

Specification

Cable Specification

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1 PURPOSE

The purpose of this specification is to specify the minimum requirements of cables, which are to be installed within DC traction substations on the Yarra Trams network.

The configuration, ratings and any other project specific equipment details shall be provided by Yarra Trams in the accompanying *Scope of Works* document.

2 SCOPE

The scope of this specification encompasses the design and construction requirements for all new cables. This specification does not apply retrospectively to existing cables on the Yarra Trams network. However, this specification is applicable if an existing cable is being altered, modified or replaced.

The scope of this document includes:

- All interconnecting power cables which are installed between equipment (e.g. HV AC power cables installed between the HV AC switchgear and the rectifier transformer).

The scope of this document does not include:

- Cables installed within equipment (e.g. the cables from the HV AC circuit breaker to the protection relay). The requirements of these cables shall be defined in the equipment specifications.

This specification applies to any party who is involved in the design or construction of cables for Yarra Trams.

3 COMPLIANCE

Any party who is involved in the design or construction of cables for Yarra Trams shall fully comply with this specification. Deviation from this specification is only permitted when a deviation or waiver has been formally requested and approved as the per Yarra Trams Deviation from Standards procedure

The Yarra Trams Engineering Change Management Procedure [CE-021-PR-0020] shall be followed in all circumstances where change is proposed to this specification.

The following definitions apply throughout the specification:

- ‘Shall’ statements are mandatory in the context of compliance with requirements stipulated in this specification.
- ‘Should’ statements are considerations in the context of compliance with requirements stipulated in this specification.
- ‘Information’ statements provide additional content for clarification purposes only and are not requirements in the context of compliance with this specification.
- ‘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 specification.



4 REQUIREMENTS

4.1 Service conditions

4.1.1 Operating conditions

- 4.1.1.1 The operating conditions are defined in the Infrastructure - Network Power – Substation Design and Construction [CE-021-ST-0023].

4.1.2 Transport and storage conditions

- 4.1.2.1 The transport and storage conditions are defined in the Infrastructure - Network Power – Substation Design and Construction [CE-021-ST-0023].
- 4.1.2.2 The *Designer* shall detail the minimum storage requirements. This information shall be contained in the equipment manuals, which are outlined in Table 4.

4.1.3 Electromagnetic compatibility (EMC)

- 4.1.3.1 The electromagnetic compatibility requirements are defined in the Infrastructure - Network Power – Substation Design and Construction [CE-021-ST-0023].
- 4.1.3.2 In accordance with clause 7.6.3 (e) of AS 2067, the incoming and outgoing wires associated with the same function should be grouped within the same cable in order to reduce the differential mode over voltages. As far as possible, control cables should be segregated from other cables.

4.2 General requirements

General requirements and other information can be found in the Infrastructure - Network Power – Substation Design and Construction [CE-021-ST-0023].

4.3 HV AC power cables

4.3.1 General

- 4.3.1.1 Depending on the system voltage, high voltage cables shall be compliant with AS 1429.1 or AS 1429.2.

4.3.2 Service conditions

- 4.3.2.1 High voltage cables shall be installed in underground conduits. However, parts of the high voltage cables may be exposed to weather and solar radiation if they are mounted on a pole owned by the Distribution Network Service Provider. Ownership of high voltage cables between the Yarra Trams substation and distribution supply assets should always be clarified as part of the high voltage supply agreements.



4.3.2.2 The specific environmental conditions (e.g. conduit size, conduit depth, soil temperature and thermal resistivity, ambient air temperature and radiation absorption) for the selected cables shall be determined by the *Designer*.

4.3.3 Ratings and characteristics

4.3.3.1 High voltage power cables shall have the ratings and characteristics in Table 1.

Table 1: High voltage power cables - Ratings and characteristics Description

Characteristic	Requirement								
Nominal voltage, U	As defined in the <i>Scope of Works</i> NOTE: The nominal voltage is typically one of 6.6 kV, 11 kV or 22 kV.								
Rated voltage, U _m	<table><tr><td><u>Nominal Voltage</u></td><td><u>Rated Voltage</u></td></tr><tr><td>6.6 kV</td><td>12.0 kV (allows for 11 kV upgrade)</td></tr><tr><td>11 kV</td><td>12.0 kV</td></tr><tr><td>22 kV</td><td>24.0 kV</td></tr></table> NOTE: Values are according to Table 1.1 of AS 1429.1 and section 1.4 of AS 1429.2.	<u>Nominal Voltage</u>	<u>Rated Voltage</u>	6.6 kV	12.0 kV (allows for 11 kV upgrade)	11 kV	12.0 kV	22 kV	24.0 kV
<u>Nominal Voltage</u>	<u>Rated Voltage</u>								
6.6 kV	12.0 kV (allows for 11 kV upgrade)								
11 kV	12.0 kV								
22 kV	24.0 kV								
Voltage designation	Category A (according to section 1.4 of AS 1429.1)								
Conductor material	Copper								
Conductor cross-section	To be determined by the <i>Designer in conjunction with the owner/maintainer of the cable</i> NOTE: The conductor cross-section shall be selected according to the specific application requirements such as continuous current rating, voltage drop and fault rating using IEC 60287 and should take into account the class 6 rating required from the rectifier unit and possible additional load from second rectifiers where equipment is fitted with high voltage bus tie transfer systems.								
Stranding	In accordance with AS 1125								
Insulation material	XLPE (X-HF-90) Note: XLPE (X-HF-110) cables can be considered if <i>The Designer</i> feels there is cost benefit. Approval of Yarra Trams Engineering required prior to use in design or construction.								
Maximum conductor temperature	90°C continuous 105°C emergency								



Characteristic	Requirement
	250°C short circuit (maximum 5 s duration)
Metallic screen	Yes
Screen material	Copper
Screen size	To be determined by the <i>Designer</i> NOTE: The screen size shall be selected according to the specific application requirements such as fault rating and EMC.
Armour	Not required unless mounted on an overhead pole
Sheath material	UV resistant PVC
Sheath colour	Black

4.3.3.2 The *Designer* is fully responsible for providing suitable ratings for the high voltage power cables and shall therefore verify the values in Table 1. It is the responsibility of the *Designer* to verify that the typical cables in Table 1 are suitable for specific applications and are in accordance with relevant third party (e.g. Supply Authority) and Yarra Trams Standards.

4.3.3.3 If the nominal voltage is 6.6 kV, the design of the high voltage power cables shall allow the nominal voltage to be increased to 11 kV at a later date, without replacing the cables.

4.3.3.4 The cables installed within the substation shall be installed in continuous lengths between each piece of equipment. No joints shall be permitted.

4.3.4 Earthing and bonding

4.3.4.1 The screens shall be connected to earth at the supply cable end only. For high voltage cables installed in proximity to traction installations (e.g. tram depots) the bonding scheme is to be considered taking into account traction stray current and earth potential rise considerations as defined in the Infrastructure - Network Power – Substation Design and Construction [CE-021-ST-0023].

4.3.4.2 All other requirements are defined in the Infrastructure - Network Power – Substation Design and Construction [CE-021-ST-0023].

4.3.5 Labelling and identification

4.3.5.1 Cable markings shall be in accordance with the relevant clauses of AS 1429.1, AS 1429.2 or AS 5000.1.



4.4 DC Traction power cables

4.4.1 General

- 4.4.1.1 Traction DC voltage power cables shall be compliant with AS 5000.1 and the requirements of Infrastructure – Network Power – Traction Power – Design and Construction [CE-021-ST-0037].
- 4.4.1.2 In general, all DC Traction positive cables shall have a copper screen. Unscreened cables may only be used on the positive system between the DC circuit breaker and positive isolators where the cable is secure within the substation and unlikely to be tampered with.
- 4.4.1.3 Non-flexible cables are to be used. However, if the *Designer* wishes to propose the use of flexible cables, then they will need to seek type approval or a waiver through the relevant Yarra Trams processes.
- 4.4.1.4 Cables which are part of the DC Traction negative system and are unlikely to be re-purposed as positive cables, are not required to be screened.
- 4.4.1.5 Underground cable terminations shall be according to Figure 1.
- 4.4.1.6 Cable terminations for connections between equipment in substations shall be according to Figure 1.

4.4.2 Service conditions

- 4.4.2.1 The DC Traction power cables within the substation may be installed on cable trays or in underground conduits as the situation requires. DC Traction power cables from the substation to the overhead wiring (or track negatives) shall be installed in underground conduits from the substation building to the pole (or track location) at which the external connections are made. DC Traction cable trays should be kept separate from AC voltage cable tray systems to accommodate different earthing and bonding schemes and risks of step and touch potentials.
- 4.4.2.2 Where cables are mounted on poles to connect to the overhead wiring (via a switch or directly), the cables shall be designed for outdoor conditions, and fully enclosed in a metal cable guard up to at least 3 m above ground level, then exposed for the remainder of their length.
- 4.4.2.3 The specific environmental conditions (e.g. conduit size, conduit depth, soil temperature, thermal resistivity, ambient air temperature and radiation absorption) for the selected cables shall be determined by the *Designer*.



4.4.3 Ratings and characteristics

- 4.4.3.1 DC Traction power cables shall have the ratings and characteristics in Table 2 and be in accordance to the requirements of Infrastructure – Network Power – Traction Power – Design and Construction [CE-021-ST-0037].

Table 2: DC Traction power cables - Ratings and characteristics Description

Characteristic	Requirement
Nominal voltage, U	600 V DC with the ability to be used at 750 V DC at a future stage
Rated voltage, U _m	As per AS 5000.1 and AS 3000 as applicable.
Conductor material	Copper
Stranding	In accordance with AS 1125
Insulation material	XLPE (X-HF-90 minimum)
Insulation colour	DC positive cables – Red DC negative cables – Black
Metallic screen	DC positive cables – Yes DC negative cables – No
Screen material (if applicable)	Copper
Screen size (if applicable)	160 mm ² (37 / 2.03 mm) Provision for a 630mm cross section variant cable
Sheath material	UV resistant PVC
Sheath colour	Black
Minimum Bending Radius	Temporary Determined by Designer Permanent Determined by Designer

- 4.4.3.2 The *Designer* is fully responsible for providing suitable ratings for the DC Traction power cables and shall therefore verify the values in Table 2. The Designer shall ensure that the correct cables are used for the correct application.

4.4.4 Earthing and bonding

- 4.4.4.1 DC Traction Cable screens shall be connected to the negative return system at one end only to be specified by Yarra Trams protection engineer. The other end shall not be connected to prevent current flow.



4.4.4.2 All other requirements are defined in the Infrastructure - Network Power – Substation Design and Construction [CE-021-ST-0023] and Infrastructure – Network Power – Traction Power – Design and Construction [CE-021-ST-0037].

4.4.5 Labelling and identification

4.4.5.1 The DC Traction feeder cable naming shall be in accordance with the Infrastructure - Network Power – Substation Design and Construction [CE-021-ST-0023] and Infrastructure – Network Power – Traction Power – Design and Construction [CE-021-ST-0037].

4.5 All other cables

4.5.1 Low voltage cables and control wiring

4.5.1.1 Low voltage cables and control wiring shall be selected in accordance with AS 3000.

4.5.1.2 PVC cables shall not be acceptable

4.5.2 SCADA communication cables

4.5.2.1 The SCADA communication cables shall have the ratings and characteristics in Table 3.

Table 3: SCADA communication cables - Ratings and characteristics

Description	Requirement: Ethernet	Requirement: Fibre
Type	CAT6 (or higher category)	OM3 (Duplex), Multi-mode
Connector	RJ45	SFP LC
Colour	Blue or grey	To be determined by the <i>Designer</i>
Shielding	Braiding and/or foil	N/A
Twister pair shielding	Foil	N/A



4.6 Testing

- 4.6.1.1 The tests defined in this section refer only to the High voltage power cables and DC Traction power cables. All other cables shall be tested according to the requirements of AS 3000.
- 4.6.1.2 The tests for the power cables shall be compliant with the relevant parts of AS 1429.1, AS 1429.2 and AS 5000.1. Yarra Trams reserves the right to witness all or any of these tests. After delivery, the cable will be inspected and may be subjected to such tests as may be considered necessary to determine compliance with this Specification.
- 4.6.1.3 Type tests shall be provided for all power cables not having a type test certificate.
- 4.6.1.4 The *Scope of Works* shall detail any special tests that may be required.

High voltage power cables (for working voltages 1.9/3.3 (3.6) kV up to and including 19/33 (36) kV)

- 4.6.1.5 The type tests, routine tests and samples tests shall be in accordance with clause 3.1 of AS 1429.1.

High voltage power cables (for working voltages 19/33 (36) kV up to and including 87/150 (170) kV)

- 4.6.1.6 The type tests, routine tests and samples tests shall be in accordance with clause 3.1 of AS 1429.2.

DC Traction power cables

- 4.6.1.7 The type tests, routine tests and samples tests shall be in accordance with clause 17 of AS 5000.1.

4.6.2 Types tests

- 4.6.2.1 For high voltage cables (up to 33 kV), this includes the following tests from clause 3.1 of AS 1429.1:
- Volume resistivity of extruded conductor screen (AS/NZS 1660.3)
 - Volume resistivity of extruded insulation screen (AS/NZS 1660.3)
 - Bending test followed by partial discharge test (clause 3.4)
 - DDF ($\tan \delta$) measurement at elevated temperature (clause 3.6)
 - Heat cycling test followed by partial discharge test (clause 3.7)
 - Impulse withstand test followed by a high voltage test (clause 3.8)
 - High voltage a.c. test for 4 h (clause 3.9)
 - Compatibility test after ageing in air oven for sheath and oversheath (AS/NZS 1660.2.2)



4.6.2.2 For DC traction cables, this includes the following tests from clause 17 of AS 5000.1:

- High voltage a.c. test for 4 h (AS/NZS 1660.3)
- Compatibility test after ageing in air oven for sheath and oversheath (AS/NZS 1660.2.2)
- Vertical flame propagation (AS/NZS 1660.5.6)

4.7 Reliability, Availability, Maintainability and Safety (RAMS)

4.7.1.1 Power cables shall be warranted by the supplier against faulty design, materials, processing, and workmanship for a minimum of five years from delivery.

4.7.1.2 All other requirements are defined in the Infrastructure - Network Power – Substation Design and Construction [CE-021-ST-0023].

4.8 Documentation

4.8.1.1 Submitted documentation shall at least comprise the items outlined in Table 4. This documentation shall be provided for the power cables throughout the procedure outlined in EMS Design Acceptance Standard [CE-023-ST-0020].

Table 4: Documentation

Documentation	Step 1: System Design Specifications (SDS)	Step 2: Acceptance Test Criteria	Step 3: Preliminary Design	Step 4: Detailed Design	Step 5: Production	Step 6: Installation/Site Assembly	Project completion
Statement of compliance			✓				
Technical specification			✓				
Test reports					✓	✓	✓

5 DIAGRAMS AND GUIDANCE

5.1 DC Traction power cables - Underground cable termination to overhead detail

(note that drawing is not really clear on-screen termination)

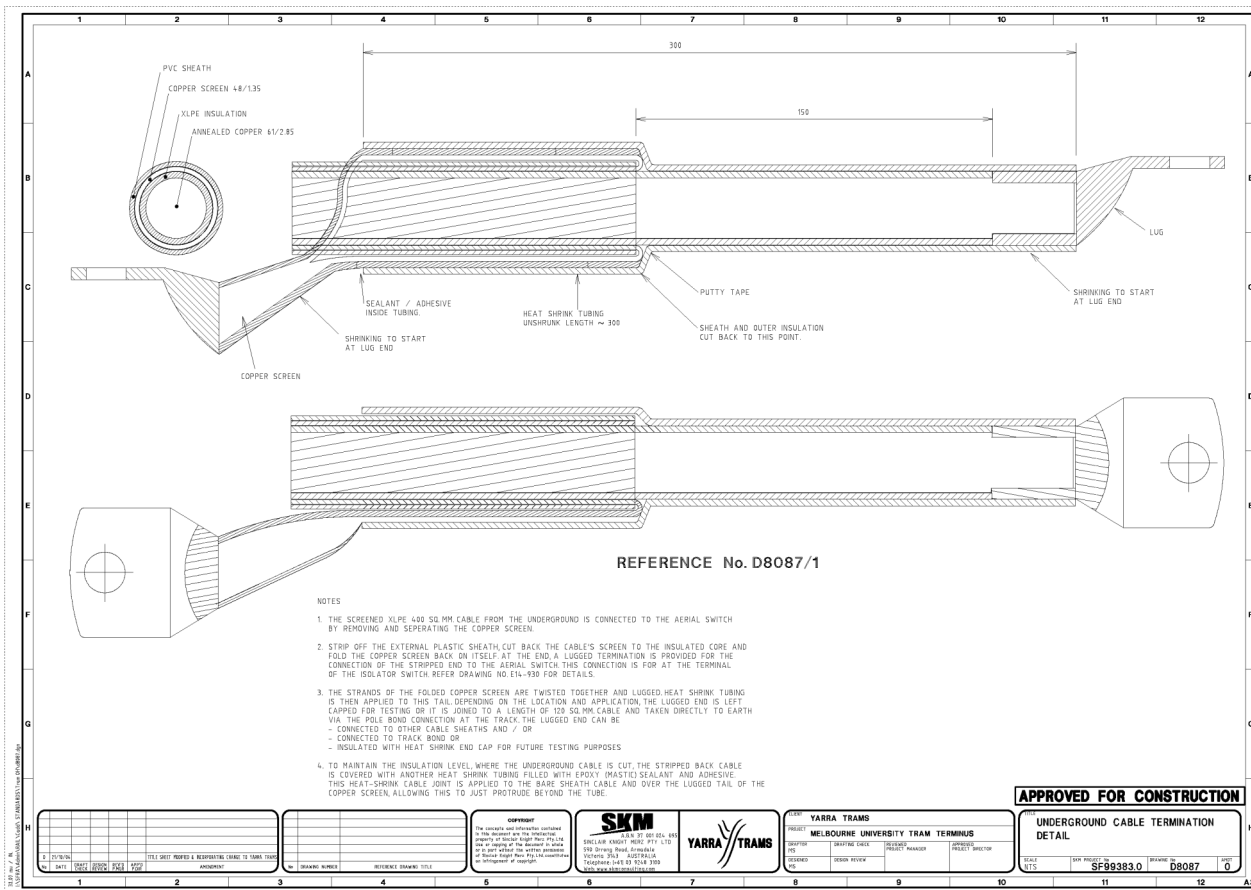


Figure 1: DC Traction power cables - Underground cable termination detail



6 RELATED LEGISLATION & DOCUMENTS

- 6.1.1.1 The design and construction of cables shall comply with all of the referenced documents listed in this section. These referenced documents shall be read in conjunction with this specification.
- 6.1.1.2 All referenced documents shall refer to the most recent published versions of them at the time of invitation to tender.
- 6.1.1.3 Wherever a conflict exists in the requirements of these documents, the order of precedence shall be observed as defined in the Infrastructure - Network Power – Substation Design and Construction [CE-021-ST-0023].

Table 5: Referenced documents

Name	Document number
Yarra Trams	
EMS Design Acceptance Standard	CE-023-ST-0020
Infrastructure - Network Power – Substation Design and Construction	CE-021-ST-0023
Infrastructure – Network Power – Traction Power – Design and Construction	CE-021-ST-0037
Public Transport of Victoria	
PTV Infrastructure Drafting Standards	
Regulations & other legislative documents	
As defined in the Network Power – Substation Design and Construction (CE-021-ST-0023)	
Industry codes of practice, guidelines, policies, and rules	
As defined in the Network Power – Substation Design and Construction (CE-021-ST-0023)	
Australian Standards	
Conductors in insulated electric cables and flexible cords	AS 1125
Electric cables – Polymeric insulated – For working voltages 1.9/3.3 (3.6) kV up to and including 19/33 (36) kV	AS 1429.1
Electric cables – Polymeric insulated – For working voltages above 19/33 (36) kV up to and including 87/150 (170) kV	AS 1429.2
Substations and high voltage installations exceeding 1 kV a.c.	AS 2067
Electrical installations (known as the Australian/New Zealand Wiring Rules)	AS 3000
Electrical installations – Selection of cables – Cables for alternating voltages up to and including 0.6/1 kV – Typical Australian installation conditions	AS 3008.1.1
Electric cables – Polymeric insulated – For working voltages up to and including 0.6/1 (1.2) kV	AS 5000.1



Electric cables – Polymeric insulated – For working voltages up to and including 450/750 V	AS 5000.2
International Standards	
Electric cables – Calculation of the current rating – Current rating equations (100% load factor) and calculation of losses – General	IEC 60287-1-1
Electric cables – Calculation of the current rating – Thermal resistance – Calculation of thermal resistance	IEC 60287-2-1

DOCUMENT VERSION CONTROL

Table 6: Document version control

Version History	Date	Detail
1.0	28/07/2021	Original approved issue
1.08	13/05/2025	Minor update. Updated Authoriser
1.10	23/06/2026	Changed ST to SP and updated the cover page YJM logo. From CE-019-ST-0055 to CE-019-SP-0055.

APPENDIX A – DEFINITIONS & ABBREVIATIONS

Table 7: Glossary - Words

Word	Definition
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.
Designer	Authors, creates or produces a change (including designs if relevant), or carries out engineering activities or engineering investigations relating to a change or design.

Table 8: Glossary - Abbreviations

Abbreviation	Definition
AC	Alternating Current
DC	Direct Current
DCCB	Direct current circuit breaker
EMC	Electromagnetic Compatibility
EMS	Engineering Management System (internal Yarra Trams abbreviation)
FAT	Factory Acceptance Test



Abbreviation	Definition
HV	“High Voltage” means a nominal voltage exceeding 1000 V AC or exceeding 1500 V DC
LV	“Low Voltage” means nominal voltage exceeding 50 V AC / 120 V DC but not exceeding 1000 V AC / 1500 V DC
PTV	Public Transport of Victoria
RAMS	Reliability, Availability, Maintainability and Safety
RMS	Root Mean Square
SCADA	Supervisory Control and Data Acquisition
UV	Ultraviolet



APPENDIX B – TENDER REQUIREMENTS

Statement of compliance

The *Designer* shall return a clause by clause statement of compliance to this specification. The Yarra Trams statement of compliance template and deviation procedure for specifications is provided within the Infrastructure - Network Power – Substation Design and Construction [CE-021-ST-0023].

Equipment selection principles

The equipment selection principles are defined in the Infrastructure - Network Power – Substation Design and Construction [CE-021-ST-0023].