Superseded by TS 03954:1.0, 10/05/2022

Transport Asset Standards Authority

T HR SS 80002 ST

Standard

Low Voltage Electrical Installations

Version 2.0

Issue date: 14 June 2019

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Superseded by TS 03954:1.0, 10/05/2022

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Standard governance

Owner: Lead Stations and Buildings 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

Version	Summary of changes
1.0	First issue 21 June 2018
2.0	Updated references to AS/NZS 3000:2018 and minor updates from feedback on version 1

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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 outlines the various requirements associated with low voltage (LV) installations on railway land including stations, offices, car parks and associated rail facilities such as stabling yards. This standard contains technical and operational requirements, and was developed by the ASA in consultation with other TfNSW divisions and agencies.

This is a second issue.

The changes from the previous version include the following:

- updated references to align with the latest version of AS/NZS 3000:2018 *Electrical installations (known as the Australian/New Zealand Wiring Rules)*
- inclusion of arc fault detection devices installation considerations
- minor updates from feedback on version 1

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Table of contents

1. Introduction 7
2. Purpose 7
2.1. Scope 7
2.2. Application 7
3. Reference documents 8
4. Terms and definitions 10
5. Distribution supply to an electrical installation 13
5.1. Near 1500 V dc track 14
5.2. Not near 1500 V dc track 14
5.3. Alternative power supply 15
5.4. Uninterruptible power supply or battery backup 17
5.5. Earthing and bonding 17
6. Electrical protection 19
6.1. Fault level 19
6.2. Overcurrent and short-circuit protection 19
6.3. Additional protection by residual current devices 19
6.4. Arc fault detection devices 20
6.5. Discrimination 20
6.6. Lightning and surge protection 20
6.7. Alterations additions and repairs 21
7. Switchboards 21
7.1. Replacement of existing switchboards 22
7.2. Location of switchboards 22
7.3. Switchboard construction 23
7.4. Switchboard fixing and installation 25
7.5. Tunnel LV services boards 25
7.6. Motor control centres 26
7.7. Power factor correction 28
7.8. Harmonics 28
7.9. Hazardous materials 28
8. Wiring systems 29
8.1. LV cables 29
8.2. Below-ground installations 35
8.3. Above ground installations 36
8.4. Enclosures 36
8.5. Cable trays and ladders 38
8.6. Fixings 39
8.7. Accessories 40
9. Energy metering 42

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10. Railway stations - additional guidance on specific applications 43
10.1. Leased areas within station precincts 43
10.2. Third party assets 44
11. Identification of assets and labelling 45
11.1. Safety 45
11.2. General 45
11.3. Switchboard labelling 45
11.4. Meter labelling 46
11.5. Electrical fixtures labelling 46
11.6. Private post or pole labelling 47
11.7. Power factor equipment labelling 47
11.8. Alternative power supply labelling 47
12. Assurance 47
12.1. General requirements 48
12.2. Design 48
12.3. Construction, integration and acceptance 51
12.4. Operation and maintenance 53
12.5. Decommissioning and disposal 53
Appendix A Alternative power supplies and UPS or battery backup 54

Superseded by TS 03954:1.0, 10/05/2022

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1. Introduction

Low voltage (LV) electrical installations near 1500 V dc track need to contend with the effects of stray traction currents. Specific requirements are therefore necessary to ensure the safety of the electrical installations, users and adjacent assets.

In addition, other unique issues arise for electrical installations in the rail environment and methodologies have been developed to reduce safety risks and improve customer service.

2. Purpose

This standard specifies requirements for LV electrical installations serving buildings and facilities on railway land.

2.1. Scope

This standard details requirements for specific aspects of the whole-of-life of LV electrical installations.

Although some of the following specific subjects are mentioned in this standard, they are not within the scope of this standard:

- lighting and emergency lighting
- fire and life safety
- operational technology systems including associated telecommunications cabling, closed circuit television (CCTV), public address (PA) systems, telephones, ticketing equipment, passenger information and digital clocks and so forth
- signalling power supplies
- shore supplies
- photovoltaic arrays
- control systems such as supervisory controlled and data acquisition (SCADA) and building automation systems
- earthing and bonding

2.2. Application

This standard shall be read and applied in conjunction with AS/NZS 3000:2018 *Electrical installations (known as the Australian/New Zealand Wiring Rules)* and the NSW Department of Industry, Skills and Regional Development, Division of Resources and Energy *Service and Installation Rules of New South Wales.*

This standard applies to all new and upgraded LV electrical installations on railway land.

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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

IEC 60364-1:2005-11 Low-voltage electrical installations – Part 1: Fundamental principles, assessment of general characteristics, definitions

IEC 61643-12 Low-voltage surge protective devices – Part 12: Surge protective devices connected to low-voltage power distribution systems – Selection and application principles

IEC 62606 General requirements for arc fault detection devices

Australian standards

AS 2700 Colour standards for general purposes

AS 3996:2019 Access covers and grates

AS 62053.21 Electricity metering equipment (ac) - Particular requirements - Part 21: Static meters for active energy (classes 1 and 2) (IEC 62053-21:2016 (ED.1.1) MOD)

AS/CA S009 Installation requirements for customer cabling (Wiring rules)

AS/NZS 1768 Lightning protection

AS/NZS 2053 (all parts) Conduits and fittings for electrical installations

AS/NZS 2053.1 Conduits and fittings for electrical installations – Part 1: General requirements

AS/NZS 3000:2018 Electrical installations (known as the Australian/New Zealand Wiring Rules)

AS/NZS 3008.1.1 Electrical installations – Selection of cables – Part 1.1: Cables for alternating voltages up to and including 0.6/1 kV – Typical Australian installation conditions

AS/NZS 3013 Electrical installations – Classification of the fire and mechanical performance of wiring system elements

AS/NZS 3112 Approval and test specification – Plugs and socket-outlets

AS/NZS 3133 Approval and test specification – Air-break switches

AS/NZS 4325.1 Compression and mechanical connectors for power cables with copper or aluminium conductors – Part 1: Test methods and requirements

AS/NZS 4680 Hot-dip galvanized (zinc) coatings on fabricated ferrous articles

AS/NZS 5000.1 Electric cables – Polymeric insulated – Part 1: For working voltages up to and including 0.6/1 (1.2) kV

AS/NZS 5000.2 Electric cables – Polymeric insulated – Part 2: For working voltages up to and including 450/750 V

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AS/NZS 61000 (all parts) Electromagnetic compatibility (EMC)

AS/NZS 61439.1 Low-voltage switchgear and controlgear assemblies – Part 1: General rules (IEC 61439-1, Ed. 2.0 (2011), MOD)

AS/NZS IEC 60947.1 Low-voltage switchgear and controlgear – Part 1: General rules

SA/SNZ TR 61439.0:2016 Low-voltage switchgear and controlgear assemblies – Part 0: Guide to specifying assemblies (IEC TR 61439-0, Ed. 2.0 (2013), MOD)

Transport for NSW standards

EP 12 00 00 02 SP Low Voltage Distribution and Installations Earthing References and Definitions

EP 12 10 00 20 SP Low Voltage Distribution Earthing

EP 12 10 00 21 SP Low Voltage Installations Earthing

EP 20 00 04 05 SP Cable Pits

EP 21 00 00 01 SP Insulation Co-ordination and Surge Arrester Selection

ESC 340 Tunnels

SPG 0705 Construction of Cable Routes and Signalling Civil Works

SPG 0712 Lightning and Surge Protection Requirements

SPM 0123 Reinforced Pre-Cast Concrete Cable Pits

T HR EL 00002 PR Electrical Power Equipment - Integrated Support Requirements

T HR EL 00004 ST Buildings and Structures under Overhead Lines

T HR EL 08006 ST Services Erected Above Overhead Wiring

T HR EL 11004 ST Electrical SCADA Interface Requirements

T HR EL 12002 GU Electrolysis from Stray DC Current

T HR EL 17000 ST Demarcation of RailCorp Low Voltage Distribution System

T HR EL 17001 ST Electrical Distribution System Installation Connection and Inspection

T HR EL 17002 SP Low Voltage Isolating Transformer

T HR SS 80001 ST Infrastructure Lighting

T HR SS 80003 ST Infrastructure Emergency Lighting

T HR TE 21002 ST Communications Earthing and Surge Suppression

T MU AM 00003 ST Assurance and Governance Plan Requirements

T MU AM 01001 ST Life Cycle Costing

T MU AM 04001 PL TfNSW Configuration Management Plan

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T MU MD 00006 ST Engineering Drawings and CAD Requirements

T MU MD 20001 ST System Safety Standard for New or Altered Assets

T MU TE 41001 ST Packet Switched Networks – Wired Networks

T MU TE 61005 ST Customer Information Systems for Public Transport Buildings and Conveyances

TN 016: 2015 Overbridges and footbridges – Earthing and bonding requirements

Transport Service Provider Asset Management Plan Standard

Transport for NSW standard drawings

EL0003988 Railway stations remote controlled door lock for public toilets

Legislation

Disability Standards for Accessible Public Transport 2002

Electricity (Consumer Safety) Act 2004

Electricity (Consumer Safety) Regulation 2015

Transport Administration Act 1988

Work Health and Safety Act 2011

Work Health and Safety Regulation 2011

Other reference documents

NSW Department of Industry, Skills and Regional Development, Division of Resources and Energy 2015, Service and Installation Rules of New South Wales

RailSafe, NGE 222 Working around electrical infrastructure

SafeWork Australia, 2016, Code of Practice, How to Manage and Control Asbestos in the Workplace

Sydney Trains, PR D 78104 Locking Systems for Electrical Equipment (available on the RailSafe website)

The Australian Building Codes Board, National Construction Code, volume one

TfNSW 2017, Sustainable Design Guidelines, Version 4.0

4. Terms and definitions

The following terms and definitions apply in this document:

AFDD arc fault detection device; a device intended to mitigate the effects of arcing faults, within installation wiring and plug and lead connection of electrical equipment, by disconnecting the circuit when an arc fault is detected (AS/NZS 3000:2018)

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alternative power supply an independent supply to an installation connected using a change-over arrangement. This does not include a UPS or battery backup

ASA Asset Standards Authority

ATS automatic transfer switch

BMS building management system

CCEW certificate of compliance for electrical work (CCEW); issued under the *Electricity (Consumer Safety) Act 2004* and *Electricity (Consumer Safety) Regulation 2015*

CCTV closed circuit television

containment cable tray, cable ladder, wire basket, pipe, tube, duct, conduit or cable trunking for the housing or protection of cables

distribution board switchboard other than a main switchboard

DNSP distribution network service provider; a person who owns or controls a distribution system

DSMSB distribution supply main switchboard; the first LV switchboard between the transformer terminals and the LV installation. The DSMSB is the responsibility of the EDU and is the location to establish the one and only connection between earth and neutral.

EDU electrical distribution unit; the name of the business unit accountable for the rail transport DNSP responsibilities. The EDU currently resides in Sydney Trains

electrified area the section of railway provided with 1500 V dc overhead wiring, nominally bounded by Hamilton in the north, Kiama in the south, Bowenfels in the west and Glenlee in the south west

ELV extra low voltage; a voltage not exceeding 50 V ac or 120 V ripple-free dc

enclosure a part providing an appropriate degree of protection of equipment against external influences and against contact with live parts such as a conduit, duct, pipe or trunking

HF halogen free

HV high voltage; a voltage exceeding 1000 V ac or 1500 V dc

IMSB installation main switchboard; the low voltage switchboard from which the supply to the whole installation can be controlled. The installation prefix is used in this standard to distinguish the IMSB from the DSMSB

installation means electrical installation unless otherwise required by the context

IP ingress protection

LDNSP local distribution network service provider; the organisation which owns and controls the principal distribution system in the geographical distribution area in which the installation is located. The geographical areas of the LDNSPs are defined in the *Service and Installation Rules of New South Wales*

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LV low voltage; voltage exceeding 50 V ac or 120 V ripple-free dc but not exceeding 1000 V ac or 1500 V dc

MCC motor control centre

MCCB moulded case circuit breakers

MEN multiple earthed neutral; a system of earthing in which the parts of an electrical installation required to be earthed in accordance with AS/NZS 3000:2018 are connected together to form an equipotentially bonded network and this network is connected to both the neutral conductor of the supply system and the general mass of earth

Note: Some older TfNSW documentation uses the initialism MEN to refer to the main earth neutral connection (the only earth-neutral connection)

NCC National Construction Code

near 1500 V dc track the area within the railway boundary and within:

- 20 m of the centreline of any track with overhead wiring which is electrified at nominal 1500 V dc, or
- 20 m of any 1500 V dc negative equipment or conductors, or
- 20 m of any metal which is spark gapped to rail

measured horizontally at right angles.

point of supply the point at which the installation consumers mains connects to the distribution system

OHW overhead wiring

OHWS overhead wiring structure

PA public address

PFC power factor correction

PID passenger information display

PLC programmable logic controller

rail authority means:

(a) RailCorp or TfNSW, the Country Rail Infrastructure Authority or the Transport Construction Authority, and

(b) in the case of land, rail infrastructure facilities or buildings subject to an ARTC lease or licence, ARTC.

(*Transport Administration Act 1988*)

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railway land land owned by, vested in or under the control of a rail authority (*Transport Administration Act 1988*)

RCD residual current device

safety service system or component that operates to identify an emergency, or is intended to operate during an emergency, and is primarily associated with –

a) the safety of persons evacuating a building; or

b) fire-fighting operations; or

c) fire suppression.

(AS/NZS 3000:2018)

SCADA supervisory controlled and data acquisition

service and metering equipment the DNSP's or the accredited meter provider's equipment associated with the supply, control and metering of electricity to a customer

SFAIRP so far as is reasonably practicable

SPI station passenger information

switchboard an assembly of circuit protective devices, with or without switchgear, instruments or connecting devices, suitably arranged and mounted for distribution to, and protection of, one or more submains or final subcircuits or a combination of both (AS/NZS 3000:2018)

TPS thermoplastic-sheathed

UPS uninterruptible power supply

5. Distribution supply to an electrical installation

Electrical supply to an electrical installation on railway land may be derived from the RailCorp distribution system or from a local distribution network service provider (LDNSP).
T HR EL 17000 ST *Demarcation of RailCorp Low Voltage Distribution System* defines the demarcation of responsibility for all the possible configurations of supply from the RailCorp distribution network or a LDNSP where the Electrical Distribution Unit (EDU) within Sydney Trains is the distribution network service provider (DNSP). This is generally where any part of the installation is near 1500 V dc.

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Note that the definition of near 1500 V dc track is based on experience for the majority of situations and the minimum requirement of 20 m quoted in the definition is not always sufficient to ensure the absence of traction-induced stray currents. External factors that could increase the risk of stray traction currents being picked up by the installation include, but are not limited to the following:

- the possibility of inadvertent connection of metalwork between station and adjacent developments
- the condition of the adjacent tracks such as poor ballast
- low lying flood-prone ground areas
- nearby operational rail facilities, for example a traction substation or a rail stabling yard.

5.1. Near 1500 V dc track

The EDU within Sydney Trains is the distribution network service provider (DNSP) and is the organisation that holds authority over the RailCorp distribution system. The provisions of T HR EL 17001 ST *Electrical Distribution System Installation Connection and Inspection* shall be followed when a new electrical installation is constructed or additions or alterations to an existing electrical load of an electrical installation or a new supply is required.

Where the electrical supply to an electrical installation is derived from a LDNSP, an isolating transformer shall be provided in accordance with T HR EL 17002 SP *Low Voltage Isolating Transformer* to separate the LDNSP's multiple earthed neutral (MEN) system from the earthing system of the electrical installation.

The isolating transformer, consumers mains, LDNSP service and metering equipment, isolating transformer, distribution supply main switchboard (DSMSB) and all cables connecting these assets form part of the RailCorp distribution system. All circuit breakers mounted on the DSMSB are part of the distribution system. The DSMSB is the location to establish the one and only connection between earth and neutral.

The installation main switchboard (IMSB) and the cable that connects the IMSB and the DSMSB form part of the electrical installation.

5.2. Not near 1500 V dc track

5.2.1. Non-electrified area

Where the electrical installation is not in the electrified area, the LDNSP is the electricity supplier and there is no involvement from the EDU. An isolating transformer is not required. There will also be no DSMSB and therefore the neutral earth connection is made at the meter board with earthing installed in accordance with AS/NZS 3000:2018. The provisions of T HR EL 17001 ST do not apply, however, a copy of the application for connection that is

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submitted to the LDNSP and the customer copy of the certificate of compliance for electrical work (CCEW) issued under the *Electricity (Consumer Safety) Act 2004* and *Electricity (Consumer Safety) Regulation 2015* shall be provided to the EDU and relevant Sydney Trains assurance officer.

Approval shall be obtained from the Sydney Trains assurance officer for the location of the point of supply, service and metering equipment, and the proposed route for the consumers mains located on railway land.

5.2.2. Electrified area

Where an electrical installation on railway land is adjacent to an area defined as near 1500 V dc track, or other external factors could increase the risk of stray traction currents being picked up by the installation, the design of the electrical installation shall eliminate the likelihood of picking up traction-induced stray currents to obviate the need for use of an isolation transformer.

The EDU shall be consulted in each case.

If as a result of consultation with the EDU an agreement is reached determining that the electrical installation is classified as near 1500 V dc then the requirements of Section 5.1 shall be applied.

If as a result of consultation with the EDU an agreement is reached determining that the electrical installation is classified as not near 1500 V dc then the requirements of Section 5.2.1 shall be applied.

If there is any doubt whether a part of an electrical installation could pick up stray traction current then testing should be undertaken as per the requirements of the Lead Engineer Electrical, Asset Standards Authority (ASA). Location-specific risk minimising measures may have to be implemented.

An example of a risk-minimising design could be an at-grade car park supplied separately to other infrastructure, where the only load is lighting. Double insulated light fittings could be used in areas close to near 1500 V dc with the distribution board and other parts of the electrical installation placed on the opposite side of the car park from the track side.

5.3. Alternative power supply

In general, power supply to a station is critical both operationally and for fire and life safety with most stations requiring more than one supply (primary and alternative supply) to safeguard both.

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5.3.1. Source of an alternative power supply

An alternative power supply protects against consequences of the loss of the primary (mains) power supply by providing a sufficiently independent source of electrical power through an automatic changeover device to ensure a continuous electrical supply.

An alternative power supply may be derived from the following:

- the RailCorp system
- an LDNSP
- a permanently installed standby generator which is not the preferred option, however, it may be permitted with approval from the Lead Engineer Stations and Buildings, ASA

5.3.2. Independence of an alternative power supply

The choice of alternative supplies for underground stations and tunnel services shall be guided by ESC 340 *Tunnels*.

Any change to a station power supply or its upstream network configuration requires appropriate modelling and analysis to facilitate in-depth engineering, operational and safety risk assessments. This is to confirm the proposed solution adequacy and ensure satisfactory safeguards against the total loss of power to that station under all possible circumstances including outages for maintenance and high voltage (HV) failures. The adoption of primary and alternative power supply arrangements shall be based on these assessments and life cycle cost.

Final approval of any proposed change shall be granted by the EDU in consultation with the Lead Engineer Electrical, ASA.

5.3.3. Increasing loads beyond existing supply capacity

Where an existing power supply is insufficient due to a proposed increase in load at the installation (for example the addition of lifts), and a new larger power supply is therefore necessary, a cost benefit study shall be completed on the options of decommissioning and removing the existing power supply or retaining and reconfiguring the existing power supply to become an alternative power supply for parts of that installation.

The existing power supply shall not be removed or decommissioned without approval from the EDU.

5.3.4. Load shedding

A new alternative power supply shall not be designed to be a lesser capacity than a normal supply. An exception is the case referred to in Section 5.3.3. In this case, where an alternative power supply does not have sufficient capacity to supply a complete installation a load shedding

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arrangement, which is a disconnection of predesignated loads to avoid overloading the system, shall also be developed and implemented for the times when the installation is fed from the alternative power supply. Where an alternative power supply does not have sufficient capacity to supply all systems that are required for the station to remain operational, the EDU shall consider if there are sufficient grounds to retain it, or permit its removal.

5.4. Uninterruptible power supply or battery backup

An uninterruptible power supply (UPS) or battery backup shall not be considered to be, or be confused with, an alternative power supply. As a UPS or battery backup is time-limited, the requirement for a UPS or a battery backup shall be considered independently from the requirement for an alternative power supply.

Appendix A provides detailed requirements of facilities and station types that are required to be equipped with alternative power supplies and also provides guidance on where a UPS or battery backup is required for specific equipment within the facility or station.

5.5. Earthing and bonding

Electrical installations near 1500 V dc track do not employ the MEN distribution system that forms the standard distribution system used in Australia and New Zealand. The mitigation of stray traction currents necessitates the use of a tailored earthing system which meets the requirements of clause 5.1.4 of AS/NZS 3000:2018.

Where a standard MEN system (a TN-C-S system with the combined protective and neutral conductor (PEN)separated into protective conductor (PE) and neutral conductor (N) at the origin of the installation, refer to figure 31B2 in IEC 60364-1:2005-11 *Low-voltage electrical installations – Part 1: Fundamental principles, assessment of general characteristics, definitions*) relies on connections to earth in multiple locations, the RailCorp LV earthing system is connected to earth at a single location. The explanation of the letters T, N, C and S can be found in clause 5.1.3 of AS/NZS 3000:2018.

The RailCorp LV earthing system is connected to earth at the DSMSB and not earthed at the transformer. The neutral from the transformer secondary to the DSMSB is the PEN. The PEN is separated into PE and N at the DSMSB where the one and only earth-neutral connection is made.

There shall be no earth-neutral connections within the electrical installation. It is essential that this is accounted for when calculating the minimum size of conductors within the electrical installation. In any case the size of the earthing conductors linking switchboards shall be not less than 16 mm^2 in effective cross sectional area.

Under a fault condition, the 1500 V dc traction system can also pose a risk of electric shock to persons at a station where the1500 V dc wiring is attached to structures on platforms or overhead bridges which form part of a station. This risk shall be eliminated through the design

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of appropriate isolation of exposed metallic components, or where this is not reasonably practical, the bonding of these exposed metallic components to the station earth or connected to rail through a spark gap depending on the circumstances. An earthing and bonding design is required to achieve an optimum balance of the risks associated with step and touch voltages and the effects from stray dc currents. If there is a conflict of requirements, the requirements for controlling electrical safety risks shall have precedence over those for controlling corrosion from electrolysis.

Exposed metallic components at a station include, but are not limited to, the following:

- canopies
- steel stanchions and structures
- metallic fences
- light posts
- mechanical services ductwork
- mechanical services pipe work
- fire and hydraulics pipe work
- architectural steelwork
- structural steelwork
- lift guide rails

For further information on earthing, galvanic isolation and bonding refer to the following TfNSW standards:

- EP 12 00 00 02 SP *Low Voltage Distribution and Installations Earthing References and Definitions*
- EP 12 10 00 20 SP *Low Voltage Distribution Earthing*
- EP 12 10 00 21 SP *Low Voltage Installations Earthing*
- T HR EL 00004 ST *Buildings and Structures under Overhead Lines*
- T HR EL 12002 GU *Electrolysis from Stray DC Current*
- TN 016: 2015 *Overbridges and footbridges – Earthing and bonding requirements*

Where the electrical installation is supplied directly from the LDNSP network and no part of the electrical installation is near 1500 V dc track then the standard MEN system applies.

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6. Electrical protection

Operating characteristics of switchgear and controlgear shall be suitable for the required duty, fault level, current rating, voltage rating, frequency and temperature rise with protective devices selected such that their design function is properly performed within the operating environment.

6.1. Fault level

Calculations shall demonstrate that adequate fault withstand capability (stated in kA for one second) was specified for equipment at the point of its insertion in the system.

As fault capability of the equipment shall be suitable for any upstream distribution network switching configuration that may be implemented the fault level calculations shall be based on the worst case configuration.

> *Note: In some instances the DNSP may be able to assist in this task by providing the fault level data at a specific point in the electrical network.*

The minimum fault level requirement for any electrical installation switchboard is 10 kA.

Light fittings shall be individually protected by 2 A, 6 kA breaking capacity fuses or circuit breakers. In locations where higher fault levels occur, suitable fuses of current limiters to restrict the lighting circuit fault current to below 6 kA shall be employed. The only exceptions to this are non-operational buildings such as offices, depots, and commercial areas.

6.2. Overcurrent and short-circuit protection

Fuses (with the exception of fuses in individual light fittings) shall not be used to protect any part of a new electrical installation.

Details of the type, frame size and settings shall be included on the electrical installation single line diagram for each protection device.

Electronic trip units shall be used for devices rated at and above 250 A.

Moulded case circuit breakers (MCCBs) and miniature circuit breakers (MCBs) equipped with remote switching capabilities, metering or energy metering functions shall utilise an ASA approved communications protocol.

Duplex type circuit breakers shall not be used.

6.3. Additional protection by residual current devices

For the protection of final subcircuits, residual current devices (RCDs) shall be installed at the switchboard at which the final subcircuit originates, as specified in AS/NZS 3000:2018.

As elevated levels of harmonics may be present in parts of the RailCorp system, the suitability of RCDs with respect to waveforms of the supply and to the connection to an electrical

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installation needs to be considered. Particular types of RCDs referenced in clause 2.6.2.2 of AS/NZS 3000:2018 may have to be employed in these locations to provide the expected level of protection and avoid random or spurious tripping.

6.4. Arc fault detection devices

The installation of arc fault detection devices (AFDD) that meet the requirements of IEC 62606 *General requirements for arc fault detection devices*, should be considered as an additional protection for final subcircuits for new installations and when carrying out alterations to final subcircuits in existing wiring systems. Particular consideration should be given to the risks of arc faults in the following locations:

- underground or enclosed stations
- high volume interchanges
- buildings constructed largely of flammable or combustible materials e.g. wooden buildings
- fire propagating structures
- premises with sleeping accommodation

6.5. Discrimination

Discrimination between protective devices depends on coordination between the operating characteristics of two or more protective devices such that a downstream device with a time-current curve below that of upstream protective devices shall operate for a given fault current while the other protective devices shall not operate.

Full discrimination shall be achieved for the safety services and the services listed in Table 5 in Appendix A. This may exceed the requirements of clause 2.5.7.2.2 of AS/NZS 3000:2018.

Discrimination shall be assured in accordance with clause 2.5.7.2.3 of AS/NZS 3000:2018 for all other services.

Protective devices shall also be co-ordinated for backup (cascading) protection in accordance with clause 2.5.7.2 of AS/NZS 3000:2018.

> *Note: The DNSP should be consulted for discrimination requirements between the electrical installation protective devices and the DNSP service protective devices. The relevant details shall be recorded as part of the design.*

6.6. Lightning and surge protection

Lightning protection shall be implemented in accordance with AS/NZS 1768 *Lightning protection.*

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Sharp rising surges (spikes) of short time duration from lightning strikes and high voltage switching can result in severe damage to electrical and electronic systems.

Surge protection devices shall be located within the DSMSB enclosure and other switchboard enclosures where required and conform to AS/NZS 1768 and IEC 61643-12 *Low-voltage surge protective devices – Part 12: Surge protective devices connected to low-voltage power distribution systems – Selection and application principles.* The requirements of T HR TE 21002 ST *Communications Earthing and Surge Suppression*, SPG 0712 *Lightning and Surge Protection Requirements* and EP 21 00 00 01 SP *Insulation Co-ordination and Surge Arrester Selection* shall also be complied with.

6.7. Alterations additions and repairs

Every alteration of, or addition to, an existing electrical installation shall be deemed to be a new electrical installation, and all relevant provisions of this standard and AS/NZS 3000:2018 shall apply. It shall not alter the compliance of the remaining unaltered parts of the existing installation.

Repairs to an existing electrical installation shall not alter the compliance of the existing installation.

7. Switchboards

This standard covers all switchboards that form part of an electrical installation, including the IMSB, distribution boards, other switchboards and motor control centres (MCC).

Switchboard design shall adequately address the intended function, switchboard location, load rating and prospective fault levels, harmonics voltage fluctuations and in-situ environmental issues (ambient temperature, humidity, pollution such as brake dust, ventilation, ingress protection (IP) rating, vermin-proofing and so forth). All major components shall be arranged such that they are readily accessible for maintenance or replacement.

Switchboards shall be of metal construction and fitted with hinged lockable doors. Where the switchboard is located in a lockable dedicated space the doors of the switchboard do not have to be lockable.

All new switchboards shall have at least 30% spare capacity both in the number of physical spaces and current carrying capacity.

Switchboards shall be configured to facilitate switching in accordance to AS/NZS 3000:2018.

Power supplies to safety services and the services listed in Table 5 in Appendix A that are required to operate during fire and other emergencies shall be arranged as described in clause 7.2.3 of AS/NZS 3000:2018.

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7.1. Replacement of existing switchboards

An existing switchboard shall be replaced with a new switchboard if it does not have enough capacity to accommodate the required loads, either in current carrying capability or physical space. If appropriate, a new chassis could be installed if there is sufficient room within the switchboard enclosure and the enclosure is in good condition.

All circuits shall be verified.

All switchboards shall be inspected regularly under a technical maintenance plan and the assessed condition recorded in a database. There shall be a major maintenance plan in place for the replacement of switchboards approaching the end of life.

When an existing switchboard is identified as requiring replacement with a new switchboard, relevant calculations shall be carried out as part of the design. All existing circuits shall be identified and tested prior to reconnection.

When replacing a switchboard, individual connectors are not to be used to extend sub-circuit cables when the cables are too short. All cables shall be joined as a group using appropriately sized distribution terminals mounted and labelled appropriately. Examples would be to mount a terminal strip within the switchboard or use a terminal block mounted in a separate cubicle or a junction box.

Refer to Section 8.1.5 for requirements on submain cabling.

Installation of an additional small switchboard to overcome the deficiency of an existing switchboard is unacceptable.

7.2. Location of switchboards

In addition to the requirements of clause 2.10.2 of AS/NZS 3000:2018 all switchboards shall be located with consideration of the following:

- switchboard size and function, busbar and device ratings
- controlled access, security and vandalism
- fire risk, impact of smoke and fire on egress paths
- interconnection to existing electrical infrastructure, centre of electrical load; impact on cable sizes and volt drops
- safety and ergonomics for operators and maintainers, accessibility for installation and servicing
- electromagnetic interference, particularly with electronic systems such as signalling systems, communication systems, induction hearing loops and so forth
- environmental factors including weather, ambient temperature, humidity and so forth

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The following locations are prohibited:

- within a train driver's line of sight
- in emergency egress and exit paths and under stairs
- in leased areas (except for a distribution board that is dedicated for that area)
- in areas with direct exposure to the weather, including rain, snow, ice and sunlight (UV radiation)

All IMSBs shall be located in a secure area. IMSBs shall not be located in public areas.

The IMSB and any switchboard that supplies power to safety services or services listed in Table 5 in Appendix A that are required to operate during fire and other emergencies, shall be able to operate for the required duration (four hours or two hours, or a longer time prescribed by a fire engineered solution).These switchboards shall be located in an adequately fire-rated, dedicated cupboard or electrical room.

Where a building is located on a rail platform, and the IMSB is not located on the platform, a separate distribution board is required to be located in the main building on that platform. Smaller buildings on the same platform may be fed from that distribution board.

Electrical rooms and cupboards shall be secured by a standard electrical discipline key. Locks shall be fitted as follows:

- substation rooms shall be fitted with C1A locks
- IMSB rooms to be fitted with C1B locks
- distribution supply switchboard rooms and battery rooms shall be fitted with C1A locks

Refer also to PR D 78104 *Locking Systems for Electrical Equipment*.

7.3. Switchboard construction

Switchboards shall utilise type tested designs (part type tested assembly (PTTA) in accordance with AS/NZS 61439.1 *Low-voltage switchgear and controlgear assemblies – Part 1: General rules (IEC 61439-1, Ed. 2.0 (2011), MOD)*). The design and construction shall be in accordance with AS/NZS IEC 60947.1 *Low-voltage switchgear and controlgear – Part 1: General rules*.

Form 4b (as described in SA/SNZ TR 61439.0:2016 *Low-voltage switchgear and controlgear assemblies – Part 0: Guide to specifying assemblies (IEC TR 61439-0, Ed. 2.0 (2013)* MOD) switchboards should be considered for special applications for example, IMSB for a rail control centre. Form 3b (as described in SA/SNZ TR 61439.0:2016) or higher shall be used for any switchboard where one or more of the following applies:

- the rated supply current to the switchboard is 800 A or more per phase
- a safety service is fed from the switchboard

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- a service listed in Table 5 in Appendix A is fed from the switchboard
- the switchboard feeds another switchboard that provides power to a safety service or a service listed in Table 5 in Appendix A

All switchboards rated 800 A or more shall be constructed to withstand internal arcing faults and be designed for arc-containment.

Non-critical switchboards that supply power to other non-critical switchboards or distribution boards shall be a minimum Form 2b (as described in SA/SNZ TR 61439.0:2016). All other switchboards may be Form 1 or Form 2b (as described in SA/SNZ TR 61439.0:2016) as determined by electrical design (life cycle costs and the effect on maintenance and operation shall be considered).

Outdoor switchboards shall be constructed to IP65. Fabrication shall minimise the number of gasketed openings to the outside of the switchboard and shall provide for a sloped roof.

Switchboards shall be painted electrical orange (X15 as specified in AS 2700 *Colour standards for general purposes*) externally and white (N14 as specified in AS 2700) internally.

Switchboard busbars shall be sized and supported in such a way that they are capable of withstanding the mechanical and thermal stresses resulting from the prospective fault level.

Busbars shall be made from hard drawn, high conductivity copper with rolled edges. The minimum busbar rating (continuous) is 100 A.

All busbars shall be insulated unless the switchboard is constructed as Form 3B (as described in SA/SNZ TR 61439.0:2016) or higher.

Busbar links located within the current transformers compartment shall be provided for the current transformers. The current transformer busbar link shall not cross between compartments.

Cables within switchboards shall be neatly run minimising excessive length, be firmly supported to ensure minimum stress on terminations, for example, circuit breaker terminals, and shall not impede access to the neutral and earth bars. Control cables shall be neatly run in slotted PVC trunking and tied together with suitable cable ties at intervals not exceeding 300 mm.

Multiphase cables shall be colour coded as indicated for cables in figure 3.2 of AS/NZS 3000:2018 as follows:

- active phases – red white blue
- neutral – black
- earth – striped yellow and green

All other cables shall be colour coded in accordance with table 3.4 of AS/NZS 3000:2018.

All circuit breaker spaces not in use shall be closed with suitable covers or pole fillers.

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Bearing in mind life cycle costs and ease of maintenance consideration should be given to a busbar disconnection system (for example, isobar chassis), to improve safety and access to individual circuits and the use of hinged escutcheon panels to alleviate manual handling risks.

7.4. Switchboard fixing and installation

Fixing of switchboards shall be secure, safe and sized to suit switchboard weight, loading, shape and rigidity, location, vibrations and other relevant conditions.

When holes are drilled in switchboards subsequent to paint finishing exposed steel shall be rust-proofed and finished to the same colour as the switchboard prior to inserting fixtures or fittings.

For small wall-mounted switchboards galvanised metal thread screws, bolts and nuts with metal expanding plugs into brick (not mortar) and concrete work shall be used.

7.5. Tunnel LV services boards

The services supplied from tunnel LV services boards include lighting, emergency lighting and general tunnel-related electrical services such as tunnel single-phase and three-phase socket outlets.

Tunnel LV services boards shall be located in stations adjacent to tunnels and outside tunnel portals for discrete tunnels. In longer tunnels, or sections of underground railway, the services within the tunnel can be supplied from two switchboards, one at each end. In such cases there shall be no connection between the services supplied from either end with each service housed in its own enclosure.

Tunnel LV services boards shall be either single-phase or three-phase, IP65, rated 30 kA for 0.1 second, Form 3b (as described in SA/SNZ TR 61439.0:2016) construction.

The power supply to tunnel LV services boards shall be derived from an IMSB or DSMSB that is powered from at least two alternative power supplies.

The power supply cable to tunnel LV services boards shall be protected to WS5XW as defined in AS/NZS 3013 *Electrical installations – Classification of the fire and mechanical performance of wiring system elements* and routed to safeguard and minimise the risk of vandalism and accidental or intentional damage so far as is reasonably practicable (SFAIRP).

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Tunnel LV services board functionality is determined by specific design and may include some of the following segregated sections or more:

- incoming supply, busbars, distribution or outgoing circuits
- control unit and network interface for emergency tunnel lighting (as specified in T HR SS 80003 ST *Infrastructure Emergency Lighting*) and any other tunnel lighting
- interface to the electrical SCADA (refer to T HR EL 11004 ST *Electrical SCADA Interface Requirements*)

Busbar rating shall be a minimum of 250 A. The breaker curve is to be selected according to its function (for example, lighting circuit protection) tunnel LV services boards shall be suitable for both top and bottom entry cables. A permanently attached schedule shall be affixed to the inside of the switchboard door.

7.6. Motor control centres

Power and control to electric motors and related equipment such as pumps, ventilation fans and similar equipment shall be provided from a central location, an MCC.

7.6.1. Safety services MCCs

An MCC that serves safety services or services listed in Table 5 in Appendix A that are required to operate during fire and other emergencies, shall be able to operate for the required duration (four hours or two hours, or a longer time prescribed by a fire engineered solution).

The MCC shall be located in a dedicated room with a controlled environment.

The MCC shall be supplied from two independent power supplies originating in separate DSMSBs. The normal and alternative power supply cables to the MCC shall meet all of the following criteria:

- be protected to WS5XW as defined in AS/NZS 3013
- segregated as defined in Section 8.1.3
- separated from other services by the minimum distance as specified in clause 3.11.5 of AS/NZS 3000:2018 or 100 mm whichever is the greater
- routed to protect and minimise the risk of vandalism and accidental or intentional damage to SFAIRP

MCCs shall be of metal clad, extensible modular construction. Typically an MCC shall be three-phase. All MCCs shall be rated at least 30 kA for 0.1 second minimum Form 3b (as described in SA/SNZ TR 61439.0:2016) construction.

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MCCs shall be purpose designed and include the following segregated sections:

- Incomers terminations in separate compartments, isolators for each of the two incoming supplies, automatic transfer switch (ATS) with normal supply selectable locally or remotely to either of the two supplies, ATS manual override. Local and remote indication and alarm to include the following:
  - normal supply or alternate supply (available or selected)
  - power failure (ATS output)
  - other as required by the design
- Fully insulated and phase segregated copper busbar system. Busbar continuous current rating shall be minimum 300 A.
- Fully segregated to contain fault damage motor controller units including contactors, solid-state motor starters, variable frequency drives, overload relays to protect the motor, circuit breaker to provide short-circuit protection and a disconnecting switch to isolate the motor circuit and so forth. The breaker curve is to be selected according to its function for example, motor starting. Fuses are prohibited.
- Controls to include equipment for local and remote control, monitoring, system operation and indication of equipment status.
- Metering to monitor energy consumption and power quality.
- Device level networks to communicate with a programmable logic controller (PLC) or process control system via a data network. Refer SCADA standard T HR EL 11004 ST for interface to the electrical SCADA for remote management and monitoring.
- Other as required by the design.

The effect of possible harmonic distortion on the operation of the ATS phase failure relays, PLCs and electronic control equipment shall be considered and appropriate units selected.

MCCs shall be suitable for both top and bottom entry cables.

Complete set of documentation provided with the MCC, single line diagram, schedules and other relevant information shall be permanently affixed to MCC cubicle door.

Tunnel MCCs are usually located in dedicated rooms in tunnel adjacent stations and outside tunnel portals for discrete tunnels.

7.6.2. Other MCCs

MCCs that do not serve safety services or services listed in Table 5 in Appendix A that are required to operate during fire and other emergencies may be supplied from a single power source (IMSB or DSMSB). All other requirements of Section 7.6.1 apply.

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MCCs mounted outdoors shall be rated IP65.

7.7. Power factor correction

The electrical installation power factor shall be higher than 0.90.

Automatic power factor correction (PFC) equipment shall be integrated into or located directly adjacent to the IMSB.

High levels of harmonics may be present in parts of the rail power network resulting in abnormally high current levels through the capacitors in turn requiring oversizing of all parts of the power correction system. Detuned reactors shall be incorporated in PFC to prevent harmonic resonance problems.

A PFC bank shall be sized using multiples of 25 kVAr of effective power steps.

7.8. Harmonics

The addition of PFC capacitors can aggravate potential harmonic problems.

The harmonics can be reduced by passive filters inductor capacitor resistor (LCR) or active harmonic compensators which restore the waveform back to its undistorted state. The designer shall investigate power quality in the project location and employ relevant mitigating measures to ensure compliance with the AS/NZS 61000 (all parts) *Electromagnetic compatibility (EMC).*

7.9. Hazardous materials

Older equipment such as meter and switchboard panels may contain asbestos or other hazardous materials. Such equipment shall be identified, appropriately labelled and included in a register containing all relevant details.

When work is undertaken on any equipment that contains hazardous materials, the decision on removing the hazardous materials, or continuing operation without removing the hazardous materials, should be based on a life cycle assessment that includes consideration of all the necessary ongoing precautions throughout the life of the equipment.

All work shall be undertaken by competent and authorised personnel. Prior to undertaking work a safe work method statement shall be developed and a pre-work brief carried out and signed off by all personnel involved.

Work on equipment containing asbestos shall comply with SafeWork Australia *Code of Practice, How to Manage and Control Asbestos in the Workplace*.

Work on equipment containing lead and hazardous chemicals such as polychlorinated biphenyls (PCBs) shall comply with the *Work Health and Safety Regulation 2011*.

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8. Wiring systems

All electrical installation wiring shall be routed to protect and to minimise the risk of vandalism and accidental or intentional damage SFAIRP.

All wiring shall be installed in a wiring containment compliant with ASA standards. Fire and life safety and other rail-operation-critical concerns may stipulate location-specific requirements for example, mechanical and environmental protection, fire rating, halogen free (HF), low smoke emission, flame retardant cable and so forth.

No wiring systems shall be located in areas where access can only be achieved by securing a possession, for example under platform copings. All cables shall be accessible from behind the yellow line on the platforms.

Any part of an electrical installation shall be located or mounted at least 2 m away from 1500 dc V overhead wiring (OHW) and overhead wiring structures (OHWS). EP 12 10 00 21 SP provides further detailed requirements.

Where any part of the cable run is in a steel or metallic enclosure or cable tray or ladder the conductors shall be insulated and sheathed.

8.1. LV cables

Only cables with stranded copper conductors may be used for LV purposes. An exception to this is 1 mm² control wiring. Cables shall be in accordance with AS/NZS 5000.1 *Electric cables – Polymeric insulated – Part 1: For working voltages up to and including 0.6/1 (1.2) kV* except where allowed for final sub-circuits, refer to Section 8.1.7. Insulation shall be a minimum of V-75 grade. Use of the following cables is prohibited:

- armoured, lead sheathed, earth sheath return (ESR) and neutral screened cables
- mineral insulated metal sheathed (MIMS) cables
- aluminium cables (except aerial cables)
- cables that have vulcanised Indian rubber (VIR)

8.1.1. Cable selection

Cables shall be selected in accordance with AS/NZS 3008.1.1 *Electrical installations – Selection of cables – Part 1.1: Cables for alternating voltages up to and including 0.6/1 kV – Typical Australian installation conditions*. Calculations for cable selection shall be provided as part of the design process. Cable runs shall utilise appropriate installation methods to ensure adequate cooling. To eliminate the need for de-rating cables shall be arranged and spaced to avoid self-heating and heating from other current carrying conductors.

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Cable size shall remain the same throughout the entire length of each circuit. Design cable ratings for stated cable sizes shall be maintained throughout the entire cable route. Particular attention is required regarding the cable runs in proximity to each other in areas such as switchboards.

The neutral conductors associated with the mains, sub-mains and final circuits shall not be less than that of the associated active conductors. As high harmonics content may be present in parts of the RailCorp system, it may be necessary for the capacity of a neutral conductor to be greater than that of the associated active conductors.

Only low smoke zero halogen (LSZH) cables shall be used in the following situations:

- tunnels
- underground stations
- surface stations with at least one end of a platform connected to a tunnel
- stations where adjacent tracks are covered linearly for a length of more than 90 m
- stations, where appropriate natural ventilation cannot adequately extract smoke to the degree necessary to ensure viable egress for agreed scenarios
- major rail stations and transport interchanges
- pedestrian subway forming part of a station

8.1.2. Cables for safety services

Wiring systems that supply power to safety services and services listed in Table 5 in Appendix A that are required to operate during fire and other emergencies shall be able to operate for the required duration (four hours or two hours, or a longer time prescribed by a fire engineered solution). These cables need to be adequately fire rated (by using a combination of suitably fire rated cable and appropriate installation method) separated and segregated from any other services.

The cables shall comply with clause 7.2.2 of AS/NZS 3000:2018 and as a minimum shall be protected to not less than WS52W as defined in AS/NZS 3013.

The cables shall be protected from mechanical damage by a suitable enclosure or by locating the wiring system where it will not be exposed to mechanical damage.

In addition, specific controls shall be implemented to eliminate or where not possible, mitigate the risk of unauthorised access, vandalism or other intentional or accidental damage to the cables SFAIRP.

Power supply cables to station lifts not classified as emergency or evacuation equipment are required to be capable of maintaining supply to the equipment when exposed to fire and shall be rated at least WS52W in accordance with AS/NZS 3013.

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Joints in cables providing power to safety services and services listed in Table 5 in Appendix A are prohibited.

8.1.3. Cable segregation

Cables shall be segregated as required in AS/NZS 3000. Effective segregation may be achieved by the use of independently sheathed cables, barriers of fire-resistant material or by distance.

To enhance security of supply this standard prescribes additional requirements for the physical segregation of specific nominated cables to reduce the following risks:

- mechanical or fire damage by a single physical event
- electromagnetic interference with other cables or systems
- confusion with another cable when work is being undertaken

Power supply cables for systems and equipment that utilise dual power supplies (circuits from different supply sources for example, normal and alternative power supplies that are provided from different switchboards) shall be segregated from each other in their own separate cable containments routed in separate fire compartments. Circuits of different supplies cannot be terminated in the same enclosure unless it is a source-changeover panel.

Control and communication cables for systems and equipment that utilise dual or redundant arrangements shall have their respective cables (or groups of cables) segregated from each other in their own separate cable containments routed in separate fire compartments.

Where separate fire compartments are not available to route the cables, the cable containments shall be separated as far as possible in different physical spaces and routes. Routes within the same spaces and exposed to the same risks are not considered adequate physical segregation.

In addition, the following cables shall be segregated in their own separate cable containment:

- safety services, including their control or alarm cables
- services listed in Table 5 in Appendix A including their control or alarm cables
- circuits with different voltages (that is HV cables, LV cables or extra low voltage (ELV) cables)
- cabling upstream of IMSB
- circuits from different switchboards
- signalling cables and cables providing power supply for signalling
- emergency lighting circuits for central systems

Refer to T HR SS 80003 ST for requirements for single point systems (self-contained emergency luminaires).

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The following circuits shall be segregated as much as practicable:

- normal lighting
- general power
- circuits powering specific equipment groups such as heating or ventilation

Communications cables, including optical fibre, shall be separated from LV cables by a minimum of 50 mm or by a durable barrier. The only exception to this is communication or control cables directly related to the LV cables such as those that are part of the same building management system.

Refer also to the requirements of AS/CA S009 *Installation requirements for customer cabling (Wiring rules)* and SPG 0705 *Construction of Cable Routes and Signalling Civil Works*.

8.1.4. Cable termination

Assembled components forming part of a cabling system shall perform without distress under the normal (within the operating parameters), emergency (two hour overload) and fault conditions. Only class B proprietary, tinned copper connectors compliant with AS/NZS 4325.1 *Compression and mechanical connectors for power cables with copper or aluminium conductors – Part 1: Test methods and requirements* shall be used.

Narrow palm lugs shall be used for connection to MCCBs. The lug hole shall be coordinated with stud size to ensure correct fit. Solderless clamp terminals can be used to secure stranded cable directly to the MCCB.

Earthing connections shall be affixed using nut and bolt or proprietary terminals. Self-tapping screws are not acceptable.

Cold shrink or heat shrink insulation shall be applied over cable tails and connectors to a sufficient degree to ensure safety and prevent unintentional contact with live parts. Phase identification shall be ensured.

All terminations shall be adequately marked to ensure phase, neutral or earth conductors of each circuit can be unambiguously identified.

8.1.5. Cables upstream of installation main switchboard (IMSB)

The following cables shall utilise single core double-insulated stranded copper cables for active and neutral conductors plus single-insulated stranded copper earth conductor:

- cables between the DSMSB and IMSB for LV installations that are either near 1500 V dc track or not near 1500 V dc track
- consumers mains cables between LDNS point of supply and IMSB for LV installations that are not near 1500 V dc track

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These cables shall be installed in a dedicated wiring enclosure.

Sizing of the cables upstream of an IMSB shall include future increase in maximum demand. If this cannot be enumerated at the time of the design then an allowance of 30% shall be included in the calculation of the cable size. The use of next larger cable size is permitted, provided that the cable spare capacity is at least 25%.

Where the LV installation supplies safety services or services listed in Table 5 in Appendix A that are required to operate during fire and other emergencies, the method of installation shall ensure that their integrity shall be maintained for the required duration (four hours or two hours, or a longer time prescribed by a fire engineered solution). These cables shall comply with clause 7.2.2 of AS/NZS 3000:2018 and as a minimum shall be protected to not less than WS52W as defined in AS/NZS 3013 and adequately fire rated by using a combination of suitably fire rated cable and appropriate installation method.

Alterations to existing cables upstream of an IMSB shall be treated as a new installation except where specified in the *Service and Installation Rules of New South Wales*.

Joints in consumer mains or any other cables upstream of IMSB are prohibited. Cable entry to IMSB shall be through the bottom of the switchboard.

T HR EL 17001 ST states the qualifications required to work on consumers mains; this also extends to LV cables upstream of an IMSB.

Near 1500 V dc

Sizing of the cables upstream of an IMSB based on AS/NZS 3000 calculation methods of the installation maximum demand that have been developed for a MEN system may not be adequate for an electrical installation where a RailCorp LV earthing system is used.

In the RailCorp LV earthing system the location of the earth-neutral connection is upstream of the electrical installation. As this connection may be located at a considerable distance from the IMSB, the cables upstream of IMSB may have to be upsized to comply with the voltage drop and earth fault-loop impedance requirements of AS/NZS 3000.

The minimum size of the cables upstream for LV installations near 1500 V dc track is 16 mm^2. The only exception is for the cables serving small retail concessions on railway stations where the minimum size is 6 mm^2.

Not near 1500 V dc

The sizing of consumer mains for an electrical installation that is not near 1500 V dc track and is supplied from a LDNSP network shall be based on AS/NZS 3000.

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8.1.6. Submains

Flat thermoplastic-sheathed (TPS) cables shall not be used for submains but circular double insulated single core or multicore cables may be utilised. Where an earth cable is required to be larger than the associated active and neutral due to mandatory minimum size requirements, for example a minimum 16 mm^2 earth cable linking switchboards, single core cables are preferred. Sub-mains shall not be installed in the same cable enclosure as final subcircuits.

Sub-mains shall not exceed 1.5% V drop of the nominal voltage unless the sub-main is exceptionally long or if the installation's electrical load is small and the total voltage drop measured from DSMSB does not exceed 5%.

Sub-mains that supply safety services and the services listed in Table 5 in Appendix A shall be protected to maintain their integrity to the degree defined in Section 8.1.2.

Joints in sub-mains are prohibited. Preferred submains cable connection configuration is through the bottom of the respective switchboards.

8.1.7. Non-critical final circuits

Double insulated single core or multicore TPS cables with 450/750 V grade insulation in accordance with AS/NZS 5000.2 *Electric cables – Polymeric insulated – Part 2: For working voltages up to and including 450/750 V* may be used. The use of multi-core cables is preferred for final subcircuits such as platform lighting.

The minimum cable size for general power circuits shall be 2.5 mm^2. The minimum cable size for lighting circuits shall be 1.5 mm^2, except where the cable is to be installed in underground ducts, for example, platform lighting columns and illuminated signs, where the minimum cable size shall be 2.5 mm^2. The minimum cable size for control wiring is 1 mm^2.

Joints in any cables installed underground are prohibited, this includes cable joints in cable pits, which are considered part of the below-ground installation. For final circuits run above ground, jointing may be permitted if made in easily accessible enclosures.

Where a platform lighting column is removed for installation of a canopy and an underground pit exists, a new length of cable shall be installed between the next adjacent luminaires (on the same circuit) on either side of the column, to eliminate the underground joint. Where no pit exists, the conduit shall be made good by best practice method and the section rewired without joints.

With exception of concealed ceiling spaces, all TPS cables shall be placed in enclosures (conduits or trunking). Where TPS cables are run in concealed ceiling spaces (for example, suspended ceilings) these shall be run on a cable support system independent from the ceiling structure. The cable system shall be accessible from non-public areas.

All general power circuits wiring shall be installed using the loop-in loop-out principle.

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8.2. Below-ground installations

All underground installations shall meet the requirements of AS/NZS 3000:2018 for Category A underground wiring systems. Where the LV cables are buried in a shared trench with another service that has a requirement to be buried at a greater depth, the LV cables shall be buried at the same depth as the other service, and consistent with the segregation requirements of Section 8.1.3 so that the LV cables shall not be disturbed if access is required to the other service.

Cable routes shall follow straight lines wherever possible, preferably parallel to buildings or landscape features, and be checked on site for interference from existing services prior to wiring systems procurement and installation. Wiring systems installed underground shall be identified in accordance with the requirements of AS/NZS 3000. Civil construction requirements shall be as specified in SPG 0705.

Rigid heavy duty PVC shall be used for in ground and concrete embedded conduits. Conduits in structural concrete slabs shall be installed with long sweeping bends above lower reinforcement steel and below top reinforcement without compromising concrete cover required by reinforcing. The conduit and associated fittings shall not penetrate or come into contact with damp-proofing or waterproofing membranes. To avoid weakening structural concrete slabs the in-slab conduits shall not be bunched together.

Metal enclosures are prohibited in-ground where the electrical installation is near 1500 V dc track due to stray dc currents and corrosion issues. The exception to this requirement is where it can be demonstrated that there will not be appreciable dc leakage current as defined in EP 12 00 00 02 SP.

8.2.1. Cable pits

To ensure long-term ability to add, replace or maintain cables run in underground ducts and conduits, suitably sized and oriented cable pits shall be installed at 90 degree bends or similar constraints along the route. Cable pits shall also be installed to assist in the installation of large cables. Pits shall be located to exclude water collection, suitably sealed, drained and interconnected by heavy duty unplasticised PVC (uPVC) conduits. Access for the purpose of installing cables, duct sizes and maximum spacing between pits shall ensure that maximum pulling tension for the used cable types and sizes is not exceeded.

Cable pit access covers shall comply with AS 3996:2019 *Access covers and grates* and duty-rated as Class B, C, D, E, F, G, as outlined in clause 3.1 of AS 3996:2019. Cable pit covers may be reduced to Class A in accordance with AS 3996:2019 only where the area is not accessible to any type of vehicle or machinery including maintenance equipment such as scissor lifts. Removal of pit access covers shall be by use of a lifting key, the arrangement shall be compliant with clause 3.2.2.6 of AS 3996:2019.

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Site constraints, civil design, safe access to confined space, pit chamber shape and dimensions for specified minimum cable bend radius and bell-mouthed ducts shall be considered as part of design.

Design requirements specified for signals and communication pits in SPM 0123 *Reinforced Pre-Cast Concrete Cable Pits* shall be adopted where applicable.

Indelible labels shall be securely affixed to the cable pit lid to indicate the pit contains electrical cables.

Refer also to EP 20 00 04 05 SP *Cable Pits*.

8.3. Above ground installations

Unless purposely specified by the architect all wiring, cable tray and ladder systems, and cable enclosures in public accessible areas shall be fully concealed.

All cable enclosures shall be easily accessible, installed in a neat and orderly manner, evenly spaced, level and plumb or parallel with building members. Access points such as junction and inspection boxes and accessible bends shall be provided to facilitate the installation of cables.

In all public areas and where enclosures are exposed to mechanical damage, that is mounted lower than 2.4 m above ground or floor level, mechanical protection to WSX3 as defined in AS/NZS 3013 shall be provided.

Where a wiring system passes through elements of building construction, such as floors, walls, roofs, ceilings, partitions or cavity barriers that are required to be fire-rated, the system selection and installation shall conform to clause 3.9.9 of AS/NZS 3000:2018.

Electrical installation wiring installed above 1500 V dc OHW is not desirable, however where it is unavoidable for LV electrical services to cross above the 1500 V dc OHW, the requirements of T HR EL 08006 ST *Services Erected Above Overhead Wiring* apply.

8.4. Enclosures

Acceptable cable and wiring enclosures comprise metal conduits, insulated conduits, tubing, ducts and cable trunking defined in clause 3.10.2 of AS/NZS 3000:2018. All enclosures shall be selected and constructed in compliance with designations in appendix H of AS/NZS 3000:2018 and be compliance tested in accordance with AS/NZS 3013.

Enclosures and their fixings for classifications WSX1, WSX2 and WSX3 shall be type-tested. While enclosures for classifications WSX4 and WSX5 can be type-tested, it is anticipated that these enclosures will be designed by a structural engineer. Classifications are as defined in AS/NZS 3013.

All enclosures shall have 30% spare capacity to allow for future electrical wiring taking into account the enclosure maximum space factor defined in table C6 of AS/NZS 3000:2018.

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Care shall be taken to ensure that fire rated systems rating is not compromised by the manner cable enclosures are attached to walls and structures.

Care shall be taken to ensure that the IP enclosure rating is not compromised by the manner external cables enter the enclosure.

No metallic enclosures shall pass within 2 m of any OHWS. If this is impractical then it shall be fitted with an insulated joint at least 2 m distant from each side of the OHWS and the earthing of the metal enclosure included as part of the earthing and bonding design for the installation.

8.4.1. Trunking

Where metallic cable trunking or duct is used, it shall be made of minimum 1.2 mm thick galvanised steel with a cover which cannot be removed without the use of tools. The minimum size is 50 mm x 50 mm.

Non-metallic trunking or duct shall not be used in public areas.

8.4.2. Conduits

Conduits shall comply with AS/NZS 2053.1 *Conduits and fittings for electrical installations – Part 1: General requirements*.

Conduit installation shall be accomplished using procedures recommended by the manufacturer. The minimum conduit size shall be as follows:

- 32 mm where installed in ground
- 25 mm where installed in concrete
- 20 mm elsewhere

8.4.3. PVC conduits

Only rigid PVC conduits shall be used.

Conduits shall comply with AS/NZS 2053 (all parts) *Conduits and fittings for electrical installations*. All non-metallic conduits and fittings shall be protected against solar radiation (T), be of non-flame propagating type and shall pass the test of ignitability and flame propagation in accordance with AS/NZS 2053.1. Only HF conduits and fittings in accordance with AS/NZS 2053.1 shall be used in the following areas:

- tunnels
- underground stations
- surface stations with at least one end of a platform connected to a tunnel
- stations where adjacent tracks are covered linearly for a length of more than 90 m

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- stations where appropriate natural ventilation cannot adequately extract smoke to the degree necessary to ensure viable egress for agreed scenarios
- major rail stations and transport interchanges

In-ground or concrete-embedded heavy duty conduits do not need to comply with these requirements.

8.4.4. Galvanised steel conduits

Only rigid screwed galvanised steel conduit and fittings shall be used.

All sharp edges, burrs and so forth shall be removed and the conduit ends painted with a rust-inhibiting metallic paint which maintains conductivity prior to being screwed together.

8.4.5. Flexible and corrugated conduits

The use of flexible conduit is prohibited except where used for the hard wiring of hot water tanks, stoves and similar equipment and then only where bends are required and not in public areas.

The use of corrugated non-metallic conduit is only permitted for the following applications:

- in lieu of non-metallic flexible conduit
- for the interconnection of sections of Unistrut or equivalent supporting light fittings
- for the interconnection of rigid PVC conduits around structural members
- in short lengths for the extension of rigid PVC conduit to light fittings

8.5. Cable trays and ladders

Any reference to cable trays shall apply to cable ladders and wire baskets.

Cable trays may be used for runs consisting of multiple cables or conduits and shall be sized to cater for the required cable runs (spaced as directed in Section 8.1.1) plus an allowance of 30% spare space for future cabling. Accordingly, the cable tray system shall be selected to adequately carry the anticipated cable tray load inclusive of the load of future cabling.

Cable trays and related accessories such as tees, bends, supports and mountings and so forth shall be hot dipped galvanised steel as specified in AS/NZS 4680 *Hot-dip galvanized (zinc) coatings on fabricated ferrous articles* with all system components supplied from the same manufacturer.

The cable tray system shall be selected and constructed in compliance with designations in appendix H of AS/NZS 3000:2018 and be compliance tested in accordance with AS/NZS 3013.

Where exposed to the outside environment cable trays shall be equipped with protective covers. All cable trays shall be appropriately earthed.

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Cable trays shall be located at a height and position that ensures safe and easy accessibility using a ladder. Cable trays shall follow the structural members of building and be constructed and concealed in a manner that has minimum visual impact on the building or facility.

Cables shall be neatly installed on cable trays, using proprietary straps and fixings. The requirements for segregation of cable systems in Section 8.1.3 should be noted.

No metallic cable tray or ladder shall pass within 2 m of any OHWS. If this is impractical then it shall be fitted with an insulated joint at least 2 m distant from each side of the OHWS and the earthing of the metal cable tray or ladder included as part of the earthing and bonding design for the installation. Where cable trays are installed in tunnels refer to ESC 340 for further requirements.

8.6. Fixings

Electrical wiring and wiring containments shall be adequately affixed in position by suitable means so as to not damage the building fabric, the wiring or the containment. Fixing shall be secure, safe and mechanically sized to suit conditions of weight, shape, location, vibrations, loading and rigidity. Manufacturer's instructions shall be followed at all times.

The rail environment can have high levels of ongoing vibration and all fixing methods chosen for this environment shall adequately prevent failure. Positive, anti-vibration and anti-corrosion fixings shall be used for all applications. Friction fixings shall not be used.

Only vandal-resistant fixings shall be installed at heights lower than 2.4 m.

Fixings, fastenings or systems manufactured from dissimilar materials shall not be used unless factory equipped with separation barriers designed to exclude galvanic corrosion.

Core holes for all fastening anchors shall be sized to manufacturer’s recommendations. Plugs and anchors shall be installed flush with the surface when inserted and affixed.

In all cases appropriate junction boxes, bends and cable access points shall be provided.

Use of explosive powered fixings is prohibited.

8.6.1. Fixing of cable enclosures

If the cable enclosure is chased in masonry walls then it shall be sealed in a manner consistent with the finished surface.

Trunking shall be installed strictly in accordance with manufacturer’s recommendations.

Conduit saddles shall be double-sided metallic type with heavy corrosion protection in accordance with AS/NZS 2053.1. The exception to this may be in the use of a single-sided saddle for the first saddle at the very top of a tight bend. The use of spring-clip type saddles is prohibited.

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Saddles shall match conduits in size. Where conduits in public accessible areas are allowed saddles shall be spaced a maximum 1000 mm apart for horizontal runs and 600 mm apart for vertical drops.

For other locations saddles shall be spaced at a maximum of 1.2 m centres on horizontal runs and 2.0 m centres on vertical runs.

Where flexible couplings are used at structural expansion joints saddles shall be spaced as close as possible to the flexible coupling on both sides.

The use of cable ties or similar arrangements to fix conduits or trunking in place is prohibited.

8.6.2. Cable trays and ladders

Cable tray and ladder systems shall be installed strictly in accordance with manufacturer's recommendations using proprietary fixings. Care shall be taken to ensure that fire rated systems rating is not compromised by the manner cable trays and ladders are attached to walls and structures.

Cables shall be adequately secured with cable ties. In public areas and in areas exposed to sunlight only stainless steel cable ties shall be used.

In all other areas black, UV stabilised cable ties shall be used.

8.6.3. Fixings for TPS cables

Cable clips shall be used at suitable centres to prevent sagging and maintain cable run integrity without contact with building elements.

8.6.4. Fixings for luminaires

For requirements for fixing luminaires refer to T HR SS 80001 ST *Infrastructure Lighting.*

8.7. Accessories

Switches and socket-outlets shall be installed using a wall box or a mounting block.

8.7.1. Switches

Switches for lighting and small power circuits shall have a minimum rating of 10 A and be single or multi-gang for architrave or wall mounting as appropriate and with white plates unless another colour is specified. Switches shall comply with AS/NZS 3133 *Approval and test specification – Air-break switches*.

Switches shall not be located in public areas except where essential and approved through the stakeholder review process and then in locked enclosures.

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Unless specifically required by design documentation the mounting heights of switches shall be 1000 mm above finished floor level with a tolerance of 100 mm above or below this level, particularly to align with door handles or other controls. Refer to section 21.1 of the *Disability Standards for Accessible Public Transport 2002*.

8.7.2. Socket-outlets

Socket-outlets or general purpose outlets (GPO) shall comprise a 10 A switch, 10 A, 3-pin flat pin receptacle and, where required, a neon indicator, all mounted under a common plastic flush plate, white in colour unless otherwise specified. Outlets shall comply with AS/NZS 3112 *Approval and test specification – Plugs and socket-outlets.*

It is preferable for socket-outlets to not be located in public areas. Where there is no clear alternative such as socket-outlets required for cleaning purposes of a large public space they shall be of the lockable type.

Designs for other specific purposes such as recharging of electrical devices in designated waiting rooms should consider the requirements of section 21.1 of the *Disability Standards for Accessible Public Transport 2002* while also locating the socket-outlet out of the reach of children. Where a bench is used the socket-outlets shall be 200 mm above bench level.

In work areas socket-outlets shall be 300 mm above finished floor level or 200 mm above bench level where appropriate.

The maximum number of socket-outlets per final subcircuit shall be less than or equal to the number allowed by AS/NZS 3000. For new installations, the number of socket-outlets connected to a final subcircuit shall not exceed 80% of that allowed by AS/NZS 3000.

Three-phase outlets, outlets dedicated to specific equipment and, in general, fixed appliances shall each be provided with a separate final subcircuit in order to ensure that if a problem occurs it is localised and does not affect other equipment or systems.

Fixed appliances and equipment shall be provided with appropriate isolating switches, lockable in the off position.

Each office shall have socket outlets connected to two different circuits. No socket-outlets shall be installed in public toilets.

Additional circuits and outlets dedicated to special use may also be required for PA systems, security systems, ticketing systems, air conditioners and station passenger information (SPI) systems.

8.7.3. Hand dryers

Hand dryers installed in public toilets or public wash rooms shall be permanently connected by hard wired connections to the hand dryer terminal block.

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In staff amenities the hand dryer shall be plugged into a designated socket-outlet mounted beside the hand dryer, with each socket-outlet connected to a separate circuit.

Each hand dryer shall be supplied from a separate circuit with RCD protection. Each hand dryer location shall be a suitable distance from wet areas as defined in AS/NZS 3000:2018.

8.7.4. Public toilet power operated door locks

Power operated door locks shall be connected to a dedicated circuit (refer to TfNSW drawing EL0003988 *Railway stations remote controlled door lock for public toilets*). A separate push button facility to remotely operate the door locks shall be located adjacent to the office window or as required by the operational stakeholder, one each for male and female or family accessible toilets where these are available.

9. Energy metering

Every stand-alone facility or building shall be equipped with tariff metering to record the consumption of electricity.

Refer to T HR EL 17000 ST for whole station electrical energy metering (tariff metering).

The energy meters shall be accuracy class 1 as defined in AS 62053.21 *Electricity metering equipment (ac) - Particular requirements - Part 21: Static meters for active energy (classes 1 and 2) (IEC 62053-21:2016 (ED.1.1) MOD)* or better. Every station shall be equipped with a facility to record the station maximum demand and power factor.

All new stations and stations that have their power supply upgraded shall have energy monitoring facilities that enable recording and comparison of energy consumption during user-defined periods as follows:

- for stations exceeding a floor area of 2500 m^2 (inclusive of platform areas), energy monitoring facilities defined in Specification J8.3 of the *National Construction Code (NCC), volume one*
- for stations not exceeding a floor area of 2500 m^2 inclusive of platform areas, energy monitoring facilities that enable separate monitoring of energy consumption for lighting and power
- in addition, regardless of the floor area, stations shall be equipped with a facility to monitor power quality (harmonics)

The data shall be remotely accessible with central reporting via a network-wide system.

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10. Railway stations - additional guidance on specific applications

EP 12 10 00 21 SP provides guidance on the separation between the earthing system of the LV installation, including earthed metalwork such as fences and vending machines and any OHWS which are not bonded to the same earthing system or metalwork connected to a separate earthing system.

The following systems, some of which are covered by specific TfNSW standards, shall each be connected to dedicated power supplies or circuits:

- SPI system
- help points
- PA
- ticketing and fare collecting equipment
- digital clocks
- induction hearing loops (refer to T MU TE 61005 ST *Customer Information Systems for Public Transport Buildings and Conveyances)*
- CCTV, access control and other security systems
- gate and platform hubs
- building management system (BMS)

10.1. Leased areas within station precincts

Leased areas within station precincts can be supplied from either the DSMSB or from the IMSB in accordance with T HR EL 17000 ST and T HR EL 17001 ST.

Each leased area shall be equipped with its own tenancy distribution board powered by a dedicated submain and separately metered at either of the following:

- dedicated tenancy switchboard (that supplies multiple tenancies) located in a separate meter room - where a separate tenancy switchboard does not exist the Sydney Trains assurance officer will nominate the source distribution switchboard
- DSMSB
- IMSB
- tenancy distribution board – non-preferred

Where there are multiple tenancies in a precinct it is preferable for a separate tenancy switchboard to be installed.

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An application for connection shall be submitted to the relevant DNSP in accordance with T HR EL 17001 ST. Where the DNSP is not Sydney Trains a copy of the application for connection shall be provided to the Sydney Trains assurance officer.

If metering is not practical and the power usage is easily estimated the cost of electricity can be estimated and included in the lease agreement where approved.

All electrical, lighting, fire detection and alarm, telecommunications and any other service fit-out within a tenancy is the responsibility of the tenant. Any change to existing systems required to accommodate the tenancy or the tenancy internal layout changes will be at tenant expense. If there is an existing fire or smoke detection and suppression system installed at the station approval to alter, amend or extend the system shall be obtained from the authorised operator or maintainer of the station.

Any electrical works carried out within the leased premises must meet the requirements of this standard.

10.2. Third party assets

Third party assets requiring electrical power to operate, such as advertising signage (including electronic signage and electronic screens), automatic teller machines, commercial vending machines and other appliances that dispense consumer goods or services are normally covered under a commercial agreement.

These shall be powered via dedicated circuits. Where a group of the same, or similar, types of assets are co-located (that is virtually touching) they can be supplied from one dedicated circuit. The maximum number of assets on such a circuit shall be limited as set out in AS/NZS 3000. Each asset shall be controlled by an individual local isolation switch. If additional third party assets are added to an existing circuit the circuit shall comply with the requirements of this standard.

Dedicated circuits shall be used to power life safety and related equipment that require power to operate, for example, a defibrillator.

In addition to the electrical requirements specified in EP 12 10 00 21 SP, including the 2 m clearance from OHWSs, third party assets shall also be located at least 2 m from a water tap.

Each circuit shall be protected by a combination RCD circuit breaker (30 mA type) that is appropriately rated for the intended duty and the fault level. Under no circumstances is a circuit dedicated for a third party asset to be connected to a distribution board which supplies a safety service or a service listed in Table 5 in Appendix A.

NOTE: All parts of this standard apply to third party assets.

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11. Identification of assets and labelling

The operator shall employ a system to facilitate easy asset identification, maintenance planning and reporting. The system shall ensure that uniform numbering and labelling principles are applied throughout the heavy rail network and permit unique numbering of each electrical asset throughout the network.

Distribution and circuit board numbers shall be included as part of asset identification.

11.1. Safety

Danger warning notices and signs shall be placed as required by relevant legislation or standards. This shall include potential risks such as simultaneously touching a station awning and 1500 V dc structure that are isolated from each other whilst working on a station roof.

11.2. General

Identification and marking shall conform with both AS/NZS 3000 and the *Service and Installation Rules of New South Wales* and shall comply with the additional requirements of this standard. All fixed electrical equipment and its major components shall be labelled using engraved Traffolyte type labels securely affixed by screws, glue or cable ties as appropriate. Labels shall be in English only with black letters on white background and shall remain legible over the life of the equipment.

It is preferred that abbreviations and acronyms are not used on labels but where this is impractical caution shall be exercised to ensure that there is no confusion that could lead to incorrect switching.

11.3. Switchboard labelling

Refer to the labelling requirements of the *Service and Installation Rules of New South Wales* for acceptable switchboard labelling. In addition, each switchboard shall be clearly labelled to identify the following:

- switchboard name, designation (identification number)
- supply source or sources
- rated current and fault rating for one second
- IP rating
- function of all circuit breakers and devices within a switchboard or subcircuits and final circuits
- manufacturer's name

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The outgoing circuits shall be sequentially numbered on each switchboard. Neutral, earthing and bonding cables or terminals shall also be individually marked to facilitate circuit identification.

The font height of capital letters shall be as follows:

- main assembly ≥ 25 mm
- sub-assemblies ≥ 15 mm
- outgoing functional units ≥ 8 mm
- all other lettering ≥ 5 mm

Either a single line diagram or printed schedule, or both, shall be provided and permanently affixed or fitted in a holder located within the board enclosure and covered by a suitable clear Perspex type sheet. When a change is made to the switchboard configuration a new diagram or schedule shall be printed and the existing diagram or schedule removed. Hand-written alterations shall not be made to single line diagrams or printed schedules.

As part of the handover process for new or altered switchboards a soft copy of the circuit schedule in a spreadsheet format shall be provided. This schedule shall denote the following:

- the switchboard
- circuit numbers
- ratings of switches, circuit breakers
- load types and load locations
- spare poles
- the contractor and person that updated the schedule (typed names)
- date of schedule update

11.4. Meter labelling

Every energy meter shall be uniquely labelled to describe its application for example, lighting, power, or entire facility or building.

11.5. Electrical fixtures labelling

Electrical fixtures such as socket-outlets, light switches, permanently connected equipment or devices such as hand dryers shall be labelled including circuit number and switchboard name or number. The label shall comprise the switchboard descriptor followed by the circuit breaker number supplying the fixture.

For lighting refer to T HR SS 80001 ST.

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11.6. Private post or pole labelling

A customer's pole shall be clearly labelled PRIVATE POLE to differentiate it from the electricity distributor and other utility poles. Lettering shall be a minimum 25 mm high.

11.7. Power factor equipment labelling

The power factor equipment shall have a nameplate securely affixed in an easily accessible position. The label shall include the following:

- manufacturer's name
- rating
- type
- serial number (capacitors and detuning reactors)

11.8. Alternative power supply labelling

Warning labels shall be provided for dual-supply switchboards and where generators are installed.

Appropriate signage shall be provided at the switchboard and at the on-board lift power supply.

12. Assurance

A documented process for demonstration of assurance at each configuration management gateway, other project milestones and continuously throughout asset lifecycle shall be applied. Section 12 provides non-exhaustive, LV installation specific assurance requirements and references that shall be applied in conjunction with the requirements described in T MU AM 04001 PL *TfNSW Configuration Management Plan* and T MU AM 00003 ST *Assurance and Governance Plan Requirements*.

The assurance process shall include active coordination and integration assurance inclusive of all interfaces related to electrical installation work.

Assurance statements shall include certification that in relation to all prior activities, the requirements of all relevant legislation, regulations, Australian standards and TfNSW standards were achieved with no qualifications or exclusions, and that the following occurred:

- project progress and completion to the level required was achieved
- the systems and equipment were fit for the intended purpose and related declaration that the relevant requirements were achieved in subsequent project phases and activities
- all work was been carried out by suitably qualified and experienced personnel

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- all assurance activities were performed by the individuals with specific and relevant competencies appropriate to the life cycle stage
- all relevant documentation was produced, collated and handed over

12.1. General requirements

The rail operator shall assess existing installations and upgrade them to comply with the requirements of this standard where required for mitigation of risks.

Where a periodic risk assessment of existing installations concludes that the installation shall be upgraded to mitigate safety, operational or other risks the installation should be upgraded to comply with the requirements of this standard.

Industry best practice should be employed while installing all components of electrical installations.

12.2. Design

It is a TfNSW requirement that a whole-of-life view be taken as the basis of design decisions. Refer to T MU AM 01001 ST *Life Cycle Costing*.

Wherever applicable, the relevant elements of environmentally sustainable design (ESD) shall be incorporated in LV electrical design. Typical factors to be assessed and considered include innovative technologies that are energy efficient, demonstrate quality, reliability and maintainability, longevity and low maintenance. In addition, care shall be taken to avoid the use of products that incorporate hazardous or polluting materials. If their use is unavoidable, safe disposal of these shall be incorporated in life cycle costing (for example, phosphors and mercury in fluorescent tubes).

Uniformity of the type, model and manufacture of each individual item of equipment and accessories shall be preserved throughout the entire installation or contract as much as possible.

Where possible, equipment specified for additions to existing installations shall be uniform in type with the existing equipment type and manufacture.

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12.2.1. Feasibility studies

The feasibility stage is to define the requirements and examine alternative systems that can fulfil them with a view to selecting the best option in conjunction with the selected building and services option. The assurance process shall demonstrate that all relevant factors were considered and conclusions documented for all systems. The assurance process shall be guided by, but not be limited to, the following:

- electrical load
- basic design elements, notional load centres and distribution
- single or dual power supply, interface to external service providers
- basic space planning for all electrical requirements
- preliminary estimate and comparison of life cycle costs for the considered options
- configuration management gateway approval

12.2.2. Concept design

The concept stage is to outline the selected electrical system including capability and capacity of major system elements. The assurance process shall demonstrate that all relevant factors were considered and conclusions documented for all systems. The assurance process shall be guided by, but not be limited to, the following:

- conceptual arrangements for all electrical and technology systems in relation to the project including single line diagrams for each system
- external interfaces and intra-project integration and coordination
- sizing of major switchboards, electrical power distribution elements and their arrangement, with due consideration of anticipated electrical load centres
- detailed space planning including switchboards locations, major cables routes and cable risers, electrical cupboards, all in conjunction with the building design and site details
- basic lighting design requirements
- building automation system (where required)
- concept design report sufficiently elaborating each system and relevant interdependencies
- suitable assurance of fitness for purpose for all systems
- preliminary cost estimate of required accuracy

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12.2.3. Reference design

The reference stage is to enhance the concept design with more details to guide further stages of the design. The assurance process shall demonstrate that all relevant factors were considered and conclusions documented for all systems. The assurance process shall be guided by, but not be limited to, the following:

- enhanced concept for each electrical and technology system to ensure that further design stages are sufficiently and unambiguously informed
- typical arrangements for all electrical and technology systems
- target W/m^2 documented for all project areas
- trial lighting design for typical spaces, showing location and heights of luminaires to achieve the desired lighting levels
- energy efficiency measures implemented in line with TfNSW *Sustainable Design Guidelines*
- building control system extent and control methodology
- design compliance with the requirements, any discrepancies noted and brought to stakeholders attention and resolution agreed and implemented

12.2.4. Final design and documentation

The final design and documentation stage is to provide detailed design and specifications for the electrical and technology systems including all elements suitable for tender and construction purposes.

The assurance process shall demonstrate that all relevant factors were considered and conclusions documented for all systems. The assurance process shall be guided by, but not be limited to, the following:

- Correct and relevant input data.
- Relevant aspects of project specific environment and site context considerations included in the design.
- Conclusive assurance of fitness for purpose, compliance with relevant acts, regulations, Australian standards and TfNSW standards, suitable proof of certification.
- Delineation of external interfaces.
- Elaboration of intra-project integration and coordination.
- Achievement of required operational efficiency, reliability and maintainability.
- Testing and commissioning methodology and detailed requirements.

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- Identification of hazards related to design, documentation of impact on installers, maintainers and the public. Demonstration that the design eliminated all risks. Where complete elimination of risk is not possible, demonstration of relevant risk mitigation to SFARP in accordance with TfNSW guidelines and requirements.
- Demonstration that all necessary grading studies, calculations such as prospective fault levels (three-phase and single-phase to earth), earth fault-loop impedance, protective device selection and selectivity in operation, maximum demand, voltage drops, lighting calculations (including isolux diagrams for all areas) and such other calculations as may be applicable to a specific project have been completed.
- Final design drawings, specifications, design reports and other items required by contract (marked for tender or for construction). These documents shall be clear and unambiguous and require no further elaboration in order to build the project.
- CCEW.
- Life cycle costing in the considerations (refer to T MU AM 01001 ST).

12.3. Construction, integration and acceptance

The construction stage includes all construction activities including testing, commissioning and handover.

Newly constructed LV electrical assets shall be assured as part of the construction process. Construction and handover shall be carried out in accordance with legislative and contractual requirements stipulated in the relevant documents. The assets are accepted into operation upon this basis.

Only competent personnel will undertake work on LV electrical installations. All activities shall appropriately consider and incorporate adequate safety precautions. Refer to the *Work Health and Safety Act 2011* and *Work Health and Safety Regulation 2011*. Refer to T MU MD 20001 ST *System Safety Standard for New or Altered Assets* and RailSafe NGE 222 *Working around electrical infrastructure.*

The RailSafe website can be used to obtain the latest safe working information. The website has safe working information including the network rules and procedures, network local appendices as well as contractor information, safe working policies, safe tracks flyers, weekly notices and safe notices.

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The assurance process shall demonstrate that all relevant factors were considered and conclusions documented for all systems. The assurance process shall be guided by, but not be limited to, the following:

- All equipment was installed as directed by equipment manufacturer, in correct locations, and in observance of applicable requirements.
- Uniformity of the type, model and manufacture of each individual item of equipment and accessories was preserved throughout the entire installation or contract. Equipment specified for additions to existing installation shall be uniform in type with the existing equipment type and manufacture.
- All adjustments to existing equipment, cables and the like were undertaken in accordance with relevant standards.
- Unless specifically directed otherwise, all electrical equipment, material and cables that became redundant as a result of works undertaken were removed from site. Where redundant services are left on site, such services location shall be documented on as-built drawings and marked as redundant, both on as-built drawings and in-situ.
- All systems and equipment were factory tested as applicable.
- Site testing and commissioning carried out, documented and verified by the designer in accordance with the approved inspection and test plans (ITPs) incorporating applicable pass or fail criteria.
- CCEW was issued at project completion.
- Complete asset support information required to operate and maintain the equipment throughout the operational life as described in T HR EL 00002 PR *Electrical Power Equipment - Integrated Support Requirements*, particularly a set of operation and maintenance manuals.
- As-built drawings conforming to the requirements of T MU MD 00006 ST *Engineering Drawings and CAD Requirements*. The drawings shall accurately depict the installed works and include layout of all equipment, conduit and cable reticulation, equipment rating, single line diagrams, control schematics and other relevant information to assist in maintenance and/or alterations to the installation. The operation and maintenance documents shall include manufacturers' documentation related to design, installation, factory test certificates, warranty and other information, as applicable.

Refer to T MU AM 02001 ST *Asset Information and Register Requirements* for further information on asset information management.

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12.4. Operation and maintenance

Refer to *Transport Service Provider Asset Management Plan Standard* for maintenance planning requirements.

Electrical installation shall be periodically assessed in relation to safety and operation to indicate any pertinent risks and relevant actions shall be carried out to mitigate the risks.

12.5. Decommissioning and disposal

Disposal of life expired assets generally occurs during introduction of new assets on brown field sites as a result of major refurbishment, end of life capital renewals, changes in asset utilisation or performance capability upgrades. Assurance shall reflect the specific requirements related to work performed on site, removal and safe disposal.

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Appendix A Alternative power supplies and UPS or battery backup

Table 1 to Table 6 summarise facilities and station types that are required to be equipped with alternative power supplies and a UPS or battery backup for specific equipment within the facility or station.

Table 1 – Special facilities

Facility type	Alternative power supply	Comment
Rail management centres *Note that additional back-up in the form of a generator and a UPS may be required for specific installations*	Required	Not considered to be stations and stops assets
Signalling	Required	Not considered to be stations and stops assets.

Table 2 – Stations

Station type	Alternative power supply	Comment
All underground and surface stations with at least one end of a platform connected to a tunnel	Required	Additional back-up in the form of UPS or battery is required for equipment nominated in Table 4 and Table 5.
Major rail stations and interchanges with other transport modes Stations where tracks are covered linearly at track or at adjacent platform for a length of more than 80m. Stations, where appropriate natural ventilation cannot adequately extract smoke to the degree necessary to ensure viable egress for agreed scenarios.	Required	Additional back-up in the form of UPS or battery is required for equipment nominated in Table 4 and Table 5.
Station equipped with systems listed in Table 4 and Table 5 as requiring an alternative power supply	Required	Additional back-up in the form of UPS or battery is required for equipment nominated in Table 4 and Table 5.
Stations that are required to operate continuously by relevant TfNSW policy (for example, customer environment)	Required	Additional back-up in the form of UPS or battery is required for equipment nominated in Table 4 and Table 5.

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Table 3 – Other facilities

Facility type	Alternative power supply	Comment
Tunnel lights, pumps and ventilation equipment (all tunnels)	Required	Not considered to be stations and stops assets
Car parks where appropriate natural ventilation cannot adequately extract smoke to the degree necessary to ensure viable egress for agreed scenarios	As per *NCC, volume one* requirements	
Stabling yards and siding buildings, depots and workshops	Required as per NCC, volume 1 requirements	Required for train maintenance centres Other facilities as per *NCC, volume one* requirements
Other buildings or facilities	As per project brief.	If not specified, as per *NCC, volume one* requirements

Table 4 – Stations equipped with the following safety services defined in AS/NZS 3000

Safety service equipment (typically related to fire and life safety)	Alternative power supply	UPS or battery backup (installed regardless of whether the station has an alternative supply)
Sprinkler systems and fire hydrant pumps, air handling systems, alarms, warning and communication systems and emergency lighting circuits that serve an atrium	Required to comply with Specification G3.8, clause 6 of the *NCC, volume one*	As required by *NCC, volume one* and Table 5
Fire hydrant booster pumps.	Required	Normally not required – equipment is too large for this type of backup
Pumps for automatic sprinkler systems, water spray or deluge systems and similar fire-extinguishing systems.	Required	Normally not required – equipment is too large for this type of backup
Pumps for fire-hose reels, where such hose reels form the sole means of fire protection, that is where fire hydrants and automatic fire-sprinkler systems are not installed.	Required	Normally not required – equipment is too large for this type of backup
Air-handling systems intended to exhaust and control the spread of fire and smoke in stations and integrated tunnels	Required	Normally not required – equipment is too large for this type of backup
Emergency lifts (BCA) or Special lifts (AS/NZS 3000:2018)	Required	UPS or emergency battery power that enable the lift to rise or descend to the nearest floor and release the doors

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Safety service equipment (typically related to fire and life safety)	Alternative power supply	UPS or battery backup (installed regardless of whether the station has an alternative supply)
Control and indicating equipment for the above-listed Safety Services including auxiliary equipment such as: powered airflow sensors for fan operation, combustion air fan for back-up power generators, supply and return air detector circuits used to initiate zone pressurisation smoke control systems, power supply for motorised smoke damper actuators.	Required	Required Four or two hours depending on the station type
Fire detection and alarm systems	Not required	Yes. four or two hours depending on the station type and note 1
Sound systems and intercom systems for emergency purposes (including PA designed as part of an early warning and intercommunication system (EWIS)) Passenger information display (PID) where designed as part of a fire engineered solution Fire CCTV where designed as part of a fire engineered solution	Not required	Four or two hours depending on station type and as per the requirements of AS 1670 Plus as required by the fire engineered solution
Central emergency evacuation lighting systems	Not required	Four or two hours as required by T HR SS 80003 ST
Single point system emergency lighting	Not required	Four or two hours as required by T HR SS 80003 ST

Table 5 –Stations equipped with the following services

Equipment (typically related to non-fire emergency or ongoing property operation)	Alternative power supply	UPS or battery backup (installed regardless of whether the station has an alternative supply)
All stations that have equipment required to operate in order to safeguard the continuity of business for example, nominated dewatering pumps	Required	
All stations that use lifts for emergency evacuation of disabled persons	Required	UPS or emergency battery power that enable the lift to rise or descend to the nearest floor and release the doors

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Equipment **(typically related to non-fire emergency or ongoing property operation)**	**Alternative power supply**	**UPS or battery backup (installed regardless of whether the station has an alternative supply)**
Stations where the evacuation of disabled persons is effected through alternative procedures that do not use lifts are exempt from the requirement of having an alternative power supply Majority of existing lifts are keyed for emergency services and fitting a stretcher, although usually these lifts are not accommodated in in a fire isolated lift shaft	Not required	UPS or emergency battery power that enable the lift to rise or descend to the nearest floor and release the doors
Power supplies to station control rooms or similar rooms that have IT equipment that is used during an emergency	To be determined by risk analysis or fire engineered solution	To be determined by risk analysis or fire engineered solution
Power supplies to communication network equipment (for example, telecommunications equipment rooms)	See note 2	See note 1
PA systems) where not designed as part of an EWIS	See note 2	See note 1
Power supplies to equipment required for safe operation of the railway	See note 2	See note 1
Passenger information (including PID, digital clocks, hearing loops and PA systems that are not designed as part of EWIS)	See note 2	See note 1 Existing stations have a number of individual UPSs (one per rack) that will supply power for a minimum of 30 minutes
CCTV or access control	See note 2	See note 1 Currently each station has a UPS that will supply power for a minimum of 30 minutes
Digital (internet protocol) CCTV	See note 2	Refer to T MU TE 41001 ST *Packet Switched Networks – Wired Networks*
Ticketing (including Opal card top up machines, gates, Opal readers and any ancillary equipment such as air conditioning for the equipment rooms)	See note 2	See note 1
BMS controllers	Not required	Yes, minimum four hours
Any other control systems	See note 2	See note 1

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Note 1 – Minimum backup time requirement is the longer of the following:

- *as defined in relevant TfNSW standard that covers the specified system and equipment*
- *as defined by the relevant Australian standard that covers the specified system and equipment*
- *minimum four or two hours depending on the station type*

Note 2 – As defined in relevant TfNSW standard that covers the specified system and equipment

Table 6 –Stations equipped with the following non-critical systems

System	Alternative power supply	UPS or battery backup (installed regardless of whether the station has an alternative supply)
Standard power (including office computers and powered toilet door locks)	Not required	Normally not required
Interior and exterior lighting (not emergency lighting)	Not required	Normally not required
Retail concessions (including vending machines, public phones, ATMs and electronic advertising signage)	Not required Allowed in cases where they are a minor load that is fed directly from a station board and the whole station has an alternative power supply	Not applicable

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