

Specification

LV Switchboards

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1 PURPOSE

The purpose of this specification is to specify the minimum requirements of the LV switchboards, 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 LV switchboards. This specification does not apply retrospectively to existing LV switchboards on the Yarra Trams network. However, this specification is applicable if an existing LV switchboard is being altered, modified or replaced.

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

3 COMPLIANCE

Any party who is involved in the design or construction of LV switchboards 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 per the 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 LV switchboards shall be indoor.

4.1.1.2 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 3.

4.1.3 Noise

4.1.3.1 The permissible noise levels inside and outside the substation are defined in the Infrastructure - Network Power – Substation - Design and Construction [CE-021-ST-0023].

4.1.4 Electromagnetic compatibility (EMC)

4.1.4.1 The electromagnetic compatibility requirements are defined in Infrastructure - Network Power – Substation - Design and Construction [CE-021-ST-0023] and Infrastructure – Network Power – Traction Power – Design and Construction [CE-021-ST-0037].

4.2 LV AC switchboard

4.2.1 General

4.2.1.1 The LV AC switchboard shall contain all of the LV auxiliary switchgear and controlgear (e.g. circuit-breakers), gear which shall comply with the AS 60947 series.

4.2.1.2 The LV AC switchboard shall comply with AS 3000. The LV AC switchboard shall comply with the parts of AS 60439.1 and AS 60439.2 required by AS 3000 Appendix K.

4.2.1.3 The LV AC switchboard shall be supplied from at least two ‘separate’ LV auxiliary supplies, which form a main supply and a backup supply. The *Scope of Works* shall define which of the following acceptable LV auxiliary supply options apply:

Option 1

- Main supply: an LV auxiliary supply from an auxiliary transformer which is supplied from the HV AC switchgear, or alternative solution that is not directly linked to a supply from the rectifier transformer, and



- Backup supply: an LV auxiliary supply from a generator, in accordance with section 4.2.12 of this document.

Option 2

- Main supply: an LV auxiliary supply from an auxiliary transformer which is supplied from the star secondary winding of the rectifier transformer; and
- Backup supply: an LV auxiliary supply from a generator, in accordance with section 4.2.12 of this document.

4.2.1.4 During the abnormal condition where the main supply is lost and the substation is using the backup supply, the substation is only required to operate as a tie station. During this condition, the substation backup supply shall supply at least the following loads:

- Battery charger;
- Substation lighting: Interior lighting; exterior lighting; emergency lighting and signage;
- Strategically placed GPOs (these GPOs shall have signage indicating that it can be supplied from the backup supply); and
- Fire alarm system: e.g. (such as but not specifically a) VESDA and fire indication panel.

4.2.1.5 Option 2 shall only be used in existing installations. The *Designer* shall not use option 2 for new installations.

4.2.1.6 A supply changeover device between the main supply and backup supply, in accordance with section 4.2.10 of this document, shall be installed within the LV AC switchboard.

4.2.1.7 Each supply (main supply and backup supply) shall be controlled by a main switch or switches on the LV AC switchboard.

4.2.2 Insulation coordination

4.2.2.1 The insulation levels shall be those defined in the Infrastructure - Network Power – Substation - Design and Construction [CE-021-ST-0023].

4.2.3 Earthing and bonding

4.2.3.1 The enclosure of the LV AC switchboard shall be earthed

4.2.3.2 The frame shall be earthed to the substation equipotential earthing conductor

4.2.3.3 Provision and details of the location of MEN system shall be provided.

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

4.2.4 Enclosure



General

- 4.2.4.1 The LV AC switchboard enclosure shall be metallic with a hinged door. The door shall be fitted with a lock of the Emka triangular type.
- 4.2.4.2 The LV AC switchboard shall have an escutcheon which allows the switchgear and controlgear to be operated without exposure to any live elements.
- 4.2.4.3 The minimum degree of protection provided by the enclosure (according to AS 60529) shall be IP21.
- 4.2.4.4 The LV AC switchboard enclosure and the DC switchboard shall be in separate enclosures.

Covers and doors

- 4.2.4.5 The covers and doors which are part of the enclosure shall be metallic. When they are closed, they shall provide the same degree of protection as specified for the enclosure. Covers and doors shall not be made of woven wire mesh, expanded metal or similar.

Ventilating openings

- 4.2.4.6 Ventilation openings and vent outlets shall be arranged or shielded so that they provide the same degree of protection as specified for the enclosure. Such openings may make use of wire mesh or the like provided that it is of suitable mechanical strength.

Installation

- 4.2.4.7 The maximum height above the floor of the circuit breakers when mounted is 1800 mm.
- 4.2.4.8 The minimum height from the floor for the control equipment (relays and changeover device equipment) is 800 mm.
- 4.2.4.9 It shall not be necessary to lean over other equipment or enclosures to operate the switchboard.

4.2.5 Protection

- 4.2.5.1 The LV AC switchboard shall include at least the following protection:
 - AC supply failure protection.

AC supply failure protection

- 4.2.5.2 A phase failure relay shall be provided downstream of the changeover device.
- 4.2.5.3 An indication of the failure shall be provided to a local indicator on the LV AC switchboard and to the SCADA system.



4.2.6 Interlocking

4.2.6.1 The definitions of interlocking are defined in Infrastructure - Network Power – Substation - Design and Construction [CE-021-ST-0023].

4.2.6.2 The LV AC switchboard shall include at least the interlocking outlined in Table 1.

Table 1: Summary of interlocking

Interlocking description	Interlocking type	Prerequisite conditions ¹	Notes
Changeover device	Mechanical ²	All of the following: The LV auxiliary supply shall be disconnected prior to changeover (i.e. ‘break before make’).	The interlocking shall prevent both LV auxiliary supplies being paralleled.
¹ The order of the prerequisite conditions does not necessarily represent the order of switching operations.			
² The interlocking type shall be mechanical AND electrical when LV auxiliary supply option 2 is applicable.			

4.2.7 Control panel

4.2.7.1 A control panel shall be provided on the LV AC switchboard and shall have at least:

- Exterior security lighting: LED pilot light indicator;
- Exterior security lighting: Local control;
- AC supply failure status: LED pilot light indicator;
- Main supply status: LED pilot light indicator(s);
- Backup supply status: LED pilot light indicator(s); and
- Changeover device: Local control.

4.2.8 Equipment interfaces

SCADA

4.2.8.1 The following information shall be available remotely:

- Position status for each protective device; and
- Fault status for each protective device.

4.2.8.2 The LV AC switchboard shall include at least the SCADA points outlined in Table 2. Each point shall be brought to the SCADA cubicle. The interpretation of Table 2 and additional SCADA requirements shall be in accordance with the Infrastructure - Network Power – Substation - Design and Construction [CE-021-ST-0023].



Table 2: Summary of SCADA points

Point description - 'Plant'	Point description - 'Designation'	Point description - 'Quantity'	Analogue, Status or Command	Hardwired or Digital	Details	Conditions or Controls
AC distribution board	AC supply	State	Status	Hardwired	1 Bit	0 = Fault 1 = Normal [Normal]
L & P Change Over	ATS condition either normal or alternate supply	State	Status	Hardwired	2 Bit	00 = Disconnected 01 = Backup supply 10 = Main supply [Normal] 11 = Indeterminate
Lights	Substation lights	State	Status	Hardwired	1 Bit	0 = Off [Normal] 1 = On
Lights	External	State	Status	Hardwired	1 Bit	0 = Off [Normal] 1 = On
Lights	External	Control	Command	Hardwired	1 Bit, Latched	0 = Off [Normal] 1 = On

4.2.8.3 Yarra Trams understands that the SCADA points outlined in Table 2 are only a minimum requirement. The *Designer* shall include additional SCADA points, where required for the effective operation and diagnostics of the equipment.

4.2.8.4 If the *Designer* is planning to include additional SCADA points or deviate from the points outlined in Table 2, this information shall be provided to Yarra Trams in accordance with the Infrastructure - Network Power – Substation - Design and Construction [CE-021-ST-0023].

4.2.8.5 For safety critical devices, each indication signal brought back to the SCADA cubicle shall consist of a pair of voltage free contacts with one normally open and one normally closed.

Cables

4.2.8.6 Requirements for the cables are given in the Cable Specification [IN-021-ST-0003].

Auxiliary transformer

4.2.8.7 Interfaces with the auxiliary transformer are defined in the Auxiliary Transformer Specification [IN-021-ST-0017].



Battery and battery charger

4.2.8.8 Interfaces with the battery and battery charger are defined in the Battery and Battery Charger Specification [IN-021-ST-0010].

4.2.9 Labelling and identification

General

4.2.9.1 The enclosure shall be labelled with the words "LV AC switchboard". Each circuit breaker shall have a label according to its circuit, which shall be visible with the escutcheon in place. The labels shall be Traffolyte type labels.

4.2.9.2 Labelling shall be consistent with the electrical schematics and any further labels provided on the equipment panels supplied by the circuit breakers.

Warning labels

4.2.9.3 The enclosure shall be labelled with the words "WARNING | DUAL SUPPLY".

Cubicle identification

4.2.9.4 Cubicle identification shall be in accordance with IEC 60445.

4.2.9.5 Additionally, the equipment designation (e.g. +SA1), which is defined in the *Scope of Works*, shall be clearly marked on the enclosure.

4.2.10 Supply changeover device requirements

4.2.10.1 For LV auxiliary supply 'Option 2', the following shall apply:

- The changeover device shall be an automatically switched, mechanically and electrically interlocked changeover contactor;
- The contactor shall prevent both supplies being paralleled ('break before make'); and
- During normal operating conditions, the contactor shall automatically revert back to the main supply, whenever it is available.
- The changeover device shall have isolation on all connected supplies inclusive of load to comply with AS 3010:2016

4.2.10.2 The changeover device shall be mounted in a separate compartment in the LV AC switchboard.

4.2.10.3 During normal operating conditions, the LV AC switchboard shall be supplied from the 'Main supply', which is defined in clause 4.2.1.3 of this document.



4.2.10.4 Changeover of supplies shall not result in nuisance tripping of any protection, fuses or circuit breakers and allow appropriate discharge time to ensure snubber circuits on chargers etc. have discharged prior to re-energisation on the alternate supply.

Information: Appropriate discharge time will be required to ensure snubber circuits on drives and chargers have discharged prior to re-energization on the alternate supply.

4.2.10.5 An indication of when the auxiliary supply is being fed from the main supply or backup supply shall be provided to a local indicator on the LV AC switchboard control panel and to the SCADA system. This shall clearly highlight the abnormal supply condition.

4.2.11 Circuit breaker requirements

4.2.11.1 The LV AC switchboard shall contain AC circuit breakers for the switching and protection of the auxiliary supplies.

4.2.11.2 The circuit breakers shall have minimum breaking capacity of 6 kA.

4.2.11.3 The LV AC switchboard shall include, but is not limited, the following number of circuit breakers:

- One circuit breaker for the HV AC switchgear;
- One circuit breaker for the SCADA cubicle;
- One circuit breaker for the electrolysis mitigation cubicle (32 A D-Curve);
- One circuit breaker for the substation GPOs;
- One circuit breaker for smoke detectors;
- One circuit breaker for the exhaust fans;
- One circuit breaker for the sewage pump;
- One circuit breaker for the sewage pump control circuit;
- One circuit breaker for the battery charger;
- One circuit breaker for normal substation lighting; and
- One circuit breaker for the substation internal emergency and exit lights.

4.2.11.4 At least 20% (minimum two spare circuit breakers) shall be provided with additional space on the switchboard for a further 20% expansion. Any additional circuit breakers shall be specified in the *Scope of Works*. The circuit breakers shall be arranged on the panel in a logical way, ergonomically positioned and able to be operated when the switchboard is mounted in service.

4.2.12 Generator requirements

4.2.12.1 The generator shall not be permanently located at the substation. In the event the generator is required, Yarra Trams shall bring a portable generator to the substation.



4.2.12.2 The LV AC switchboard and auxiliary supply system shall be designed to accept one of the following standard portable generators of suitable capacity to maintain substation operation capacity at 100%

Information: At the time of writing this specification, Yarra Trams only have a single standard portable generator type. Subject to approval, Yarra Trams is open to discussing the purchasing of additional standard generator types.

4.2.12.3 The generator socket should be wired to the white phase and neutral to accept the supply from the portable generator. The generator socket shall be located on the outside of the substation building.

4.2.12.4 There shall be a dedicated area for the portable generator to be operated and connected to the generator socket.

4.3 ELV DC switchboard

4.3.1 General

4.3.1.1 The ELV DC switchboard shall contain all of the switchgear and controlgear (e.g. circuit-breakers) for equipment connected to the control battery and therefore requiring a reliable auxiliary power supply. This gear shall comply with the AS 60947 series.

4.3.1.2 The ELV DC switchboard shall comply with AS 3000. The ELV DC switchboard shall comply with the parts of AS 60439.1 and AS 60439.2 required by AS 3000 Appendix K.

4.3.2 Insulation coordination

4.3.2.1 The insulation levels are defined in Infrastructure - Network Power – Substation - Design and Construction [CE-021-ST-0023].

4.3.3 Earthing and bonding

4.3.3.1 The reliable auxiliary power supply circuit is not earthed. However, the potential difference between the battery terminals and the substation earth shall be monitored by the battery charger.

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

4.3.4 Enclosure

4.3.4.1 The requirements for the ELV DC switchboard enclosure are the same as for the LV AC switchboard enclosure. Suitable designed and rated 48V DC circuit breaker shall be utilised. Each Feeder Panel shall have their own dedicated circuit breaker.

4.3.5 Equipment interfaces



Battery charger and control battery

4.3.5.1 Interfaces with the battery and battery charger are defined in the Battery and Battery Charger Specification [IN-021-ST-0010].

4.3.6 Labelling and identification

General

4.3.6.1 The enclosure shall be labelled with the words “DC switchboard”. Each circuit breaker shall have a label according to its circuit which shall be visible with the escutcheon in place. The labels shall be Traffolyte type labels.

4.3.6.2 Labelling shall be consistent with the electrical schematics and any further labels provided on the equipment panels supplied by the circuit breakers.

Cubicle identification

4.3.6.3 Cubicle identification shall be in accordance with IEC 60445.

4.3.6.4 Additionally, the equipment designation (e.g. +SA1), which is defined in the *Scope of Works*, shall be clearly marked on the enclosure.

4.3.7 Circuit breaker requirements

4.3.7.1 The ELV DC switchboard shall contain non-polarity conscious 48 V DC circuit breakers for the switching and protection of the reliable auxiliary supply circuits.

4.3.7.2 The ELV DC switchboard shall include, but is not limited to, the following number of circuit breakers:

- One main circuit breaker for isolation of each substation control battery set (Note that a dual rectifier substation may have the two substation battery systems connected in parallel to a single ELV DC switchboard);
- One circuit breaker for each DC Traction feeder panel;
- One circuit breaker for the negative cubicle;
- One circuit breaker for each rectifier unit;
- One circuit breaker for each HV rectifier supply circuit breaker;
- One circuit breaker for the SCADA cubicle;
- One circuit breaker for the VicTrak communications cubicle; and
- One circuit breaker for the auxiliary part of the ELV DC switchboard itself.

4.3.7.3 At least 30% (minimum two spare circuit breakers) shall be provided with additional space on the switchboard for a further 30% expansion. Any additional circuit breakers shall be specified in the *Scope of Works*. The circuit breakers shall be mounted on an insulating



panel. They shall be arranged on the panel in a logical way, ergonomically positioned and able to be operated when the switchboard is mounted in service.

4.4 Testing

4.4.1.1 Test reports and/or certificates and manufactures quality test certificates shall be supplied prior to installation and commissioning.

4.5 Reliability, Availability, Maintainability and Safety (RAMS)

4.5.1.1 The RAMS requirements are defined in Infrastructure - Network Power – Substation - Design and Construction [CE-021-ST-0023].

4.6 Documentation

4.6.1.1 Submitted documentation shall at least comprise the items outlined in Table 3. This documentation shall be provided for the LV AC switchboard and ELV DC switchboard throughout the procedure outlined in EMS Design Acceptance Standard [CE-023-ST-0020].

Table 3: 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			✓				
Single-line diagram of main circuit			✓				
General layout			✓				
Detailed drawings of electrical circuits (main and auxiliary)				✓	✓	✓	✓ ¹
Detailed drawings of mechanisms				✓	✓	✓	✓ ¹
Detailed drawings of mechanical arrangement, including cable boxes				✓	✓	✓	✓ ¹
Connection guide (conductors, earthing, auxiliary circuits, etc)			✓	✓	✓	✓	✓ ¹
Bill of materials				✓	✓	✓	✓ ¹
Test reports					✓	✓	✓
Installation manual(s)			✓ ²		✓	✓	✓



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
Operation manual(s)			√ ²		√	√	√
Maintenance manual(s)			√ ²		√	√	√
List of recommended spare parts and their availabilities			√ ²		√	√	√
PLC ladder diagrams and software (if applicable)							√
¹ Drawings shall be submitted into PTV's Drawing Management System Compliant library according to the requirements of clause 4.6.1.2. ² Only typical non-project specific documentation required.							

4.6.1.2 The documentation shall be compliant with the requirements defined in Infrastructure - Network Power – Substation - Design and Construction [CE-021-ST-0023].



5 DIAGRAMS AND GUIDANCE

Refer to Infrastructure - Network Power – Substation – Design and Construction [CE-021-ST-0023] for typical LV auxiliary supply arrangements.

6 RELATED LEGISLATION & DOCUMENTS

- 6.1.1.1 The design and construction of LV switchboards shall be consistent with the best engineering practices and 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 4: 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
Cable Specification	IN-021-ST-0003
Auxiliary Transformer Specification	IN-021-ST-0017
Battery and Battery Charger Specification	IN-021-ST-0010
Building Specification	IN-021-ST-0006
Public Transport of Victoria	
PTV Infrastructure Drafting Standards	
Regulations & other legislative documents	
As defined in the Infrastructure - Network Power – Substation – Design and Construction [CE-021-ST-0023]	
Industry codes of practice, guidelines, policies, and rules	
As defined in the Infrastructure - Network Power – Substation – Design and Construction [CE-021-ST-0023]	
Australian Standards	
Electrical installations (known as the Australian/New Zealand Wiring Rules)	AS 3000
Degrees of protection provided by enclosures (IP Code)	AS 60529



Low-voltage switchgear and controlgear	AS 60947 series
Low-voltage switchgear and controlgear assemblies General rules	AS/NZS 61439.1
Electrical Installations – Generating Sets	AS/NZS 3010
International Standards	
Basic And safety principles for man-machine interface, marking and identification – Identification of equipment terminals, conductor terminations and conductors	IEC 60445

DOCUMENT VERSION CONTROL

Table 5: Document version control

Version History	Date	Detail
1.0	28/07/2021	Original approved issue
1.01	30/07/2021	Referenced Documents table updated
1.02	2/09/2021	Minor typing errors corrected
1.08	13/05/2025	Periodic review. No change
1.09	10/03/2026	Periodic review. No change
1.10	30/06/2026	Changed from a Standard to a Specification. Document number changed from CE-019-ST-0057 to CE-019-SP-0057. Logo updated to YJM.

DEFINITIONS & ABBREVIATIONS

Table 6: Glossary - Words

Word	Definition
Control voltage	See “Reliable auxiliary supply”. The terms “Control voltage” and “Reliable auxiliary supply” are used interchangeably.
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.
Reliable auxiliary supply	Supply voltage of closing and opening devices and of auxiliary and control circuits.
Scope of Works	The <i>Scope of Works</i> 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.
Tie station (by design or as result of operational constraint)	An electrical installation not equipped or currently supplied to transform and rectify HV AC supplies, but equipped with 600 V DC circuit breakers to distribute traction power through the overhead system.



Table 7: Glossary - Abbreviations

Abbreviation	Definition
AC	Alternating Current
DC	Direct Current
EMC	Electromagnetic Compatibility
ELV	“Extra-Low Voltage” means nominal voltage not exceeding 50 V AC / 120 V DC
EMS	Engineering Management System (internal Yarra Trams abbreviation)
FAT	Factory Acceptance Test
GPO	General Purpose Outlet
HV	“High Voltage” means a nominal voltage exceeding 1000 V AC or exceeding 1500 V DC
LED	Light-Emitting Diode
LV	“Low Voltage” means nominal voltage exceeding 50 V AC / 120 V DC but not exceeding 1000 V AC / 1500 V DC
PLC	Programmable Logic Controller
PTV	Public Transport of Victoria
RAMS	Reliability, Availability, Maintainability and Safety
RMS	Root Mean Square
SCADA	Supervisory Control and Data Acquisition System
VESDA	Very Early Smoke Detection Apparatus

APPENDIX B – TENDER REQUIREMENTS

Table 8 summarises the information which shall be defined by Yarra Trams in the *Scope of Works* at the time of tender.

Table 8: Summary of information to be defined in the Scope of Works

Description	Requirement
Equipment designation	
LV auxiliary supply option	

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 Infrastructure - Network Power – Substation - Design and Construction [CE-021-ST-0023].