Standard

Infrastructure – Network Power – Traction Power – Design and Construction

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Keolis Downer

PROUD OPERATOR OF yarra trams

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1 PURPOSE

The purpose of this standard is to specify the minimum requirements for design, maintenance and integration of the Yarra Trams traction power system.

This standard also demonstrates Yarra Trams alignment to the following PTV Network Technical Standards:

- PTV-NTS-004:2017 Traction Power Systems.

2 SCOPE

The scope of this standard encompasses the design requirements for the Yarra Trams traction power system, which includes, but is not limited to:

- DC traction substations,
- Overhead wiring system,
- Compatibility of the traction power system with rolling stock,
- Compatibility of the traction power system with ancillary systems including points, maintenance plant and equipment,
- Protective provisions against electric shock, and
- Provisions against the effects of stray currents caused by DC traction systems.

The scope of this document does not include:

- Rolling stock; and
- Plant and Equipment linked to the traction power system, such as work platforms, wheel lathe systems)
- Signalling and telecommunications apparatus.

The requirements of this standard apply to all existing and new traction power system installations, including all cabling and equipment from the main incoming power supply through to distribution at the pantograph interface.

The requirements in this standard are derived from the following sources:

- International and Australian Standards listed in this document as Related Legislation and Documents.
- VRIOGS
- Local subject matter experts within Yarra Trams and suppliers to Yarra Trams.
- Department of Transport (DoT) subject matter experts.

The requirements in this standard are derived from the following documents:

- VRIOGS 010.7 Track Bonding, Track Circuit Connections and Traction Interfaces,
- OEM manuals for equipment,
- Knowledge and experience from previous work on the traction power system, and
- Local and industry subject matter expertise about the traction power system.

This standard applies to any party who is involved in the design, integration, maintenance or modification of the Yarra Trams traction power system.

3 COMPLIANCE

Any party who is involved in the design, maintenance or modification of the Yarra Trams traction power system should fully comply with this standard. Where this is not practicable, the *Designer* shall identify deviations and raise these with the Engineering Design Authority at Yarra Trams.

Deviation from this standard is only permitted when a deviation or waiver has been formally requested and approved by the Engineering Design Authority at Yarra Trams.

The Yarra Trams Engineering Change Management Procedure [CE-021-PR-0020] shall be followed in all circumstances where change is proposed to the traction power system or to this standard.

The following definitions apply throughout the standard:

- 'Shall' statements are mandatory in the context of compliance with requirements stipulated in this standard.
- 'Should' statements are considerations in the context of compliance with requirements stipulated in this standard.
- 'Information' statements provide additional content for clarification purposes only and are not requirements in the context of compliance with this standard.
- 'So far as is reasonably practicable' statements must at a minimum result in the provision of a technical risk assessment including proposed list of design controls to demonstrate compliance to this standard.

Any party who is involved in the design, maintenance or modification of the Yarra Trams traction power system shall complete and return a statement of compliance for this standard. Assessment of compliance shall be provided for each requirement, defined by one of three permissible responses:

- Compliant;
- Partially compliant; or
- Non-compliant.

4 REQUIREMENTS

4.1 Description of the traction power system

Information: The tram traction power system is a complex collection of interconnected systems. Distribution Network Service Providers supply power from the National Electricity Market to Yarra Trams DC traction substations, where this power is converted from HV AC to 600 V DC. The DC current is then transmitted to the trams via 600 V DC positive feeding cables and the overhead wiring system. The DC current returns to the traction substation via the rails and through track bonds and negative cables. At the time of writing this standard, the Yarra Trams traction power system contains approximately 60 traction substations. Substations may also provide ac supply to adjacent tramway facilities.

The overhead wiring is divided into different electrical sections, using section insulators. Typically, an electrical section is fed from two different traction substations and the overhead wires on adjacent tracks are connected in parallel to the same section. In many sections, an auxiliary side feeder is connected in parallel to the overhead wiring to increase the total cross-sectional area of the positive conductors.

The 600 V DC traction system is unearthed; the rails are not directly connected to earth but in most cases, they are embedded in the road surface and so they may not considered to be floating as well. Generally, all

rails are used for the traction return current (i.e. there are no dedicated signalling rails). As part of the process of dc distribution there are various external assets that are subject to stray current damage. For this reason, the traction power system also includes components for electrolysis mitigation equipment that are integrated into electrolysis protection systems operated by Energy Safe Victoria. The HV AC and LV AC systems are earthed

4.2 Traction power system requirements

4.2.1 Network traction power

4.2.1.1 The design, configuration and operation of the Melbourne Metropolitan Tram Network (MMTN) traction power system shall ensure that it is always possible for the trams to operate and meet the authorised design timetable requirements under N and N-1 conditions.

Only the following N-1 conditions shall be considered:

- Substation rectifier outage
- Substation Feeder Panel Failure

Operation of trams on diversion routes is considered to be an N-1 event.

A rectifier outage when operating diversion services is considered to be an N-2 event.

Information: The substation rectifier outage may be caused by events such as the loss of HV AC supply, failure of the HV AC switchgear or failure of the rectification system.

All other N-1 conditions are excluded, including, but not limited to:

- 600 V DC external isolator failure; and
- 600 V DC positive feeder cable failure.

4.2.1.2 An analysis of diversionary routes and special event routes should be undertaken to ensure satisfactory operation of the specified rolling stock fleet under such conditions.

4.2.2 Traction power voltage

4.2.2.1 Traction power voltage shall comply with the following requirements of EN 50163:

- All requirements in EN 50163 which refer to a "train" shall apply for "tram" on the MMTN.

4.2.2.2 In reference to section 4.1 of EN 50163 and EN 50124-2, the characteristics of the main voltage system for the MMTN are specified in Table 1.

Table 1: 600 V DC system – Nominal voltage and its permissible limits in values and duration

Electrification system	Lowest non-permanent voltage U_{min2} [V]	Lowest permanent voltage U_{min1} [V]	Nominal voltage U_n [V]	Highest permanent voltage U_{max1} [V]	Highest non-permanent voltage U_{max2} [V]	Highest long-term overvoltage U_{max3} [V]
d.c. (mean values)	420[2]	420[2]	600	720[1]	800	900

[1]The maximum voltage developed during regenerative braking shall not exceed the voltage advised by the Victorian Electrolysis Committee for the Yarra Trams network.

[2]U_{min1} and U_{min2} shall be:

- 500 V in electrical sections which run D class trams;
- 450 V in electrical sections which run C2-Class trams; and
- 420 V in all other electrical sections.

4.2.2.3 The traction power system insulation coordination shall fully comply with EN 50124-1 and EN 50124-2.

4.2.2.4 The mean useful voltage at the pantograph, $U_{mean\ useful}$, shall be 540V DC in accordance with EN 50388. The following definitions shall apply for $U_{mean\ useful}$:

- In accordance with Annex B of EN 50388, $U_{mean\ useful}$ (train) shall be used and is the mean useful voltage at the pantograph of each tram taken in isolation; where only the traction periods of the tram are considered; and
- The $U_{mean\ useful}$ (train) geographical zones shall be between platforms.

4.2.3 Regenerative braking

4.2.3.1 The traction power system shall be designed to permit the use of regenerative braking.

4.2.3.2 The regenerative braking requirements shall comply with section 12 of EN 50388.

4.2.4 Overhead wiring system

Electrical clearances

4.2.4.1 Electrical clearances shall comply with:

- Electricity Safety (Installations) Regulations; and
- EN 50119.

4.2.4.2 Clearances from the top of the rail to the underside of the contact wire shall comply with the values specified in the Yarra Trams Network Power – Overhead standard. The values are also presented in Table 2 below for clarification.

Table 2: 600 V DC overhead wiring system – Electrical clearances

Voltage	Minimum [mm]	Normal [mm]	Maximum [mm]
600 V DC	3600	5640	5800

Temperature rises in conductors

4.2.4.3 The overhead wiring system shall be designed to cater for the electrical current loading (steady and fault) defined by the system design, including return circuits and feeder connections, under all environmental operating conditions and in accordance with the guidance provided in EN 50119. The traction power system shall be assessed for short circuit faults.

4.2.4.4 The maximum acceptable temperatures, over which the mechanical properties of the conductor material can be impaired, shall comply with the specified values in Table 3 below.

Table 3: 600 V DC overhead wiring system – Maximum acceptable material temperatures

Suspension systems for contact wires	Material	Maximum temperature [°C]
Catenary type suspension[1]	Hard drawn copper	75
Non-catenary type suspension	Tin copper alloy	TBC[2]

[1]The 'traditional railway' overhead contact line with a catenary type suspension system is only used in the following sections of the Yarra Trams network:

- Port Melbourne section; and
- St. Kilda Beach section.

[2]The overwhelming majority of the Yarra Trams OHW system is a non-catenary type suspension system using tin copper alloy wire. This tin copper alloy is not common in industry and therefore Yarra Trams are not able to obtain the maximum acceptable material temperature at this time from any manufacturer. The Designer of a change to the MMTN traction power system should complete an investigation or study of the maximum temperature limit for non-catenary type suspended conductors.

4.2.5 Rolling Stock interoperability

4.2.5.1 The traction power system shall comply with the following requirements of EN 50388 to ensure compatibility of the traction power system with rolling stock.

- Any requirements which are specific to TSI lines are not applicable; and
- All requirements in EN 50388 which refer to a "train" shall apply for "tram" on the Yarra Trams network.

4.2.6 Electromagnetic compatibility

4.2.6.1 The traction power system design and configuration shall comply with the electromagnetic compatibility requirements of the EN 50121 series.

4.2.6.2 The traction power system shall comply with the following standards, regarding exposure limits for electromagnetic fields:

- Victorian Traction Industry Electrical Safety Rules (The Orange Book);
- ICNIRP Guidelines: Guidelines for limiting exposure to time-varying electric and magnetic fields (1 Hz to 100 kHz); and
- ICNIRP Guidelines: Guidelines for limiting exposure to electric fields induced by movement of the human body in a static magnetic field and by time-varying magnetic fields below 1 Hz.

4.2.7 Protection against electric shock

4.2.7.1 The traction power system shall comply with the requirements for prevention of electric shock in EN 50122-1, except for the more stringent requirements of clause 4.2.7.4 of this standard.

4.2.7.2 In accordance with Annex F of EN 50122-1, a voltage limiting device complying with EN 50122-1 shall be connected between earth and the negative return circuit in each traction substation.

4.2.7.3 In accordance with Annex F of EN 50122-1, additional voltage limiting devices may be required in locations such as platforms. The *Designer* shall use suitable protection equipment and ensure compliance with EN 50122-1.

Potential situations which may require the use of additional voltage limiting devices include, but are not limited to:

- In reference to clause 6.2.2.1 of EN 50122-1, an exposed conductive part is located within the contact line zone or the current collector zone which is not insulated from earth and therefore has not been bonded to the return circuit, to prevent stray current corrosion. In the event of the 600 V DC contact line falling on this exposed conductive part, the part may present a hazardous voltage; and
- In reference to section 7.1 of EN 50122-1, low voltage non traction power supplies may be endangered by the traction power return circuit.

4.2.7.4 The maximum permissible effective touch voltages for long-term and short-term conditions shall be in accordance with the values specified in Table 4 below and shall apply to all locations across the traction power system and under all normally expected operating conditions including N-1 outages.

Table 4: Maximum permissible effective touch voltages in d.c. traction systems as a function of time duration

Time, t [s]	$U_{te, max}$ Long-term [V]	$U_{te, max}$ Short-term [V]
>3	60	
0.7	100	
<0.7		350
0.6		360
0.5		385
0.4		420
0.3		460
0.2		520
0.1		625
0.05		735
0.02		870
t: Time duration. $U_{te, max}$: Permissible effective touch voltage.		

4.2.8 Protection against stray currents

4.2.8.1 The traction power system shall comply with:

- Electrical Safety (Cathodic Protection) Regulations; and
- Requirements of the VEC.

Information: ESV is responsible (in the State of Victoria) for the protection of underground and underwater structures from the corrosive effects of stray electrical currents – electrolysis. ESV is advised by the VEC.

4.2.8.2 Subject to the requirements of clause 4.2.8.1, the traction power system shall comply with EN 50122-2.

4.2.9 Traction power modelling

4.2.9.1 Any party who is involved in the design, maintenance or modification of the Yarra Trams traction power system should perform a dimensioning study in order to assess the ability of the power

supply system to achieve present and future performance as specified by Yarra Trams. This study, known as traction power modelling, shall include, but is not limited to:

- Compliance with section 8 of EN 50388;
- Review of Yarra Trams plans for future tram operations
- Consideration of capacity needs for at least 20 years.
- Evidence of accuracy and, wherever possible, validation against known operational data; and
- Include infrastructure proposals which meet the performance criteria with the best value for money, where value for money is defined by the perceived CAPEX and OPEX costs of the infrastructure proposals.

Information: Power studies, or dimensioning studies of the power network, are mainly required when significant changes occur to the power network. For example, a renewal or construction of a new substation, or when the type, number or timetable of rolling stock is changed.

4.2.9.2 The traction power modelling shall be endorsed by the DoT.

4.2.9.3 The traction power modelling shall include, but is not limited to, the topics and performance criteria outlined in Table 5.

Table 5: Traction power modelling – Performance criteria

Topic	Performance criteria	Background	References
Traction voltage: Pantograph to rail	$U_{mean\ useful\ (train)}$ shall not be lower than 540 V DC, during the N condition. The instantaneous2 voltage at any tram pantograph shall not be lower than U_{min2}, during the N-1 condition. *Information: Where the instantaneous voltage at any tram pantograph within an electrical section is between U_{min1} and U_{min2}, during the N-1 condition, Yarra Trams shall record these instances and discuss the operational risks with DoT.*	The purpose of these criteria is to ensure that trams have adequate supply voltage. The level of this supply voltage affects a tram's operational and acceleration characteristics and therefore its ability to meet a given timetable.	EN 50388 EN 50163
Rectifier capacity	The rolling RMS substation output current, calculated over a 2-hour period, shall not exceed 100% of the rectifier and associated transformer capacity, during the N-1 condition[1]. The rolling RMS substation output current, calculated over a 60 second period, shall not exceed 150% of the rectifier and associated transformer capacity, during the N-1 condition[1].	The purpose of these criteria is to ensure that the rectifiers and associated rectifier transformers in each substation are sized appropriately. If the equipment is overloaded beyond capacity, the equipment may trip from overtemperature and degrade the traction power system.	EN 50388 IN-021-ST-0002
Feeder DCCB and cable capacity	The rolling RMS output current of each 600 V DC feeder, calculated over a 2-hour period, shall not exceed the manufacturer's capacity recommendations of the associated DCCB feeder panel or the associated feeder cable, during the N-1 condition.		EN 50388
Negative return cable capacity	As a minimum to be compliant with the Rectifier Capacity Ratings. Should also include some future proofing against the difficulty of accessing negative conductor connections to rail.		

Topic	Performance criteria	Background	References
Traction voltage: Rail to earth	The instantaneous[2] rail to earth voltage, U_{RE}, at any point on the traction power system shall not exceed 100 V, during the N and N-1 conditions. The rolling RMS rail to earth voltage, U_{RE}, at any point on the traction power system, calculated over a 3 second period, shall not exceed 60 V, during the N and N-1 conditions.	The purpose of these criteria is to ensure the safety of personnel against electric shock.	EN 50388 EN 50122-1
OHW temperature	The instantaneous temperature of the overhead wiring system[3] at any point on the traction power system shall not exceed the maximum acceptable material temperatures[4], during the N-1 condition. TBC	The purpose of these criteria is to ensure: Prevention of Annealing: The overhead wiring system conductors maintain an adequate margin under their annealing temperature; and Sag: The change in length of the overhead wiring system conductors, due to changes in conductor temperature, is limited to ensure safe and reliable operation of the trams.	EN 50388 EN 50119
Sectional running times	To be in accordance with currently approved operational timetables and to also consider changes to the long term operating plans.		
Electrolysis system	Electrolysis is not currently modelled.		

[1]This criterion is specific to rectifiers and associated rectifier transformers which have a class VI duty cycle, the most commonly seen duty cycle for the equipment in the Yarra Trams traction power system. However, this criterion shall be adjusted as required according to the site-specific duty cycles of the rectifiers, associated rectifier transformers and HV AC supply capacity.

E.g. a specific substation may have class VI duty cycle equipment installed, but the HV AC supply can't provide more than 100% capacity. In this instance, the modelling performance criteria for this specific substation shall be changed to reflect the HV AC supply limiting factor.

[2]Instantaneous is defined as the simulation time step of the traction power modelling software, which is typically 1 second.

Topic	Performance criteria	Background	References
[3]Typically, the hottest spots of the overhead wiring system are at the locations next to where the 600V DC feeder cables are connected to each electrical section. To simplify the traction power modelling, this criterion for assessment of hottest spots for the overhead wiring systems may be limited to the analysis of likely hot spots where loading is worst or electrical feeder configuration results in minimum cross section. See Table 3.			

4.2.10 Traction power modelling – Parameter values

Information: The traction power modelling parameter values for the Yarra Trams DC traction power system has not been finalised at the time the initial issue of this standard was published. Version 2 of this standard will include traction power modelling parameter values.

4.2.10.1 The *Designer* shall use the traction power modelling parameter values listed in Table 6 below.

Table 6: Traction power modelling – Parameter values

Parameter	Value
Cp = conductor specific heat [J/(kg*°C)]	TBC
ak = Temperature coefficient of electrical resistivity [$°C^{-1}$]	TBC
α = Solar absorptivity (.23 to .91) [no units]	TBC
Q_{se} = Total solar and sky radiated heat intensity corrected for elevation [W/m^2]	TBC
Θ = Effective angle of incidence of the sun's rays [radians]	TBC
ρ_f = Density of air [kg/m^3]	TBC
V_w = Speed of air stream at conductor [m/s]	TBC
μ_f = Absolute (dynamic) viscosity of air [kg/m-s or $N-s/m^2$]	TBC
k_f = Thermal conductivity of air at temperature Tfilm [W/(m-°C)]	TBC
T_a = Ambient air temperature [°C]	TBC
ε = Emissivity (.23 to .91) [no units]	TBC
Contact wire wear [%]	TBC

4.3 Substations

Information: Design requirements for substations are described in the Yarra Trams standard 'Network Power – Substations'. The information presented below should be considered when completing designs for new or changes to existing substations. For complete guidance on substation requirements, refer to the Yarra Trams standard 'Network Power – Substations'.

4.3.1 Design and configuration considerations

4.3.1.1 Before a DC traction substation design can commence, a system level design should be completed by Yarra Trams. The system level design shall include the following as a minimum:

- Existing traction power system:
- Evidence of non-compliance of the electrical sections, using references to clauses in this standard; and
- Traction power modelling of the existing traction power system, evidencing non-compliance.
- Traction power system with proposed substation configuration:
- Evidence that the proposed solutions will bring the non-compliant electrical sections into compliance;
- Traction power modelling of the traction power system with the proposed substation, evidencing that the proposed solutions will bring the non-compliant electrical sections into compliance;

- The high-level configuration of equipment within the substation including a single line diagram showing the quantities and ratings of incoming supplies, rectifiers, 600 V DC feeder panels as well as how the equipment shall be interconnected;
- 600 V DC sectionalising arrangements;
- Details of the Distribution Network Service Provider that will supply the HV AC power;
- The required size and quantity of 600 V DC feeder cables;
- The required size and quantity of negative feeder cables; and
- The geographical location and physical size of the substation.
- Substation acceptance criteria:
- Acceptance criteria for the proposed substation; and
- A high-level test methodology for evidencing the acceptance criteria.
- Operational Fleet profiles based on confirmed operational timetables and fleet type

Information: The system level design provides the necessary information for the Scope of Works to be prepared.

4.3.1.2 The *Designer* shall consider the following when determining the geographical location of the substation:

- Availability of incoming HV AC supply;
- Electrical sectioning – location of 600 V DC overhead sectioning point (the existing sectioning points may have to be changed to facilitate the location of sectioning points adjacent to substations);
- Site access - all weather heavy vehicle access for construction and future maintenance requirements;
- Space availability and site topography;
- Location from track and orientation to track;
- Amenities – require stormwater and sewerage connections;
- Security considerations;
- Susceptance of site to adverse weather conditions; and
- Site specific environmental requirements and considerations.

4.4 Traction power system test methodology

Information: The test methodology for the Yarra Trams DC traction power system has not been finalised at the time the initial issue of this standard was published. Version 2 of this standard will include a test methodology.

4.5 Tram and train interfaces at road crossings (Tramway Squares)

4.5.1 Design and configuration requirements

4.5.1.1 Where tram and train lines interface (tramway square areas) there must be bonding at and around the square for both the 1500 V DC traction for trains and the 600 V DC power for trams.

4.5.1.2 All rails of the actual tramway square for either tram or train are electrically bonded together.

4.5.1.3 The outer extremities of the tramway square are physically isolated by the use of IRJs joints in all rails.

4.5.1.4 The negative return cables either side of the tramway square shall be routed to a Negative Return Cable Connection Box and then to a heavy duty electrical switch that is manually or electrically controlled and operated, for the passage of either a train (1500 V) or tram (600 V) to ensure the correct negative return is available for the passage of either the tram or train and in the correct sequence. The cables from the switch shall be connected to the actual tramway square for the return of negative traction power for tram and train.

4.5.1.5 The actual position of the negative return switch shall be both controlled and indicated to an identified and controlled location or area. The negative return switch shall be such that a clean break between tram and train position during the operation of the switch must be achieved.

5 RELATED LEGISLATION & DOCUMENTS

5.1.1.1 The documents listed in Table 7 below shall be read in conjunction with this standard.

5.1.1.2 Unless stated otherwise, all referenced documents shall be the most recent published versions.

5.1.1.3 If Australian Standard or Code of Practice exists, a relevant European, British, American or International Standard shall be adopted.

5.1.1.4 Wherever a conflict exists in the requirements of referenced documents, the hierarchy of Yarra Trams technical standards shall apply, in accordance with Governance of Technical Standards Guideline [CE-021-GL-0003].

Table 7: Referenced documents

Name	Document number
Acts, Regulations and Codes of Practice	
Electricity Safety Act 1998	
Rail Safety Act (Local Operations) Act 2006 (Vic)	
Rail Safety National Law Application Act 2013 No 22	
Occupational Health and Safety Act	
Regulations & other legislative documents	
Rail Safety (Local Operations) (Accreditation and Safety) Regulations	
Electricity Safety (Installations) Regulations	
Electricity Safety (Cathodic Protection) Regulations	
Industry codes of practice, guidelines, policies and rules	
Victorian Traction Industry Electrical Safety Rules (known as the Orange Book)	

Name	Document number
Yarra Trams documents	
Engineering Change Management Procedure	CE-021-PR-0020
Deviation from Standards Procedure	CE-021-PR-0004
Electrical Infrastructure Safety Rules (known as the Yellow Book)	IN-002-ST-0002
Governance of Technical Standards Guideline	CE-021-GL-0003
International Standards	
ICNIRP Guidelines: Guidelines for limiting exposure to time-varying electric and magnetic fields (1 Hz to 100 kHz)	
ICNIRP Guidelines: Guidelines for limiting exposure to electric fields induced by movement of the human body in a static magnetic field and by time-varying magnetic fields below 1 Hz	
Railway applications - Power supply and rolling stock - Technical criteria for the coordination between power supply (substation) and rolling stock to achieve interoperability	EN 50388
Railway applications - Fixed installations - Electric traction overhead contact lines	EN 50119
Railway applications - Supply voltages of traction systems	EN 50163
Railway applications – Electromagnetic compatibility	EN 50121 series
Railway applications - Insulation coordination - Part 1: Basic requirements - Clearances and creepage distances for all electrical and electronic equipment	EN 50124-1
Railway applications - Insulation coordination - Part 2: Over voltages and related protection	EN 50124-2
Railway applications – Fixed installations – Electrical safety, earthing and the return circuit – Part 1: Protective provisions against electric shock	EN 50122-1
Railway applications – Fixed installations – Electrical safety, earthing and the return circuit – Part 2: Provisions against the effects of stray currents caused by d.c. traction systems	EN 50122-2

6 DOCUMENT VERSION CONTROL

Table 8: Document version control

Version History	Date	Detail
1.00	20 Mar 2020	Original approved issue

7 GLOSSARY

Table 9: Glossary - Words

Word	Definition
Contact wire	Overhead cable used to transmit electrical energy from the substations to the trams via direct contact with the pantograph.
Designer	The party who is fully responsible for the suitability and compliance of the design of the DC traction substation and all its equipment and subsystems.
Feeder Panel	The term “Panel” or “Feeder Panel” means any enclosed assembly comprising a DC feeder circuit breaker, together with any associated protection and control equipment for the purpose of supplying current to the overheads system for tram operation.
N condition	Normal operating condition. See section 4.2.1 for further details.
N-1 condition	Abnormal operating condition. See section 4.2.1 for further details.
Panel	See “Feeder Panel”.
Scope of Works	The Scope of Works is a key document that defines the specific project-related requirements such as the configuration and rating of equipment to be installed. It prevails over all the specifications.
Specifications	Set of documents that define the general requirements applicable to each item of equipment or subsystem to be installed within a DC traction substation.
Substation	An electrical installation equipped to transform and rectify HV AC supplies before distributing it through 600 V DC circuit breakers to the overhead system.
Tie station	An electrical installation not equipped to transform and rectify HV AC supplies but equipped with 600 V DC circuit breakers to distribute traction power through the overhead system.
Traction Power System	Traction Power System. Assets required to supply, switch and protect the 600 V DC supplies to electrified trams.
Trolley wire	See “Contact wire”.

Table 10: Glossary - Abbreviations

Abbreviation	Definition
AC	Alternating Current
CAPEX	Capital Expenditure
CB	Circuit Breaker
DC	Direct Current
DCCB	Direct Current Circuit Breaker
DoT	Department of Transport
EMC	Electromagnetic Compatibility
ESV	Energy Safe Victoria
HV	“High Voltage” means a nominal voltage exceeding 1000 V AC or exceeding 1500 V DC

Abbreviation	Definition
LV	"Low Voltage" means a nominal voltage exceeding 50 V AC / 120 V DC but not exceeding 1000 V AC / 1500 V DC
OHW	Overhead Wiring
OPEX	Operational Expenditure
POC	Power and Operations Centre
PTV	Public Transport of Victoria
RMS	Root Mean Square
TBC	To Be Confirmed. These requirements may be included in later versions of the standard.
TSI	High speed or conventional rail line being part of the Trans-European Rail Network (TEN) and complying with the requirements of the relevant Technical Specifications for Interoperability (TSI) (according to EN 50388).
U_n	Nominal voltage (according to EN 50163)
U_{max1}	Highest permanent voltage (according to EN 50163)
U_{max2}	Highest non-permanent voltage (according to EN 50163)
U_{max3}	Highest long-term overvoltage (according to EN 50163)
$U_{mean\ useful}$	Mean useful voltage at the pantograph (according to EN 50388)
$U_{mean\ useful}$ (train)	Voltage identifying the dimensioning train and which enables the effect on its performance to be quantified (according to EN 50388)
U_{min1}	Lowest permanent voltage (according to EN 50163)
U_{min2}	Lowest non-permanent voltage (according to EN 50163)
U_{RE}	Rail potential (according to EN 50122-1)
VEC	Victorian Electrolysis Committee
VRIOG	The Victorian Rail Industry Operators' Group comprising the following members: VicTrack V/Line Passenger Metro Trains Melbourne Yarra Trams Australian Rail Track Corporation Public Transport Division of the Department of Transport