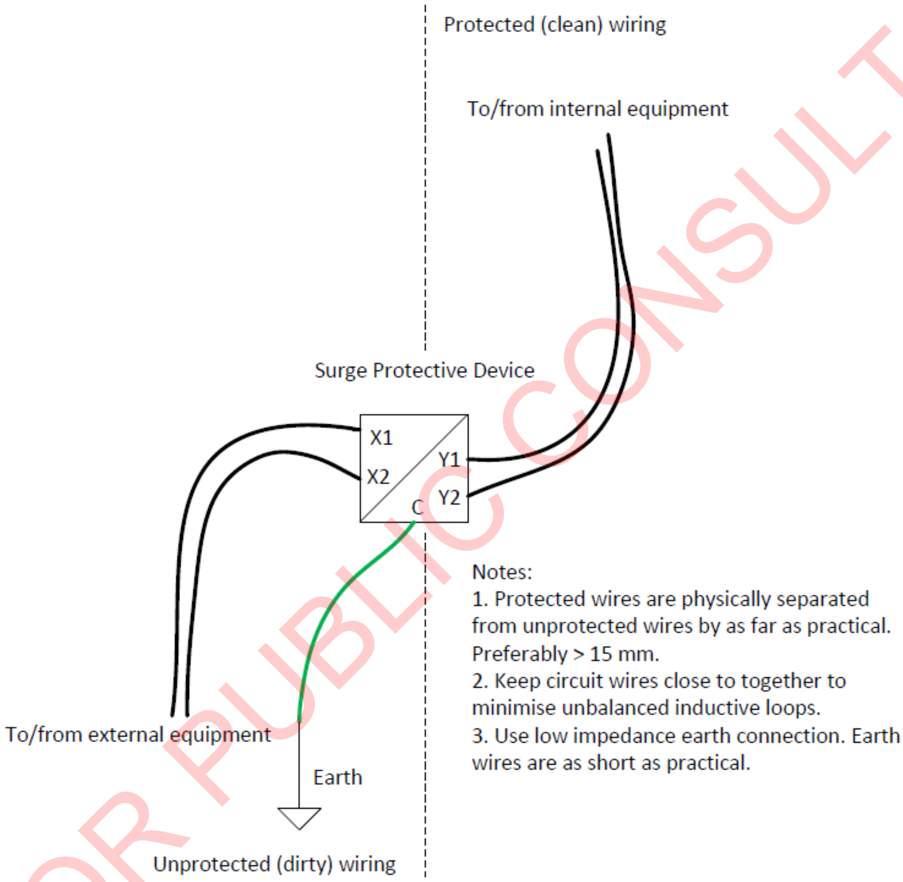

Figure 1 Concept of separation

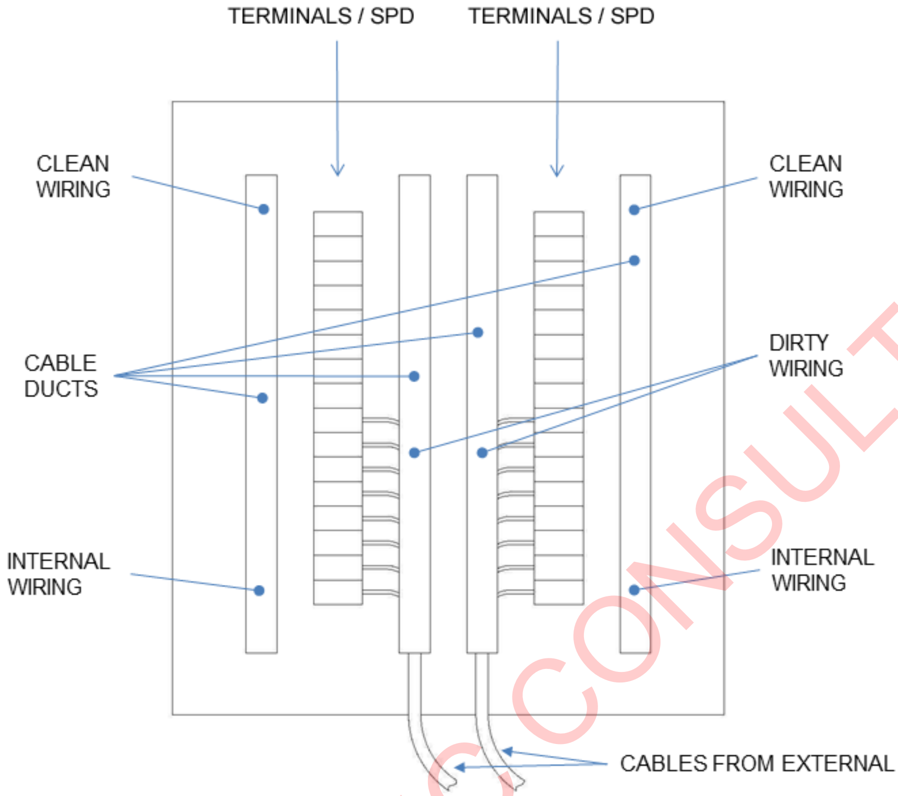

Figure 2 Example of separation in an enclosure

4.2.4 Labelling

Earthing and surge-protection components shall be clearly and permanently labelled in accordance with the approved design and RIM requirements.

Labels shall remain legible and securely attached for the expected service life under the applicable environmental conditions.

Section 5 Testing and commissioning

5.1 General requirements

The testing and commissioning of all signalling earthing and surge protection systems and devices shall be carried out in accordance with the testing and commissioning plan prepared for a specific project or location and approved by the RIM.

The testing and commissioning plan shall comply with the requirements of RIM's approved safety management plan in conjunction with AS 7717:2026.

The testing and commissioning process shall verify and validate that the signalling earthing and surge protection system was installed safely in accordance with the design.

NOTE: See Appendix E for general guidance information.

5.2 Inspection and test plans

Tests for the signalling earthing arrangement shall include:

(a) earth resistance;

(b) soil condition (e.g., wet, dry, backfilled, etc.);

(c) visual inspection (e.g., cable size, length and cable routing); and

(d) earth bonding continuity.

AS 1768:2021 shall be the basis for the methods to be used for carrying out earth resistance tests.

5.3 Testing of safety integrity of inter-connections

The testing and commissioning shall verify the integrity of the signalling earthing and surge protection system and the equipment installed or modified.

The testing and commissioning shall ensure that all interfaces between the new or modified signalling earthing and surge protection equipment are effective and operational.

5.4 System availability risk and management

The testing and commissioning activities shall mitigate the risk of accidental disruption to the availability of operating systems by the works being carried out.

NOTE: The testing and commissioning plan should identify the risk to current operational system availability of the works to be carried out and how this is to be managed.

5.5 Testing documentation

All testing and commissioning works shall be carried out in accordance with the RIM's approved procedure to ensure the use of approved and current plans.

Works shall be satisfactorily constructed to the design requirements. Test certificates shall be produced to record the measurements and results of testing.

Approved as-constructed drawings, equipment schedules, test certificates, deviations and maintenance information shall be provided before handover or within a period approved by the RIM.

Appendix A Hazard Register (Informative)

Hazard Number	Hazard	Related Factors
9.2.1.2	Cables failure (Design)	Leakage between circuits
9.2.1.4	Cables failure (Design)	Low frequency / mains induction
9.4.1.2	Cable communications failure (Design)	Crosstalk between communication channels
9.4.1.5	Cable communications failure (Design)	Low frequency / mains induction
9.5.1.9	Wireless communications failure (Design	Power, transients and earthing
9.6.1.1	Field equipment and or enclosures failures (Design)	Equipment not operating as intended and/or equipment failure
9.7.1.1	Level crossing failure (Design)	Incorrect design resulting in the crossings not operating as intended which, in turn, could result in road or rail collisions
9.9.1.15	Power supply failure (Design)	Inadequate surge protection
9.10.1.8	Signals (Definition: Any indication given to a driver, lights on stick, driver display, notice boards) failure (Design)	Inadequate isolation between aspects
9.10.1.10	Signals (Definition: Any indication given to a driver, lights on stick, driver display, notice boards) failure (Design)	Inadequate transient protection & earthing
9.10.1.18	Signals (Definition: Any indication given to a driver, lights on stick, driver display, notice boards) failure (Design)	Inadequate consideration of failure modes
9.12.1.1	Train detection failure (Design)	Incorrectly showing section to be clear when actually occupied
9.12.1.3	Train detection failure (Design)	Incorrectly showing occupied when clear, disrupting the operation of the network, moving to a degraded mode
9.13.1.19	Interlocking failure (Design)	Inappropriate Power Supply Units, no break supply, earthing or transient protections.
9.13.1.21	Interlocking failure (Design)	No consideration for maintainers
9.14.1.1	Communication cables & route lines failure (Construction)	Cables damaged and earth to core
9.14.1.6	Communication cables & route lines failure (Construction)	Cables having low insulation resistance core to core and earth

Hazard Number	Hazard	Related Factors
9.14.1.8	Communication cables & route lines failure (Construction)	Cables jointed and faults to earth
9.14.1.9	Communication cables & route lines failure (Construction)	Low frequency / mains induction
9.15.1.1	Cable routes failure (Construction)	Cable routes close to hazardous voltages
9.16.1.5	Cable communications failure (Construction)	Low frequency and mains induction
9.18.1.19	Control system failure (Construction)	Lightning surge damage to equipment
9.19.1.1	Field equipment and or enclosure failures (Construction)	Lightning surge damage to equipment
9.22.1.13	Power supply failure (Construction)	Surge protection being ineffective
9.22.1.14	Power supply failure (Construction)	Signalling power supply being connected to earth
9.25.1.4	Train detection failure (Construction)	Shorting or electrical interference of train detection equipment in the location case
9.26.1.20	Interlocking failure (Construction)	Power, availability, ranges, earthing, suppression
9.27.1.1	Communication cables & route lines failure (Test and Commission)	Testing Processes
9.28.1.17	Control system failure (Test and Commission)	Scope definition between contractors and the Railway being inadequately defined (who tests what)
9.31.1.5	Power supply failure (Test and Commission)	Stray voltages on busbar
9.31.1.11	Power supply failure (Test and Commission)	Surge protection ineffective
9.31.1.12	Power supply failure (Test and Commission)	Signalling power supply being connected to earth
9.31.1.13	Power supply failure (Test and Commission)	Incorrect interfacing to existing systems
9.32.1.6	Signals failure (Test and Commission)	Incorrect or uncalibrated tools and test equipment
9.32.1.15	Signals failure (Test and Commission)	Scope definition between contractors and the Railway remaining inadequately defined (who tests what)

Hazard Number	Hazard	Related Factors
9.35.1.6	Interlocking failure (Test and Commission)	Incorrect or uncalibrated or wrong version of tools and test equipment
9.35.1.16	Interlocking failure (Test and Commission)	Scope definition between contractors and Railway being inadequately defined (who tests what)
9.46.1.1	Communication cables & route lines failure (Maintenance)	Signalling circuit wrong side failure from stray voltage
9.47.1.6	Control system (including telemetry failure) failure (Maintenance)	Introduction of new COTS (Commercial off the shelf) products and versions
9.55.1.6	Interlocking failure (Maintenance)	The introduction of new COTS products and versions
9.56.1.3	Communication cables & route lines failure (De-commission)	Signal equipment being damaged
9.58.1.1	Field equipment and or enclosure failure (De-commission)	Signal infrastructure failure
9.59.1.1	Level crossing failure (De-commission)	Signal infrastructure failure
9.60.1.1	Points and or release failure (De-commission)	Decommissioning the wrong equipment leading to signal equipment failure

Appendix B Guidance Information – General (Informative)

NOTE: The scope of this appendix is to provide guidance information on the application, implementation and adoption of Section 2 of this document.

B.1 Principles

A procedure for verification and validation for each lifecycle of the signalling earthing and surge protection systems should be developed to demonstrate compliance with the requirements of the design. This will also ensure that the system is able to achieve the requirements and performance that was originally intended for its safe operation.

B.2 Type approval

Type approval provides confidence that signalling earthing and SPDs are suitable for use in the railway environment and that their performance characteristics have been assessed and documented.

Type approval should confirm that the device is suitable for its intended signalling application and environmental conditions.

The assessment should consider, as applicable:

(a) compliance with the relevant product standards;

(b) electrical ratings, surge duty and insulation coordination;

(c) functional and credible failure modes;

(d) compatibility with signalling IT power systems;

(e) environmental, mechanical and electromagnetic performance;

(f) installation, inspection, testing and maintenance requirements;

(g) failure indication and replacement criteria; and

(h) manufacturer test reports, certificates and technical documentation.

Type approval should define any limitations or conditions of use, including approved circuit applications, installation arrangements and maintenance requirements.

Type approval is not a substitute for project-specific engineering assessment. The suitability of the type approved device for site specific applications should be assessed against site specific requirements, interfaces, hazards and conditions including expected surge environment, equipment immunity characteristics and system safety requirements.

SPD type approvals typically provide application conditions of use for the SPD. These may include applicability/suitably of the SPD in protecting specific signalling equipment.

Refer to AS 7702 for further information regarding type approval.

B.3 Design life

The design life of signalling earthing and surge protection systems should be aligned with the intended service life of the signalling installation and the maintenance strategy of the RIM.

Different components of an earthing and surge protection system may have different service lives. For example, earth electrodes and buried conductors may have a significantly longer service life than SPDs which could require replacement following repeated surge events or end-of-life deterioration.

The design life should consider, as applicable:

(a) the intended life of the signalling installation;

(b) environmental exposure, including moisture, temperature, contamination and corrosion;

(c) expected surge, fault-current and switching duties;

(d) degradation of electrodes, conductors, connections, SPDs and insulating components;

(e) inspection, testing, maintenance and replacement intervals;

(f) availability of replacement parts and manufacturer support; and

(g) accessibility and practicability of renewal.

For buried earthing systems, corrosion allowance, soil characteristics and expected fault current duty should be considered during design to ensure long-term performance is maintained.

Components with a service life shorter than the signalling system should be identified, together with their inspection, replacement and end-of-life criteria.

B.4 Modification of earthing and surge protection systems

Signalling earthing and surge protection arrangements can be affected by works that appear unrelated to signalling activities. Modifications undertaken by other disciplines can alter earth resistance, bonding arrangements, cable routing, surge current paths or the effective separation between earthing systems.

Examples of activities that can affect signalling earthing and surge protection include:

(a) excavation and civil works;

(b) installation of new electrical or telecommunications infrastructure;

(c) construction of metallic structures;

(d) installation or relocation of underground services;

(e) modifications to drainage systems;

(f) changes to traction power infrastructure; and

(g) replacement or relocation of signalling equipment.

It is good practice to establish baseline measurements of the existing earthing and surge protection system before commencing works. Baseline information may include:

(h) earth resistance measurements;

(i) continuity testing;

(j) insulation resistance measurements;

(k) earth leakage detector status; and

(l) visual inspection records.

An assessment of the proposed modification should be conducted. The modification assessment should consider, as applicable:

(a) changes to earthing-system independence or bonding;

(b) effects on touch, step and transferred potentials;

(c) changes to surge-current paths and SPD coordination;

(d) compatibility with signalling IT power systems and ELD operation;

(e) interfaces with traction, public-supply, telecommunications and adjacent structures;

(f) temporary arrangements required during the work; and

(g) updates to drawings, labels, test records and maintenance information.

Following modification, inspection and testing should confirm that the approved earthing and surge-protection performance has been restored and that no adverse effect has been introduced into existing systems. Comparison with the baseline measurements can assist in identifying unintended changes to the earthing arrangement.

Appendix C Guidance Information – Design and Development (Informative)

NOTE: The scope of this appendix is to provide guidance information on the application, implementation and adoption of Section 3 of this document.

C.1 General requirements

Design processes should be in accordance with AS 7718; This standard covers all aspects of the design lifecycle and is applicable to earthing and surge protection systems.

Many surge protection standards have references to signalling. They could relate to signalling for telecommunication purposes and are not directly applicable to railway signalling.

IT and MEN earthing arrangements are significantly different and exist for different purposes. The principle difference is that the neutral connection is not earthed in an IT earthing system, where the neutral earth is directly connected in an MEN arrangement.

A MEN system is not suitable for signalling systems, as a fault in an MEN system will result in immediate disconnection of the power supply. This can result in a greater risk (e.g., shut down of the signalling system) than the risk realized from the fault. Therefore, signalling systems typically use IT earthing arrangements which allow continuity of power in fault conditions.

AS 1768 assumes that the electrical supply is a MEN arrangement which is not the typical arrangement for signalling equipment. As a result, the requirements stated in AS 1768:2021 need to be assessed against the safety requirements of railway systems before applying those requirements to an IT system.

The basis of any design is the inputs into the design. It is therefore important that the right inputs are gathered, and that the quality of those inputs can be ascertained.

Inputs into earthing and surge protection design can include:

(a) site surveys;
(b) identified hazards;
(c) site specific interfaces;
(d) equipment immunity specifications;
(e) lightning susceptibility assessments;
(f) earthing assessments;
(g) environmental assessments;
(h) maintenance requirement assessments; and
(i) EMC assessments.

The design of all signalling earthing and surge protection should be integrated as part of the signalling design management plan. The plan should clearly identify the design requirements, constraints, strategy, planning and resource requirements of the design project.

The design should provide for a means to test the equipment without interrupting the operation of the circuit it is protecting.

The applicable electrical safety and earthing requirements should be determined according to the source of the hazardous potential. These may include:

(j) the RIM traction electrical safety requirements and IEC 62128-1 for traction-related conditions;

(k) AS 2067 for high-voltage installations;

(l) AS/NZS 3000 for low-voltage and MEN installations; and

(m) AS 1768 for lightning-related conditions.

IEC 61643-1 has been withdrawn and has been replaced by IEC 61643-11. Some of the referenced documents still refer to the withdrawn version.

C.2 Interface coordination

Interface coordination should be carried out early in the design stage to enable the mitigation of the identified risks.

C.3 Installation design

IEC 62305-4 provides information on the effect of lightning electromagnetic impulses and methods on reducing the effect by the use of spatial shielding, line routing and line shielding. These methods include controlling how and where wiring and cabling is installed. Shielding, reducing inductive loops, keeping some wiring together and separating other wiring are key concepts that can be applied as part of construction.

Parts of IEC 61643 that cover selection and application principles for SPDs also include installation cabling considerations for the SPD.

C.4 Functional safety

Functional safety relates to the ability of the signalling system to maintain a safe state in response to inputs, disturbances, faults, or failures, including those arising from earthing and surge protection arrangements.

When selecting or implementing an SPM, a review of the SPM should be undertaken to ensure the SPD does not introduce any dormant or undetected line faults to earth. Safety issues could arise if a second fault to earth occurs on the same or even a different circuit, where the two faults to earth together can then provide an electrical path between one circuit and another via the earth, potentially causing an unsafe condition.

C.5 Cables and wires

To mitigate the effects of surge currents on cables they may be buried, twisted pair, longitudinal spiral, shielded or armoured.

In non-electrified areas, an established means of mitigating the effect of ground surge currents is the provision of an earthed stainless steel drain wire 300 mm below ground level, and 300 mm above the cables. However, careful consideration is required to ensure that this does not create problems due to high-voltage power supply EPR faults being transferred to other locations via the stainless steel wire.

Typically:

(a) metallic troughing or conduit is used to provide shielding; and

(b) Polyvinyl chloride (PVC) or glass reinforced plastic (fibreglass) troughing or PVC conduit is used to provide supplementary insulation.

C.6 Surge protection

C.6.1 General

No guidance information provided for this clause.

C.6.2 Alignment with AS 1768

Signalling trackside equipment locations are small buildings in terms of AS 1768:2021.

The risk management calculation tool provided with AS 1768:2021 does not include the loss and damages resulting from compromised functional safety of the railway signalling system. It is therefore important that this is included in the assessment (see Clause 4.2.2).

In the no avoidable risk approach structures, miscellaneous structures and property are allocated a required protection level of at least AS 1768 Protection Level IV. A higher protection level may be allocated by the RIM, based on the criticality of the railway signalling site to the operation of the railway.

C.6.3 Protection

Signalling earthing and surge protection should provide improvement in the availability (i.e. reduced failure rates) and contribute to prolonging the life of the equipment being protected.

C.6.4 Surge protection measures

No guidance information provided for this clause.

C.6.5 Surge protection devices

SPDs should fail safe. Credible failure modes, including open circuit, short circuit, resistive leakage to earth, cross-circuit fault and loss of surge protection, should be assessed so that no single credible SPD failure compromises the functional safety of the protected signalling function. See Clause 3.4.2 for fail safe requirements.

Where practicable, the SPDs should be self-restoring. This means that once the surge has passed, the system should not prevent the operation of the system that is protected either by a fuse or not continuing follow on current, etc. This will minimize the need for immediate maintenance intervention.

Surge protection should be able to be replaced without requiring a system power off/shutdown.

The expected failure modes of the surge protection equipment should not prevent the protected equipment continuing normal operation if the protected equipment is still operational.

All identified potential electrical interference hazards should be recorded in the hazard log. The hazard log should also include earthing and surge protection mitigations for the identified hazards.

When selecting SPDs, the following applies:

(a) For SPDs exposed to 50 Hz EPR or LFI, the immunity rating should at least meet the IEC 61643-21:2025 AC durability test using 20 A for 1 s, applied five times.

(b) The SPD should conform to the standardized terminal numbering specified in the applicable IEC 61643 series.

C.7 Earthing arrangement

C.7.1 General

The signalling earthing arrangement provides a functional earth for surge protection, noise filtering and signalling safety power supplies.

AS/NSZ 3000:2018, AS 7703:2020, and this document should be the primary source for requirements and recommendations for earthing and surge protection. Other standards may also apply, including:

(a) EN 50122 for traction systems; and

(b) AS/CA S009 for telecommunications systems.

Lightning earthing components compliant to AS/NSZ 3000 might not be suitable for use in a railway context. However, if, following a risk assessment, the RIM determines the risk is low enough, components which comply with AS/NZS 3000 may be used.

Welding, including exothermic welding, may be used as a permanent connection in the LPS.

It is important that protective provisions are not removed when designing earthing arrangements. Protective provisions may be basic insulation rated for the associated supply voltage, protective barriers or enclosures, obstacles, or placing out of arm's reach.

The signalling earthing arrangement applies to fixed signalling infrastructure installed in the rail corridor. The rail corridor may have different earthing arrangements for the following where installed in the rail corridor or crossing the rail corridor:

(c) Signalling.

(d) Signalling ELD test.

(e) Telecommunications.

(f) Electrical LV.

(g) Electrical HV.

(h) Electric traction and services.

SPDs may affect EMC immunity of the protected circuit due to a reduction in shielding effectiveness and line balance. Some signals circuits use low resistance per km conductors which results in higher EPR fault currents, increasing the likelihood of an EPR damaging an SPD.

Human errors can introduce risks when installed and maintained incorrectly. One such risk is the installation of a similar but incorrect SPD that has the potential to introduce a hazard.

C.7.2 Functional earthing

A hazardous state can occur due to damage caused by lightning that compromises the functional safety provided by the signalling equipment. This hazard can indirectly cause the loss of human life or injury to people travelling on a train and physical damage due to train collision or derailment as a result of lightning damage.

IEC 62305-4 provides more detail regarding SPM, including the basic protection measures of earthing and bonding, magnetic shielding and line routing, coordinated SPD system and isolating interfaces.

AS/CA S009 provides informative guidance in an appendix on interference from HV power systems which covers EPR hazard zones, LFI and electrostatic coupling. This guidance information is focused on the safety of people.

AS 1768, IEC 62305 (all parts) and IEC 61643 (all parts) have not identified and controlled the risks associated with the application of surge protection to railway signalling systems. Selection and application of surge protection to railway signalling systems needs to identify and control the risks.

The railway applications standard IEC 62425 identifies hardware component failure modes and provides detailed technical requirements for assurance of operation under fault free conditions and the effects of faults for areas of the system that have been allocated a safety function.

An EPR event has two main causes: Firstly, an EPR event can be caused by a lightning flash; Secondly an EPR event can be caused by an electrical power or electric traction fault to earth. Each cause is addressed separately.

The use of inherent fail-safe principle means that there will be no un-revealed safety failures for the SPD, no need to indicate safety related failures for the SPD, and no preventative maintenance activities necessary to inspect and test for the safety-related conditions of the SPD.

All SPDs should be designed to limit nuisance tripping of circuit protection due to normal operation of the SPD.

C.7.3 Bonds

No guidance information provided for this clause

C.7.4 AC traction earthing guidance

The risk associated with touch potential should guide the requirements for bonding. This should be developed through a risk assessment.

Equipment located outside of the contact zone or beyond the acceptable touch potential distance may not require bonding where it can be demonstrated that the residual risk has been demonstrated to be acceptable so far as is reasonably practicable.

C.7.5 DC traction earthing guidance

Co-ordination between telecommunications and electric low voltage can be through provision of physically independent earthing arrangements connected by means of a potential earth clamp between the signals and electrical LV earth.

If no electrical LV earth is provided at the particular site, the telecommunications earth may be directly bonded to the signalling earthing without the use of a potential earth clamp.

The design of signalling earthing in DC traction territory could be constrained by state based legislation for the prevention of corrosion on metals due to electro-chemical reaction caused by stray DC currents known as electrolysis. Designers should review local legislation to confirm requirements.

The separation criterion should be determined from the permissible touch voltage and equipment insulation or immunity for the applicable fault magnitude and duration.

C.7.6 Non-electrified railway earthing arrangement

Typically, a maximum resistance of ten ohms is used for signalling equipment. However, this could be unachievable due to several different factors. This is where a calculated earth resistance can be used to assess the risk of increasing the allowable maximum resistance.

Earthing conductors may need to be larger than 16 mm^2 where required by fault current, lightning current or mechanical protection assessment.

Earthing and bonding conductors should be compatible with the connected electrodes, earth bars and equipment, and suitable for the required current duty, environment and design life.

Connections should use approved methods and materials suitable for the conductor and electrode types. Dissimilar metal interfaces should be avoided or protected against corrosion.

Buried joints should be minimized and, where unavoidable, should be mechanically secure, electrically continuous, corrosion protected and recorded. Test joints should be accessible.

Earth bars, test links and connection points should be identified. Test links should allow individual electrodes or earthing systems to be tested without disturbing unrelated bonds.

Connections between separate earthing systems should be defined in the approved earthing design, including the connection type, rating, operating conditions and inspection requirements. All connections should be installed to the manufacturer's instructions and verified for continuity before commissioning.

C.7.7 Adjacent structures

For the purpose of Clause 3.7.8, adjacent structures include:

(a) towers;

(b) tunnels;

(c) bridges;

(d) viaducts;

(e) fences;

(f) electric traction overhead structures; and

(g) other conductive structures within the rail corridor.

C.7.8 Earth leakage detectors

No guidance information provided for this clause.

C.7.9 Achieving independent earthing systems

Where multiple earthing systems exist within a signalling installation, independence should be achieved through a combination of physical separation, electrical isolation, controlled bonding arrangements and installation practices. The objective is to prevent hazardous voltages, fault currents or traction-related currents from being unintentionally transferred between earthing systems while maintaining the functional requirements of each system.

Methods that can be used to achieve effective independence include:

(a) provision of separate earth electrodes and earth conductors for each earthing system;

(b) segregation of signalling, telecommunications, electrical LV, electrical HV and traction earth conductors throughout the installation;

(c) use of dedicated earth bars for each earthing system;

(d) prevention of unintended bonding through equipment mounting arrangements, cable screens, armours, metallic conduits and building services;

(e) use of galvanic isolation, optical interfaces, isolation transformers or equivalent measures where circuits pass between independently earthed systems; and

(f) controlled interconnection through devices such as potential earth clamps, isolating spark gaps or other approved bonding arrangements where required by the design.

Particular attention should be paid to interfaces between signalling, telecommunications and electrical power systems, as these can unintentionally create parallel bonding paths through cable shields, SPDs, power supplies, data communications equipment or equipment enclosures.

While two earthing systems can appear physically separated, conductive paths could be created through interconnected equipment, metallic cable routes, structural steelwork, fencing or third-party services. These paths should be identified and assessed during design.

For complex installations containing signalling, telecommunications and electrical power systems, the design should identify:

(g) the components connected to each earth;

(h) all intentional bonds between earthing systems;

(i) all interfaces between independently earthed equipment; and

(j) the method used to maintain separation.

A good design practice is to produce an earthing co-ordination drawing showing all earth electrodes, earth bars, intentional bonds, potential earth clamps, isolation devices and inter-system interfaces. This assists in verifying that assumptions about independence remain valid throughout the lifecycle of the installation.

C.8 Inspections and monitoring

The following inspections and tests should be conducted:

(a) Periodic examination of earthing electrodes, conductors and connections and measurement of earth resistance as determined by the RIM.

(b) Proper monitoring of the integrity of the earthing system to ensure that the system continues to be fit for the purpose it was designed.

(c) Inspection of SPDs for indicator status and any signs of deterioration, at regular intervals.

(d) Regular testing of ELDs using a simulated fault condition, independent of the detection part of the ELD and the detection earth, to confirm correct operation.

When surge protection breaks down due to a surge event, the failure of the device should be readily identified.

ELD indications should be remotely monitored.

Indication of an earth fault is an accepted method of indicating that the ELD is unable to perform its function.

ELDs should be suitable for the monitored AC, DC or AC/DC IT system.

ELDs should comply with IEC 61557-8 where applicable.

Alarm thresholds should be set in accordance with AS 7703. The alarm response time should be greater than 2 s and less than 10 s, and preferably less than 5 s for detection during point operation.

Local indication should be provided, with remote indication where required by the RIM. A visual indication only for the local warning is acceptable with the audible indication not required as part of the device.

Functional testing should verify the complete alarm path using an independent test path. A first earth fault should initiate investigation without automatic disconnection; a second earth fault should be treated as urgent.

Appendix D Guidance Information – Construction and Implementation (Informative)

NOTE: The scope of this appendix is to provide guidance information on the application, implementation and adoption of Section 4 of this document.

D.1 General requirements

It is important to note that construction and implementation activities can cause loss of integrity of an installed earthing system.

A procedure should be established so that main earth connections are protected from accidentally being removed.

D.2 Factors to be reviewed

Hazards which should be identified and risks mitigated from nearby installations to ensure the safe conduct of installation of the new system and equipment include:

(a) conductive materials within the installation;

(b) conductive structures;

(c) electrical transmission lines, and

(d) communication cable lines.

D.3 Safety integrity of inter-connections

Before making an interconnection, the existing and proposed earthing arrangements should be verified against the approved design.

The verification should consider, as applicable:

(a) correct identification of earth bars, conductors, bonds and connection points;

(b) continuity and mechanical integrity of each connection;

(c) conductor size, routing and termination;

(d) preservation of required independence between earthing systems;

(e) compatibility with signalling, traction, telecommunications and public-supply earthing arrangements;

(f) absence of unintended parallel earth or traction-return paths; and

(g) protection of existing equipment and circuits during the work.

Any discrepancy or unintended connection should be referred to the designer and resolved before the interconnection is placed into service.

D.4 Signalling system availability risk and possible solution

Factors that could lead to loss of integrity of the signalling earthing and SPD include the following:

(a) Construction works, including that of adjacent locations, which could affect the existing arrangement of earthing conductors.

(b) Site access.

(c) Relocation of equipment (even minor relocations could have significant effect).

(d) Digging.

(e) Changes to drainage which affect earth resistance.

(f) New electrical installations.

D.5 Wiring separation and cable routes

The routing and separation of wiring forms an important part of the overall surge protection strategy. Poor cable routing can significantly reduce the effectiveness of SPDs and can allow surge energy to be coupled from unprotected circuits into protected circuits.

Clean wiring and dirty wiring should remain separated throughout the installation, including cable routes, location cases, equipment rooms, relay racks, terminal assemblies and equipment enclosures.

The point at which a circuit transitions from dirty wiring to clean wiring should be clearly identified within the design.

Dirty wiring generally includes:

(a) external field wiring before surge protection is applied;

(b) conductors directly connected to SPDs on the field side;

(c) external cable screens connected to surge protection earths;

(d) surge protection earth conductors; and

(e) wiring that can possibly be exposed to lightning, traction-related surges or EPR events.

Clean wiring generally includes:

(f) internal wiring electrically filtered, isolated or separated from dirty wiring;

(g) wiring on the protected side of SPDs; and

(h) internal equipment interconnections.

Where possible, known dirty wiring should be separated from other dirty wiring to reduce noise or surges from being induced/propagated from very dirty wiring to less dirty wiring.

Where the recommended separation cannot be achieved, an alternative arrangement providing equivalent control of electromagnetic and surge coupling should be assessed and documented.

Clean and dirty wiring should be routed in separate ducts where practicable. Where separate ducts are not provided, a separation greater than 15 mm should be maintained where practicable, consistent with Figure 1.

Parallel runs between clean and dirty wiring should be avoided. Long parallel runs increase the possibility of magnetic and electric field coupling and can transfer surge energy into protected circuits. Where parallel routing cannot be avoided, the separation distance should be maximized and the parallel run length minimized.

Where clean and dirty wiring cross, the conductors should cross at approximately 90 degrees. Perpendicular crossings minimize the coupling mechanism and reduce the likelihood of surge energy being transferred between circuits. SPD earthing conductors should be kept as short and direct as practicable and should be separated from clean wiring.

The use of unnecessarily long cable routes, large cable loops and excess cable storage should be avoided as these arrangements can increase induced voltages during lightning and EPR events.

Bends in cables and earthing conductors should comply with the manufacturer's minimum bend radius requirements. Tight bends can degrade cable performance, increase mechanical stress and increase inductive impedance during transient events.

D.6 Labelling

Labels should be clear, permanently marked, securely attached and suitable for the environmental conditions at the installation.

Labelling should identify, as applicable:

(a) earth bars and their function;

(b) earthing and bonding conductors;

(c) test links and isolation points;

(d) earth electrodes and inspection pits;

(e) SPDs and their protected circuits;

(f) potential earth clamps or isolating spark gaps;

(g) independent earthing systems;

(h) ELD detection and test earths; and

(i) relevant electrical or transferred-potential hazards.

Labels should correspond with the approved drawings and should remain legible for the expected service life.

Appendix E General Guidance – Testing and Commissioning (Informative)

NOTE: The scope of this appendix is to provide guidance information on the application, implementation and adoption of Section 5 of this document.

E.1 General requirements

Testing typically involves the use of a multimeter with 2 mm diameter test probes.

Test links, as defined in AS 1768:2021, or disconnection points should be provided to support earth resistance testing during maintenance.

Care needs to be taken when using earth resistance testers, as they generate a signal that could cause interference to railway equipment.

E.2 Inspection and test plans

Inspection and test plans should identify, as applicable:

(a) the item, system or interface to be inspected or tested;

(b) the inspection or test method and applicable procedure;

(c) the acceptance criterion;

(d) hold, witness and review points;

(e) required personnel competency and authorisation;

(f) test equipment and calibration requirements;

(g) required system, isolation and environmental conditions;

(h) records and test certificates to be produced; and

(i) the person responsible for review and acceptance.

The inspection and test plan should cover the applicable design, construction, interface and commissioning requirements, and should identify any tests that could affect operational signalling systems.

E.3 Testing of safety integrity of inter-connections

Testing should verify, as applicable:

(a) correct point-to-point connection against the approved drawings;

(b) continuity and resistance of earthing and bonding conductors against the design or RIM acceptance limits;

(c) required electrical independence between separate earthing systems;

(d) correct operation of SPDs, ELDs and potential earth clamps using safe and controlled test methods;

(e) absence of unintended earths, bonds or parallel return paths;

(f) correct restoration of temporary test links, bonds and isolations; and

(g) that test equipment and test methods do not adversely affect operational signalling circuits.

Any discrepancy should be recorded, assessed and resolved before the system is placed into service.

E.4 System availability risk and management

Testing and commissioning planning should identify activities that could affect the availability or safe operation of existing signalling systems.

The planning should consider, as applicable:

(a) possession, isolation and access requirements;

(b) temporary protection or alternative arrangements;

(c) staging and sequencing of testing;

(d) rollback and restoration arrangements;

(e) protection of operational earthing and bonding systems;

(f) control of test-induced interference or unintended earth connections;

(g) co-ordination with operations, maintenance and other affected disciplines; and

(h) contingency actions where the planned test cannot be completed or produces an unacceptable result.

The system should be restored to the approved operational configuration before being returned to service.

E.5 Testing documentation

Test certificates should include, as applicable:

(a) site and equipment identification;

(b) applicable drawings and revision status;

(c) test instrument identification and calibration status;

(d) test method and procedure;

(e) environmental and soil conditions;

(f) system isolation or operating state;

(g) raw readings, calculated results and measurement uncertainty where relevant;

(h) acceptance criteria and pass/fail outcome;

(i) nonconformances and corrective actions;

(j) tester, checker and approver names and signatures; and

(k) references to updated as-built drawings and records.

Test records should be traceable to the inspected or tested item and retained in accordance with RIM requirements.

Bibliography (Informative)

The following referenced documents are used by this Standard for information only:

- AS/NZS 4117:1999, *Surge protective devices for telecommunications applications*
- IEC 60664-1:2020, *Insulation coordination within low voltage systems, Part 1*
- IEC 61557-8:2014, *Electrical safety in low voltage distribution systems up to 1 000 V a.c. and 1 500 V d.c. - Equipment for testing, measuring or monitoring of protective measures - Part 8: Insulation monitoring devices for IT systems*
- IEC 61643:2025, *Low voltage surge protective devices*
- IEC 62305-4:2024, *Protection against lightning, Part 4: Electrical and electronic systems within structures*
- IEC 62425:2025, *Railway applications, Communication, signalling and processing systems, Safety related electronic systems for signalling*
- IEC 62497-1:2010, *Railway applications, Insulation coordination, Part 1*
- IEC 62561-7:2024, *Lightning Protection System Components (LPSC) - Part 7: Requirements for earthing enhancing compounds*
- *Work Health and Safety Acts and Regulations*
- *Rail Safety National Law and Regulations*

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