Standard

Rolling Stock - Tram - Power Systems

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PROUD OPERATOR OF

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1 PURPOSE

The purpose of this document is to specify the minimum requirements for traction power and auxiliary power on existing Yarra Trams rolling stock fleet.

2 SCOPE

The scope of this standard is functional and performance requirements applicable to the maintenance and modification of existing trams.

This standard does not specify requirements for design or procurement of new trams or tram systems.

This standard supports safe maintenance of traction power and auxiliary power systems on existing Yarra Trams rolling stock fleet.

This standard considers the differing age profiles and tram designs in use and any changes to the existing trams. This standard recognises that any previous designs or modifications to a tram system will have been designed to those standards in force at the time of the tram design and manufacture. Some of the existing trams will have been designed to standards no longer in force and possibly no longer available. Accordingly, this standard only documents the 'as designed' or current modification level performance characteristics and maintenance requirements for each tram type.

The requirements in this standard have been derived from the following sources:

- OEM manuals supplied at the time of manufacture
- Previous upgrades/ modifications undertaken since the time of manufacture
- The original specifications for the trams
- Standards available at the time of design
- Local Subject Matter Expert knowledge

Unless otherwise stated, application of this standard is not retrospective to existing trams that are not being modified.

Any future modifications or enhancements to trams, for example for obsolescence, safety or to improve performance, shall, so far as is reasonably practicable, seek to comply with currently accepted standards.

The design and review process shall comply with requirements of the Yarra Trams 'Manage Design Procedure' (CE-021-PR-0006).

3 COMPLIANCE

This standard shall be fully complied to when undertaking maintenance or modifications on the existing tram fleets. Deviation from this standard is only permitted when a Waiver has been sought 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 traction power and auxiliary power systems. For the avoidance of doubt this shall include, but not be limited to:

- An engineering risk assessment in accordance with the Enterprise Risk Assessment and Assurance Framework (c016wi11).
- An assessment to determine the appropriate Safety Integrity Level (SIL) for any modification that has electrical/electronic/programmable electronic safety-related systems. The SIL assessment shall comply with International Electrotechnical Commission's (IEC) standard IEC 61508.
- Complying with the requirements of EN 50155 for any modification that has electronic equipment.
- A list of all applicable laws and standards to be complied with for that modification for review and agreement by Yarra Trams Engineering Design Authority.

A compliance schedule shall be completed and returned for any engineering change activities on traction power and auxiliary power systems. Assessment of compliance shall be provided for each requirement, defined by one of three permissible responses:

- Compliant;
- Partially Compliant;
- Non-Compliant.

Absolute requirements in this standard are defined within square brackets and a tolerance level as a percentage or range e.g. [AM 4000mm ± 10%. or 3960mm to 4040mm].

Compliance terminology defined in this standard shall be adhered to with the following definitions:

- ‘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 an engineering risk assessment in accordance with the Yarra Trams Safety Management System and So Far As Is Reasonably (SFAIRP) Guidance Notes (Rail Safety Regulator).

Note: All standards referred to within this document are correct at the time of writing. It is the responsibility of the user to always ensure the most current version of any standard is referred to when applying any given standard.

4 REQUIREMENTS

4.1 Maintenance of Existing Trams

4.1.1 Auxiliary battery system

4.1.1.1 The battery system shall be maintained and tested in accordance with the recommended Technical Maintenance Plan and instructions. These should ensure the battery system provides sufficient power to, as a minimum, the safety critical electrical systems and start-up functions for a period commensurate with the existing or modified design.

4.1.2 Pantograph

4.1.2.1 All pantographs shall be maintained in accordance with the recommended Technical Maintenance Plan and instructions and the recommendations of the original equipment manufacturers (OEM) manual.

4.1.2.2 Particular attention shall be made to ensure the maintenance instructions specify the pantograph height settings (nominal, maximum and minimum) from rail head and upward contact force to the overhead wire to meet the specifications of the exiting design or modification.

4.1.2.3 No tram shall enter service with a damaged pantograph or carbon owing the potentially catastrophic consequence with respect to damaging OLE.

4.1.2.4 Particular attention shall be given to evidence of abnormal carbon wear arcing, damage and signs of fatigue that could contribute towards pantograph failure. Any tram pantograph exhibiting such damage should be reported.

4.2 Modifications to Existing Trams

4.2.1 Traction Power

The following shall be considered for any new or modified traction power supplies.

4.2.1.1 The tram main power supply system shall collect power from the 600V DC overhead contact wire of the infrastructure traction power supply system using pantographs and return current to the running rails through wheel axle earthing units.

4.2.1.2 The traction power system shall supply power to the traction module and provide over-current and over/under-voltage protections.

4.2.1.3 The traction power system shall prevent high inrush or discharge currents to and from the traction supply system at all times (whether powering, coasting or braking).

4.2.1.4 Overcurrent from short circuits and failures in the traction circuits shall immediately trip a high-speed circuit breaker in the traction protection system to clear fault currents.

4.2.1.5 So far as reasonably practicable, continuous monitoring using sensor systems, protection relays or equivalent systems shall be used to detect fault conditions and shall comply with EN 50388.

4.2.1.6 A surge arrester shall provide protection to onboard equipment in accordance with IEC 62497.

4.2.1.7 Power electronics (such as the traction inverter, the on-board network inverter and chopper) should be non-forced air cooled where possible using natural air cooling by means of convection and/or driving wind.

4.2.1.8 Power electronics (such as the traction inverter, the on-board network inverter and chopper) shall comply with EN 61287.

4.2.1.9 Brake resistors should be placed in a housing designed to be readily accessible for cleaning and to protect them from direct contact danger, flying debris and reduce EMC effects.

4.2.1.10 Brake resistors shall be designed in accordance with EN 60322 and shall be rated to comply with the full performance specified within the original tram design without exceeding the temperature limits specified in EN 60322.

4.2.2 Auxiliary Supply – General

4.2.2.1 The auxiliary power system is powered from the main power supply and provides power to all tram auxiliary systems in normal operation and in emergency conditions via the auxiliary battery system.

4.2.2.2 The auxiliary power system shall prevent high inrush or discharge currents to and from the auxiliary power system at all times (whether powering, coasting or braking).

4.2.2.3 The tram auxiliary power systems shall invert and/or convert the infrastructure power supply line voltage into an auxiliary power supply with characteristics suitable to provide a stable power supply to onboard auxiliary systems, for example:

- Ventilation and climate control systems,
- Lighting systems
- Traction and other tram control circuits
- Communication and signalling systems
- Battery chargers
- Safety and operational critical systems

4.2.2.4 Where fitted, auxiliary shore supply systems shall have the capability to charge the batteries and operate all the auxiliary loads.

4.2.2.5 The location of new general purpose outlets (GPO) shall be agreed with Yarra Trams Engineering Design Authority.

4.2.2.6 New GPOs shall provide a nominal 230V AC 50Hz 10A of power.

4.2.2.7 The auxiliary supply invertor or converter, battery and their protection devices shall have sufficient capability to supply all auxiliary systems over the full range of supply, load and battery state of charge.

4.2.2.8 The auxiliary supply system shall continue to operate through momentary interruptions of infrastructure power supply.

4.2.3 General circuit voltages

4.2.3.1 Tram control and lighting circuits shall not exceed the extra low voltage set out in EN 50153.

4.2.3.2 Tram single phase AC circuit voltages and frequency shall be nominal 230 V AC 50 Hz for auxiliary systems and general power outlets, in accordance with AS 60038 Standard Voltages.

4.2.3.3 General power outlets shall comply with AS/NZS 3112.

4.2.3.4 Tram three phase AC circuit voltages and frequency shall be nominal 400 V AC, 50 Hz in accordance with AS 60038.

4.2.4 Electrical protection and safety

4.2.4.1 Tram electrical safety provisions shall comply with EN 50153.

4.2.4.2 Any new or modified equipment shall provide protection to cover a full range of credible failures and abnormal conditions.

4.2.4.3 Interruptions to the infrastructure power supply output should be indicated to the driver. Where applicable the cause of the output interruption shall be recorded for fault finding purposes.

4.2.4.4 Trams auxiliary power supplies shall be provided with the following electrical protection and safety systems:

- Safety earthing switch or equivalent system
- Onboard power source overcurrent protection
- Individual circuit (functions) overcurrent protection and isolation device

4.2.4.5 Individual circuit functions and equipment should be protected using overcurrent magnetic circuit breakers that can be used to isolate the individual circuit functions.

4.2.4.6 The selection of circuit breakers shall consider circuit characteristics, including the effects of long cable runs, to ensure the desired reaction time of the circuit breaker.

4.2.4.7 Components supplied by three-phase AC power sources and circuits should be protected by ganged three phase magnetic circuit breakers or fuses.

4.2.4.8 Circuit breakers shall not be used in lieu of dedicated switches or switch controlled contactors where regular manual isolation switching is required for an electrical circuit or equipment.

4.2.5 Electromagnetic compatibility

4.2.5.1 Tram electrical circuits and equipment shall not have an impact on the operation of other onboard electrical systems.

4.2.5.2 Tram electrical circuits and equipment shall not have an impact on the operation of rolling stock from neighboring rail operations and road electrical infrastructure systems.

4.2.5.3 The tram shall comply with and be tested for electromagnetic compatibility in accordance with EN 50121.

4.2.6 Tram battery system

4.2.6.1 In the event of a loss of the infrastructure power or converter/invertor failure, a new or modified battery system shall have the capacity to provide essential services with electrical power for a minimum period of 90 minutes.

4.2.6.2 As a minimum, a new or modified battery system shall, as minimum, provide emergency power to enable the following:

- Minimum ventilation requirements in cab and passenger areas as defined in Yarra Trams Standard, Rolling Stock - Tram - Environmental Systems (CE-021-ST-0025).
- Minimum lighting requirements in cab and passenger areas as defined in Yarra Trams Standard, Rolling Stock - Tram - Auxiliary Systems (CE-021-ST-0026).
- Where fitted, operation of the emergency exit lights, step lights, hazard lights, direction indicator lights, and stop lights.
- Operation of the onboard communication systems including the public address and radio communication systems.
- Operation of all passenger doors for emergency egress.
- Where fitted, operation of the driver's display unit and control interfaces to maintain control of critical systems and enable fault-finding activities.
- Where fitted, operation of event recorders, video surveillance and fire detection systems.
- Where fitted, orderly shutdown of processor driven systems to prevent inadvertent effects due to sudden loss of power.
- Re-start of the tram traction and auxiliary power supply systems after the input power has been restored.

4.2.6.3 When the tram is in a stabling mode (if an available operational state), battery power shall still be provided to selected systems, for example the incident/event recording device. Yarra Trams Engineering Design Authority shall determine which systems shall retain power whilst in stabling mode.

4.2.6.4 Tram battery banks should be protected by high rupturing capacity fuses or equivalent fuses on both the positive and negative terminals.

4.2.7 Pantograph Design Requirements

4.2.7.1 The pantographs fitted to the trams operating on the Yarra Trams network shall comply with the characteristics and test requirements specified in EN 50206.

4.2.7.2 The geometry and shape of the pantographs shall be designed in accordance with EN 50367/IEC 60486.

4.2.7.3 The pantograph design shall meet the requirements of Yarra Trams Standard, Infrastructure – Overhead Network – Design and Construction (CE-021-ST-0036); section covering Tramway Overhead Infrastructure Line Geometry Requirements.

4.2.7.4 The pantograph shall be designed to exert an upwards force on the contact wire of 90 ±5N.

4.2.7.5 During normal operation the pantograph shall meet the kinematic envelope requirements of Yarra Trams Standard, Rolling Stock - Tram – Outlines (CE-021-ST-0019)

4.2.7.6 The pantograph head shall be located over a bogie centre.

4.2.7.7 The pantograph head shall not exceed 340 mm in length measured along the track in order to avoid bridging the overhead wiring section insulators.

4.2.7.8 If pantograph design includes a horn, it shall be a closed design and shall not allow the pantograph horn to hook over the overhead line.

4.2.7.9 The pantograph shall be fitted with a device which in the event of the pantograph being subjected to an impact force, causes it to drop to protect the traction overhead wiring system.

4.2.7.10 The pantograph should be capable of being reset by maintenance staff from within the Tram to enable the Tram to be driven back to the depot for maintenance in a degraded condition.

4.2.8 Technical Manuals

4.2.8.1 All new or modified tram electrical circuits and electrical equipment shall be provided with a detailed technical manual.

4.2.8.2 The technical manual shall include relevant safety warnings against risks and hazards while operating or maintaining all electrical circuit and equipment.

4.2.8.3 The technical manual shall use, where applicable, functional systems diagrams, sequence charts and other diagrams necessary to explain the operation of circuits and electrical equipment to electrical technicians and engineers to enable detailed assessment, maintenance, fault-finding and future modification and upgrades to the rolling stock electrical system.

4.2.8.4 Technical manuals shall be included for plug-in type modules, including plug-in circuit board cards contained within larger equipment modules which may not be readily accessible.

4.2.8.5 Explanation of relevant circuit theory should be included to completely describe the operation of electrical circuits.

4.2.8.6 The technical manuals shall include detailed installation and overhaul instructions for all electrical equipment, including the tools and equipment required to efficiently complete the task.

4.2.8.7 The technical manuals shall include a comprehensive diagnostics and fault-finding procedure, including test sequence and expected measurable values such as voltage, resistance and current readings

4.2.9 Technical Maintenance Plans

4.2.9.1 The technical maintenance plan for new or modified electrical circuits and electrical equipment shall detail all the maintenance requirements to enable the electrical circuit and equipment to operate as specified and to prevent in-service failures.

4.2.9.2 The technical maintenance plan shall detail all the maintenance requirements to ensure the specified life of the electrical circuit and equipment.

5 RELATED LEGISLATION & DOCUMENTS

Document Number	Name
AS/NZS 3112	Approval and test specification - Plugs and socket-outlets
AS 60038	Standard voltages
CE-021-PR-0006	EMS04 Manage Design Procedure
CE-021-PR-0020	EMS06 Engineering Change Management Procedure
CE-021-PR-0004	EMS05 Deviation from Standards Procedure
c016wi11	Enterprise Risk Assessment and Assurance Framework
IEC 60077	Railway Applications – Electric Equipment for Rolling Stock
IEC 61508	Functional Safety
EN 50121	Railway applications. Electromagnetic compatibility
EN 50153	Railway applications - Rolling stock - Protective provisions relating to electrical hazards
EN 50206	Railway applications - Rolling stock - Pantographs: Characteristics and tests
EN 50155	Railway Applications - Rolling Stock - Electronic Equipment
EN 50367/IEC 60486	Railway applications - Current collection systems - Technical criteria for the interaction between pantograph and overhead line.
EN 50388	Railway Applications. Power supply and rolling stock.
EN 60322	Railway applications - Electric equipment for rolling stock
EN 61287	Railway Applications – Power converters installed on board rolling stock
IEC 62497	Railway applications – Insulation coordination
CE-021-ST-0025	Rolling Stock – Tram – Environmental Systems
CE-021-ST-0026	Rolling Stock – Tram – Auxiliary Systems
CE-021-ST-0019	Rolling Stock – Tram - Outlines
CE-021-ST-0036	Infrastructure – Overhead Network – Design and Construction

6 DOCUMENT VERSION CONTROL

Version History	Date	Detail
1.0	20 March 2020	Original approved issue

7 GLOSSARY

Term	Definition
Engineering Design Authority	The person or position designated by the Franchisee with the authority to approve engineering design changes, modifications and the TMPs under a system which complies with AS/NZS ISO 9001 Quality Management Systems or similar standard and AS4292 Railway Safety Management as applicable to rolling stock providers.
EMC	Electromagnetic Compatibility
GPO	General purpose outlets
IEC	International Electrotechnical Commission
OEM	Original Equipment Manufacturers
OLE	Overhead Line Equipment, i.e. the overhead power supply including catenary
SIL	Safety Integrity Level
Traction inverter	Electronic device that converts energy to drive the motors in the drivetrain
Waiver	Waiver process as per EMS05 Deviation from Standards Procedure.