Standard

Low Voltage Distribution and Installations Earthing

Version 1.0
Issue date: 13 December 2019
Important message

This document is one of a set of standards developed solely and specifically for use on Transport Assets (as defined in the Asset Standards Authority Charter). It is not suitable for any other purpose.

The copyright and any other intellectual property in this document will at all times remain the property of the State of New South Wales (Transport for NSW).

You must not use or adapt this document or rely upon it in any way unless you are providing products or services to a NSW Government agency and that agency has expressly authorised you in writing to do so. If this document forms part of a contract with, or is a condition of approval by a NSW Government agency, use of the document is subject to the terms of the contract or approval. To be clear, the content of this document is not licensed under any Creative Commons Licence.

This document may contain third party material. The inclusion of third party material is for illustrative purposes only and does not represent an endorsement by NSW Government of any third party product or service.

If you use this document or rely upon it without authorisation under these terms, the State of New South Wales (including Transport for NSW) and its personnel does not accept any liability to you or any other person for any loss, damage, costs and expenses that you or anyone else may suffer or incur from your use and reliance on the content contained in this document. Users should exercise their own skill and care in the use of the document.

This document may not be current and is uncontrolled when printed or downloaded. Standards may be accessed from the Transport for NSW website at www.transport.nsw.gov.au

For queries regarding this document, please email the ASA at standards@transport.nsw.gov.au or visit www.transport.nsw.gov.au

© State of NSW through Transport for NSW 2019
Standard governance

**Owner:** Lead Electrical Engineer, Asset Standards Authority

**Authoriser:** Chief Engineer, Asset Standards Authority

**Approver:** Executive Director, Asset Standards Authority on behalf of the ASA Configuration Control Board

Document history

<table>
<thead>
<tr>
<th>Version</th>
<th>Summary of changes</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.0</td>
<td>First issue</td>
</tr>
</tbody>
</table>
Preface

The Asset Standards Authority (ASA) is a key strategic branch of Transport for NSW (TfNSW). As the network design and standards authority for NSW Transport Assets, as specified in the ASA Charter, the ASA identifies, selects, develops, publishes, maintains and controls a suite of requirements documents on behalf of TfNSW, the asset owner.

The ASA deploys TfNSW requirements for asset and safety assurance by creating and managing TfNSW's governance models, documents and processes. To achieve this, the ASA focuses on four primary tasks:

- publishing and managing TfNSW's process and requirements documents including TfNSW plans, standards, manuals and guides
- deploying TfNSW's Authorised Engineering Organisation (AEO) framework
- continuously improving TfNSW's Asset Management Framework
- collaborating with the Transport cluster and industry through open engagement

The AEO framework authorises engineering organisations to supply and provide asset related products and services to TfNSW. It works to assure the safety, quality and fitness for purpose of those products and services over the asset's whole-of-life. AEOs are expected to demonstrate how they have applied the requirements of ASA documents, including TfNSW plans, standards and guides, when delivering assets and related services for TfNSW.

Compliance with ASA requirements by itself is not sufficient to ensure satisfactory outcomes for NSW Transport Assets. The ASA expects that professional judgement be used by competent personnel when using ASA requirements to produce those outcomes.

About this document

This standard supersedes RailCorp standards EP 12 10 00 20 SP Low Voltage Distribution Earthing, version 3.0 and EP 12 10 00 21 SP Low Voltage Installations Earthing, version 3.0. Standard waiver ES05/0072 relevant to EP 12 10 00 20 SP issued by Rail Infrastructure Corporation, which has been in force since 30 September 2002, is also withdrawn.

The changes to previous content include:

- updates to reflect organisational changes and changes in responsibilities
- amendments and clarification to content
- conversion of the standard to ASA numbering, format and style
Table of contents

1. Introduction .................................................................................................................................................. 6
2. Purpose ........................................................................................................................................................ 6
   2.1. Scope .................................................................................................................................................. 6
   2.2. Application ......................................................................................................................................... 6
3. Reference documents ................................................................................................................................ 6
4. Terms and definitions .................................................................................................................................. 9
5. Low voltage distribution system .................................................................................................................. 10
   5.1. Installations with single power supply from the RailCorp HV distribution system ......................... 12
   5.2. Installations with single power supply from a local DNSP’s system .................................................. 13
   5.3. Installations with dual power supplies ............................................................................................... 15
6. Low voltage installations ............................................................................................................................... 17
   6.1. Isolation and clearance ......................................................................................................................... 17
   6.2. Metallic Conduits .................................................................................................................................. 18
   6.3. Cable support systems ......................................................................................................................... 19
   6.4. Metallic Pipework ................................................................................................................................. 19
   6.5. Earth cables ......................................................................................................................................... 20
   6.6. Overbridges ......................................................................................................................................... 20
   6.7. Train maintenance centres .................................................................................................................. 22
7. Light fittings mounted on 1500 V structures .................................................................................................. 24
   7.1. Special cases ....................................................................................................................................... 25
8. Signalling systems ......................................................................................................................................... 25
9. Communications systems ............................................................................................................................ 26
10. Photovoltaic arrays ..................................................................................................................................... 26
11. Lightning Protection ................................................................................................................................... 27
12. Superseded practice .................................................................................................................................... 27
Appendix A Diagrams ...................................................................................................................................... 28
Appendix B Suggested reading .......................................................................................................................... 32
1. Introduction

Earthing is an integral part of the distribution and supply of low voltage (LV) electricity for all assets operated within the RailCorp electrical network. The presence and proximity of the 1500 V dc traction system presents additional complexity to the normal challenges associated with earthing of electrical supplies in other utilities.

2. Purpose

The purpose of this document is to address the complexity associated with earthing of electrical supplies by specifying earthing requirements for LV power systems which are considered within the influence of or ‘near to’ the 1500 V dc traction system.

2.1. Scope

The scope of this standard includes earthing of:

- LV distribution supplies
- LV electrical installations
- LV supply systems for maintenance facilities and signalling installations

Demarcation between the LV installation (generally the responsibility of the customer) and the LV distribution system (generally the responsibility of the DNSP or LDNSP) is further detailed within T HR EL 17000 ST Demarcation of RailCorp Low Voltage Distribution System.

2.2. Application

This standard applies to all new and modified LV installations and distribution systems within the electrified area of the heavy rail corridor. This approach is consistent with the means of compliance for alterations and repairs as defined in Section 1.9.3 AS/NZS 3000:2018.

3. Reference documents

The following documents are cited in the text. For dated references, only the cited edition applies. For undated references, the latest edition of the referenced document applies.

International standards


EN 50162:2004 Protection Against Corrosion by Stray Current from Direct Current Systems

IEC 60364 Low-voltage electrical installations (All parts)
Australian standards

AS/NZS 1768 Lightning protection
AS/NZS 2053.1 (R2016) Conduits and fittings for electrical installations – Part 1: General requirements
AS 2239 Galvanic (sacrificial) anodes for cathodic protection
AS/NZS 3000 Electrical installations (known as the Australian/New Zealand Wiring Rules)
AS 2067 Substations and high voltage installations exceeding 1 kV a.c.
AS/NZS 5033:2014 Installation and safety requirements for photovoltaic (PV) arrays

Transport for NSW standards

SPG 0708 Small Buildings and Location Cases
SPG 0712 Lightning and Surge Protection Requirements
SPG 0729 Signalling Power Systems
T HR EL 17000 ST Demarcation of RailCorp Low Voltage Distribution System
T HR EL 12002 GU Electrolysis from Stray DC Current
T HR TE 21002 ST Communications Earthing and Surge Suppression
T HR SS 80002 ST Low Voltage Electrical Installations
T HR SS 80006 ST Renewable Energy Installations – Photovoltaic and Battery Systems

Transport for NSW drawings

EL0003147 Electrolysis – isolating joint for underground water pipe
EL0005496 Earthing systems – arrangement of LV installations in contact with 1500 V structures
EL0170330 Low voltage – double insulated point of supply – general arrangement
EL0251898 Earthing – earth leakage circuit breaker diagram of connections
EL0282072 Distribution power supply – RailCorp and backup power supply with UPS – standard schematic diagram
EL0284008 High voltage aerial lines & cables - OHEW & UGOH earth electrodes – typical installation details
EL0455387 RailCorp 415 V/415 V padmount assembly – minimum requirements information – footprint arrangement
EL0455388 RailCorp 11 kV/415 V padmount assembly – minimum requirements information – footprint arrangement
EL0464956 Distribution power supply – earthing and bonding of LV installations – arrangements (sheet 1 of 2)

EL0464957 Distribution power supply - earthing and bonding of LV installations – arrangements (sheet 2 of 2)

EL0474149 Distribution padmount substation – double insulated metering panel – general arrangement – Type 2

EL0474151 Distribution padmount substation – low voltage switchboard (DSMSB) – general arrangement – Type 2

EL0474159 Distribution padmount substation – Type R kiosk assembly – general arrangement

EL0474470 Distribution power supply – signals power supply with UPS – standard schematic for RailCorp padmount close to signals

EL0474177 Distribution padmount substation – 11 kV/415 V distribution transformer – schematic diagram – up to 315 kVA (distribution only)

EL0480394 RailCorp 11 kV/415 V padmount assembly – minimum requirements information – earthing arrangement

EL0480479 Distribution padmount substation – 415 V/415 V isolation transformer – general arrangement – Type 2

EL0480481 Distribution padmount substation – 11 kV/415 V distribution transformer – general arrangement – Type 2

EL0494646 Distribution substation – 415 V/415 V isolation transformer – schematic diagram – 3 phase

EL0494648 Distribution padmount substation – 11 kV/415 V, 500 kVA distribution transformer – schematic diagram

EL0494650 Distribution padmount substation – RailCorp dual supply arrangement – schematic diagram

EL0524979 RailCorp 11 kV/415 V padmount substation – insulated padmount earthing system – earthing arrangement (sheet 1 of 3)

EL0524980 RailCorp 11 kV/415 V padmount substation – insulated padmount earthing system – earthing arrangement (sheet 2 of 3)

EL0524981 RailCorp 11 kV/415 V padmount substation – insulated padmount earthing system – insulated footing arrangement (sheet 3 of 3)

EL0610718 Distribution power supply – 11 kV/415-240 V & 11 kV/240-120 V transformers – pole mounted substation – insulated working surface

CV0478382 Boundary fences – tubular steel fence – insulation panel – general arrangement
4. Terms and definitions

The following terms and definitions apply in this document:

- **acceptable positive potential shift** the average value of the positive potential shift between a metallic structure or a metal reinforced concrete and earth in the hour of highest train traffic that is deemed to be no cause for concern with respect to corrosion (EN 50122-2:2010 and EN 50162:2004)

- **alternative power supply** the secondary source of power supply to an electrical installation for times when normal supply is not available

- **ATS** automatic transfer switch

- **distribution system** the electricity power lines and associated equipment and electricity structures that are used to convey and control the conveyance of electricity:
  a. to the premises of wholesale and retail customers, up to the connection point in relation to the premises (which may or may not be situated on the building or land comprising the premises), or
  b. from the premises of former regulated offer customers or small customers that have a complying generator installed and connected from the connection point to the premises, or
  c. to, from and along the rail network electricity system operated by, for or on behalf of Rail Corporation New South Wales, Sydney Trains or Transport for NSW

but does not include a transmission system or any lines, equipment and structures prescribed by the regulations.

- **DNSP** distribution network service provider

- **DSMSB** distribution supply main switchboard

- **double insulated or class II** equipment in which protection against electric shock does not rely on basic insulation only, but in which additional safety precautions, such as double insulation or reinforced insulation, are provided, there being no provision for protective earthing or reliance upon installation conditions

- **ELCB** earth leakage circuit breaker

- **GST** galvanised steel trough

- **HV** high voltage
5. **Low voltage distribution system**

Electrical power supplies to installations are considered to be part of the LV distribution system. Power supplies for LV electrical installations can be obtained from the distribution network service provider (DNSP) using the RailCorp distribution system or from a local distribution network service provider’s (LDNSP’s) distribution system. In special circumstances, supply can be obtained from diesel generators on a temporary or permanent basis. For further guidance regarding generators refer to T HR SS 80002 ST *Low Voltage Electrical Installations*.
Electrical installations can have a single source of supply or dual sources. If a dual power supply is provided for an electrical installation, then the supply from the RailCorp’s distribution system shall be labelled ‘normal power supply’. The supply from the local DNSP’s distribution system or a diesel generator shall be labelled as ‘alternative power supply’. If for any reason the DNSP cannot provide the normal supply then additional labelling shall be provided to indicate the supplier of normal and alternative supplies subject to the agreement of the Lead Electrical Engineer, ASA.

The LV earthing system is a modified multiple earthed neutral (MEN) system with only one neutral earth link (NEL) which is located at the distribution supply main switchboard (DSMSB). The number of MEN points shall be minimised so as to minimise the susceptibility of the LV earthing system to stray dc currents. This standard should be read in conjunction T HR SS 80002 ST and T HR EL 12002 GU Electrolysis from Stray DC Current.

The NEL within the DSMSB shall also serve as the NEL for the supplied LV installations. A LV earthing system is provided by reticulated earthing and electrodes located at or as close as reasonably practicable to the distribution substations.

In some instances there may be a number of alternative supplies for various reasons pertaining to capacity or diversity. Irrespective of the number of power supplies only one DSMSB shall supply an installation at any time. Refer to EL0474151 Distribution padmount substation – low voltage switchboard (DSMSB) – general arrangement – Type 2 for details of a typical DSMSB.

Paralleling of LV supplies between the RailCorp network and other LDNSP networks is not permitted. Where continuity of supply is required a UPS shall be used in combination with high speed emergency changeover device (ECO).

LV earthing for electrical installations that are either beyond the electrified area or not near to the 1500 V dc traction system are not covered by this standard, except in special situations as detailed in Section 5.2.2. These installations shall comply with AS/NZS 3000 Electrical installations (known as the Australian/New Zealand Wiring Rules) and the Service and Installation Rules of New South Wales.
5.1 Installations with single power supply from the RailCorp HV distribution system

A common source of supply is a step down transformer attached to the RailCorp high voltage (HV) distribution system. In such cases where the LV supply is obtained from a HV supply through the use of a distribution substation a HV earthing design shall include the assessment and detailed design of the LV earthing systems. This shall be done to determine suitable configurations to mitigate risks associated with the HV earthing system. When a power supply is obtained from the RailCorp’s HV distribution system, the following requirements shall be adhered to:

- A LV earthing system shall be provided at the distribution substation. For further details regarding standard arrangements refer to the following:
  - EL0455388 RailCorp 11 kV/415 V padmount assembly – minimum requirements information – footprint arrangement
  - EL0474177 Distribution padmount substation – 11 kV/415 V distribution transformer – schematic diagram – up to 315 kVA (distribution only)
  - EL0480394 RailCorp 11 kV/415 V padmount assembly – minimum requirements information – earthing arrangement
  - EL0494648 Distribution padmount substation – 11 kV/415 V, 500 MVA distribution transformer – schematic diagram
  - EL0610718 Distribution power supply – 11 kV/415-240 V & 11 kV/240-120 V transformers – pole mounted substation – earthing arrangement
  - EP 12 10 00 11 SP Distribution Substation Earthing

- The earth bar of the DSMSB shall meet the following requirements:
  - be connected to the LV earthing system by green yellow polyvinyl chloride (PVC) insulated cables
  - be labelled and sized in accordance with AS 3000
  - be of a minimum 25 mm² cross sectional area

- LV electrodes shall be connected in a loop arrangement in accordance with EL0455388.

- The DSMSB shall be located preferably within the padmount enclosure in case of padmount distribution substations and as close as possible to a pole top distribution substation. Arrangements for appropriate demarcation and access are to be negotiated with the asset owner, network operator and maintainer if the DSMSB is to be located elsewhere.
• The earth and neutral bars of the DSMSB shall be connected to each other by a link, labelled 'NEUTRAL EARTH LINK' or 'NEL'. Only one NEL is to be provided for each installation. The term NEL is intended to differentiate neutral earth link from the main earth neutral link which is often shortened to MEN link and can therefore be confused for multiple earthed neutral MEN which does not apply to this modified MEN system. This is a critical distinction as no other neutral-earth connection is allowed downstream of the DSMSB which is supplying the installation. As a minimum requirement the NEL shall be sized to withstand the maximum LV fault current at DSMSB.

• The mains active and neutral conductors between the distribution substation and DSMSB shall consist of single core double insulated (SDI) copper conductors insulated to 0.6/1.0 kV with a minimum cross sectional area of 25 mm².

• The main neutral conductor upstream of NEL shall not be switched. A connection between the LV neutral point and the earth electrodes shall be maintained while the HV side of the supply is in operation.

• A 2 m distance shall be maintained between any earthed LV equipment and non-double insulated overhead wiring structures (OHWS) which are not connected to the same LV earthing system. Where this clearance cannot be achieved, a risk assessment shall be carried out to identify the hazards and suitable mitigation methods provided.

Refer to Figure 1 for a typical arrangement for a single power supply obtained from RailCorp’s distribution system in accordance with the requirements shown in this section.

5.2. Installations with single power supply from a local DNSP’s system

When a power supply is obtained from a local DNSP's system, the consumer’s mains, service and metering equipment and earthing of the associated enclosure shall be prescribed by the local DNSP but shall also consider the additional requirements outlined in this section.

The MEN system of the local DNSP is prone to pick up appreciable dc leakage current. Appropriate mitigation methods shall be implemented to protect people and equipment against potential risks, such as electric shock and active corrosion through electrolysis.

In principle, within the electrified area, the earthing system and neutral of the local DNSP shall be isolated from any part of the installation being supplied. That includes any earthed extraneous conductive part, such as pipes, fences, overhead earth wires and troughs associated with the installation.

Considerations shall be made to provide the LDNSP with access to the metering equipment whilst excluding LDNSP from entering the rail corridor.

Refer to Figure 2 for a typical arrangement for a single power supply obtained from a local DNSP’s distribution system in accordance with the requirements provided in this section.
5.2.1. Requirements at the point of supply

The following requirements shall be adhered to, as a minimum, to achieve an acceptable physical isolation:

- The connection to the local DNSP shall be done at a point as close as practicable to the boundary of the rail corridor while maintaining a clearance of 2 m between the enclosure containing service and metering equipment and a continuous boundary fence or any other earthed extraneous conductive part. Where the 2 m clearance is difficult to achieve, a double insulated enclosure which does not need to be earthed can be used. Refer to EL0170330 for a general arrangement of the low voltage and double insulated point of supply.

- The local DNSP's earthing system shall be located as far as practicable but in any case not less than 3 m away from the nearest electrified rail and any other extraneous conductive part associated with the installation. That includes exposed and supporting infrastructure such as an overhead wiring structure footings, fences or signal cable trough.

5.2.2. Requirements for an Isolation transformer

To achieve isolation, an isolating transformer shall be connected between the local DNSP's service and metering equipment and the DSMSB to isolate the earth and neutral of the supply from any part of the installation. Refer to EL0494646 Distribution substation – 415 V/415 V isolation transformer – schematic diagram – 3 phase for a typical schematic diagram involving an isolating transformer.

The following requirements shall be complied with when an isolating transformer is used:

- No earthing connection shall be made from the incoming supply to the isolating transformer neutral or case. The technical requirements for isolating transformers are provided in T HR EL 17002 ST Low Voltage Isolating Transformer. Refer to EL0480479 Distribution padmount substation – 415 V/415 V isolation transformer – general arrangement – Type 2 for general arrangement of a padmount isolating transformer and EL0455387 RailCorp 415 V/415 V padmount assembly – minimum requirements information – footprint arrangement for earthing details.

- The mains active and neutral conductors – on both sides of the isolating transformer shall consist of SDI copper conductors insulated to 0.6/1.0 kV with a minimum cross sectional area of 25 mm².

- The DSMSB shall be the first switchboard after the isolating transformer secondary terminals. The earth bar and neutral bar of the DSMSB shall be connected to each other using a link, labelled 'NEUTRAL EARTH LINK' or 'NEL'. This connection shall be the only neutral earth connection for the entire electrical installation supplied from the pertaining isolating transformer.
• The main neutral conductors upstream of the NEL shall not be switched.

**Special situations**

The following are some special situations where no isolating transformer is required:

• The LDNSP’s earthing system or any extraneous conductive part connected to it is not prone to pick up appreciable dc leakage current.

  *Note: Any installation earthing system near 1500 V dc track is prone to pick up appreciable dc leakage current. In situations where an installation is not near the 1500 V dc, then the need for isolating transformer should be determined based on a risk assessment taking into account the stray dc currents in that area and the introduction of stray current paths which shall be confirmed by way of measurement.*

• The power supply is from a local DNSP’s dedicated substation with separate high and low voltage earthing systems and with no connections to the MEN or cable screens.

• Earthing systems of the local DNSP and RailCorp’s distribution systems are proven to be electrically equivalent. The tests shall reveal low resistances between the two earthing systems or between the RailCorp’s earthing system and the structures connected to the local DNSP’s earthing system or both. Such a situation can arise in dense urban areas such as Sydney CBD. This stipulation is invalid where the cause of connection can be easily identified and removed.

• The local DNSP provides power supply to a trackside small consumer, such as the lighting of a billboard or a sign, ULB lighting, provided that the following apply:
  - o no other consumer is supplied from the same service equipment
  - o lighting is double insulated
  - o no other extraneous conductive part such as a conductive or continuous water pipe exists in close proximity to the supply point

  *Note: This is because a single footing encased in concrete is not likely to pick up appreciable dc leakage current to, then, convey to the local DNSP’s distribution system. If there is any doubt concerning the amount of stray dc currents, measurements should be taken to confirm if these currents amount to an appreciable dc leakage current and to determine the need for further action.*

5.3. **Installations with dual power supplies**

Where required, an alternative power supply for LV installations may be obtained from either a local DNSP’s distribution system or a permanent standby diesel generator. Permanent standby diesel generators are acceptable as alternative power supplies only in special circumstances
subject to approval by the Lead Stations and Buildings Engineer, ASA, see T HR SS 80002 ST for more information about this.

In cases of dual supply arrangements the alternative supply DSMSB is also required to have an NEL in cases where it is used to supply other installations as either a primary or alternative supply. In such cases two NEL links may be connected to a single installation.

In installations with dual power supplies, all requirements stated in Section 5.1 and Section 5.2 are applicable. In addition, the following requirements shall be complied with:

- The normal and alternative power supplies shall connect to an automatic transfer switch (ATS). The ATS shall be a break before make type. Refer to EL0494650 Distribution padmount substation – RailCorp dual supply arrangement – schematic diagram for a typical schematic diagram for dual supply arrangement.

- The NELs shall be located within their respective DSMSBs. No other neutral-earth connection is allowed downstream of DSMSBs.

- NELs shall not be broken unless both normal and alternative power supplies are disconnected. If the removal of an NEL is absolutely necessary (that is, for the replacement of a DSMB) with one supply still in service, extreme care shall be taken to ensure no current flow is present. The disconnected cable shall be made safe and shall not be inadvertently bridged during the disconnection process. The connection between the supply in service and the earth electrodes shall not be compromised during this process.

- A solid earth connection between the electrical installation and the supplying DSMSB shall be provided at all times.

- Where the alternative supply substation is located greater than 25m from the normal supply substation dedicated earth electrodes shall be provided to connect the alternative supply earth bar to earth.

- Any back feed shall not be possible when one supply is out of service for maintenance.

- The DSMSB shall be located within the padmount enclosure in case of padmount distribution substations and as close as possible to a pole top distribution substation. Arrangements for appropriate demarcation and access shall be negotiated with the asset owner, network operator and maintainer.

- The main neutral conductors of the normal and the alternative supply shall not be switched upstream of NEL. The neutral conductors between the normal and alternative supply is not recommended to be switched; however, if it has to be switched for any reason, all active and neutral conductors shall be switched simultaneously.

- NEL shall be arranged to minimise reticulated neutral currents in cases where the neutral of the alternative supply is not simultaneously switched with the supply active conductors.
Figure 3 and Figure 4 show possible scenarios for a dual power supply arrangement. In arrangements similar to that in Figure 3, the ATS shall not break the neutral conductor during operation. A solid neutral connection between the electrical installation and the DSMSB shall be maintained at all times. In arrangements similar to Figure 4 only the neutral to the alternative supply may be broken by way of a four pole circuit breaker. Arrangements using a four pole circuit breaker may be used in instances where voltage disturbances are expected due to reticulating neutral and earth currents. In such cases where a four pole breaker is used on the alternative supply the protective earth neutral on the alternative supply shall not be switched.

6. Low voltage installations

The design of LV electrical installations within the electrified area shall comply with the requirements stated in this section. Some specific requirements applicable to overbridges and train maintenance centres are outlined in Section 6.6 and Section 6.7. The requirements applicable to OHWS fitted with light fittings are provided in Section 7.

6.1. Isolation and clearance

The isolating and clearance requirements for LV installations are as follows:

- The RailCorp’s low voltage earthing system shall not extend beyond the heavy rail corridor.
- For example, the earthing system of the electrical installation of a railway station shall not be extended to the adjoining buildings and structures such as bus rail interchange buildings, pedestrian footbridges connecting to a nearby shopping centre, bus shelters and trackside metallic fences.
- The interface where two different earthing systems can come close to each other shall be clearly defined and observable. A clearance of 2 m to a height of 2.4 m is the preferred minimum clearance. If such a clearance cannot be provided then appropriate measures shall be taken to address prospective touch voltages between the two systems.
- The extraneous conductive parts shall be completely isolated from the earthing system of an electrical installation and separated from OHWS. When completely isolated, they can be connected to a local DNSP’s MEN earthing system.

Note: The extraneous conductive parts can include canopy supports, awning supports, gutters and downpipes, handrails, balustrades, platform fences, trackside fences, troughs and conduits, water pipes including fire hydrants, wiring conduits, reinforced concrete, steel structures, mechanical services pipework and ducts, lift structure and light poles.
- A 2 m clearance shall be maintained between the OHWS and the extraneous conductive parts, or any equipment that is part of an electrical installation or both. Where this
clearance cannot be achieved, a risk assessment shall be carried out to identify the hazards and the mitigation methods shall be implemented.

Note 1: The equipment can include vending machines, telephone cabinets, ticketing machines, CCTV cameras and lighting poles.

Note 2: In case of continuous extraneous conductive parts (for example, trackside metallic fences and galvanised steel troughs (GSTs) or conductive canopies) that are not intentionally connected to the low voltage earthing system, two isolating breaks can be inserted such that the distance between the OHWS and the continuous remotely earthed conductive part is 2 m or more. Depending on the structure appropriate isolation can be installed which can include insulated fence panels, insulated GST joints or 50 mm air gaps finished with non-conductive flashing for roof penetrations.

Isolation panels (dual isolation breaks or air gaps) are intended to break continuous structures into sections which cannot be easily breached by a single short to create a continuous section.

Insulated (floating) sections are to be used in lieu of Isolation panels. A floating section is effectively an isolation panel that is unearthed. It provides greater than 2 m separation between conductive parts decreasing the risk of continuity through the soil. Refer to CV0478382 Boundary fences – tubular steel fence – insulation panel – general arrangement drawing which demonstrates this concept.

Note 3: Where access is restricted to reach touch the 2 m clearance requirement is reduced to 1 m.

### 6.2. Metallic Conduits

The requirements for metallic conduit are as follows:

- Conductive conduits shall not be installed underground or in concrete within the electrified area due to the presence of stray dc currents.

  Based on experience short lengths of conductive conduits are not likely to present a problem. Thus, if a situation arises where a short length of buried conductive conduit is deemed necessary then an assessment shall be made to check whether the conduit will be exposed to a voltage in excess of acceptable positive potential shift. If the calculated positive potential shift is in excess, then it should not be used.

- Where above ground conductive conduits are used for mechanical protection of cables in areas accessible to public or prone to vandalism, such as lighting or vending machines on platforms, these conduits shall be connected to the installation’s earthing system and shall not extend beyond the installation without appropriate isolation.
6.3. **Cable support systems**

The requirements for cable support systems are as follows:

- All conductive cable support systems including trays and ladders shall be connected to the installation’s earthing system by appropriately sized earthing cables. Unless the cable support system as an assembly is tested to have electrical continuity in accordance with AS/NZS 2053.1 (R2016) *Conduits and fittings for electrical installations – Part 1: General requirements*, each component of it shall be earthed separately. See Section 6.3 item h for the requirements in tunnels.

- Due to their extended length and proximity to OHW and its structure, conductive cable support systems in tunnels shall comply with the following:
  - not be connected to any LV earthing system along their path to mitigate the risk of touch voltage hazard
  - be broken into short lengths by insertion of insulation joints or 50 mm gaps to mitigate the risk of corrosion due to electrolysis
  - carry double insulated cables and wires only

6.4. **Metallic Pipework**

The requirements for metallic pipework are as follows:

- All underground conductive pipes entering heavy rail corridor in an electrified area shall be electrically isolated by the permanent installation of an approved isolating joint to provide protection against stray dc currents. Location of the isolating joint shall be coordinated such that the joint is not incidentally bridged by other services. The isolating joint shall be one metre outside the rail corridor boundary and an approved sign shall be secured to the fence directly above the pipe. Refer to EL0003147 *Electrolysis – isolating joint for underground water pipe* for details.

- The railway side of the water pipe shall be connected to the earthing system of the installation. Only one connection shall be provided and it can be made at the earth bar of the nearest switchboard including the DSMSB. The location of the water pipe connection shall be clearly labelled on the switchboard from which the earthing cable originates. The earth cable shall be clearly labelled as ‘WATER PIPE EARTHING CONNECTION’.

*Note: There are situations where additional connections have been made to reinstate earth connections to sections of metallic water pipes which have been made discontinuous through the installation of sections of nonconductive piping. Care shall be taken to avoid parasitic paths or reticulating earth loops when reinstating earth connections between local switchboards and sections of disconnected buried water pipes.*
• The green yellow sheathed earthing cables connected to conductive pipes shall be of copper and of the same size as the pertaining switchboard incoming earthing cable, to a maximum size of 70 mm² and not smaller than 16 mm². Connections should be braised or with a bimetallic joint to minimise corrosion.

6.5. Earth cables

The requirements for earth cable are as follows:

• A green yellow sheathed earthing cable that is connecting the earth bars of any two LV switchboards shall be of copper and have a size of not less than 16 mm². This includes the earthing cable between the installation main switchboard and any downstream switchboard.

• Sub circuits shall contain an earthing conductor as required by AS/NZS 3000.

For mechanical protection of earthing cables refer to Section 6.6.3.

6.6. Overbridges

Where overbridges including pedestrian footbridges within the electrified area carry LV equipment or wiring or both and at the same time are used as OHWS, the following requirements shall be adhered to:

• The overbridge shall be as follows:
  o connected by an earthing cable to a vertical earth electrode located as close as possible to the overbridge
  o connected by an earthing cable to the earth bar of the switchboard from which the associated LV wiring originates or the equipment or both is supplied
  o connected by a bonding conductor to a traction rail through an approved rail spark gap
  o where the bridge forms part of the station and platform access and a metallic water pipe is installed on or nearby to the bridge a bond shall be provided to the water pipe by means of 70 mm² bonding conductor.

Refer to EL0005496, EL0464956 and EL0464957 for a typical arrangement of connections.

6.6.1. Earth electrode

The requirements for earth electrodes are as follows:

• The vertical earth electrode shall be a 6 m long thick copper tube with an outside diameter of 14.29 mm and an inside diameter of 11.03 mm. The inside diameter is to allow a 70 mm² conductor to be a close fit for a crimped joint.
- The vertical earth electrode can be driven where conditions are suitable; otherwise, a hole with a diameter of 50 mm shall be drilled and then back filled with a conducting medium mixture.

- The mixture can be a mixture of bentonite, gypsum and sodium sulphate mixed in accordance with AS 2239 *Galvanic (sacrificial) anodes for cathodic protection*.

- Top of each vertical earth electrode shall finish 200 mm below ground level and have a collar installed with the inside of the collar backfilled with earth to 300 mm below ground level. A lid is to be placed over the collar. Alternatively a standard electrode inspection box can be used as per EL0284008

### 6.6.2. Earthing cables

The requirements for earthing cables are as follows:

- The green yellow sheathed earthing cable that is connecting the overbridge to the vertical earth electrode shall be as follows:
  - a 70 mm² copper conductor and be secured to the overbridge by a crimped closed lug lock nutted onto a stud of minimum size of 12 mm and coated with zinc rich paint to prevent corrosion.
  - stripped of its insulation for a length of 75 mm, then, the 75 mm of bare conductor shall be inserted inside the vertical earth electrode and crimped. A hydraulic crimp may be used with two crimps and a 70 mm² die over the 75 mm of insert or a hand crimp with five crimps over the 75 mm of insert.

- The earthing cable that is connecting the overbridge to the earth bar of the switchboard shall be as follows:
  - a copper conductor of the same size as the switchboard incoming earthing cable, to a maximum size of 70 mm² and not smaller than 16 mm²
  - be secured to the overbridge by a crimped closed lug lock nutted onto a stud of minimum size of 12 mm and coated with zinc rich paint to prevent corrosion

- The incoming earthing cable to the switchboard and the earthing cable going out to the overbridge shall be clearly labelled and terminated adjacent to each other at one end of the switchboard earth bar. Labels shall read as, 'INCOMING EARTHING CABLE' and 'OVERBRIDGE EARTHING CABLE'.

- The location of the connection point of the earthing cable to the overbridge shall be clearly labelled on the switchboard from which the earthing cable originates.
6.6.3. Mechanical protection of earthing cables

In situations where an earthing cable can be exposed to mechanical damage, theft or malicious damage, the conductor shall be effectively protected from ground level to a height of 2.4 m. Protection shall be in the form of a galvanised steel conduit or by installing the conductor in a PVC conduit and protecting the PVC by a galvanised steel sleeve to the full height of 2.4 m.

6.7. Train maintenance centres

Buildings containing overhead wiring, such as those in train maintenance centres, will have a minimum of two power supplies. One supply is referred as 'normal power supply' and the other as 'train shore power supply'.

The normal power supply is used for general lighting and power for the buildings and any additional special equipment such as cranes. The train shore power supply is used to supply auxiliary power to trains.

6.7.1. Normal power supply

The requirements pertaining to the normal power supply and associated installations are outlined as follows:

- The neutral point of the LV winding of the transformer of the normal power supply shall be connected to the earth bar of the DSMSB using NEL.
- The earth bars of all the switchboards fed from normal power supply shall be connected to the earth bar of the DSMSB directly or through their upstream switchboards.
- The steelwork of all the buildings supplied from the normal power supply shall be connected to the earth bar of the DSMSB directly or through the earth bar of the closest switchboard.
- The frame of the building supplied by the normal power supply shall also be bonded to rail using an approved rail spark gap to provide a path for any dc fault current resulting from the failure of insulators attached to the steel structure of the building supporting the overhead wiring.
- A bonding design is required to coordinate between the earthing requirements of this section and the 1500 V dc bonding requirements.

Hazardous situations

The trains standing on rails are at rail potential, which in normal circumstances is not necessarily at the local earth potential. This poses a prospective hazard in maintenance centres due to spatial limitations, fences, light poles, cranes and other conductive parts connected to LV
The earthing system can be located within 2 m of trains, for example, these can be touched simultaneously by a person.

Such situations shall be assessed and appropriate hazard mitigation measures shall be put in place to mitigate prospective hazards. This can include the use of double insulated light fittings, insulating light poles from the earth and placing insulating panels in the fence line.

A hazardous situation can also arise when maintenance personnel use portable or hand held tools supplied by power points on trains which are at rail voltage. To mitigate this hazard, possible contact with the LV earthing system shall be avoided.

This can be achieved by using one or both of the following options:

- Using double insulated portable tools and equipment. A warning label reading 'USE DOUBLE INSULATED TOOLS AND EQUIPMENT' shall be affixed at a visible location to indicate this requirement.

- Fitting the power points that can be used for such purposes with a small isolating transformer. The intent here is to remove the earthing connection. Neither the screen nor the case of the isolating transformer is to be earthed.

### 6.7.2. Train shore power supply

The requirements applicable to the train shore power supply and associated installations are outlined as follows:

- The neutral of the train shore power supply shall not be earthed, but shall be connected to the rails. The rail connection point shall be clearly labelled on the rail web and the location identified at the train shore switchboard (TSSB).

- Train shore power supply and the consumers fed from it shall be isolated from the earthing system of the normal power supply including the building frame and pipes.

- An isolating transformer shall be used to supply a dedicated TSSB. TSSB shall have a bar labelled 'NEUTRAL RAIL BOND BAR' or “NRBB”. The neutral of the secondary winding of the isolating transformer and all the rails shall be connected to the NRBB using a minimum 120 mm² copper bonding conductor insulated with black PVC.

- Where a dedicated HV/LV transformer is used to supply the TSSB an isolation transformer is not required.

- The TSSB and related shore supply outlets shall have labels attached warning staff not to bridge the metallic switchboard or outlets to the earthed building structure with their body or conductive tools and equipment.
6.7.3. Lifting shops

The following are the requirements related to lifting shops:

- Insulated joints shall be inserted in both rails on both sides of the lifting shop. A sign shall be installed on both sides of the lifting shop adjacent to the track at an appropriate distance to warn train drivers not to stable their trains across the insulating joint.

- The following items shall be connected to the earth bar of the lifting shop switchboard by means of earthing cables:
  - the insulated sections of the rails that pass through the lifting shop
  - the contact and catenary anchors on the face of the lifting shop
  - the lifting shop structure
  - the earth bar of the supply main switchboard of the transformer supplying the location

- The earthing cable shall be of copper and a minimum size of 120 mm² insulated with green-yellow PVC. The number of 120 mm² conductors shall be determined based on its application.

7. Light fittings mounted on 1500 V structures

Lighting should not be installed on 1500 V OHWS, however, if deemed necessary then the following requirements apply:

- The lighting circuit shall be supplied from an isolating transformer as per T HR EL 17002 SP Low Voltage Isolating Transformer. The earth terminals of the light fittings shall be connected to the neutral of the isolating transformer which shall also be connected to the OHWS.

- If required to be installed on the OHWS a double insulated enclosure shall be utilised for the installation of circuit protection devices, links and for the marshalling of cables. This enclosure can be mounted to the structure.

- Where the light fittings, supplied from a common switchboard, are mounted on more than one OHWS an individual isolating transformer shall be mounted on each OHWS. Active and neutral conductors used to connect the supply side of the isolating transformers shall be double insulated. The incoming earthing conductor to the isolation transformer shall not be connected to the neutral or case of the transformer and shall only be connect to the protective screens of the transformer.

- If double insulated light fittings are used on multiple OHWS, then only one isolating transformer is required. In this situation, double insulated active and neutral conductors shall be used to connect the light fittings to the isolating transformer. With this arrangement there shall be no earth connections and the neutral shall not be connected to the OHWS.
• Each OHWS fitted with a light fitting shall be connected to a traction rail using an approved rail spark gap.

• The installation of lighting and enclosures shall not compromise the integrity of the OHWS.

7.1. **Special cases**

Subject to thorough risk assessment, testing and agreement from the ASA Lead Electrical Engineer, isolating transformers for light fittings mounted on OHWS may not be required if achieving isolation or adequate clearance is deemed not practicable.

This situation can arise in locations such as maintenance centres where spurious interconnections or low impedance paths exist between various OHWS, reinforced structures and buildings. In such cases isolating transformers even if installed will be bypassed and will not serve their purpose.

The determination to not install isolating transformers is acceptable only when the following applies and can be demonstrated:

• the safety of people is not compromised
• the integrity of metallic structures (for example, building frames) is not at risk due to corrosion from electrolysis
• appropriate control measures are in place to maintain the safety over the life of the assets
• an electrolysis correlation measurement is conducted to understand the existing interconnectivity and isolation of various metallic structures or parts before deviating from the requirements of Section 7

In cases where unintended interconnections between OHWS and adjacent buildings are identified and correlation between rail and structures is identified, only class II luminaires shall be used.

A bonding design shall include the implementation of a bonding circuit shall be installed to positively connect the building to rail by a spark gap. The 1500 V dc bonding strategy shall coordinate with the earthing design verification requirements.

8. **Signalling systems**

The signalling power distribution system (120 V or extended 415 V) is considered an unearthed system equivalent to an Isole'-Terre (IT) earthing system in accordance with IEC 60364 *Low-voltage electrical installations*.

The following requirements are applicable to signalling power supplies:

• The secondary winding neutral of the isolating transformer shall not be directly earthed and the isolating transformer screen shall be connected to the primary side earthing system.
This connection is required to provide a direct path to the earthing system to ensure the operation of the primary side protection if the double insulation of the isolating transformer breaks down.

- Earthing system and neutral shall not be connected unless authorised by the Sydney Trains signalling engineer.

- The active and neutral conductors from the LV DSMSB or service equipment to the isolating transformer and from the isolating transformer to the signalling location switchboard shall be SDI.

- The conductive screen of the isolating transformer shall be earthed using a method that will maintain the double insulation of the isolating transformer. Depending on the connection details of the isolating transformer, this can involve over sleeving the earthing cable for the section internal to the transformer and insulating the connection. The connection shall be mechanically secure. Any switch in the circuits downstream of the isolating transformer shall switch both the active and neutral conductors simultaneously.

- Where the power supply is from the RailCorp's HV distribution system, stepped down directly to 120 V or Extended 415 V, the active and neutral conductors from the transformer to the DSMSB and then to the signalling location switchboard shall be double insulated.

- The conductive screen of the transformer shall be connected to the HV earthing system. Any switch in the circuits downstream of the transformer shall switch both the active and neutral conductors simultaneously.

- In signalling locations where the normal power supply is from a local DNSP's distribution system and the alternative power supply is from a diesel generator, the supply arrangements shall be in accordance with the requirements stated in this document.

For comprehensive earthing requirements associated with the signalling power distribution system, refer to the signalling standards and guides including SPG 0708 Small Buildings and Location Cases, SPG 0712 Lightning and Surge Protection Requirements and SPG 0729 Signalling Power Systems.

9. Communications systems

For earthing requirements associated with the communications systems, refer to T HR TE 21002 ST Communications Earthing and Surge Suppression.

10. Photovoltaic arrays

Earthing arrangements of photo voltaic (PV) arrays shall be in accordance with AS/NZS 5033:2014 Installation and safety requirements for photovoltaic (PV) arrays. Where PV arrays are installed at railway stations with combined LV earth and 1500 V dc bonding systems
then a risk assessment shall be done to confirm the requirement for commercial grade panels which are suitably rated for installation within a 1500 V dc environment.

No earth connections shall be made between PV arrays and LDNSP should power be fed into the LDNSP network. Refer to T HR SS 80006 ST Renewable Energy Installations – Photovoltaic and Battery Systems.

11. Lightning Protection

LV installations such as stations and buildings will require a lighting protection risk assessment as per AS/NZS 1768 Lightning protection. Lightning protection systems shall be required to the extent that results in tolerable risk outcomes as per the risk assessment. Highly sensitive locations such as buildings housing signalling equipment in signalling control centres shall be protected against indirect strikes and direct strikes to a minimum protection level III. For additional lightning protection requirements for signalling locations refer to SPG 0712 Lightning and Surge Protection Requirements and SPG 0729 Signalling Power Systems.

12. Superseded practice

Voltage operated earth leakage circuit breakers (ELCBs) are encountered in the installations built before 1988. No such equipment shall be used in new installations. The legacy arrangement is shown in EL0251898 Earthing – earth leakage circuit breaker diagram of connection.
Appendix A  Diagrams

The arrangement for a single power supply from the RailCorp's distribution system is shown in Figure 1. Refer to Section 5.1 for a description.

![Diagram of single power supply arrangement from the RailCorp's distribution system](image)

**Figure 1** – Single power supply arrangement from the RailCorp’s distribution system
The arrangement for a single power supply from a local DNSP's distribution system is shown in Figure 2. Refer to Section 5.2 for a description.

Figure 2 – Single power supply arrangement from a local DNSP's distribution system
The dual power supply arrangement scenario 'A' is shown in Figure 3. Refer to Section 5.3 for a description.

Figure 3 – Dual power supply arrangement – scenario 'A' (No switched neutral conductor)
The dual power supply arrangement 'B' is shown in Figure 4. Refer to Section 5.3 for a description.

Figure 4 – Dual power supply arrangement – scenario 'B' (Switched neutral conductor on the alternative supply only)
Appendix B  Suggested reading

AS 2067 Substations and high voltage installations exceeding 1 kV a.c.

EL0282072 Distribution power supply – RailCorp and backup power supply with UPS – standard schematic diagram

EL0474149 Distribution padmount substation – double insulated metering panel – general arrangement – Type 2

EL0474159 Distribution padmount substation – Type R kiosk assembly – general arrangement

EL0474470 Distribution power supply – signals power supply with UPS – standard schematic for RailCorp padmount close to signals

EL0480481 Distribution padmount substation – 11 kV/415 V distribution transformer – general arrangement – Type 2

EL0524979 RailCorp 11 kV/415 V padmount substation – insulated padmount earthing system – earthing arrangement (sheet 1 of 3)

EL0524980 RailCorp 11 kV/415 V padmount substation – insulated padmount earthing system – earthing arrangement (sheet 2 of 3)

EL0524981 RailCorp 11 kV/415 V padmount substation – insulated padmount earthing system – insulated footing arrangement (sheet 3 of 3)

Energy networks association 2006, Substation Earthing Guide ENA EG1

EP 17 00 00 11 SP Low Voltage Isolating Transformer

RailCorp 2004, Guideline on Earthing and Bonding at Railway Stations