Standard

Infrastructure - Tram Track Design

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PROUD OPERATOR OF

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1 PURPOSE

The purpose of this standard is to specify the minimum requirements in the design of tram track for the Yarra Trams network.

2 SCOPE

The scope of this standard covers all design related requirements and parameters to be applied to new tram track design. This standard does not apply retrospectively to existing designs for tram track on the Yarra Trams network.

The following scope previously covered in VRIOGS 005.1 Tram track Design and VRIOGS 005.2 Tram Track Construction, are excluded from the tram track design standard and will be covered in future Yarra Trams standards as appropriate:

- Tram track sub-structure design and construction requirements;
- Tram track autopoints, bonding, feeder conduits and pit requirements associated with civil design to accommodate these features;
- Design and construction of sub-surface drainage.

This standard is applicable to all tram track design activity on the Yarra Trams network and any third parties or Contractors who undertake design activities for Yarra Trams.

3 COMPLIANCE

This standard shall be fully complied with.

Deviation from this standard is only permitted when a waiver has been sought and approved by Yarra Trams.

'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 a technical risk assessment including proposed list of design controls to demonstrate compliance to this standard.

Any third party or contractor undertaking tram track design activities on the Yarra Trams network shall complete and return a compliance schedule for this standard. Assessment of compliance shall be provided for each requirement, defined by one of three permissible responses:
a) Compliant;

b) Partially Compliant;
c) Non-Compliant.

Absolute requirements in this standard are defined within square brackets i.e. [AM 4000mm]. Absolute values shall not be accepted without prior consultation and acceptance by Yarra Trams. Deviation beyond Absolute values shall not be accepted under any circumstances.

4 REQUIREMENTS

4.1 General

4.1.1 Design Principles

4.1.1.1 The design and review process shall be managed in accordance with the Yarra Trams 'Manage Design' procedure.

Information: This procedure requires consideration of design constructability, Safety in Design, RAM, Human Factors, design sustainability, single design platform, security in design, design competency and all relevant statutory requirements.

4.1.1.2 All design activity shall be undertaken by engineers with engineering design competency accepted and delegated by Yarra Trams in accordance with 'Engineering Design Authority' procedure.

4.1.1.3 The designer shall inform the relevant design lead or project manager within Yarra Trams of any conflicting requirements as soon as they become apparent.

4.1.1.4 The designer shall seek approval for all deviations from standards whenever a requirement cannot be met in accordance with the Yarra Trams 'Deviation from standards' procedure.

4.1.1.5 Design Drawings submitted to Yarra Trams shall clearly identify any departures from standards with red cloud, including relevant explanatory comments.

4.1.1.6 All relevant elevations, coordinates, grades, location and dimensions of physical features inside the track design area with relevant tie-in points shall be captured in the survey drawing for Yarra Trams review in accordance with Tramway Engineering Survey Standard.

4.1.1.7 The tram track designer shall prepare functional testing regime for Yarra Trams acceptance, required to reveal installation and or maintenance errors during commissioning of new track.

4.1.1.8 The designer shall provide longitudinal section (horizontal) drawings for vertical alignment to clearly illustrate the centerline of track and or the two outer rails elevation.

4.1.1.9 Vertical alignment design should be completed after horizontal alignment has been approved by Yarra Trams.

Information: In some cases, the vertical alignment may affect the horizontal alignment.

4.1.1.10 Clearance line diagrams for tram swept paths shall be provided to Yarra Trams showing where any clearance lines or fairway lines are to be painted.

4.1.1.11 Where structures are located in close proximity to the swept path of tram as per drawing STD_T0306, the final tram to structure clearances shall be clearly marked on drawings for Yarra Trams review and approval.

4.1.1.12 The designer shall coordinate with VicRoads on all design, maintenance and safety issues at tramway crossings, to ensure any changes in infrastructure or operation contemplated by one party shall be reviewed and consulted with the other party, including impact to road grade, signs, line marking , traffic signal and any additions of new road vehicle classes to routes, and or changes in speed limits.

4.1.1.13 All track system components shall be of a standard type, be proven technology in a similar tramway environment and compatible with the existing track system.

4.1.1.14 Tam track design over an existing bridge shall not impair the integrity of the bridge structural elements.

4.1.1.15 Tram track design shall accommodate the existing bridge articulation movements.

4.1.1.16 Tram track design for new routes and State funded projects from the published date of this standard shall comply with the additional design requirements stipulated in Appendix D of this standard.

4.1.1.17 Tram track design for new routes and State funded projects from the published date of this standard shall comply with the design life requirements stipulated in Appendix E of this standard.

4.1.2 Human Factors

4.1.2.1 The tram track design shall consider accessibility requirements of the Disability Discrimination Act (DDA), Disability Standards for Accessible Public Transport (DSAPT), and relevant Standards and legislation.

4.1.2.2 The tram track design shall avoid placing infrastructure requiring frequent maintenance access in areas with poor accessibility so far as is reasonably practicable.

4.1.2.3 The tram track design shall avoid installing track automatic switches, drains and or pits across pedestrian crossings so far as is reasonably practicable.

4.1.2.4 The tram track design shall be suitable for routine and unplanned maintenance, cleaning, and emergency situations during normal and degraded modes of operation so far as is reasonably practicable.

4.1.2.5 The tram track design shall comply with legislated environmental requirements including noise emissions, construction materials and waste disposal.

4.1.2.6 The tram track design shall be compatible with surrounding environments, including roads, pedestrian crossings, bicycle tracks and emergency service routes so far as is reasonably practicable.

4.1.2.7 The tram track design shall include assessments on the impact of design decisions on Yarra Trams operational training, staffing and resourcing requirements.

4.1.2.8 The tram track design shall reduce driver workload, and or distractions that would impair performance of tram drivers so far as is reasonably practicable.

4.1.3 Safety

4.1.3.1 The tram track design should avoid tram route placement across pedestrian and cyclist pathways or interaction with other vehicle movements at grade, so far as is reasonably practicable.

4.1.3.2 The tram track designer shall identify single points of failure, including sources of human error that could result in track system failure, so far as is reasonably practicable.

4.1.3.3 The tram track designer shall identify potential reasons for deliberate vandalism or misuse of the track system, to ensure proposed design controls minimise violation risk so far as is reasonably practicable.

4.1.3.4 The tram track design shall comply with maintenance requirements as per Yarra Trams Tram Track Maintenance Standards IN-023-MA-0002.

4.1.3.5 Where check rails are used to guide opposing tram wheels through V-crossings, the tram track design shall be capable of supporting the full lateral force of the guided wheel.

4.1.3.6 V-crossing flange bearing ramps shall be designed to lift each wheel tread clear off the top of rail running surface and gap, so no damage is caused to the nose of the V-crossing, reducing the wheel impact.

4.1.3.7 Where new tram tracks are to be placed over an existing road bridge structure a detailed inspection, assessment and load rating shall be undertaken in accordance with both AS 5100.7 and VicRoads requirements, to assess the impacts on the structure.

4.2 Track Design

4.2.1 General

4.2.1.1 The tram track shall allow for left hand track running.

4.2.1.2 The tram track design shall ensure compatibility with existing traction power systems.

4.2.1.3 The tram track shall be separated with reserved track area from road traffic so far as is reasonably practicable.

4.2.1.4 The tram track design shall investigate provision of 'hard separation' barriers between reserved track and roadways by introducing kerbs and or elevating the track.

4.2.1.5 Road crossings over reserved track shall be minimised so far as is reasonably practicable.

4.2.1.6 The maximum truck axle load in tram and vehicle road share areas shall be determined in coordination with VicRoads.

4.2.1.7 The tram track shall be designed for all tram classes operating in the Melbourne network regardless of current fleet deployment at the design location, to ensure full flexibility for future Yarra Trams deployment of fleet scenarios.

4.2.1.8 Mainline tracks running on reserved track and or parallel along shared roadways shall be designed as per Type 2 track structure with bitumen and crushed rock cover.

Information: Refer to Standard Drawing STD_T9010 for Typical Track Structures.

4.2.1.9 Mainline tracks where vehicles drive perpendicular to and over the tramway or heavy vehicle trafficable areas shall be designed as per Type 3 track structure with full depth bitumen.

Information: Refer to Standard Drawing STD_T9010 for Typical Track Structures.

4.2.1.10 The track drainage system shall be designed to eliminate silting, flooding and sand build up on rails so far as is reasonably practicable.

4.2.1.11 The tram track flangeway gaps shall be in accordance with values specified in Appendix B7 of this standard.

4.2.1.12 Tram track monoblock switches and crossings used on Yarra Trams network shall comply with design requirements of the VDV-OR 14 standard.

4.2.1.13 Grooved rails shall have drainage slots provided as required, allowing for connection to the drainage system.

4.2.1.14 Where the tramway is immediately adjacent to general road traffic, track surface drainage shall be provided.

4.2.1.15 Tramway drainage shall ensure the road surface is drained to prevent pooling, so far as is reasonably practicable.

4.2.2 Rail Type

1.1.1.1 Tram track design shall use approved Yarra Tram rail types as prescribed by the selection criteria in Appendix B17 of this standard.

4.2.2.1 Tram rail profiles shall conform to those specified in standard drawing STD_T9002.

4.2.2.2 Tram rails shall comply with the requirements of AS 1085.1.

4.2.3 Track Gauge

4.2.3.1 The nominal tangent tram track gauge shall be 1435 mm.

Information: All formulae in this standard are applicable to this gauge, commonly referred to as standard gauge.

4.2.3.2 The track gauge shall be measured between the two opposite running faces of the rails at 9mm below the top of rail running surface, eliminating any distortion in measurement caused by rail head flow.

4.2.3.3 The track gauge shall be narrowed to 1430 mm through H Crossings only.

4.2.3.4 Where track is narrowed to 1430 mm, the tram track design shall include 5 m [AM 2 m] of straight track for gauge transition.

4.2.3.5 Gauge transitions required into and out of H crossings shall not pass through junctions.

4.2.4 Loading

4.2.4.1 The tram track shall be designed to meet the minimum design speeds specified in Appendix B16 of this standard.

4.2.4.2 The tram track design shall ensure integrity between track design and supporting substructure, including existing substructures.

4.2.4.3 The tram track shall be designed to avoid track distortion during extreme hot and cold weather conditions, so far as is reasonably practicable.

4.2.4.4 The tram track shall be designed to distribute load uniformly across track, sleepers, and relevant substructure.

4.2.4.5 The tram track shall be designed to withstand worst case load scenarios resulting from maximum tram axle load, track thermal load, tram lateral load, dynamic load and braking load as determined from tram fleet parameters provided in Appendix C of this standard.

4.2.4.6 Design of new routes and State funded projects from the published date of this standard shall comply to tram axle loading of 12.5t, all other works shall comply to a maximum axle load of 10.6t on the existing network.

4.2.4.7 Sleeper and bearer design shall be completed in accordance with STD_T9010 and STD_T9060 drawings.

4.2.4.8 Sleeper and bearer design shall be assessed against worst case load scenarios, to ensure vertical support, gauge and lateral restraint is maintained against track misalignment or buckling.

4.2.4.9 Where tracks traverse over bridges, the tram track design shall not exceed the maximum load limits specified by AS 5100.2.

4.2.4.10 The tram track design shall avoid vertical track stiffness being changed abruptly.

4.2.4.11 The tram track structure transitions between ballasted and embedded track shall be designed in accordance with STD_T9060 drawing, to ensure gradual transition in track vertical stiffness is achieved.

4.2.5 Geometry

4.2.5.1 The tram track design shall comply with limits for radii, transitions, cant, and cant deficiency on track alignment provided in Appendix B of this standard.

4.2.5.2 Tram track design shall minimise the use of curves below 500m radius so far as is reasonably practicable to improve passenger ride quality.

4.2.5.3 The minimum track curve radius shall be no less than 25m.

4.2.5.4 Tram track design optimisation shall not introduce reverse curves or non-tangent track into switches.

4.2.5.5 The tram track design shall include controls to minimise risk of derailment and damage to crossings, so far as is reasonably practicable.

4.2.5.6 The vehicle design speed shall be the maximum speed that trams shall not exceed.

4.2.5.7 Where cant is applied to curved track, the outer tram track rail shall be higher than the inner rail.

Information: At moderate levels of operation centrifugal force has no effect on safety, but may affect the comfort of passengers. To counter the effects of centrifugal force on passengers, cant is applied to the curve by lowering the inside rail and raising the outside rail by equal amounts.

4.2.5.8 Track cant applied to curves shall be determined by the formula in figure 1.

Figure 1: Determination of cant

The equilibrium cant is calculated as follows:

$$Eq = 11.8 \times \frac{V^2}{R}$$

$$Eq = (\text{Gauge} + \text{Rail head width})/(\text{gravity}*(\text{conversion km/h to m/s})2) \times \frac{V^2}{R}$$

$$Eq = (1435+70)/(9.8*3.62) \times \frac{V^2}{R}$$

where:

Eq = Equilibrium cant in mm

V = Vehicle design speed in km/h

R = Radius of curve in m

4.2.5.9 Where the maximum allowable vehicle speed exceeds the maximum allowable line speed, the line speed shall be used with cants recalculated accordingly.

4.2.5.10 The tram track cant shall be governed by the physical constraint of existing road levels to ensure the safe passage of road vehicles across tram tracks in shared roadway environments.

Information: The theoretical cant requirement depends on the radius of the curve and the velocity of the tram. However, in most cases the overall shape of the road governs the amount of cant which can be applied to a curve.

4.2.5.11 The maximum allowable vehicle speed for any curve shall be determined by the formula in figure 2

Figure 2: Determination of speed

$$V = 0.291\sqrt{E_q \text{ x } R}$$

where:

V = Maximum allowable vehicle design speed for curve in km/h

Eq = Equilibrium cant in mm = Ea + Ed

Ea = Actual cant in mm

Ed = Cant deficiency in mm

R = Radius of the curve in m

4.2.5.12 Track design for road share areas shall ensure existing tram fleet can comply with mandated road speeds.

4.2.6 Horizontal Alignment

4.2.6.1 The horizontal alignment of tram track centres shall be in accordance with values specified in appendix B2 of this standard.

4.2.6.2 Horizontal tram track alignment shall be defined by a combination of straight, circular and transition segment types only.

Information: Various combinations of circular and transition curves are used, the most desirable being a circular curve with identical transition curves at each end. This is the most common usage of a transition curve (linking a circular curve to a straight).

There are five different types of transitions in use in the tramway system, each serving its own purpose and with its own limitations.

1. *Euler Spiral: known as the Clothoid is the preferred transition for all track work.*
2. *Switch Spiral: the same as the Plain End Spiral but has the first 5°20'10" replaced with a constant radius of 45.720m.*
3. *Cubic Parabola: an approximation to the Euler spiral and can only be used up to 24°.*
4. *Plain End Spiral: a series of constant radius arcs of decreasing value, also known as Lorains No 3 Spiral.*
5. *30.480m Radius: a constant radius of 30.480m for an angle of 7°02'33". This is only used in extreme cases where space is limited and in depots.*

4.2.6.3 The tram track design shall use Euler spirals for curve transitions.

4.2.6.4 The tram track design shall use switch spirals for junctions.

4.2.6.5 Tram track straights shall be as long as is reasonably practicable.

4.2.6.6 Tram track curve radii shall be as large as is reasonably practicable.

4.2.6.7 Tram track radii of less than 50m shall not be used for angles less than 10°.

4.2.6.8 Curves less than 100m in radius shall be carefully considered as they may produce significant rail head squeal.

4.2.6.9 The maximum allowable speed through a bend shall be determined by the formula in figure 3.

Figure 3: Maximum allowable speed through a bend

$$V = 2.20 \times \sqrt{\frac{Ed \times B}{A}}$$

where:

V = Maximum allowable vehicle design speed in km/h

Ed = Allowable cant deficiency in mm

B = Bogie centres of rolling stock in m

A = Angle between two tangent tracks in deg

4.2.6.10 Where curves are introduced into mainline running tracks, normal transitions shall be used to ensure tangent or high radius tracks do not introduce situations that will impact on line running speed, so far as is reasonably practicable.

4.2.6.11 Circular curves without transitions shall only be applied to existing standard drawings including crossovers and depots to suit site constraints, subject to prior consultation and approval by Yarra Trams.

4.2.6.12 The minimum length of transition on any curve shall be determined by the formula in figure 4.

Figure 4: Lengths of transitions

The length of transition on any curve shall be the highest value result from the following three calculations:

1. $L = 0.0079 \times E_a \times V$
2. $L = 0.0079 \times E_d \times V$
3. $L = 0.4 \times E_a$

where:

L = Transition length in m

E_a = Actual cant in mm

E_d = Cant deficiency in mm

V = Maximum allowable vehicle design speed in km/h

Note: 0.0079 is calculated from (1/(rate of change of cant x conversion km/h to m/s))

4.2.6.13 Full transitions shall be applied on the rails attached to the curves of the switch.

4.2.6.14 Horizontal bends should be avoided so far as is reasonably practicable.

Information: Bends occur where two tangent tracks meet at near 180 degrees without an intermediate curve.

4.2.6.15 Tram track cant gradient shall not be steeper than 1 in 400.

4.2.6.16 Tram track rate of change of actual cant or cant deficiency shall not exceed 35 mm/sec [AM 55 mm/sec].

Information: In certain circumstances it may not be possible to apply the standard transition lengths as calculated from formula in Fig 4. If so, alternative solutions in increasing order may include:

1. *Adopting a greater rate of change of cant than specified in Fig 4, then recalculating the ideal transition lengths using the absolute maximum of 55 mm/sec instead.*
2. *Adopting a higher can deficiency.*
3. *Adopt a shorter transition than calculated but commence canting the track before the commencement of the transition and increase the cant until the full cant is applied. The distance over which the cant is increasing is to be symmetrical with the distance over which the track is transitioned.*

4.2.6.17 The minimum tram track centerline radius for curved platforms shall be 600 m.

4.2.7 Vertical Alignment

4.2.7.1 Where track grade changes by more than 0.2%, the tram track shall include a vertical curve between the two gradients.

4.2.7.2 The minimum desirable vertical curve radius shall be no less than 760 m [AM 500 m].

4.2.7.3 The tram track vertical alignment design shall be optimised for current grade work to match new works, so far as is reasonably practicable.

4.2.7.4 The tram track vertical grade alignment shall not exceed the maximum grade values specified in Appendix B8 of this standard.

4.2.7.5 The superelevation of inner rails on straight track in shared and or tram reserve areas shall be 6 mm above the outer rails, calculated to suit the general cross fall of the road.

Information: The higher track may slope down towards the lower track when there is a steep cross fall.

4.2.7.6 Where there is heavy cross traffic as determined by VicRoads, the four tram track rails shall be kept in one plane.

4.2.7.7 The tram track rails shall be kept in one plane, through junctions and or crossovers, to ensure that each rail has an even longitudinal profile.

4.2.7.8 The tram track design shall aim to maximise tram speed and minimise derailment risk at intersections, ensuring the maximum grade change in vertical alignment does not exceed 1.0 % [AM 4.0 %] in accordance with the prescribed grades used by Austroads specified in Table 1.

Table 1: Maximum grade change without a vertical curve, from Austroads 2016

Vehicle Operating Speed (km/h)	Grade Change %
40	1.0
50	0.9
60	0.8
70	0.7
80	0.6
90	0.5
100	0.4
110	0.3
120	0.2

4.2.7.9 Switches shall be designed so that the whole switch is placed at level grade.

4.2.7.10 Monoblock switches shall not exceed ±3 mm cant tolerance over the length of the switch.

4.2.7.11 No cant shall be applied to the 3 m [AM 2 m] of track on the incoming and outgoing sides of track switches, including mono-block switches.

4.2.7.12 No vertical curve shall be applied to the 3 m [AM 2 m] of track on the incoming and outgoing sides of track switches, including mono-block switches.

4.2.7.13 The change of track height on the 3 m [AM 2 m] of straight track preceding the switch shall not exceed 1 mm / 1 m of track length.

4.2.7.14 The tram track design shall assess twist through special works for input into asset lifecycle planning by determining acceptable maintenance tolerances.

4.2.8 Clearances

4.2.8.1 The tram track design shall ensure clearances to structures comply with the tram structure gauge drawing STD_T9000.

4.2.8.2 The tram track design shall ensure there is no interference between kinematic envelopes (STD_T0306) of two passing trams on straight track.

4.2.8.3 The tram track design shall ensure there is no interference between swept kinematic envelopes (STD_T0306) of two passing trams on curved track.

4.2.8.4 The tram track design shall ensure a minimum clearance of 350 mm [AM 250 mm] is maintained between tram swept envelopes when travelling on tracks curving in opposite direction.

4.2.8.5 Curved track design shall ensure a minimum clearance of 200 mm from the swept kinematic envelope of the tram to the outside traffic edge of any clearance or fairway line is maintained at all times.

4.2.8.6 Minimum tram track clearances to other road vehicles on at grade tangent tracks must be in accordance with standard drawing STD_T0310.

Information: Clearance to other road vehicles will be provided by a 150 mm continuous yellow line at 900 mm offset on straight track, measured from the running edge of rail to the outside traffic edge of the line.

4.2.9 Buffer Stops

4.2.9.1 Tram track design shall include the provision of buffer stops at the termination of all passenger-carrying tracks.

4.2.9.2 Buffer stops shall be consistent with the level of deceleration required to bring a fully laden tram coasting at 15km/h to a complete stop in an emergency.

4.2.9.3 Buffer stops shall be compatible with the front of all types of trams which operate on the Yarra trams network.

4.2.9.4 Buffer stops shall ensure tram deceleration rate is unlikely to so far as is reasonably practicable cause driver or passenger injury.

5 RELATED LEGISLATION AND DOCUMENTS

The following documents must be read in conjunction with this standard. Latest version of the referenced standards, procedures, guidelines, rules, and codes of practice shall be used. Yarra Trams internal standards have precedence over external standards in case of any discrepancies. Where referenced documents or requirements in this standard conflict, the most arduous conditions or requirements shall apply, and it shall be brought to Yarra Trams attention.

Name	Document number	Reference / Compliance
Tramway Engineering Survey Standard	TBA	Full Compliance
Guide to Road Design Part 3: Geometric Design (2016 Edition)	AGRD03-16	Full Compliance
VicRoads: Traffic Engineering Manual	TEM	Reference
Tram Class C1, C2, D1, D2 & E1 Axle Group Loads Estimate	STD_T0010	Full Compliance
Tram Kinematic Envelope	STD_T0306	Full Compliance
Typical Cross Sections at Grade Tracks	STD_T0310	Full Compliance
Tramway Structure Gauge	STD_T9000	Full Compliance
Rail Wheel Profiles – 60kg, 41kg, Ri57 & Ri57A	STD_T9002	Full Compliance
Standard Tie Bar	STD_T9003	Full Compliance
Plain End and Switch Spirals	STD_T9004	Full Compliance

Name	Document number	Reference / Compliance
Standard Check Plate, Block & Assembly – 41kg	STD_T9005	Full Compliance
Track Curve Construction – Special Check Plate, Block & Assembly – 41kg	STD_T9006	Reference
Track Construction at Crossing for Turnouts – Special Check Plate – 41kg	STD_T9007	Reference
De-stressing Procedure for 41kg Tram Rail – Gauge-Lock Clip Arrangement	STD_T9008	Full Compliance
Protection of Kirby Joints in CWR Ballast Track	STD_T9009	Full Compliance
Typical Track Structures	STD_T9010	Reference
Ballast Construction Track Design	STD_T9011	Full Compliance
Ballast Construction with Centre Poles Track Design	STD_T9012	Full Compliance
Left Hand Crossover for Straight Track Layout Plan	STD_T9015	Reference
Right Hand Crossover for Straight Track Layout Plan	STD_T9016	Reference
Left Hand Turnout for Straight Track Layout Plan	STD_T9017	Reference
Right Hand Turnout for Straight Track Layout Plan	STD_T9018	Reference
Right Hand Y Turnout for Straight Track Layout Plan	STD_T9019	Full Compliance
Track Drainage Trench Grate Arrangement	STD_T9020	Full Compliance
Track Drain – Triangular Pit for 41kg & Ri57- Assembly Details	STD_T9021	Full Compliance
Maximum Overhang of Trams – Combination of A, B, Z & W Classes	STD_T9056	Reference
Auto Points Typical Set Out	STD_T9057	Reference
Monoblock Crossing – Ri57A rail – Typical Assembly and Sections	STD_T9058	Full Compliance
Monoblock Points – Left Hand Crossover for Straight Track	STD_T9059	Full Compliance
Track Structures Transition – Ballast Track & Full depth Concrete Track	STD_T9060	Full Compliance
Auto Points Construction Details	STD_T9061	Full Compliance
Yarra Trams Tram Track Maintenance Standards	IN-023-MA-0002	Full Compliance
Melbourne and Metropolitan Tramways ACT 1958	No. 6311	Full Compliance
'Verband Deutscher Verkehrsunternehmen' (Association of German transportation companies) – Construction Guidelines – Part 14: Switches and Crossings	VDV-OR 14	Reference

Name	Document number	Reference / Compliance
Technical Drawing Part 201 – Mechanical drawing	AS 1100.201	Reference
Railway track material - Steel rails	AS 1085.1	Reference
Railway track material - Steel rails - History (Supplement 1 to AS 1085.1-2002)	AS 1085.1-2002 Sup 1:2017	Reference
Railway track material - Steel rails - History (Supplement 1 to AS 1085.1-2002)	AS 1085.1-2002 Sup 1:2017	Reference
Railway track material - Turnouts, switches and crossings	AS 1085.21	Reference
Railway safety management - General requirements	AS 4292.1	Reference
Railway safety management - Track, civil and electrical infrastructure	AS 4292.2	Reference
Aggregates and rock for engineering purposes - Railway ballast	AS 2758.7	Reference
Installation of underground utility services and pipelines within railway boundaries	AS 4799	Reference
Manual of uniform traffic control devices Part 2: Traffic control devices for general use	AS 1742.2	Reference
Manual of uniform traffic control devices Part 12 Bus, transit, tram and truck lanes	AS 1742.12	Reference
Manual of Uniform traffic control devices Part 14: Traffic signals	AS 1742.14	Reference
High-strength steel fastener assemblies for structural engineering - Bolts, nuts and washers - Technical requirements	AS 1252.1	Reference
High-strength steel fastener assemblies for structural engineering - Bolts, nuts and washers – Verification testing for bolt assemblies	AS 1252.2	Reference
Methods for sampling and testing aggregates	AS 1141	Reference
Railway Applications - Track - Special Purpose Rail - Grooved and Associated Construction	UNE EN 14811	Reference
Bridge Design – Design Loads	AS 5100.2	Reference

Name	Document number	Reference / Compliance
Human Factors Integration in Engineering Design – General Requirements	AS 7470	Reference
Procedure Safety Interface Coordination	SS-024-PR-0001	Reference
Procedure Deviation from Standards	CE-021-PR-0004	Reference
Manage Design Procedure	CE-021-PR-0006	Reference
Engineering Design Authority Procedure	CE-021-PR-0019	Reference

6 DOCUMENT VERSION CONTROL

Version History	Date	Detail
1.0	10/01/2020	Document first published
1.01	13/01/2020	Metadata change: Doc Group changed from CE to IN
1.02	17/03/2020	Title name change, metadata change from Doc Group IN to CE

APPENDIX A – GLOSSARY

Word	Definition
Design	Is the process of defining the solution (conceptual, preliminary or detailed) of the system, system elements or system component items.
Full Plateau	Refers to matching the grade on both rails at the same perpendicular plane to ensure minimal track twist and optimum ride quality.
Rail Infrastructure (As defined in Rail Safety (Local Operations) (Accreditation and Safety) Regulations 2017	Is defined in the Act as "the facilities that are necessary to enable a railway to operate and includes railway tracks and associated railway track structures, service roads, signalling systems, communications systems, rolling stock control systems, train control systems and data management systems, notices and signs, electrical power supply and electric traction systems, associated buildings, workshops, depots and yards, plant, machinery and equipment, tram stops and tram stations, but does not include rolling stock any facility, or facility of a class, that is prescribed by the national regulations not to be rail infrastructure".
Rail Infrastructure Manager (RIM)	Means a rail infrastructure manager within the meaning of the Rail Safety (Local Operations) Act 2006. In this Standard, it refers to Infrastructure Director or delegate.
Special Works	In this standard special works refers to all crossings, diamonds, switches, and connecting tracks
Straight Track	In strict railway terminology is defined the same way as tangent track. It must be noted however, that in Yarra Trams the term “straight track” may

Word	Definition
	be used to describe track with large curve radii, that is any track radius of more than 500 m.
Tangent Track	Is track with no curve radius. A tangent track shall be defined by direct connecting of a pair of tangent points, a pair of bends, or a combination of both.
Circular Track	Is track with a constant curve radius.
Transition Track	Is track used primarily for the connection of circular track with straight track to provide a smooth transition of varying curve radius.

APPENDIX B – ALIGNMENT PARAMETERS

B1. Horizontal Alignment - Track Gauge	
Straight and curved track (except turnouts)	1435 mm
Straight track through H Crossings	1430 mm
Straight track through Diamonds	1435 mm
Turnouts, (turnout move) opposite V Crossings	1435 mm
Turnouts, (through move) opposite V Crossings where cant is applied	1435 mm
Straight track for elevated track over maintenance pits	1430 mm

B2. Horizontal Alignment - Track Centres	
Normal straight track	3353 mm
Straight track for minimum kerb access or Easy access	3800 mm
Straight track with centre poles	4200 mm [AM 4000 mm]

B3. Horizontal Alignment - Radius	
Minimum main line[1]	500 m
Minimum from one street to another[1]	25 m
Minimum for depot[1]	25 m
Note[1]: All specified radii must include allowance for transitions.	

B4. Horizontal Alignment - Cant Deficiency	
Maximum cant deficiency	85 mm
Maximum rate of change for cant	1:400 (35mm/sec)
B5. Horizontal Alignment - Transitions	
Curves	Euler Spiral
For turnouts	Switch Spiral
Desirable main line length	25 m
Desirable city streets length (main line transition length)	12 m

B6. Horizontal Alignment - Miscellaneous	
Desirable minimum straight between reverse curves without transition (not required for curves with transitions)	8.5 m
Standard crossover angle	11°25’00”
Standard switch radius	45720 mm
Horizontal bend angle without curve	0°15’0”

B7. Horizontal Alignment - Flangeway Gaps	
Check Plated Rail or Grooved Rail - normal straight and curved track	30 mm
Check Plated Rail or Grooved Rail - through and opposite crossings	26 mm
In Concrete - sloped	25 - 50 mm

B8. Vertical Alignment - Grade	
Absolute maximum mainline track longitudinal alignment	6.67 %
Maximum mainline track longitudinal alignment	3.50 %
Absolute maximum tram stop track longitudinal alignment	2.50 %
Maximum tram stop track longitudinal alignment	0.50 %
Absolute maximum turnback and stabling track longitudinal alignment	1.00 %
Maximum turnback and stabling track longitudinal alignment	0.50 %
Minimum track longitudinal alignment[2]	0.25 %
Maximum grade change in road longitudinal alignment	1.00 %
Absolute maximum grade change in road longitudinal alignment	4.00 %
Note[2]: Minimum grade of 0.25 % allows for the required drainage slope to prevent pooling.	

B9. Vertical Alignment - Radius	
Minimum desirable curve	760 m
Absolute minimum for under curve	[AM 500 m]
Absolute minimum for over curve	[AM 500 m]

B10. Vertical Alignment - Cant	
Tangent track, inner rail above outer rail	6 mm
Maximum	100 mm
Desirable development rate	1 in 600
Maximum development rate	1 in 400
Maximum twist (10m chord)	25mm
Maximum twist (1.8m chord)	0 mm [AM 4 mm]
B11. Levels - Differences	
Desirable outer rail above margin	15 mm
Maximum outer rail above margin	30 mm
Desirable range between inner rails	20 - 50 mm
Maximum between inner rails	100 mm

B12. Check Plates (Guard Rails)	
Height above rail head	3 mm

B13. Clearances - Tram to Tram	
Minimum on curves between tram swept envelopes	350 mm [AM 250 mm]

B14. Clearances - Tram to Structures	
Minimum to permanent structures shall comply with[3]	STD_T9000
Minimum on curves from worst case tram swept envelope to overhead poles and flexible fences only	450 mm
Note[3]: Refer to Tramway Structure Gauge (STD_T9000)	

B15. Clearances - Tram to Other Vehicles	
Standard clearance line offset on straight track only	900 mm
Minimum clearance from edge of swept kinematic envelope on curved track[4]	200 mm
Note[4]: Additional distances must be allowed for overhang of trams on curved track.	

B16. Minimum Design Speed	
Straight Track and Tangent Track	85 km/h
Curves up to 50 m radius	15 km/h
Curves from 50 to 100 m radius	20 km/h
Curves from 101 to 240 m radius	30 km/h
Curves from 240 to 429 m radius	45 km/h
Curves from 430 to 999 m radius	60 km/h
Greater than 1000 m radius	85 km/h
Through special work[5]	15 km/h
Minimum speed for mainline curves into tram stops	40 km/h
Note[5]: Cant deficiency may exceed the maximum allowable through special works only.	

B17. Rail Types	
41kg T-rail for all ballast and running shed pits to be head hardened- HSHM	41 kg/m
Grooved rail for embedded track sections greater than 500 m radius, 18 Metre Lengths (57.37kg/m) - Grade S700	Ri57A/R10
Grooved rail for embedded track sections less than 500 m radius and junctions shall be head hardened - HSHM	Ri57A/R10

APPENDIX C – TRAM SPECIFICATIONS

Tram Class	W8	Z3	A1	A2	B1	B2	Citadis C1	Citadis C2	Combino D1	Combino D2	Flexity E
Trams in Fleet	2	114	28	42	2	130	36	5	38	21	(80)
Dates Delivered	2013 - >	1979-1984	1984-1985	1985-1986	1984-1985	1988-1994	2001-2002	2008	2002-2003	2003-2004	2013 - >
Configuration, Dimensions and Capacity											
Bogie Configuration	M - M	M - M	M - M	M - M	M - T - M	M - T - M	M - M	M - T - M	M - M	M - T - M	M -T - M - M
Overall length	14.17 m (46ft-6in)	16.64 m	15.01m	15.01m	23.53 m	23.63 m	22.99 m	32.517 m	20.04 m	29.85 m	33.45 m
Overall width	2.74 m (9 feet) over step boards	2.67 m	2.67 m	2.67 m	2.67 m	2.67 m	2.65 m	2.65 m	2.65 m	2.65 m	2.65 m (max 2.755 m)
Overall height	3.149 m (10ft - 4ins)	3.540 m	3.346 m	3.346 m	3.346 m	3.650 m	3.360 m	3.27m	3.635 m	3.635 m	3.65 m
Weight		Body - 12.24 t Bogie - 4.78 t Tare - 21.80 t	Body - 12.64 t Bogie - 4.78 t Tare - 22.20 t	Body - 12.64 t Bogie - 4.78 t Tare - 22.20 t	Body - 20.50 t MB - 4.78 t Tare - 32.50 t	Body - 21.39 t MB - 4.75 t Tare - 34.00 t	Tare: 28.6 t	Tare: 39.6 t	Tare: 26.8 t	Tare: 37.4 t	Tare: 46.0 t
Seating capacity	46	38	40	40	74	74	40	56	36	64	64
Total passenger capacity		125	117	117	182	182	145 (4pax/m2)	231 (4pax/m2)	124 (4pax/m2)	194 (4pax/m^2)	210 (4pax/m2)
Bogie Details											
Bogie Type	No 15	DUWAG	DUWAG	DUWAG	DUWAG	DUWAG	ALSTOM Solfege	ALSTOM Arpege	Siemens	Siemens	Bombardier
Bogies - centre to centre	8534mm (28feet)	8500mm	8500mm	8500mm	8500mm	8500mm	12791mm	11143mm	11440mm	9810mm & 11440mm	9650mm 5520mm 9650mm
Bogie wheel Base (b/n axles)	1575mm (5ft-2ins)	1800mm	1800mm	1800mm	1800mm	1800mm	1850mm	1600mm	1800m	1800mm	1850mm
Min. Ground Clearance							60 mm (worn wheels)	50mm	65mm	65mm	
Wheels	Solid 710mm	Bochum 660-600mm	Bochum 660-600mm	Bochum 660-600mm	Bochum 660-600mm	Bochum 660-600mm	Valdunes 610-550mm	Valdunes 610-550mm	LUCCHINI 600-520mm	LUCCHINI 600-520mm	Bochumer Verein 600-520mm
Motors	GE 247 DC 4x30 kw (40 hp)	AEG ABS 3322 DC 2x195 kw	AEG ABS 3322 DC 2x195 kw	AEG ABS 3322 DC 2x195 kw	AEG ABS 3322 DC 2x195 kw	AEG ABS 3322 DC 2x195 kw	ALSTOM 4LMA1245N AC 4 x 100kW air cooled	ALSTOM AC 4 x 120kW water cooled	Siemens 1TB1422-0GA03 AC 4 x 100kW air cooled	Siemens 1TB1422-0GA03 AC 4 x 100kW air cooled	Bombardier 4WXA2257 AC 6 x 105kW water cooled
Control and Performance Details											
Traction Control		Foot controller / DC Chopper	Foot controller / DC Chopper	Foot controller / DC Chopper	Foot controller / DC Chopper	Foot controller / DC Chopper	Hand controller / AC VVVF inverter	Hand controller / AC VVVF inverter	Hand controller / AC VVVF inverter	Hand controller / AC VVVF inverter	Hand controller / AC VVVF inverter
Control		AEG SIEMENS CCU	AEG SIEMENS CCU	AEG SIEMENS CCU	AEG SIEMENS CCU	AEG SIEMENS TCU	ALSTOM Agate	ALSTOM Agate	SIEMENS TCU, VCU	SIEMENS TCU, VCU	Bombardier
Max speed		65Km/hr Powers off	65Km/hr Powers off	65Km/hr Powers off	65Km/hr Powers off	65Km/hr Powers off	77-80Km/hr Powers off	70Km/h	70Km/hr Powers off	70Km/hr Powers off	80km/h
Tram Class	**W8**	**Z3**	**A1**	**A2**	**B1**	**B2**	**Citadis C1**	**Citadis C2**	**Combino D1**	**Combino D2**	**Flexity E**

Forced braking		75Km/hr forced braking	75Km/hr forced braking	75Km/hr forced braking	75Km/hr forced braking	75Km/hr forced braking	No forced braking	No forced braking	No forced braking	No forced braking	60km/h traction cut, 65km/h brakes apply
Auxiliary power		MA 43A@27.6v	MA 43A@27.6v	MA 43A@27.6v	MA 90A@27.6v	Inverter 220A@27.6v	Inverter 350A@28Vdc XXXA@400Vac	Inverter 13KW @28Vdc 12KVa@400Vac	Inverter 285A@27.6Vdc	Inverter 285A@27.6Vdc	Inverter 24VDC / 8kW 230VAC / 3.6kVA 400VAC / 55kVA
Max. Traction Current Demand		550A	550A	550A	550A	1000A	970A		1200A	1200A	1200A
Air Conditioning		6.5 A @220V where fitted	6.5 A @220V	NA	NA	50A	83A @600V 111A @450V	18kW			23kW x 3 4.5kW x 2 (cab)
Speed at max. current draw (km/h)		Approx. 30	Approx. 30	Approx. 30	Approx. 30	Approx. 30	29 km/h @600V 21.8 km/h @450V		39-55	30-55	
Voltage Cut out level (Volts)		330	330	330	400	400			400	400	
Power Limiting		Yes 350A	Yes 350A	Yes 350A	Yes 600A	Yes 600A	No		Yes, 1300A	Yes, 1300A	
Pantograph max. operational height	6.54 m	6.24 m	6.24 m	6.24 m	6.24 m	6.24 m	6.69 m		6.34 m	6.34 m	5.9m
Pantograph auto-drop	900N or 90kg	N/A	N/A	N/A	N/A	N/A	900N or 90kg	N/A	N/A	N/A	auto drop fitted
Acceleration		1.5 m/s^2 ± 0.05	1.5 m/s^2 ± 0.05	1.35 m/s^2 ± 0.05	1.35 m/s^2 ± 0.05	1.35 m/s^2 ± 0.05	1-30kph ± 1.57 m/s^2 1-60kph ± 1.57 m/s^2	1.03 m/s^2 - 5%	≤1.3m/s^2 to 39kph ≤0.95m/s^2 avg. to 70kph	≤1.3m/s^2 to 30kph ≤0.86m/s^2 avg. to 60kph	1.3m/s^2 to 30kph (fully loaded)
Deceleration		**Dynamic** 1.6 m/s^2 ± 0.05 **Mechanical** 1.4 m/s^2 ± 0.1	**Dynamic** 1.6 m/s^2 ± 0.05 **Mechanical** 1.4 m/s^2 ± 0.1	**Dynamic** 1.6 m/s^2 ± 0.05 **Mechanical** 1.4 m/s^2 + 0.3 -0.1	**Dynamic** 1.55 m/s^2 ± 0.05 **Mechanical** 1.4 m/s^2 ± 0.1	**Dynamic** 1.55 m/s^2 ± 0.05 **Mechanical** 1.4 m/s^2 ± 0.1	Normal service control position 1.2 m/s^2	**Dynamic** 1.39 m/s^2 -5% **Mechanical** 1.2 m/s^2	max ≤1.61m/s^2 average ≤1.35m/s^2	max ≤1.47m/s^2 average ≤1.25m/s^2	avg. 1.5m/s^2
Emergency braking		Mostly over ≤ 3.0m/s^2	Mostly over ≤ 3.0m/s^2	Mostly over ≤ 3.0m/s^2	Mostly over ≤ 3.0m/s^2	Mostly over ≤ 3.0m/s^2	⍰ 3.0 m/s^2	⍰ 2.67 m/s^2	max ≤3.40m/s^2	max ≤3.30m/s^2 average ≤2.74m/s^2	avg. 2.8 m/s^2

APPENDIX D – ADDITIONAL DESIGN REQUIREMENTS

ID	Requirement
D001	New routes and State funded tram tracks shall be designed for a maximum rolling stock axle load of 12.5t.
D002	Vertical alignment of tram tracks should be designed to ensure vertical acceleration does not exceed 2.25%g [AM 3.25%g] under normal operating conditions.
D003	Tram track turnouts shall be selected to ensure the maximum non-compensated lateral acceleration on turnouts diverging track does not exceed 0.40 m/s^2 [AM 0.79 m/s^2].
D004	Tram track turnouts shall be selected to ensure the maximum entry and exit jerk does not exceed 0.40 m/s^3 [AM 0.61 m/s^3].
D005	Where a wire-free traction system has been selected, the track structure shall ensure that the drainage arrangement provided for the tram track accommodates the requirements of the traction power system.
D006	New tram tracks shall be designed and constructed to ensure rolling stock does not cause excessive noise and vibration pollution, so far as is reasonably practicable.
D007	Prescribed noise limits within neighbourhood buildings shall be as low as reasonably practicable.
D008	New tram tracks should use proven track-form systems, including cost appropriate noise and vibration mitigation measures.

APPENDIX E – TRACK RELATED DESIGN LIFE REQUIREMENTS

ID	Asset (Rail Systems)	Design Life
E001	Rails on plain line track	40 years
E002	Rails where the horizontal radius is <100m	15 years
E003	Rail joints (welds, insulated, movement)	40 years
E004	Rail pads, rail base plates and fixings	20 years
E005	Track turnouts and crossings	40 years
E006	Sleepers	50 years
E007	Ballast	25 years
E008	Sub ballast mats and specialist formation treatments	50 years