

Standard

# Rolling Stock - Tram - Traction Systems

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PROUD OPERATOR OF



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## Table of Contents

1	PURPOSE .....	3
2	SCOPE .....	3
3	COMPLIANCE .....	3
4	REQUIREMENTS .....	5
4.1	Maintenance of Existing Trams .....	5
4.2	Modifications to Existing Trams .....	5
4.2.1	General requirements .....	5
4.2.2	Performance requirements .....	6
4.2.3	Traction Power .....	6
4.2.4	Traction Control Unit (TCU) .....	6
4.2.5	Motors and Drive train (including gearbox, coupling, suspension) .....	7
4.2.6	Electro Magnetic Compatibility .....	8
4.2.7	Electrical Equipment Design .....	8
4.2.8	Testing .....	9
4.2.9	Technical manuals .....	9
4.2.10	Technical Maintenance Plans (TMP) .....	9
5	RELATED LEGISLATION & DOCUMENTS .....	10
6	DOCUMENT VERSION CONTROL .....	11
7	GLOSSARY .....	11



## 1 PURPOSE

The purpose of this document is to specify the minimum requirements for the function and performance of tram Traction Systems installed on the existing Yarra Trams rolling stock fleet.

## 2 SCOPE

The scope of this standard is requirements for the function and performance of traction systems applicable for maintenance and modifications to existing trams.

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

This standard considers the differing age profiles, current designs and system types in use on existing trams.

This standard recognises that owing to age range of existing fleets, any previous designs or modifications to a tram and associated systems will have been designed to those standards in force at the time of the tram design, manufacture or modification.

This standard recognises that some of the existing trams will have been designed to standards no longer in force and possibly no longer available.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 functions, performance characteristics and maintenance requirements for each existing tram type.

The requirements in this standard are 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 the Traction System. 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 the traction system. 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  $\pm$  1%. 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 Enterprise Risk Assessment and Assurance Framework (c016wi11) 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

A tram traction system comprises of three main element, the traction control unit, motors and a drive train system. The traction control unit governs the traction power supply to the motors, which provide propulsion via a drive train arrangement through to the wheels. The traction system has several interfaces to other key systems that determine how the system functions.

### 4.1 Maintenance of Existing Trams

4.1.1.1 A maintenance plan shall be in place that identifies all specifications, procedures and processes, including examination, inspection, testing and repair of the traction system or components of the traction system.

4.1.1.2 Examination, inspection and testing and repair of the traction system or components of the traction system, shall be applied at a frequency adequate to ensure that the traction system is always in a safe and compliant condition.

### 4.2 Modifications to Existing Trams

Any modifications to the traction systems or equipment shall consider the following requirements.

#### 4.2.1 General requirements

4.2.1.1 Modifications to the traction system or equipment within the traction system shall not be undertaken without the engineering risk assessment determining the effects on the other parts of the traction system.

4.2.1.2 Modifications to the traction system or equipment within the traction system shall not be undertaken without the engineering risk assessment determining the effects on interface systems, interface equipment and tram performance parameters, including, but not limited to:

- Original design by the OEM or any subsequent design modifications
- Traction/Brake controller
- Brake Control Unit (BCU)
- Wheel Slide Protection (WSP), if fitted
- Tram Control and Management System (TCMS), if fitted
- Traction Power
- Load-weigh system, if fitted
- Tram mass and axle loads
- Drive train (gearbox, linkage to axle)
- Brake resistors
- On Tram Monitoring Recorder (OTMR) (also referred to as event recorder or trip recorder)
- Mechanical interfaces e.g. bogie
- Jerk rate



- Acceleration and brake rates
- Electromagnetic Interference

4.2.1.3 The environmental design parameters of modifications to the traction system or equipment within the traction system should consider the requirements of EN 50125.

### 4.2.2 Performance requirements

Modifications to the traction system or equipment within the traction system, shall ensure:

4.2.2.1 The braking jerk rates in all braking modes remains within the existing limits.

4.2.2.2 The maximum jerk rate in acceleration does not increase.

4.2.2.3 The traction system is capable of matching the existing tram traction effort performance curve under all load conditions.

4.2.2.4 The requirements of Yarra Trams Standard, Rolling Stock - Tram - Braking Systems (CE-021-ST-0029) are met.

4.2.2.5 The requirements of Yarra Trams Standard, Rolling Stock - Tram - Power Systems (CE-021-ST-0020) are met.

4.2.2.6 The requirements of the Yarra Trams Standard, Rolling Stock - Tram - Fire Safety Systems (CE-021-ST-0024) are met.

4.2.2.7 The unsprung mass remains within the existing limits.

4.2.2.8 The tram dynamics under all load conditions are no worse.

4.2.2.9 Axle loads under all load conditions do not increase.

### 4.2.3 Traction Power

4.2.3.1 For information, the Yarra Trams system uses a nominal 600 V DC (direct current) traction supply distributed to trams via an overhead contact system.

4.2.3.2 A modified or new traction system shall demonstrate compatibility with the existing traction supply system in addition to compliance with EN 50163.

### 4.2.4 Traction Control Unit (TCU)

A new or modified Traction Control Unit (TCU) shall consider the following requirements:

4.2.4.1 TCU interface is compatible with the existing systems, including, but not limited to:

- Traction/brake controller.
- OTMR (also referred to as event recorder or trip recorder).
- Brake Control Unit (BCU).
- Door control systems, if fitted.



- 4.2.4.2 TCU should support interfaces and integration with other remote information systems.
- 4.2.4.3 TCU shall present the relevant information under normal and tram fault conditions to the TCMS (if fitted), using easily understood terminology. Vital / critical data shall be separated from other tram-borne systems and have a secure architecture.
- 4.2.4.4 TCU shall provide both regenerative and rheostatic braking capability.
- 4.2.4.5 TCU shall provide the ability to maximise the dynamic brake capability and it shall take precedence over the friction brake throughout the whole range of service brake applications.
- 4.2.4.6 TCU shall control the traction converter to avoid the wheel slide in accordance with EN 15595.
- 4.2.4.7 TCU noise level shall not exceed the requirements of ISO 3381.
- 4.2.4.8 TCU shall allow the tram to be moved/assisted under rescue conditions by another vehicle when its own traction power is not available.
- 4.2.4.9 TCU should not generate excessive heat which might affect other on-board systems and impair the safety and comfort of passengers or staff.
- 4.2.4.10 TCU physical dimensions shall not exceed the existing space provided.
- 4.2.4.11 TCU shall meet the software tram control and protection systems requirements of EN 50128, with reference to EN 50129.
- 4.2.5 Motors and Drive train (including gearbox, coupling, suspension)
- 4.2.5.1 For information, the existing trams use a mixture of DC and AC asynchronous motors depending on the class. The rotational power output from the motor is transmitted through a drive train to rotate the axle.
- 4.2.5.2 Any new or modified motor and/or drive train shall consider the following requirements:
- New motors shall meet the electronic converter feed requirements of EN 60349.
  - New or modified motor output torque shall be no worse than the existing motor.
  - New or modified motor short-circuit torque shall not exceed the design capability of the existing drivetrain components.
  - New or modified motor efficiency shall be no worse than the existing motors.
  - Motor noise level shall not exceed the requirements of ISO 3381.
  - New motors shall fit in the space provided.
  - New motors should be easily maintainable.
  - New or modified drive trains shall fit in to space provided in the existing tram.
  - New or modified drive trains shall be compliant with the existing, new or modified motors.
  - New or modified drive trains should not cause additional track wear compared to the existing tram.



- New or modified drive trains should be easily accessible and maintainable.
- New or modified drive trains should interface to the existing suspension arrangements.
- New or modified drive trains shall comply with the shock and vibration testing requirements of EN 61373.

### 4.2.6 Electro Magnetic Compatibility

4.2.6.1 Any modification or new electrical/electronic equipment shall meet the emission and immunity requirements of EN 50121. This shall include, but not be limited to:

- Any modification or new electrical/electronic equipment shall not generate electromagnetic emissions that could affect the safe operation of other trams, infrastructure systems and equipment, or other existing rolling stock on neighbouring railways.
- Any modification or new electrical/electronic equipment shall be immune to electromagnetic emissions from infrastructure systems and equipment, other existing trams on the Melbourne Tram lines, and other existing rolling stock on neighbouring railways.
- Any modification or new electrical/electronic equipment shall be immune to electromagnetic emissions from infrastructure systems and equipment, and other existing rolling stock on neighbouring railways.

### 4.2.7 Electrical Equipment Design

4.2.7.1 Any modified or new electrical/electronic equipment shall also comply with the requirements and tests set by the following standards:

- Electrical protection requirements of EN 50153.
- Electric/electronic hardware requirements of EN 50155 and EN 60077.
- Electrical hardware and cable requirements of EN 50261 and EN 50343.
- Equipment and electrical insulation requirements of EN 50124.
- Supply voltage requirements of EN 50163.
- Validation requirements of EN 50317 and EN 50318.





### 4.2.8 Testing

4.2.8.1 A test program shall be developed commensurate with the changes made to the traction system or equipment within the traction system, including acceptance criteria.

4.2.8.2 The test program shall consider the output from the engineering risk assessment.

4.2.8.3 The test program shall comply with any relevant tests set by the standards referenced in this standard.

4.2.8.4 The test program shall be agreed with Yarra Trams Engineering Authority prior to commencement.

4.2.8.5 The test program should consider the dynamic behaviour testing set in EN 14363.

### 4.2.9 Technical manuals

4.2.9.1 Any modification shall assess the existing technical manuals and provide the updates as necessary.

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

4.2.9.3 The technical manual should 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.

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

4.2.9.5 Technical manuals should include detailed installation and overhaul instructions including the tools and equipment required to efficiently complete the task.

4.2.9.6 Technical manuals should include a comprehensive diagnostics and fault-finding procedures.

### 4.2.10 Technical Maintenance Plans (TMP)

4.2.10.1 Any modification shall assess the existing TMP and provide updates as necessary.

4.2.10.2 The TMP shall detail all the maintenance requirements of the modified system, equipment and interfaces.

4.2.10.3 Reliability, Availability, Maintainability and Safety (RAMS) analysis should be used to determine the optimum TMP to achieve asset performance and whole life cost requirements. This should assess system design and the use of preventative, corrective and condition-based asset maintenance strategies based on current and forecast asset condition to determine the most appropriate and effective solution.

4.2.10.4 The TMP update should consider EN 17018, EN 17023, EN 17095.



## 5 RELATED LEGISLATION & DOCUMENTS

Document Number	Name
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
ISO 3381	Acoustics. Measurement of noise inside rail bound vehicles
IEC 61508	Functional Safety
EN 14363	Railway applications -Testing and Simulation for the acceptance of running characteristics of railway vehicles - Running Behaviour and stationary tests
EN 15595	Railway Applications - Braking - Wheel slide Protection
EN 17018	Railway applications - Rolling Stock Maintenance - Terms and definitions
EN 17023	Railway applications - Rolling stock maintenance - Creation and modification of maintenance plan
EN 17095	Railway applications - Rolling stock maintenance - Maintenance records
EN 50121	Electromagnetic compatibility. Rolling stock. Train and complete vehicle
EN 50124	Railway Applications – Insulation coordination
EN 50128	Railway applications - Communication, signalling and processing systems - Software for railway control and protection systems
EN 50129	Railway applications – Communication, signalling and processing systems – Safety related electronic systems for signalling
EN 50163	Railway Applications – Supply voltages of traction systems
EN 50153	Rolling stock. Protective provisions relating to electrical hazards.
EN 50155	Railway Applications - Rolling Stock - Electronic Equipment
EN 50163	Railway applications. Supply voltages of traction systems
EN 50261	Mounting of Electronic Equipment



Document Number	Name
EN 50317	Railway applications - Current collection systems. Requirements for and validation of measurements of the dynamic interaction between pantograph and overhead contact line
EN 50318	Railway applications - Current collection systems - Validation of simulation of the dynamic interaction between pantograph and overhead contact line
EN 50343	Rolling stock. Rules for installation of cabling
EN 60077	Electric equipment for rolling stock
EN 60349	Electrical traction. Rotating electrical machines for rail and road vehicles
EN 61373	Railway applications. Rolling stock equipment. Shock and vibration tests
CE-021-ST-0029	Rolling Stock - Tram - Braking Systems
CE-021-ST-0020	Rolling Stock - Tram - Power Systems
CE-021-ST-0024	Rolling Stock - Tram - Fire Safety Systems

## 6 DOCUMENT VERSION CONTROL

Version History	Date	Detail
1.0	12 <sup>th</sup> 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.
IEC	International Electrotechnical Commission
Jerk Rate	The rate of change of acceleration or deceleration
OEM	Original Equipment Manufacturers
OTMR	On Tram Monitoring Recorder (also referred to as event or trip recorder)



Term	Definition
Regenerative braking	Braking current is returned into the overhead contact wire
Rheostatic braking	Braking current is fed into a resistor
TCU	Traction Control Unit
SIL	Safety Integrity Level
Waiver	Waiver process as per EMS05 Deviation from Standards Procedure.