Traction Power Substations

Version 1.0

Issued date: 25 May 2017
Important message

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

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

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

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

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

This document may not be current and is uncontrolled when printed or downloaded. Standards may be accessed from the Asset Standards Authority website at www.asa.transport.nsw.gov.au
Standard governance

Owner: Lead Electrical Engineer, Asset Standards Authority
Authoriser: Chief Engineer, Asset Standards Authority
Approver: Executive Director, Asset Standards Authority on behalf of the ASA Configuration Control Board

Document history

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

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

© State of NSW through Transport for NSW 2017
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 document sets out the requirements for the configuration and performance of traction power substations for light rail.

This document is a first issue.
# Table of contents

1. Introduction ........................................................................................................................................ 6  
2. Purpose ........................................................................................................................................... 6  
   2.1. Scope .......................................................................................................................................... 6  
   2.2. Application ................................................................................................................................. 6  
3. Reference documents ............................................................................................................................... 6  
4. Terms and definitions ............................................................................................................................... 7  
5. General requirements ............................................................................................................................... 8  
6. Building requirements ............................................................................................................................... 8  
   6.1. Site location ............................................................................................................................... 9  
   6.2. Standardisation ........................................................................................................................... 9  
   6.3. Maintenance requirements ......................................................................................................... 9  
   6.4. Spatial requirements .................................................................................................................. 10  
   6.5. Protection against unauthorised access ....................................................................................... 10  
   6.6. Ambient conditions ..................................................................................................................... 10  
   6.7. Fire protection ............................................................................................................................ 11  
   6.8. Sound levels ............................................................................................................................... 11  
   6.9. Communication requirements ................................................................................................... 11  
   6.10. Signage requirements ............................................................................................................... 12  
7. Control and monitoring of equipment .................................................................................................. 12  
   7.1. TPS staff emergency alert ......................................................................................................... 12  
8. Equipment requirements ........................................................................................................................... 13  
   8.1. Type approval of equipment ....................................................................................................... 13  
   8.2. Standardisation ........................................................................................................................... 14  
   8.3. Connection of overhead conductor system to rail .................................................................... 14  
   8.4. Electrical protection .................................................................................................................... 15  
   8.5. Rectifier sets ............................................................................................................................. 16  
   8.6. HV ac switchgear ....................................................................................................................... 16  
   8.7. 750 V dc switchgear ................................................................................................................ 16  
   8.8. 750 V dc feeder circuit status evaluators ................................................................................... 17  
   8.9. Voltage limiting device ............................................................................................................... 18  
   8.10. Emergency push-buttons ....................................................................................................... 18  
   8.11. Control power – dc auxiliary supply ....................................................................................... 19  
   8.12. Earthing ................................................................................................................................. 19  
   8.13. SCADA ................................................................................................................................... 19  
   8.14. Stray current drainage feeder system ...................................................................................... 21  
   8.15. Lightning and surge protection ............................................................................................... 21  
   8.16. Harmonic filter equipment .................................................................................................... 22  
9. Human factors ...................................................................................................................................... 22  
10. Standards and codes ........................................................................................................................... 22  
11. Electrical protection ............................................................................................................................. 22  
12. Connection of overhead conductor system to rail ............................................................................ 22  
13. Spatial requirements ........................................................................................................................... 22  
14. Building requirements ........................................................................................................................... 22  
15. General requirements ........................................................................................................................... 22  
16. Equipment requirements ....................................................................................................................... 22  
17. Control and monitoring of equipment ............................................................................................... 22  
18. Human factors .................................................................................................................................... 22  
19. Standards and codes ............................................................................................................................. 22  
20. Summary and conclusion ..................................................................................................................... 22  
21. References ......................................................................................................................................... 22  

1. **Introduction**

Traction power substations (TPS) are located along a light rail network with the primary function of providing the facility and equipment to convert the high voltage (HV) alternating current (ac) supply to the 750 V dc traction supply for light rail vehicles.

2. **Purpose**

The purpose of this document is to provide the requirements for the configuration and performance of TPSs and the equipment housed within them.

2.1. **Scope**

This document provides the requirements for TPSs which are connected to the HV ac supply and the traction power supply reticulation system. TPSs contain the equipment to convert this to the 750 V dc traction supply and the associated control and monitoring equipment.

2.2. **Application**

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

Unless otherwise stated, application is not retrospective to existing infrastructure which is not otherwise being altered.

This standard is intended to be used by Authorised Engineering Organisations (AEOs) that undertake work on traction power systems for light rail.

3. **Reference documents**

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

- **International standards**
  - EN 50124-1 Railway applications - Insulation coordination – Part 1: Basic requirements - Clearances and creepage distances for all electrical and electronic equipment
  - 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 - dc surge arresters and voltage limiting devices – Part 1: Surge arresters
  - IEC 62271 (all parts) High-voltage switchgear and control gear
Australian standards
AS 1319 Safety signs for the occupational environment
AS 2067 Substations and high voltage installations exceeding 1 kV a.c
AS 60146 (all parts) Semiconductor converters
AS/NZS 3000 Electrical installations (known as the Australian/New Zealand Wiring Rules)

Transport for NSW standards
T HR TE 21003 ST Telecommunications for Traction Substations and Section Huts
T LR EL 00001 ST Traction Power System Requirements
T LR EL 00005 ST Direct Current Traction Power Reticulation
T MU AM 01001 ST Life Cycle Costing
T MU EN 00005 ST Ambient Environmental Conditions
T MU HF 00001 ST Human Factors Integration – General Requirements
T MU MD 00005 GU Type Approval of Products

Legislation
Disability Discrimination Act 1992

Other reference documents
The Australian Building Codes Board, National Construction Code, all volumes
ENA Doc 015-2006 National Guidelines for Prevention of Unauthorised Access to Electricity Infrastructure
ENA Doc 018-2015 Guideline for the Fire Protection of Electricity Substations
National Standard for Occupational Noise [NOHSC: 1007(2000)]

4. Terms and definitions

The following terms and definitions apply in this document:

ac alternating current

ACCB alternating current circuit breaker

AEO Authorised Engineering Organisation

ASA Asset Standards Authority

dc direct current

DCCB direct current circuit breaker
HV high voltage
IP ingress protection
OCC operations control centre
OCS overhead conductor system
OLE overhead line equipment
RTU remote terminal unit
SCADA supervisory control and data acquisition
TPS traction power substation
VLD voltage limiting device; a protective device against permanent existence of an inadmissible high touch voltage; for example, spark gap (IEC 62128-1)

5. General requirements

TPSs shall distribute, transform and control bulk high voltage (HV) ac supplies derived from the supplying HV network. The supplying HV network is the electricity network, which supplies electricity to the light rail system at high voltage. TPSs provide 750 V dc traction supply to light rail vehicles through the traction power reticulation system.

TPSs shall comply with the requirements of the National Construction Code (NCC), AS/NZS 3000 Electrical installations (known as the Australian/New Zealand Wiring Rules) and with AS 2067 Substations and high voltage installations exceeding 1 kV a.c.

Stand-alone TPSs that utilise modular, transportable and temporary structures are generally classified as Class 10a for the purposes of the NCC. Larger TPSs integrated into buildings may be classified as Class 8.

Compliance with the Disability Discrimination Act 1992 (DDA) is not required in relation to the provision of means of access to premises or facilities which are, or form part of a TPS.

6. Building requirements

All TPSs shall be configured so that they do not include a low point 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.

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

The site location for TPSs shall comply with the following requirements:

- The location shall be electrically suitable as determined by the modelling of the light rail network.

- The location 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 construction of the TPS shall be such that the floor level shall not be less than 500 mm above the 100 year average recurrence interval flood level. Consideration of environmental factors such as climate change as specified in T MU EN 00005 ST Ambient Environmental Conditions need to be included.

- The location is accessible for maintenance activities.

- High-risk areas such as major road junctions and areas where service stations, flammable gas or liquid storage tanks are in close proximity shall be avoided.

6.2. 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 (SFAIRP), the TPS shall be internally similar in dimension, layout and equipment manufacture to the existing TPSs in that part of the light rail system.

6.3. Maintenance requirements

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

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

Maintenance access spaces shall be protected legally from future encroachment or obstruction.
6.4. Spatial requirements

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

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

TPSs shall be configured so that if only a single feeder direct current circuit breaker (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.

6.5. Protection against unauthorised access

ENA Doc 015-2006 National Guidelines for Prevention of Unauthorised Access to Electricity Infrastructure provides performance requirements for control measures to minimise unauthorised contact to electrical infrastructure at new installations.

As TPS locations can vary, the extent of 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 mechanism
- intruder alarm system, with entry of persons into each TPS automatically detected and conveyed to the operations control centre (OCC)
- security lighting
- signage and labels

6.6. Ambient conditions

TPSs shall be designed to maintain the equipment room air temperature below the rated operating temperatures of the substation equipment and in accordance with requirements of T LR EL 0001 ST Traction Power System Requirements. The design shall consider the effect of elevated temperatures on the life of the electronics and batteries.

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.
6.7. **Fire protection**

TPSs shall have fire protection as determined by ENA Doc 18-2015 *Guideline for the Fire Protection of Electricity Substations*.

Fire and smoke within each TPS shall be detected and reported at the OCC. Fire and smoke detectors shall be connected directly to the supervisory control and data acquisition (SCADA) system.

Appropriate provision 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.

AS 2067 compliance is required for fire protection.

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

6.8. **Sound levels**

The sound levels external to a TPS and arising from within that TPS shall be in accordance with the requirements of the project's environmental impact statement (EIS).

The sound level internal to a TPS arising incidentally from the equipment within that TPS shall be as low as reasonably practicable and shall not be greater than the level prescribed in the *National Standard for Occupational Noise* [NOHSC: 1007 (2000)].

6.9. **Communication requirements**

Each TPS shall be provided with the following telecommunications facilities:

- SCADA data links
- HV feeder differential protection circuits
- telephone and 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 T HR TE 21003 ST *Telecommunications for Traction Substations and Section Huts*. 
6.10. Signage requirements

TPSs shall have signs installed indicating the following:

- facility name
- emergency and OCC contact details
- signs in accordance with AS 3000, AS 2067 and AS 1319 *Safety signs for the occupational environment*
- equipment identification and marking

High voltage and 750 V dc equipment that are operated for electrical isolations are required to have identification labels that match the light rail electrical operating diagrams.

The TPS name shall not be the same as a stop name, to reduce the possibility of errors when communicating with the OCC and documentation associated with the arrangement of electrical isolations.

7. Control and monitoring of equipment

The TPSs shall be designed for unattended operation with remote supervision and control from the OCC. This includes the following operations:

- 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

Section 8.13 provides detail on the equipment that is required to be controlled and monitored from the OCC.

The control and monitoring for individual TPSs shall be implemented through a SCADA remote terminal unit (RTU) located in the TPS.

7.1. TPS staff emergency alert

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

See Section 8.10 for specific requirements for emergency push-buttons.
8. Equipment requirements

All traction power equipment and cables shall be sized to support the maximum load and the maximum fault current that it may be exposed to for the maximum credible fault duration in accordance with the system modelling. Refer to T LR EL 00001 ST Traction Power System Requirements for details of the modelling.

Equipment used as a point of isolation shall be rated appropriately, including voltage ratings (such as lightning withstand) and shall 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 other than traction rectifiers shall have a minimum ingress protection (IP) rating of IP42.

All TPS equipment shall comply with the relevant provisions of EP 00 00 00 15 SP Common Requirements for Electric Power Equipment.

Life cycle costing is required to be completed on all equipment in accordance with T MU AM 01001 ST Life Cycle Costing to ensure that whole-of-life costs to TfNSW are minimised.

Equipment that contains SF6 gas shall not be used.

8.1. Type approval of equipment

Certain equipment is required to be type approved in accordance with T MU MD 00005 GU Type Approval of Products. This includes the following equipment:

- HV ac switchgear
- 750 V dc switchgear
- traction rectifier power cubicle
- traction rectifier transformers
- voltage limiting device
- 750 V dc shorting to rail device
- dc protection relay
8.2. **Standardisation**

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

8.3. **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 the following:

- 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 and includes the following components:

- traction power feeder cables
- overhead conductor system
- 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.

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 alternate 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 provision shall be made for securing the isolation and short circuiting points during any maintenance of the power control systems.

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

8.4. **Electrical protection**

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.

8.4.1. **HV ac protection**

The HV ac protection requirements are detailed in T LR EL 00001 ST.

8.4.2. **750 V dc protection**

The 750 V dc feeder protection strategy shall ensure the following:

- faults are detected under all feeding conditions
- allowance 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 dc circuit breaker (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 is to 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 is determined by the designer, based on a safety and risk analysis incorporating the operational concept of the light rail.

The 750 V dc feeder protection concept design shall be approved by the Lead Electrical Engineer, ASA, prior to being used as the basis of detailed design.

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. **Rectifier sets**

Traction power rectifier units shall comply with EN 50328 *Railway Applications – Fixed Installations – Electronic Power Converters for Substations* and AS 60146 *Semiconductor converters*.

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

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

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

8.5.1. **Rectifier**

The main cathode circuit breaker and the negative disconnect switch shall be interlocked so that the cathode circuit breaker cannot be closed when the negative disconnect switch is open, and the negative disconnect switch cannot be opened when the cathode circuit breaker is closed.

Rectifier enclosure frame leakage protection shall be provided to detect a positive to frame fault. Operation of the rectifier frame leakage protection shall cause the rectifier to trip and lock out. 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.

8.5.2. **Rectifier transformer**

Rectifier transformers shall not be force-cooled and shall comply with the requirements of EN 50329 *Railway Applications – Fixed Installations – Traction Transformers*.

The rectifier and transformer audible sound levels shall not exceed maximum values specified in AS 60076.10 *Power Transformers Part 10: Determination of Sound Levels*.

8.6. **HV ac switchgear**

Metal clad HV ac switchgear shall be provided in accordance with IEC 62271 *High-voltage switchgear and control gear*.

8.7. **750 V dc switchgear**

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

The 750 V dc switchgear shall be rated to interrupt maximum available fault current and shall be configured to prevent accidental contact with live parts by maintenance personnel in accordance with EN 50123 and IEC 61992.
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. On-site manual reset is required.

If the instantaneous overcurrent protection does not provide 100% reach, then 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.

Rectifier cathode circuit breakers shall provide reverse current protection.

Feeder circuit breakers shall provide the following protection functions:

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

If a 750 V dc TPS bypass switch is provided and is closed, then 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.

### 8.8. 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
- safe to rail connect
- dead
- 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 overhead line equipment (OLE)
- include 750 V dc over-current protection in case of an internal fault
8.9. **Voltage limiting device**

Voltage limiting devices are commonly referred to as negative grounding device, floating negative automatic grounding system, rail grounding or short circuiting device, 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 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
- the VLD can 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.

8.10. **Emergency push-buttons**

At least one emergency push-button shall be provided in each room within a TPS except for battery rooms and there shall be no more than 10 m walking route 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 have the following attributes:

- the push-button and light shall be coloured orange and shall be a minimum of 20 mm in diameter
- all emergency push-buttons in all TPSs shall have a consistent appearance with a standard label
- the label shall be provided above each push-button
- the push-button shall send an indication to SCADA when pushed. All emergency push-buttons at an individual TPS shall be connected to a single SCADA monitoring point
- the push-button illumination shall be energised from a SCADA output
- shall be mounted approximately 1.6 m above finished floor level
- be located in the same location for all TPS with similar layout
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.

8.11. **Control power – dc auxiliary 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 the following equipment:

- step-down transformer
- battery bank
- battery charger
- dc distribution panels
- all other necessary equipment to provide a complete control power system

The battery unit shall be capable of supplying TPS demand to support control power for a minimum of four hours.

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

8.12. **Earthing**

The earthing of TPSs shall be in accordance with T LR EL 00001 ST.

8.13. **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, see the OCC section in T LR EL 00001 ST.

RTU and related equipment within a TPS shall be compatible with the SCADA master station. See T LR EL 00001 ST for SCADA master station requirements.

The RTU shall have the following attributes:

- ability to correctly record and transmit the state or value changes of all connected equipment. It shall be able to auto restart. 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 it shall 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 inputs 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 with modules 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

On field equipment, digital inputs shall be from voltage-free contacts. The substation battery positive shall originate from the field equipment where possible. Any equipment to be utilised as a remote operated point of isolation or rail connection shall be double point indicated to SCADA.

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 or IEC 60870-5.

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

• alarms from all equipment and safety systems that have a critical function for operation and safety of the light rail system, 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, is required for OCC operational decisions and is needed to be recorded for operational and fault analysis and network modelling
8.14. 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 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

8.15. Lightning and surge protection

TPSs shall be protected against lightning and switching surge damage, including through the incorporation of surge arrestors and voltage limiting devices in accordance with EN 50526-1 Railway applications - Fixed Installations - dc surge arresters and voltage limiting devices – Part 1: Surge arresters.

Overvoltage protection for the OLE in accordance with EN 50124-1 Railway applications - Insulation coordination – Part 1: Basic requirements - Clearances and creepage distances for all electrical and electronic equipment shall be provided. See T LR EL 00005 ST Direct Current Traction Power Reticulation for further details.

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

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

Surge arrester energy absorption ratings shall be coordinated with lightning and the anticipated faults from any crossing, adjacent or nearby high voltage 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 (overhead conductor system (OCS) structure) and provided with direct connections to local earth. All connections shall be insulated from the poles. See T LR EL 00005 ST for further details.

Touch voltages and accessible voltages shall be in accordance with EN 50122-1.
8.16. **Harmonic filter equipment**

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

9. **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 T MU HF 00001 ST *Human Factors Integration – General Requirements.*