**TS 03792:1.0**

T LR EL 00004 ST

**Standard**

# Traction Power Substations

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# Document information

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# Document history

| Revision | Effective date | Summary of changes |
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| 1.0 | 27/08/2025 | First issue as TS 03792, superseding T LR EL 00004 ST, version 2. Version numbering recommenced in line with new designation. Changes from previous version include removal of the requirement for the Prioritisation and Asset Management to review protection concept design, modification of the requirement for a cathode DCCB, and modification to the application of reverse overcurrent protection. |

# Preface

This standard is the first issue as TS 03792. It supersedes T LR EL 00004 ST *Traction Power Substations*, Version 2.0.

This document provides the requirements for traction power substations used in the TfNSW Light Rail network.

The changes from the previous version include:

- incorporation of the requirements set out in technical direction TD 00010:2022 *Amendment to IP rating requirements for indoor substation equipment*
- updated references to Transport, Australian and International standards
- removal of the requirement for Prioritisation and Asset Management to review protection concept design
- modification of the requirement for a cathode DCCB
- modification to the application of reverse overcurrent protection.

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# 1 Scope

This standard provides requirements for the building, equipment, control and monitoring of traction power substations for use in the TfNSW Light Rail network.

# 2 Application

The requirements of this document apply to new and altered light rail system infrastructure.

Unless otherwise stated, this document does not apply to existing infrastructure that is not otherwise being altered.

This standard is intended to be used by Technically Assured Organisations that undertake work on traction power systems for light rail.

# 3 Referenced documents

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

**International standards**

EN 50122-1 *Railway applications – Fixed installations – Electrical safety, earthing and the return circuit – Part 1: Protective provisions against electric shock*

EN 50123 (all parts) *Railway applications – Fixed installations – D.C. switchgear*

EN 50124-1 *Railway applications – Insulation coordination – Part 1: Basic requirements – Clearances and creepage distances for all electrical and electronic equipment*

EN 50163 *Railway applications – Supply voltages of traction systems*

EN 50328 *Railway applications – Fixed installations – Electronic power converters for substations*

EN 50329 *Railway applications – Fixed installations – Traction transformers*

EN 50526-1 *Railway applications – Fixed Installations – D.C. surge arresters and voltage limiting devices – Part 1: Surge arresters*

EN 50526-2 *Railway applications – Fixed installations – D.C. surge arresters and voltage limiting devices – Part 2: Voltage limiting devices*

IEC 61850 (all parts) *Communication networks and systems for power utility automation*

IEC 61992 (all parts) *Railway applications – Fixed installations – DC switchgear*

**Australian standards**

AS 1319 *Safety signs for the occupational environment*

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

AS 2676.1 *Installation, maintenance, testing and replacement of secondary batteries in buildings – Part 1: Vented cells*

AS 2676.2 *Guide to the installation, maintenance, testing and replacement of secondary batteries in buildings – Part 2: Sealed cells*

AS 3011.1 *Electrical installations – Secondary batteries installed in buildings – Part 1: Vented cells*

AS 3011.2 *Electrical installations – Secondary batteries installed in buildings – Part 2: Sealed cells*

AS 4044 *Battery chargers for stationary batteries*

AS 60076.10 *Power transformers – Part 10: Determination of sound levels (IEC 60076-10:2016 (ED. 2.0) MOD)*

AS 60146 (all parts) *Semiconductor converters*

AS 60870.5.1 *Telecontrol equipment and systems – Part 5.1: Transmission protocols – Transmission frame formats*

AS 61869.2 *Instrument transformers – Part 2: Additional requirements for current transformers (IEC 61869-2:2012 (ED 1.0) MOD)*

AS 61869.3 *Instrument transformers – Part 3: Additional requirements for inductive voltage transformers (IEC 61869-3:2011 (ED.1.0) MOD)*

AS 62271 (all parts) *High-voltage switchgear and controlgear*

AS 62271.200 *High-voltage switchgear and controlgear – Part 200: AC metal-enclosed switchgear and controlgear for rated voltages above 1 kV and up to and including 52 kV (IEC 62271-200:2011/COR1:2015, MOD)*

AS 62271.202 *High-voltage switchgear and controlgear – Part 202: High-voltage/low-voltage prefabricated substation (IEC 62271-202:2014, MOD)*AS/NZS 3000 *Electrical installations (known as the Australian/New Zealand Wiring Rules)*

AS/NZS 60076 (all parts) *Power transformers*

**Transport for NSW standards**

TD 00024:2023 *Limits for static magnetic field emissions from transport infrastructure*

TS 00026 *Ambient Environmental Conditions*

TS 01471:0.0 (T MU AM 06006 ST) *Systems Engineering*

TS 01505 (T MU AM 01001 ST) *Life Cycle Costing*

TS 03744 (EP 00 00 00 13 SP) *Electrical Power Equipment – Design Ranges of Ambient Conditions*

TS 03785 *Direct Current Traction Power Reticulation*

TS 03789 (T LR EL 0000 ST) *Traction Power System Requirements*

TS 03790 (T LR EL 00002 ST) *High Voltage Supply*

TS 04955.8 *Services, Systems and Equipment – Part 8: Low Voltage Electrical Installations*

TS 04978 *Human Factors Integration – General Requirements*

TS 04992 *Surface Transport Fixed Infrastructure Physical Security Standard*

Note: This document is not publicly available. To obtain access email standards@transport.nsw.gov.au)

TS 06178 (T MU MD 00005 GU) *Type Approval of Products*

TS 06224 (T HR TE 21003 ST) *Telecommunications for Traction Substations and Sectioning Huts*

**Other referenced documents**

Australian Building Codes Board, *National Construction Code* (NCC)

Electricity Networks Australia, ENA DOC 015-2022 *National Guidelines for the Protective Security of Electricity Networks*

Energy Networks Association, ENA DOC 18-2015 *Guideline for the Fire Protection of Electricity Substations*

NSW Rural Fire Service, 2019, *Planning for Bush Fire Protection – A guide for councils, planners, fire authorities and developers*

State of NSW and Environment Protection Authority, 2017, *Noise Policy for Industry*

# 4 Terms, definitions and abbreviations

The following terms, definitions and abbreviations apply in this document.

**ac** alternating current

**dc** direct current

**DCCB** direct current circuit breaker

**HV** high voltage

**NC** normally closed

**NCC** *National Construction Code*

**NO** normally open

**OCC** operations control centre

**OLE** overhead line equipment

**RTU** remote terminal unit

**SCADA** supervisory control and data acquisition

**$SF_6$** sulfur hexafluoride

**supplying HV network** the electricity network which supplies electricity to the light rail system at high voltage

**TfNSW** Transport for NSW

**TPS** traction power substation

**VLD** voltage-limiting device; protective device whose function is to prevent existence of an impermissible high touch voltage (Source: IEC 62128-1:2013, 3.1.20)

Note: A spark gap is an example of a VLD.

# 5 General requirements

TPSs shall distribute, transform and control bulk HV ac supplies derived from the supplying HV network. TPSs provide 750 V dc traction supply to light rail vehicles through the traction power reticulation system.

TPSs shall comply with the requirements of AS/NZS 3000 and AS 2067.

The NCC (all volumes) contains requirements that apply to TPSs.

Standalone TPSs that utilise modular, transportable and temporary structures (or a combination thereof) are generally classified as class 10a for the purposes of the NCC. Larger TPSs integrated into buildings are generally classified as class 8.

Substation buildings and yards containing live electrical equipment do not require disabled access.

All materials used in the construction of the TPS shall be selected for low smoke emission, low flame propagation, and low acid gas emission.

# 6 Building requirements

## 6.1 General

TPSs shall not include a low point that allows for the accumulation of water or heavier-than-air gas. This requirement is to eliminate risks associated with confined spaces, drainage (particularly in locations with difficult soil and topography), and hazardous gases escaping from the switchgear.

TPSs shall be designed and constructed for a minimum design life as specified in the project requirements.

If the TPS is a prefabricated building, it shall comply with AS 62271.202.

## 6.2 Site location

Site locations for TPSs shall meet the following requirements:

- Site locations shall be electrically suitable as determined by the modelling of the Light Rail network.
- Site locations shall be accessible for maintenance and construction activities.
- High-risk areas shall be avoided. This includes major road junctions and areas in close proximity to service stations, flammable gas or liquid storage tanks.

Site locations should not be subject to flooding (whether natural or due to surrounding infrastructure such as stormwater canals). If it is not possible to avoid such a location, then the floor level shall not be less than 500 mm above the 100 year average recurrence interval flood level. Environmental factors as specified in TS 00026 (such as climate change) shall be taken into account.

Where the site location is in an area that is at risk of bushfires, the recommendations in *Planning for Bush Fire Protection – A guide for councils, planners, fire authorities and developers* should be taken into consideration.

## 6.3 Standardisation

All TPSs that are delivered by the same project shall be internally similar in dimension, layout and equipment manufacture.

Where an additional or replacement TPS is required in an established part of an existing light rail system, then so far as is reasonably practicable, the TPS shall be internally similar in dimension, layout and equipment manufacture to the existing TPSs in that part of the light rail system.

## 6.4 Maintenance requirements

TPSs shall be designed to facilitate installation, removal and replacement of all large equipment that they house (including rectifier transformers and circuit breakers). This shall be achievable without structural modifications and without unreasonable crane requirements.

Adequate maintenance access, including pedestrian, vehicle and plant access (as appropriate) shall be provided. Maintenance access spaces shall be physically protected from potential future encroachment or obstruction. Maintenance access spaces shall be protected legally from future encroachment or obstruction.

## 6.5 Spatial requirements

In addition to the requirements of the NCC (all volumes), AS/NZS 3000 and AS 2067, there shall be spatial provision in each TPS for the following:

- storage of special tools (including tools for operation of the equipment and test equipment), critical equipment spares, equipment drawings, and operation and maintenance manuals
- display of light rail system and operating diagrams such that they are easily visible by operational personnel
- a desk.

TPSs shall be configured so that if only a single feeder DCCB is provided at the TPS at an end of the line, provision is made at that TPS for the installation of a second DCCB and associated equipment to allow for future extension of the line.

Where there is an incoming HV supply from the supplying HV network, space shall be provided within the TPS for the supplying HV network's equipment in accordance with the requirements of TS 03790.

Duct routes and pits for the supplying HV network operator's HV cables shall be separate from those for the traction power reticulation system.

## 6.6 Protection against unauthorised access

ENA DOC 015-2022 *National Guidelines for the Protective Security of Electricity Networks* provides guidelines for control measures to minimise unauthorised contact with electrical infrastructure at new installations.

The security arrangements for TPSs shall comply with TS 04992.

As TPS site locations vary, the extent of unauthorised exposure to the infrastructure can also vary. Each TPS within a light rail project shall be assessed and appropriate control measures implemented.

At a minimum, TPSs shall have the following control measures:

- appropriate key, locking and access control mechanisms
- an intruder alarm system, with entry of persons into each TPS automatically detected and conveyed to the OCC
- security lighting
- signage and labels.

## 6.7 Ambient conditions

TPSs shall be designed to maintain the equipment room air temperature below the rated maximum operating temperature of the substation equipment and in accordance with the requirements set out in TS 03789. The design shall take the effect of elevated temperatures on the life of the electronics and batteries into account.

Where active equipment is utilised for waste heat management, the waste heat management equipment shall be factored into the overall reliability, availability and maintainability (RAM) calculations.

## 6.8 Fire protection

TPSs shall have fire protection in accordance with the recommendations made in ENA DOC 18-2015 *Guideline for the Fire Protection of Electricity Substations*.

Fire and smoke within each TPS shall be detected and reported to the OCC. Fire and smoke detectors shall be connected directly to the SCADA system.

Appropriate provisions shall be made for fire suppression, based on a risk assessment.

Smoke detectors shall be of a type that does not give false positive indications when DCCBs operate.

The TPS shall meet the fire protection requirements set out in AS 2067.

Passive fire protection shall be provided for all main power cables.

## 6.9 Sound levels

Sound levels that are external to a TPS and arise from within that TPS shall be in accordance with the requirements of the relevant project's environmental impact statement.

Sound levels that are internal to a TPS and arise incidentally from the equipment within that TPS shall:

- be as low as reasonably practicable
- not be greater than the level prescribed in the State of NSW and Environment Protection Authority *Noise Policy for Industry.*

## 6.10 Communication requirements

Each TPS shall have the following telecommunications facilities:

- SCADA data links
- HV feeder differential protection circuits
- telephone
- outlet for a computer connection to the corporate wide area network (WAN).

The telephone shall provide a means of voice communication with the OCC independent of the cellular mobile telephone system.

Communication cabling shall be in accordance with TS 06224.

> Note: TS 06224 applies to heavy rail, but for the purposes of this document, the communication cabling requirements set out in TS 06224 apply to light rail.

## 6.11 Signage requirements

TPSs shall have the following signage installed:

- signs indicating the facility name
- signs providing emergency and OCC contact details
- signs required by AS/NZS 3000, AS 2067 and AS 1319
- signs identifying equipment and markings
- signs on internal doors identifying the room (e.g. rectifier transformer room).

HV and 750 V dc equipment that is operated for electrical isolations shall have identification labels that match Light Rail electrical operating diagrams.

TPS names shall not be the same as a stop name. This reduces the possibility of errors when communicating with the OCC and interpreting documentation associated with the arrangement of electrical isolations.

## 6.12 Aesthetics

In visually sensitive areas, the following requirements shall apply:

- TPS buildings shall be designed to minimise visual impact.
- The aesthetics of TPS buildings shall be approved by local planning and environmental bodies.

# 7 Control and monitoring of equipment

## 7.1 General

TPSs shall be designed for unattended operation with remote supervision and control from the OCC, including:

- remote monitoring, control and data recording of the HV ac, 750 V dc and auxiliary elements
- automatic detection, localisation and de-energisation of faults in order to protect persons, assets and the property of third parties
- automatic detection, localisation and mitigation of other hazardous conditions in order to protect persons, assets and the property of third parties.

See Section 8.15 for details of the equipment that shall be controlled and monitored by the OCC.

The control and monitoring for individual TPSs shall be implemented through a SCADA RTU located in the TPS.

## 7.2 TPS staff emergency alert

A push-button that personnel can use to alert the OCC to an emergency situation by a single, simple and quick action shall be provided at each TPS.

See Section 8.11 for specific requirements for emergency push-buttons.

# 8 Equipment requirements

## 8.1 General

All traction power equipment and cables shall be sized to support the maximum load and the maximum fault current that they may be exposed to for the maximum credible fault duration in accordance with the system modelling. Refer to TS 03789 for details of the modelling.

Equipment used as a point of isolation shall:

- be rated appropriately, including voltage ratings (such as lightning withstand)
- have no failure modes that could result in the isolation being compromised.

Equipment used as a point of rail connection shall be rated for the maximum fault current and shall have no failure modes that could result in the equipment opening unexpectedly or the rail connection being compromised.

All indoor equipment and enclosures shall have an ingress protection (IP) rating suitable for the environment and the application. Low-voltage switchboards shall comply with the requirements of AS/NZS 3000.

All TPS equipment shall comply with the relevant provisions of TS 03744.

Life cycle costing shall be completed on all equipment in accordance with TS 01505 to ensure that whole-of-life costs to TfNSW are minimised.

Equipment that contains $SF_6$ gas shall not be used.

## 8.2 Type approval of equipment

All major equipment used shall be equipment that has been type approved by TfNSW, in accordance with TS 06178. Typically for TPSs this includes, but is not limited to, the following:

- HV ac switchgear
- 750 V dc switchgear
- traction rectifier power cubicles
- traction rectifier transformers
- distribution transformers
- isolation transformers
- VLDs
- 750 V dc shorting to rail devices

- dc protection relays
- ac protection relays.

## 8.3 Standardisation

All TPS equipment that is delivered by the same project shall be standardised and allow for the interchanging of equipment and spare parts.

## 8.4 Connection of overhead conductor system to rail

TPSs shall provide for the isolation and short-circuiting to rail of the 750 V dc traction power reticulation system at appropriate points, to allow for:

- convenient planning and management of maintenance isolations
- minimisation of the risk to maintenance personnel
- efficient and expeditious response to unplanned contingencies.

The traction power reticulation system is the infrastructure required to connect the TPS to the light rail vehicles. It includes the following components:

- traction power feeder cables
- the overhead conductor system
- the segmented third rail system
- light rail vehicle charging points
- traction return conductors.

It excludes all aspects of the running rails except only so far as they function as traction return conductors.

All elements in the circuit for short-circuiting to rail of the 750 V dc traction power reticulation system shall be rated to withstand the relevant maximum short circuit current for the clearing time of the far end circuit breaker. The application of a short circuit to the elements of the circuit for short-circuiting to rail shall not result in any degradation or damage to any element.

The arrangements for the isolation and short-circuiting to rail of the 750 V dc traction power reticulation system shall provide for the isolation and rail connection to be adequately secured against control system failure, inadvertent operation and tampering by unauthorised persons.

Where a rail connecting switch is provided for rail connecting a 750 V dc feeder, an alternative means of rail connecting the feeder shall be available. This is required so that the rail connecting switch can be moved out of the closed position for maintenance of the rail connecting switch unless it is proven that no such maintenance will be required.

Where remote control is used, facilities shall be able to remotely verify the status of the equipment with the required level of integrity.

Appropriate provisions shall be made for securing the isolation and short-circuiting points during any maintenance of the power control systems.

Equipment providing a remotely operated point of isolation or rail connection shall have a non-volatile electrically actuated indicator associated with it. This indicator shall indicate when the equipment has been locked out and shall not be closed (isolator) or opened (rail connection) manually.

## 8.5 Electrical protection

### 8.5.1 General

Protection functions shall only be supported on electronic platforms (such as SCADA, programmable logic controller and data networks) that have the sufficient speed and integrity to support the relevant protection function.

### 8.5.2 HV ac protection

The HV ac protection requirements shall be in accordance with TS 03789.

### 8.5.3 750 V dc protection

The 750 V dc feeder protection strategy shall ensure:

- faults are detected under all feeding conditions
- allowance is made for an appropriate arcing voltage in the fault circuit
- subsequent tripping of equipment on detection of a fault is minimised to reduce operational impact
- a line test of the electrical section is required before the 750 V DCCB is closed.

The line test is required to ensure that there is no fault on the electrical section before closing the circuit breaker. The line test is performed by energising the electric section via a contactor with a current limiting resistor for a defined period of time. The designer shall determine the period of time and the pass or fail current.

The enabling of automatic reclose functionality of the 750 V DCCB after a fault opening shall be determined by the designer, based on a safety and risk analysis incorporating the operational concept of the Light Rail network.

Correct operation of the fault protection system shall not rely on manual adjustment of protection settings to deal with different traction system contingency arrangements.

### 8.5.4 DC reverse overcurrent protection

DC reserve overcurrent protection shall be provided by the rectifier cathode circuit breaker, where possible. Where a rectifier cathode circuit breaker is not provided, dc reverse overcurrent protection shall be provided by a protection relay.

DC reverse overcurrent protection shall trip and lock out the ac supply to the rectifier. Where a cathode DCCB is not provided, dc reverse current protection shall trip and lock out all DCCBs.

## 8.6 Rectifier sets

### 8.6.1 General

Traction power rectifier units shall comply with EN 50328 and AS 60146 (all parts).

Rectifier transformers and rectifier units shall be duty class VI in accordance with AS 60146 (all parts).

The displacement power factor of the traction power rectifier unit shall be greater than 95% lagging.

An accurate electrothermal model shall be provided for the rectifier sets so that the equipment temperatures can be inferred from the time-varying current.

### 8.6.2 Rectifier

The main cathode circuit breaker or cathode disconnector and the negative disconnect switch shall be interlocked so that:

- the cathode circuit breaker or cathode disconnector cannot be closed when the negative disconnect switch is open
- the negative disconnect switch cannot be opened when the cathode circuit breaker or cathode disconnector is closed.

Frame leakage protection shall be provided for the rectifier enclosure to detect a positive to frame fault. Operation of the rectifier frame leakage protection shall cause the rectifier to trip and lock out. Where this occurs, on-site manual reset is required.

The traction power rectifier unit shall be protected from damage resulting from surges and transients transmitted through the supplying HV network.

### 8.6.3 Rectifier transformer

Rectifier transformers shall not be force-cooled. Rectifier transformers shall comply with the requirements of EN 50329 and AS/NZS 60076 (all parts).

The rectifier transformer audible sound levels shall not exceed the maximum values specified in AS 60076.10.

## 8.7 HV ac switchgear

### 8.7.1 General

Metal-clad HV ac switchgear that complies with the requirements of AS 62271 (all parts) shall be provided. The metal-clad HV ac switchgear shall have an internal arc classification of A FLR 16 kA, 1.0 s and comply with AS 62271.200.

Metal-clad HV ac switchgear shall prevent accidental contact with live parts by maintenance personnel.

Where metal-clad HV ac switchgear vents arc faults below the metal-clad HV ac switchgear, the safety of any personnel working in the cable basement below the metal-clad HV ac switchgear shall be taken into account.

Current transformers provided with the metal-clad HV ac switchgear shall comply with the requirements of AS 61869.2. Voltage transformers provided with the metal-clad HV ac switchgear shall comply with the requirements of AS 61869.3.

Metal-clad HV ac switchgear that contains $SF_6$ gas shall not be used.

## 8.8 750 V dc switchgear

The 750 V dc switchgear shall be in accordance with EN 50163, EN 50123 (all parts) and IEC 61992 (all parts).

The 750 V dc switchgear shall be rated to interrupt maximum available fault current. The 750 V dc switchgear shall be configured to prevent accidental contact with live parts by maintenance personnel in accordance with EN 50123 (all parts) and IEC 61992 (all parts).

Feeder circuit breakers shall be metal enclosed single pole, draw-out type.

DCCBs shall include protection and data storage devices. Data storage devices for DCCBs shall include a local human machine interface (HMI) for establishing and adjusting breaker protective parameters and visual display of metering.

Switchgear frame leakage protection shall be provided to detect a positive to frame fault.

Operation of the 750 V dc switchgear frame leakage protection shall cause all the DCCBs on the switchgear and the rectifier HV alternating current circuit breakers (ACCBs) to trip and lock out. Where this occurs, on-site manual reset is required.

Where the instantaneous overcurrent protection does not provide 100% reach, operation of the 750 V dc switchgear frame leakage protection shall transfer-trip the far end of all dc sections connected to the TPS. An inter-tripping scheme shall be provided, which trips the remote end of the feeder when a fault is detected on a dc section.

The rectifier shall be connected to a cathode circuit breaker or cathode disconnector. A cathode disconnector may only be used at a TPS with one rectifier. For reverse overcurrent protection requirements of the cathode circuit breaker, see Section 8.5.4.

Feeder circuit breakers shall provide the following protection functions:

- instantaneous overcurrent
- long-time overcurrent
- rate of rise overcurrent.

Where a 750 V dc TPS bypass switch is provided and is closed, the transfer-trip signal shall be redirected to the adjacent substation without any reliance on equipment within the bypassed TPS. This is to ensure that the integrity of the protection system is maintained regardless of the nature of any failure or equipment unavailability within the bypassed TPS.

The arrangement for isolation and lock-out of control supplies to remote-controlled equipment providing the isolator function shall satisfy the following requirements:

- Isolation switches shall be provided at each TPS or field switch location case for each electrical section connected to that TPS or field switch.
- A ‘locked’ flag indicator shall be provided for each isolation switch.
- The ‘locked’ flag indicators shall be controlled directly by the isolation switches.
- Isolation switches shall be in a locked box external to the TPS or field switch location case.
- The isolation switches shall accept a sufficient number of padlocks appropriate to the foreseeable requirement of the isolation procedures and working arrangements.
- There shall be a fail-safe control supply contactor associated with each isolation switch. De-energising the contactor shall lock the isolating and rail connection switch.
- Indication of locked state shall be derived from the state of the control supply contactor, the state of the ‘locked’ flag indicators, and the control supply voltage at the locked device. All three shall agree that the isolator is locked before a ‘locked’ indication is provided.
- SCADA indication of locked state shall be provided.
- Local indication of locked state shall be displayed adjacent to the relevant isolation switch.
- The status of the control supply contactor and of the ‘locked’ flag indicators shall be double point indicated.

A safety integration level (SIL) assessment of the isolation and lock-out arrangement shall be undertaken before installation.

## 8.9 750 V dc feeder circuit status evaluators

750 V dc feeder circuit status evaluators shall be provided for each 750 V dc feeder at each point of remote isolation and/or rail connection. The feeder circuit status evaluators shall indicate the following:

- live
- dead
- safe to rail connect
- rail connected.

Feeder circuit status evaluators shall perform the following functions:

- continuously report the status of each 750 V dc feeder to the OCC
- be adequately protected against lightning surges on the OLE
- include 750 V dc overcurrent protection in case of an internal fault.

## 8.10 Voltage limiting device

A VLD is commonly referred to as a ‘negative grounding device’, ‘floating negative automatic grounding system’, ‘rail grounding device’, ‘short-circuiting device’ or a ‘rail earth contactor’.

A voltage limiting device (VLD-F in accordance with EN 50122-1) shall be provided at each TPS to monitor the traction negative to earth voltage and connect the rails to earth upon exceeding a pre-set limit. The VLD shall comply with EN 50526-2.

The VLD device shall perform the following functions:

- continuously monitor the potential between the traction negative bus and the TPS earth grid
- provide an open circuit when the potential is at an acceptable level
- provide a short circuit if the pre-set potential is exceeded
- open automatically and safely when the current has decreased below the preset level.

The status of the VLD shall be indicated to the OCC through SCADA.

## 8.11 Emergency push-buttons

At least one emergency push-button shall be provided in each room within a TPS except for battery rooms. There shall be no more than 10 m walking distance from any point in the room to an emergency push-button.

Where a first aid kit is provided in a room, an emergency push-button shall be located adjacent to the first aid kit.

Emergency push-buttons shall be:

- of the mushroom head type
- orange in colour
- of the mechanically latching type with a turn or rotate to release mechanism
- at least 20 mm in diameter at the head of the button
- mounted 1.6 m above finished floor level where possible. Where this is not possible, emergency push-buttons shall be mounted as close as possible to this height
- consistent in appearance with all existing emergency push-buttons in all TPSs, including the use of the same label for all emergency push-buttons used in TPSs
- labelled, with the label located above the push-button
- installed with a separate orange LED directly above the push-button. The LED shall be a minimum of 20 mm in diameter
- installed in the same location for all TPSs with similar layouts.

When the emergency push-button is pressed:

- An indication shall be sent to SCADA. All emergency push-buttons at an individual TPS may be connected to a single SCADA monitoring point.
- The OCC shall respond by energising indication lights associated with all emergency push-buttons as confirmation that the push-button signal has been received.
- Emergency push-button lights shall only be deactivated when the emergency push-button is released.

A single SCADA control point may be used to send a signal to power up the illumination of all emergency push-buttons at an individual TPS.

## 8.12 DC auxiliary power supply

Control power in the TPS shall be used for equipment controls, supply to protection relays, SCADA and other functions.

The TPS control power system shall consist of a step-down transformer, a battery bank, a battery charger, dc distribution panels, and all other necessary equipment to provide a complete control power system.

Battery chargers shall comply with AS 4044.

The battery bank shall be capable of supplying TPS demand to support control power for a minimum of four hours. Vented cell batteries shall comply with AS 2676.1 and AS 3011.1. Sealed cell batteries shall comply with AS 2676.2 and AS 3011.2.

The battery size shall be determined based upon a load calculation incorporating TPS switching operations and all static TPS loads during normal and contingency operation.

## 8.13 AC auxiliary power supply

The ac auxiliary power supply is the general supply for equipment associated with the TPS building services and substation equipment. AC auxiliary power supplies typically supply lights, general power outlets (GPOs), hot water heaters, air-conditioning, basement pumps, battery chargers and equipment heaters.

AC auxiliary power supplies shall comply with TS 04955.8.

## 8.14 Earthing

The earthing of TPSs shall be in accordance with TS 03789.

## 8.15 SCADA

This section details the SCADA requirements in substations.

An RTU, which communicates the state of equipment to the OCC and performs controls, shall be installed in each substation. For the interface to the master station, refer to Section 19 of TS 03789.

The RTU and related equipment within a TPS shall be compatible with the SCADA master station. Refer to TS 03789 for SCADA master station requirements.

The RTU shall have the following attributes:

- It shall be able to correctly record and transmit the state or value changes of all connected equipment.
- It shall be able to restart automatically.
- It shall not report spurious state changes on power resumption.
- The status of the RTU shall be visible from the front panel.
- The RTU and associated equipment shall be maintenance free; that is, it shall have no moving parts (such as fans) and resist dust and entry by vermin.
- The RTU shall be suitable for the substation battery voltage and load and have input and output contacts rated for the substation battery voltage.
- Digital input channels shall be isolated from the field wiring.
- Digital outputs shall be voltage-free.
- Every input, output, indicator lamp, LED, terminal and wire shall be clearly identified by a label.

- The RTU shall be modular. Its modules shall be capable of being replaced without the need to disassemble the RTU.
- Marshalling terminal strips shall be supplied for all power and signal connections to the RTU hardware.

Digital inputs to the RTU from equipment auxiliary contacts shall be connected to the substation battery positive supply through the equipment auxiliary contact (NO, NC) providing the input to the RTU module (which has the substation battery negative connected within the RTU).

Any equipment to be utilised as a remote-operated point of isolation or rail connection shall have positive indication of each state to SCADA – this would normally mean an independent auxiliary contact for the closed state and separate auxiliary contact for the open state.

Serial connections between RTUs and intelligent electronic devices (IEDs) shall be able to use DNP3.0 or Modbus RTU and other non-proprietary, common protocols such as IEC 61850 (all parts) or AS 60870.5.1.

Access to input and output wiring for testing shall not involve the removal of any module apart from a cover.

An input/output (I/O) schedule shall list all the inputs and outputs and contain all necessary information for configuration, testing and commissioning of the RTU and master station (for example, analogue transducer ratios).

SCADA information from the equipment is required to ensure that the OCC can make informed operational decisions. Information shall be recorded for analysis. The information shall include the following:

- position status of all equipment that has a critical function for the operation and safety of the Light Rail system
- protection relay status
- alarms from all equipment and safety systems that have a critical function for operation and safety of the Light Rail system. These are required for OCC operational decisions and are needed to be recorded for operational and fault analysis
- analogue information from all equipment that has a critical function for the operation and safety of the Light Rail system. This is required for OCC operational decisions and needs to be recorded for operational and fault analysis and network modelling.

## 8.16 Stray current drainage feeder system

Spatial provision shall be made within each TPS for a stray current drainage panel.

Cable routes in the form of conduits, cable trays or suitable alternatives shall be provided between the position allocated for the stray current drainage panel and the following locations:

- substation earth
- traction negative
- substation battery
- SCADA panel
- an external interface pit for the connection of utility provider drainage cables.

## 8.17 Lightning and surge protection

TPSs shall be protected against lightning and switching surge damage, including through the incorporation of surge arrestors and VLDs in accordance with EN 50526-1.

Overvoltage protection for the OLE in accordance with EN 50124-1 shall be provided. Refer to TS 03785 for further details.

The traction power reticulation system shall be protected against lightning and switching surge damage in accordance with EN 50526-1.

Surge arrestor voltage ratings shall be coordinated with the equipment insulation level and the system highest voltage in accordance with EN 50124-1.

Surge arrestor energy absorption ratings shall be coordinated with lightning and the anticipated faults from any crossing, adjacent or nearby HV aerial lines that have the potential to fall onto the system conductors.

Surge arrestors shall be fitted to all OLE feeder risers at TPSs, in areas of reduced electrical clearance between OLE and earthed structures, at high points along the alignment, and at other identified locations considered susceptible to lightning strikes.

Surge arrestors shall be mounted on the poles of the overhead conductor system structure and provided with direct connections to local earth. All connections shall be insulated from the poles. Refer to TS 03785 for further details.

Touch voltages and accessible voltages shall be in accordance with EN 50122-1.

## 8.18 Harmonic filter equipment

TPSs shall be designed to ensure that the supplying HV network's requirements in relation to harmonic disturbance, as set out in the relevant connection agreement with the supplying HV network operator, are met.

Where the requirements of the connection agreement are not met, then a harmonic filter is required.

# 9 Electromagnetic compatibility

TPSs shall be designed to manage the risks associated with the generation, propagation and reception of electromagnetic energy, as specified in Section 7.9 of TS 01471:0.0. The limits of any magnetic fields shall comply with TD 00024:2023.

# 10 Human factors

The selection of equipment, layout of the equipment within the TPS, and the overall design of the TPS shall incorporate the principles of human factor integration as described in TS 04978.