Specification

Rectifier Converter

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1 PURPOSE

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

The equipment detailed in this specification shall be suitable for 600 V DC operation and shall allow for 750 V DC operation in the future.

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

3 COMPLIANCE

Any party who is involved in the design or construction of rectifier converters 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 rectifier converter shall be indoor and may also be underground.

4.1.1.2 The operating conditions 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].

4.1.2 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 6.

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 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].

4.2 General requirements

4.2.1 General

4.2.1.1 The rectifier converter shall be a six-phase, twelve-pulse, semiconductor silicon diode bridge rectifier connected as per Table 4 of EN 50328 (connection no. 9) complying with EN 50328.

4.2.1.2 The rectifier converter shall meet the following requirements:

Table 1: General requirements

Description	Requirement
Diode assembly	12-pulse, parallel connection
Number of diodes per arm	As defined in the *Scope of Works*

Description	Requirement
Input: Auxiliary power supply	230 V AC
Input: Rated AC frequency	50 Hz
Input: Rated AC voltage	To be determined by the *Designer* NOTE: The rated voltage of the secondary windings shall be the AC voltage which produces the rated DC voltage at the output of the rectifier, when: - the rectifier is operating at its rated output current, - the rectifier transformer is at its centre tap position, and - the rectifier transformer supply voltage is the rated voltage.
Output: Rated DC voltage, U_{Nd}	600 V DC, with the ability to operate at a nominal output voltage (U_{Nd}) of 750 V DC in the future.
Output: Conventional no-load DC voltage, U_{d0}	To be determined by the *Designer*
Output: Real no-load DC voltage, U_{d00}	Shall be lower than 800 V DC @ Rated DC output of 600 V DC
Output: Basic DC current, I_{Bd} [A]	As defined in the *Scope of Works*
Duty Class	Class VI (according to Table 5 of EN 50328)
Type of cooling	AN (Air Natural) preferred[1]
[1]The *Designer* shall carefully consider section 4.1.3 prior to the selection of AF (Air Forced) equipment. Noise should not be the only determining factor for this point, operational maintenance and reliability should also be given due consideration.	

4.2.1.3 The *Designer* is fully responsible for providing suitable ratings for the rectifier converter and shall therefore verify the values in Table 1.

4.2.1.4 In accordance with Table 4 of EN 50328, an inter-phase reactor is required if the associated rectifier transformer coupling factor K > 0.9.

4.2.1.5 The rectifier converter shall be capable of carrying the short circuit current for a fault of negligible impedance between the positive and negative output terminals. The duration of the fault shall be the time required for the AC protection to effectively clear the fault or 200 ms, whichever is the longest.

4.2.1.6 In accordance with clause 3.7.2.4 of EN 50328, the supplier shall state the short-time withstand current capability of the rectifier converter. The short-time withstand current capability shall be stated for a short circuit:

- after continuous operation at basic current I_{Bd}, and
- for a short circuit duration of 0.15 s, and
- with a factor of 1.6 between sustained current and peak value.

4.2.2 Insulation coordination

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

4.2.3 Earthing and bonding

4.2.3.1 The frame of the rectifier converter cubicle shall be connected to rail earth through a frame leakage relay in accordance with the Infrastructure - Network Power – Substation Design and Construction [CE-021-ST-0023]. The insulating material, installed between the frame of the rectifier converter cubicle and earth, shall provide an isolation resistance of at least 1 MΩ.

4.2.3.2 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 rectifier converter shall be enclosed. Frames and enclosures shall be metallic.

4.2.4.2 The rectifier converter and its enclosure shall be designed so that normal service, inspection and maintenance operations, replacement of diodes and fuses, earthing of cables or busbars and voltage tests can be carried out easily.

4.2.4.3 The minimum degree of protection provided by the enclosure (according to AS 60529) shall be IP21.

4.2.4.4 In reference to clause 3.8.3 of EN 50328, IP00 shall not be acceptable for the bottom and top of the enclosure. Minimum degree of protection to be as per Clause 4.2.4.3.

4.2.4.5 Interlocking requirements for the enclosure are detailed in section 4.2.6 and in Infrastructure – Network Power – Substation – Design and Construct [CE-021-ST-0023].

4.2.4.6 The rectifier converter shall be a fixed, non-withdrawable, construction type that is secured to isolate and is readily accessible for change out of any Line-Replaceable Unit (LRU).

Information: The rectifier converter may be a withdrawable design, subject to approval by Yarra Trams.

Arc fault pressure relief flaps and gas exhaust ducts

The rectifier converter shall be designed to contain any arc faults within its cubicle. If this is not possible, then any arc fault pressure relief flaps and gas exhaust ducts shall be designed

4.2.4.7 The arc fault pressure relief flaps and gas exhaust ducts should vent to outside of the building to a safe space, rather than into the room itself.

Dimensions

4.2.4.8 The rectifier converter enclosure shall be designed to minimize its overall size (and subsequently the physical size of the substation) while meeting the requirements of specifications and standards.

Covers and doors

4.2.4.9 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

4.2.4.10 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.

4.2.5 Protection

General

4.2.5.1 The rectifier converter shall include at least the following protection:

- Diode failure protection;
- Frame leakage protection;
- DC traction voltage fuse(s) protection;
- Thermal protection (Temperature alarm and Temperature fault);
- Enclosure access protection; and
- Surge protection.

Table 2: Summary of protection

Protection description	Rectifier HVCB Trip	Rectifier DCCB Trip	Lockout	Indication on control panel	Indication to SCADA system	Notes
Diode failure [FAULT]	✓	✓	✓	✓	✓	
Frame leakage [FAULT]	✓	✓	✓	✓	✓	
DC traction voltage fuse(s) [FAULT]	✓	✓		✓	✓	
Temperature alarm [ALARM]				✓	✓	Thermal protection
Temperature fault [FAULT]	✓	✓		✓	✓	Thermal protection
Enclosure access [FAULT]	✓	✓		✓	✓	

Diode failure protection

4.2.5.2 The diode failure protection operation shall depend on the number of diodes per arm:

- Single diode per arm: The failure of any single diode shall cause a tripping signal and the protection to operate, as shown in Table 2. This protection shall correspond with Immunity level T as per clause 3.7.4 and Table 6 of EN 50328. The *Designer* shall decide whether fuses are required or not, as a means to satisfy this protection requirement; or
- Multiple diodes per arm: The failure of a single diode shall cause a warning signal. This protection shall correspond with Immunity level R as per clause 3.7.4 and Table 6 of EN 50328. The failure of a second diode shall cause a tripping signal and the protection to operate, as shown in Table 2. Fuses shall be required to satisfy this protection requirement.

4.2.5.3 The protection shall not attempt to reclose automatically in the event of diode failure tripping signal (an operator must attend on site to restore power).

4.2.5.4 An indication of the failure shall be provided to a local indicator on the rectifier converter control panel and to the SCADA system.

Frame leakage protection

4.2.5.5 The frame of the rectifier converter cubicle shall be connected to rail earth through a frame leakage relay in accordance with Infrastructure - Network Power – Substation Design and Construction [CE-021-ST-0023].

4.2.5.6 The relay trip setting shall be determined by the *Designer*.

4.2.5.7 In accordance with clause 6.5.7 of EN 50123-7-7, detection of a frame fault shall cause a mass trip of all infeeds to the rectifier converter cubicle to isolate the fault. Therefore, the frame leakage relay shall open a set of contacts and cause the protection to operate, as shown in Table 2.

4.2.5.8 The protection shall not attempt to reclose automatically in the event of frame leakage (an operator must attend on site to restore power).

4.2.5.9 An indication of the failure shall be provided to a local indicator on the rectifier converter control panel and to the SCADA system.

Information: If the frame of the rectifier converter cubicle is physically, and therefore electrically, connected to the frame of other DC Traction cubicles (e.g. DC Traction switchgear), then the frame leakage protection of the equipment may be combined and the rectifier converter does not need its own frame leakage protection relay. However, it is the preference of Yarra Trams that the rectifier converter cubicle has its own frame leakage protection relay.

DC Traction fuse(s) protection

4.2.5.10 Fuses shall be used to protect equipment installed across the DC Traction voltage and 0 V DC main circuit busbars inside the rectifier converter, such as RC circuits and voltage transducers. If main circuit fuses are used, a protection system shall be provided for the fuses.

4.2.5.11 The failure of any main circuit fuse shall cause the protection to operate, as shown in Table 2.

4.2.5.12 An indication of the failure shall be provided to a local indicator on the rectifier converter control panel and to the SCADA system.

Thermal protection

4.2.5.13 A thermal protection relay system shall be provided for the diodes. The system shall provide two levels:

- Temperature alarm: The first level shall operate the ventilation fans (for air-forced rectifier converters only). An indication of the temperature alarm shall be provided to a local indicator on the rectifier converter control panel and to the SCADA system; and
- Temperature fault: The second level shall cause the protection to operate, as shown in Table 2. An indication of the failure shall be provided to a local indicator on the rectifier converter control panel and to the SCADA system.

4.2.5.14 Once the temperature has fallen below the temperature fault level, the rectifier HV CB and DC CB may be closed (the temperature fault shall not lockout devices). However, the local indication shall remain set to indicate that the thermal protection has operated. This local indication shall be manually reset.

4.2.5.15 The time constants of the tripping characteristic shall be properly matched to the rectifier converter time constants and duty class.

4.2.5.16 The temperature sensors and their measurement leads shall meet the electromagnetic compatibility requirements defined in section 4.1.4 and shall be suitably insulated from live parts of the main circuit.

Enclosure access protection

4.2.5.17 In the event of the failure of the interlocking system, opening of the rectifier converter enclosure without performing the correct switching operations as outlined in 4.2.6, shall cause the protection to operate, as shown in Table 2. If applicable, the protection shall also isolate the associated auxiliary transformer if the auxiliary transformer is connected to the rectifier transformer. It must also isolate back feed from the DC network.

Surge protection

4.2.5.18 If adequate surge protection cannot be provided externally, the rectifier converter shall include suitable surge protection devices to prevent damage to the equipment. If required, these surge protection devices shall be located within the rectifier converter enclosure.

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 rectifier converter shall include at least the interlocking outlined in Table 3.

4.2.6.3 The *Designer* shall provide a detailed enclosure access procedure on the rectifier converter enclosure.

Table 3: Summary of interlocking

Interlocking description	Interlocking type	Prerequisite conditions[1]	Notes
Rectifier converter enclosure access[2]	Mechanical	All of the following: • Relevant HV AC rectifier circuit breaker earth switch is closed; • Relevant 600 V DC rectifier circuit breaker short-circuiting switch is closed; • Relevant negative isolator is closed; and • If an auxiliary transformer is connected to the star secondary winding of the rectifier transformer/converter, then the auxiliary transformer shall be isolated at its fuse links.	
[1]The order of the prerequisite conditions does not necessarily represent the order of switching operations. [2]In addition to the interlocking requirements, electrical enclosure access protection shall be provided and is outlined in section 4.2.5.			

4.2.7 Control panel

4.2.7.1 A control panel shall be provided on the rectifier converter enclosure and shall have at least:

- A DC voltmeter
- A DC ammeter

- Protection LED pilot light indicators
- Fault reset pushbutton
- 'Banana plug' sockets for real-time measurement of the DC output voltage and current.
- All voltages and currents must be measured through isolation transducers rated at 5kv or greater

Figure 1 represents a typical arrangement for the control panel of the rectifier converter. For specific details for control panel arrangements refer to *Scope of Works.*

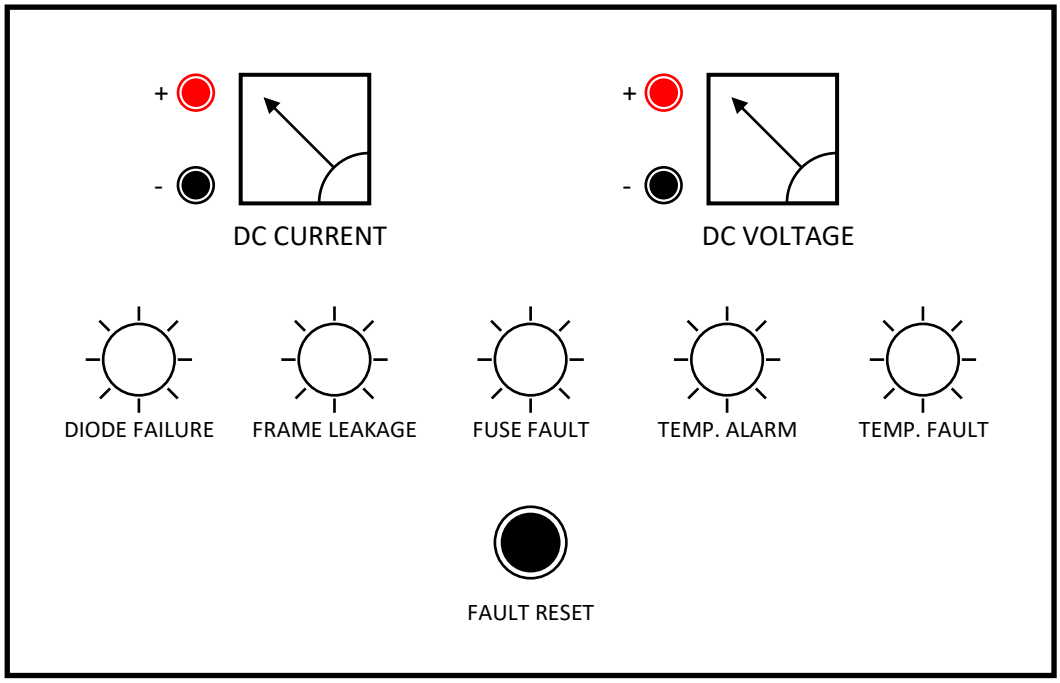

Figure 1: Control panel

4.2.8 Equipment interfaces

SCADA

4.2.8.1 The rectifier converter shall include at least the SCADA points outlined in Table 4. Each point shall be brought to the SCADA cubicle. The interpretation of Table 4 and additional SCADA requirements shall be in accordance with Infrastructure - Network Power – Substation Design and Construction [CE-021-ST-0023]. Provision to be made to make all equipment modules IOT ready from manufacture.

Table 4: Summary of SCADA points

Point description - 'Plant'	Point description - 'Designation'	Point description - 'Quantity'	Analogue, Status or Command	Hardwired or Digital	Details	Conditions or Controls
Rectifier	X[1]	Diode Failure	Status	Hardwired	1 Bit	0 = Fault 1 = Normal [Normal]
Rectifier	X[1]	Frame Leakage	Status	Hardwired	1 Bit	0 = Fault 1 = Normal [Normal]
Rectifier	X[1]	600 V DC Fuse(s)	Status	Hardwired	1 Bit	0 = Fault 1 = Normal [Normal]
Rectifier	X[1]	Temperature Alarm	Status	Digital	1 Bit	0 = Alarm 1 = Normal [Normal]
Rectifier	X[1]	Temperature Fault	Status	Hardwired	1 Bit	0 = Fault 1 = Normal [Normal]
Rectifier	X[1]	Cubicle Door	Status	Hardwired	1 Bit	0 = Open 1 = Closed [Normal]
Rectifier	X[1]	DC Voltage	Analogue	Digital	16 Bit Units: Voltage [V]	
Rectifier	X[1]	DC Current	Analogue	Digital	16 Bit Units: Amps [A]	
[1]The designation shall be determined by the *Designer*. Depending on project specific details, this may be "+VA1" or "+VA2".						

4.2.8.2 Yarra Trams understands that the SCADA points outlined in Table 4 are only a minimum requirement. The *Designer* shall include additional SCADA points, where required for the effective operation and diagnostics of the equipment.

4.2.8.3 If the *Designer* is planning to include additional SCADA points or deviate from the points outlined in Table 4, this information shall be provided to Yarra Trams in accordance with Infrastructure - Network Power – Substation Design and Construction [CE-021-ST-0023].

4.2.8.4 A remote input/output module shall be installed to provide an interface to the SCADA cubicle. Each indication signal brought back to the SCADA cubicle shall consist of voltage free contacts as per Table 4 above.

Cables

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

4.2.8.6 Control wiring shall meet the electromagnetic compatibility requirements defined in section 4.1.4 and shall be suitably insulated from live parts of the main circuit.

LV distribution

4.2.8.7 Interfaces with the LV distribution are given in the LV Switchboards Specification [IN-021-ST-0009].

4.2.9 Labelling and identification

Warning labels

4.2.9.1 All warning labels shall be in accordance with AS 2067.

4.2.9.2 The procedure for accessing the rectifier converter shall be labelled on the enclosure in accordance with the switching operations described in section 4.2.6.

Cubicle identification

4.2.9.3 Cubicle identification shall be in accordance with IEC 60445.

4.2.9.4 Additionally, the equipment designation (e.g. +VA1), which is defined in the *Scope of Works,* shall be clearly marked on the enclosure.

Nameplate

4.2.9.5 The rectifier converter shall be fitted with a nameplate identifying the entries as per clause 3.9.1 of EN 50328. In addition to the mandatory entries, the nameplate shall include the following:

- The standards the rectifier converter is compliant with;
- Overall weight;
- Degree of protection (IP code); and
- Service conditions which differ from standard conditions (e.g. -5°C to 50°C).

4.2.10 Efficiency and losses

4.2.10.1 In accordance with clause 3.3.1 of EN 50328, power losses shall be determined as part of the rectifier converter type testing and routine testing.

4.2.11 Diode mounting

4.2.11.1 The diodes shall be mounted in individual heat sinks. The diodes and heat sinks shall be arranged to allow easy access for cleaning and maintenance.

4.2.11.2 The device used to clamp the diode onto the heat sink shall provide suitable insulation between the anode and cathode connections of the diode. The breakdown voltage of this insulation shall exceed the diode reverse breakdown voltage and shall provide the specified clearances and creepage distances as per those defined in Infrastructure - Network Power – Substation Design and Construction [CE-021-ST-0023]. The device shall not require the use of specialised tools to provide correctly tensioned and aligned diode clamping. It shall include inherent visual tension indicators.

4.2.11.3 The polarity of each diode shall be clearly and positively marked.

4.2.12 Transducers and measurement devices

4.2.12.1 Sensors and transducers shall be provided to monitor the following:

- DC output voltage; and
- DC output current.

4.2.12.2 These measurements shall be available for the SCADA system, as outlined in section 4.2.8. This can require two independent outputs per transducer or two different transducers per signal (one for the measurement / instrumentation within the substation and the other for the SCADA system).

4.2.12.3 The wiring from the sensors to the transducers shall be suitably insulated from the main circuit and meet the electromagnetic compatibility requirements of section 4.1.4.

4.2.12.4 Requirements for the sensors and transducers are given in the Transducer and Measurement Device Specification [IN-021-ST-0014].

4.3 Testing

4.3.1.1 The tests defined below shall be compliant with the relevant parts of EN 50327 and EN 50328.

4.3.1.2 Testing shall at least comprise the items outlined in Table 5 and will include testing the rectifier converter with its rectifier transformer as a combined unit.

Table 5: Summary of tests

Test	Type test[1]	Routine test	Special test	Commissioning test
Insulation test	M	M		M
Light load functional test	M	M		
Load test	M	M		
Power loss determination	M	M		
Temperature rise test	M			
Checking of auxiliary devices	M	M		M
Checking the properties of the control equipment	M	M		M
Checking the protective devices	M	M		M
Short-time withstand current test			O	
Additional tests			O	
Loss determination for the converter group (according to clause 7.4 of EN 50327)			O	
Power factor measurements for the converter group (according to clause 7.5 of EN 50327)			O	
Measurement of the inherent voltage drop for the converter group (according to clause 7.6 of EN 50327)			O	
Short circuit test for the converter group (according to clause 7.7 of EN 50327)			O	
Ductor testing of all DC bus bar electrical connections				M
Insulation testing of frame insulating material				M

M: Mandatory

O: Optional. The *Scope of Works* shall detail if any of these tests are required.

[1]Type tests shall be performed for all rectifier converters not having a type test certificate.

Information: The Designer may combine relevant tests (such as the temperature rise test) for the rectifier converter and rectifier transformer.

4.4 Reliability, Availability, Maintainability and Safety (RAMS)

4.4.1.1 The RAMS requirements shall be those defined in the Infrastructure - Network Power – Substation Design and Construction [CE-021-ST-0023].

4.4.1.2 Submitted documentation shall at least comprise the items outlined in Table 6. This documentation shall be provided for the rectifier converter throughout the procedure outlined in EMS Design Acceptance Standard [CE-023-ST-0020].

Table 6: 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]
Detailed drawing of nameplate					✓	✓	✓[1]
Type test certificates					✓	✓	✓
Test reports					✓	✓	✓
Installation manual(s)			✓[2]		✓	✓	✓
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 4.5.1.2.

[2]Only typical non-project specific documentation required.

4.4.1.3 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

5.1 Typical installations

Refer to Infrastructure - Network Power – Substation - Design and Construction [CE-021-ST-0023] for typical installation diagrams. Any diagrams shown here are as an example only.

TBC
Figure 2: Typical installations – Rectifier converter at Elsternwick Substation

TBC
Figure 3: Typical installations – Rectifier converter at TBC Substation

TBC
Figure 4: Typical installations – Interlocking enclosure access procedure

TBC
Figure 5: Typical installations – Diode layout

6 RELATED LEGISLATION & DOCUMENTS

6.1.1.1 The design and construction of rectifier converters 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 Infrastructure - Network Power – Substation Design and Construction [CE-021-ST-0023].

Table 7: 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
Rectifier Transformer Specification	IN-021-ST-0002
DC Traction Transducer and Measurement Device	IN-021-ST-0014
Cable Specification	IN-021-ST-0003
LV Switchboards Specification	IN-021-ST-0009
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	
Substations and high voltage installations exceeding 1 kV a.c.	AS 2067
Degrees of protection provided by enclosures (IP Code)	AS 60529
International Standards	
Railway applications – Fixed installations – d.c. switchgear – Measurement, control, and protection devices for specific use in d.c. traction systems – Application guide	EN 50123-7-1

Railway applications – Fixed installations – Harmonisation of the rated values for converter groups and tests on converter groups	EN 50327
Railway applications – Fixed installations – Electronic power convertors for substations	EN 50328
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 8: Document version control

Version History	Date	Detail
1.0	30/07/2021	Original approved issue
1.01	2/08/2021	Referenced Documents table updated
1.02	2/09/2021	Minor typing errors corrected
1.09	10/3/2026	Periodic review. No changes
1.10	24/06/2026	Changed from standard to specification. The doc number has been changed from CE-019-ST-0051 to CE-019-SP-051 and updated the YJM logo.

DEFINITIONS & ABBREVIATIONS

Table 9: 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	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.

Table 10: Glossary - Abbreviations

Abbreviation	Definition
AC	Alternating Current
CB	Circuit Breaker
DC	Direct Current
EMC	Electromagnetic Compatibility
EMS	Engineering Management System (internal Yarra Trams abbreviation)
FAT	Factory Acceptance Test
HV	“High Voltage” means a nominal voltage exceeding 1000 V AC or exceeding 1500 V DC
I_{Bd}	Basic direct current (according to EN 50328)
LV	“Low Voltage” means nominal voltage exceeding 50 V AC / 120 V DC but not exceeding 1000 V AC / 1500 V DC
NSS	Negative Shorting Switch
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
U_{d0}	Conventional no-load direct voltage (according to EN 50328)
U_{d00}	Real no-load direct voltage (according to EN 50328)
U_{Nd}	Rated direct voltage (according to EN 50328)

APPENDIX B – TENDER REQUIREMENTS

Table 11 summarises the information which shall be defined by Yarra Trams in the *Scope of* Works at the time of tender.

Table 11: Summary of information to be defined in the Scope of Works

Description	Requirement
Equipment designation	
Number of diodes per arm	
Output: Basic DC current, I_{Bd}	
List of special tests which are required	

Statement of compliance

The *Designer* shall return a 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].