Engineering Standard

Track and Structures

# MTST 000002-01

# TRACK DESIGN AND CONSTRUCTION

**Version:** 3

**Issued:** December 2017

**Owner:** Chief Engineer

**Approved By:**

Phil Ellingworth

Chief Engineer

## Approval

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## Amendment Record

| Approval Date | Version | Description |
|---|---|---|
| 14/12/2012 | 1 | Initial Release under MTM. |
| 23/11/2016 | 2 | Document number L1-SDD-STD-007 amended to Engineering Division designation. Updated Version incorporating changes developed since initial release. The following Clauses have been amended:<br>Clause 2.2, 2.4, 3, 4, 5.1.3, 5.2, 5.3, 5.4, 6, 8.4, 9.1, 9.2, 9.3, 9.5, 9.8, 9.9, 9.10, 9.12, 9.13, 9.14, 9.15, 9.16, 10.1, 10.2, 10.3, 10.4.<br>The following Clauses have been added:<br>8.5, 8.6, 9.4, 9.6, 9.7, 9.11, 9.12, 9.17, 10.1.4, 10.1.11, 10.1.12, 10.1.14, 10.1.15, 10.2.4, 10.3.2.<br>The following clauses and sections of the previous standard have been omitted:<br>10.5, 10.6, 10.7, 10.8, 11, 12, 13, 14, 17. |
| 22/12/2017 | 3 | Revised clauses on vertical grades and general document update as detailed in MOC #22672. This version supersedes L1-CHE-INS-018. |

## PREFACE

Metro Trains Melbourne (MTM) Standards have been developed to ensure consistent approaches are employed when designing, constructing or testing any part of the Melbourne Metropolitan Rail Network. It is important to understand that standards are living documents which take into account learnings to achieve best practice.

All MTM Standards are periodically reviewed and new versions published which incorporate learnings and Design Practice Notes (DPNs). DPNs are issued between versions in order to correct any errors or ambiguities contained in an MTM Standard. Standards may also be withdrawn and replaced. As Standards are uncontrolled once printed, it is imperative to check the currency of the standard on the MTM Intranet or MTM External Document Portal.

In the event of conflicts or discrepancies between Documents, the order of precedence as defined in 'Chief Engineer's Guideline Engineering Standards Listing' (L1-CHE-GDL-005) shall be referred to.

**Note:** Any clarification described in a DPN **shall** take precedence over the impacted clause or clauses in the associated MTM Standard.

In the event a clause within a standard is not achievable a waiver must be raised in accordance with 'Engineering Waiver Procedure' - L1-CHE-PRO-001.

**Note:** MTM does not have the authority to grant waivers to any Standards which relate to Government Regulations or Legislation, e.g. Disability Discrimination Act.

### Application of this Standard

*This Standard is applicable from the approval date.*

## Table of Contents



## List of Tables

## 1 Purpose

**1.1** To define the Standard for the design and construction of main lines, sidings and other track for the Melbourne metropolitan railway.

## 2 Scope

**2.1** This Standard applies to the design and construction of all new or upgraded main lines, sidings and other track for the 1600mm broad gauge Melbourne metropolitan railway.

**2.2** The Standard applies to works on the Infrastructure Lease and to track works undertaken on other land which are intended to expand or enhance the provision of passenger services and to form part of the Infrastructure Lease.

**2.3** The provisions of this Standard are mandatory where the terminology as provided in the definitions require conformance.

**2.4** This Standard takes precedence over other documents relating to the design and construction of rail track.

## 3 Abbreviation

| | |
|---|---|
| D | Cant Deficiency. |
| Ee | Equilibrium Cant. |
| Ea | Applied Cant. |
| HCMT | High Capacity Metro Train |
| MTM | Metro Trains Melbourne Pty. Ltd. |
| L | Length of Transition Spiral. |
| R | Horizontal Curve Radius. |
| V | Speed (Design). |
| Km/h | Kilometres per hour. |

## 4 Definitions

| | |
|---|---|
| Design Grade | The effective grade on the line or section of line being the geometric gradient plus the gradient effect of curve resistance |
| Element | A straight or curved geometric component that forms part of the track alignment, with no variance in the bearing angle or radius |
| Infrastructure Lease | Is defined as the meaning in the Franchise Agreement. |
| Line Type | The demarcation of the metropolitan network based on rolling stock and line characteristics detailed in L1-CHE-MAN-010 WTT Network Configuration Governance (formally Working Timetable). |
| Ruling Gradient | The maximum Design Grade on the line or section of line |
| Shall | A requirement that is mandatory to achieve conformance to the standard. |

| | |
|---|---|
| Should | A requirement that is recommended in order to achieve compliance to the standard. It can also be used if a requirement is a design goal but not a mandatory requirement. |
| VRIOGS | Victorian Rail Industry Operators Group Standard |

## 5 References & Legislations

### 5.1 General

5.1.1 New railway track and upgraded track shall be designed and constructed in accordance with this Standard and relevant MTM Standards and Australian, Rail Industry and International Standards.

5.1.2 The design and construction of the track shall comply with all legislative requirements and codes.

### 5.2 MTM Standards and Documents

| Document Number | Title |
|---|---|
| L0-SQE-PLA-005 | Environmental Management Plan |
| L1-CHE-PRO-031 | Engineering Change Procedure |
| L1-CHE-PRO-001 | Standard Waiver Procedure |
| L1-CHE-PRO-004 | Type Approval Procedure |
| L1-CHE-STD-001 | MTM Requirements – Metropolitan Train Stabling |
| L1-CHE-SPE-001 | Heavy Rail Construction Tolerances |
| L1-CHE-STD-029 | Track Drainage Standard |
| L1-CHE-STD-030 | Earthworks & Formation Design |
| L2-TRK-PRO-029 | Welded Track Management Manual Chapter 8 – Laying Rail. |

### 5.3 Rail Industry Standards

5.3.1 This standard shall take precedence over documents below marked with *, but shall be used if this standard does not specifically replace the content of them.

| Document Number | Title |
|---|---|
| N/A* | Metrail Track Design 1986 |
| PTC 0006012* | Heavy Rail Track Design Standard Part B – 1997 (ver. 1.3) |
| AG:SPEC010* | Heavy Rail Track Construction Standard Part C – 1997 (ver. 1.3) |
| VRIOGS 001 | Structure Gauge Envelopes – Minimum Clearance for Infrastructure Adjacent to the Railway |
| n/a | PTV Infrastructure Drafting Standards |

## 5.4 Australian Standards

| Document Number | Title |
|---|---|
| AS 2758.7 | Aggregates and rock for engineering purposes - Railway ballast |
| AS 1141 | Methods for sampling and testing aggregates |
| AS 1289 | Methods of testing soils for engineering purposes. |
| AS 7635 | Track Geometry |

## 5.5 International Standards

Nil

# 6 Related Documents

| Document Number | Title |
|---|---|
| STD_C0008 | Track Formation and Ballast for Open Track 1600mm Gauge Construction (F598) |
| MTSP 000003-03 | Heavy Rail Construction Tolerances |
| L1-CHE-MAN-010 | WTT Network Configuration Governance |

# 7 Safety and Environmental

**7.1** The general requirements in relation to safety are included in MTM's Safety Management System Manual (L0-SQE-MAN-002).

**7.2** The design and construction of the track shall comply with the L0-SQE-PLA-005 - MTM Environmental Management Plan.

**7.3** All rail safety workers shall comply with Business Rules Manual for the Contracting Rail Safety Worker (L0-HMR-MAN-001) and have the appropriate competencies to undertake their role.

**7.4** Under RSNL (s46) MTM is required to:

a. Eliminate risks to safety so far as is reasonably practicable (SFAIRP); and

b. If it is not reasonably practicable to eliminate risks to safety, to minimise those risks so far as is reasonably practicable.

**7.5** Under RSNL (s47), reasonably practicable means that at a particular time, MTM were able to demonstrate how the risk/s can be reasonably managed to ensure safety, taking into account and weighing up all relevant issues including:

a. The likelihood of the hazard or the risk concerned occurring;

b. The degree of harm that might result from the hazard or the risk;

c. What the person concerned knows, or ought to reasonably know, about:

i. the hazard or risk, and ways of eliminating or minimising the risk;

ii. the availability and suitability of ways to eliminate or minimise the risk; and

d. After assessing the extent of the risk and the available ways of eliminating or minimising the risk, the cost associated with available ways of eliminating or minimising the risk, including whether the cost is grossly disproportionate to the risk.

**7.6** Under RSNL (s50), rail safety is a shared responsibility of:

a) Rail transport operators; and

b) Rail safety workers; and

c) Other persons who:

i. Design, commission, construct, manufacture, supply, install, erect, maintain, repair, modify or decommission rail infrastructure or rolling stock; or

ii. Supply rail infrastructure operations or rolling stock operations to rail operators; or

iii. In relation to the transport of freight by railway—load or unload freight on or from rolling stock.

**7.7** Safety and risk assessments shall be undertaken to inform the design. It shall take into account safety considerations for construction and maintenance personnel and any other party, including operations personnel who may be required to use the track. Risk assessments shall be conducted in accordance with the MTM Enterprise Risk Management Procedure L0-SQE-PRO-031.

**7.8** Where new equipment or systems are proposed to be introduced, the materials and equipment shall be subject to MTM Type Approval processes for use on the metropolitan train network.

## 8 Functionality

**8.1** Main line tracks shall be designed and constructed for the service level and line speeds specified in project specific functional requirements described in the relevant MTM Final Operational Requirements and Final Impact Statement for the project.

**8.2** The design shall ensure compliance with the Structure Gauge Envelopes applicable to the category of ownership of the incumbent infrastructure as outlined in VRIOGS 001.

**8.3** The designer shall provide design drawings in accordance with Appendix D.

## 9 General Principles for Track Design and Construction

**9.1** Main line track shall be designed and constructed for the safe and reliable operation of trains at line speed with axle loads identified in L1-CHE-MAN-010 WTT Network Configuration Governance, or specified in the Final Operational Requirements.

**9.2** Where practical, given the existing Infrastructure Lease, track alignment and track class, within fifteen kilometres of Flinders Street Station main line track shall be designed and constructed for an operating speed of 80 kilometres per hour. Elsewhere, main line track shall be designed and constructed for an operating speed of up to 160 kilometres per hour.

**9.3** As far as is practical, the track speed shall be designed and constructed for a uniform line speed between junctions and major stations. The line speed shall be the maximum practical in accordance with this Standard and as stated in project specific functional requirements described in the relevant MTM Final Operational Requirements and Final Impact Statement for the project.

**9.4** Track curves shall be of the maximum radius practical at the location but should not be designed and constructed so as to take the width of the easement and preclude the construction of additional tracks within the easement in the future.

**9.5** The number of individual horizontal or vertical geometry elements shall be minimised. Each element shall be as long as practical, and should provide an adequate length to suit the travel time at a maximum line speed.

**9.6** Track gauge shall be 1600mm measured between the running edge. Gauge widening shall be applied in accordance with L2-TRK-PRO-029.

**9.7** The track radius is the radius of the centreline of the track.

**9.8** The design and construction of new tracks should not introduce track gradients greater than those on the existing line that will become the ruling grade on the corridor as identified in the Metro Trains Working Timetable Addenda. Curve resistance on grades shall be taken into account in determining the effective gradient.

**9.9** The performance of metropolitan rolling stock shall be taken into account in setting maximum grades of track. A crush loaded metropolitan train with 50% of its traction system inoperative shall be capable of moving from standstill on the grade to the next station.

**9.10** The track design shall always meet the 'desirable' values set within this standard. If this can be demonstrated as impractical, the design shall remain within the 'absolute' limits and be as close to the 'desirable' values as possible. Use of the 'absolute' limits shall be subject to acceptance by the Head of Engineering – Track & Structures (or delegate), prior to construction.

**9.11** The design speed in sidings shall be 15 km/h, with consideration for the diverge speed on the main line.

**9.12** The design of turnouts shall be compatible with the specified speed for the diverge move. Standard speeds for the diverging move through tangential turnouts are to be maintained at 30, 40, 65 and 80 kilometres per hour.

**9.13** The design of turnouts and crossingwork within sidings shall be in accordance with L1-CHE-STD-001 – MTM Requirements – Metropolitan Train Stabling.

**9.14** New track construction shall use type approved components, including full depth or low profile concrete sleepers at 685mm spacing, 60kg/metre rail, resilient fastenings or other type approved MTM track construction components and in accordance with Standard Plan F598.

**9.15** Low profile sleepers may be used for new construction, maintenance and refurbishment of existing main lines.

**9.16** Construction of new and upgraded track shall be in accordance with design and the Chief Engineer Specification MTSP 000003-03 – Heavy Rail Construction Tolerances

**9.17** Main line turnouts shall be of tangential design mounted on concrete bearers, or fixed on ballastless track structures.

# 10 Track Geometry

## 10.1 Horizontal Geometry

10.1.1 The radius of a main line curve should satisfy the general principles outlined in section 9. The minimum radius for new and realigned track shall be 380 metres. Table 3 specifies the minimum radii at typical line speed increments.

10.1.2 Transition spirals shall be designed and constructed between tangent track and circular curves and between circular curves.

10.1.3 The desirable minimum length of a straight or curved element shall be calculated by:

$L_{MIN} = V / 2$

Where

$L_{MIN}$ = Element length (m)

V = Maximum Line speed (km/h)

10.1.4 The absolute minimum length of a straight or curved element shall be 25 metres.

10.1.5 Transition spirals and circular curves shall be designed and constructed with cant where necessary to reduce the lateral acceleration in a curve.

10.1.6 The applied cant should seek to limit the overall wear on the track by taking account of the variety of rolling stock using the line, the likely operating speeds and stopping patterns and the maximum permissible cant and deficiency. Typically the applied cant should be 65% of the line speed equilibrium cant.

10.1.7 Cant shall be applied to the full length of the transition spiral from the tangent point to the maximum applied cant on the curve.

10.1.8 The rate of application of cant shall meet the parameters shown in Table 1.

**Table 1: Rate of Application of Cant**

| Parameter | Rate of Application |
|---|---|
| Desirable | 1 in 1000 |
| Maximum | 1 in 667 |
| Minimum | 1 in 2000 |

10.1.9 Transition spirals shall be of a length to provide a desirable equivalent rate of change of lateral acceleration of 0.305 $m/s^3$ at line speed.

10.1.10 The length of the transition spiral shall be determined by four desirable parameters (refer Table 2) being transition design twist, rate of change of lateral acceleration, large cant to cant deficiency ratio and low cant to cant deficiency ratio.

10.1.11 The length of the transition spiral shall be set by the parameter which gives the longest spiral length and shall be rounded up to the nearest 5 metres

10.1.12 Where a reverse curve with adjoining transition spirals cannot be avoided, the calculations for the Rate of Change of Lateral Acceleration in each transition spiral shall be of a similar figure for passenger comfort.

10.1.13 Compound curves comprising two or more contiguous unidirectional curves of differing radii shall be avoided if physically and economically viable. If unavoidable, the larger radius of the curves should be not more than 25% greater than the radius of the sharpest curve

10.1.14 If the calculated desirable transition spiral length values are less than the nominated bogie centres (16.15m), the transition spiral may be omitted and a Virtual Transition may be used. Absolute limits shall not be used for Virtual Transition calculations.

10.1.15 A Virtual Transition shall not be used when a change in applied cant is required.

**Table 2: Transition Spiral Minimum Length Calculations**

| Parameter | Desirable | Absolute |
|---|---|---|
| Transition design twist | $L_{min}$ =1*C | $L_{min}$ = 0.67*C |
| Rate of change of lateral acceleration | $L_{min}$ = 0.0705*$V^3$ / R | $L_{min}$ = 0.047*$V^3$ / R |
| Large cant to cant deficiency ratio | $L_{min}$ = V*C / 90 | $L_{min}$ = V*C / 135 |
| Low cant to cant deficiency ratio | $L_{min}$ = V*D / 90 | $L_{min}$ = V*D / 135 |
| $L_{min}$ = Spiral length (metres), V=Velocity (km/h), C=Cant (mm), D=Cant Deficiency (mm), R=Radius (metres) | | |

10.1.16 For the design of all tracks through new platforms, tangent track shall be provided for the extent of the platform including any future extension provision, plus 20m beyond each end to mitigate vehicle centre or end throw.

10.1.17 For existing tracks where rehabilitation is undertaken, the existing platform geometry will determine the minimum allowable radius. Application of cant should be minimised, with a maximum applied cant should be 50mm if practicable. At locations where raised boarding platforms are required, the track geometry shall be tangent 24 metres either side of the intended boarding platform and be constructed with concrete sleepers.

**Table 3: Line Speeds, Minimum Horizontal Curve Radii, Cant and Cant Deficiency**

| Maximum Line Speed (km/h) | Minimum Curve Radius (m) | Maximum Applied Cant (mm) | Maximum Cant Deficiency (mm) |
|---|---|---|---|
| 160 | 1650 | 120 | 85 |
| 130 | 1200 | 110 | 85 |
| 115 | 950 | 100 | 85 |
| 100 | 800 | 80 | 85 |
| 80 | 510 | 80 | 85 |
| 65 | 380 | 80 | 85 |
| 65* | 340 | 80 | 85 |
| 50* | 200 | 80 | 85 |
| 40* | 150 | 80 | 85 |

* Existing conditions only, unless otherwise specified in the relevant MTM Final Operational Requirements and Final Impact Statement for the project or agreed with the Chief Engineer. Full application of cant and/or deficiency may not be practicable.

## 10.2 Vertical Curves

10.2.1 Vertical curves shall be designed and constructed between all changes of constant grade where the change in constant grade is greater than the rates of change in grade given in Table 4 for the relevant Line Type.

10.2.2 The design and construction shall be to the “desirable rates” in Table 4. Where rates of change of grade in excess of the “desirable rates” are proposed the details shall be stated in in the relevant MTM Final Operational Requirements and Final Impact Statement for the project.

10.2.3 A minimum distance of 25 metres at constant grade shall be provided between vertical curves. The rate of change of grade shall not exceed that stated in Table 4.

10.2.4 The minimum vertical curve length shall be 20 metres.

10.2.5 The design and construction of the track should minimise the co-location of horizontal and vertical curves.

**Table 4: Vertical Curves - Rates of Change of Grade**

| Track Location | Sag / Summit | Desirable Rate (metre/metre /metre) | Equivalent Desirable Radii * (metre) | Maximum Rate (metre/metre /metre) | Equivalent Minimum Radii * (metre) |
|---|---|---|---|---|---|
| Line Type 1 | Sag | 0.004/10/10 | 25,000 | 0.038/10/10 | 2,650 |
| Line Type 1a | Summit | 0.008/10/10 | 12,500 | 0.060/10/10 | 1,700 |
| Line Type 2 | Sag | 0.004/10/10 | 25,000 | 0.015/10/10 | 6,700 |
| | Summit | 0.008/10/10 | 12,500 | 0.030/10/10 | 3,350 |
| Sidings | Sag | 0.038/10/10 | 2,650 | 0.328/10/10 | 300 |
| | Summit | 0.060/10/10 | 1,700 | 0.121/10/10 | 850 |

* Radii are approximations based on equivalent quadratic parabola

## 10.3 Gradients

10.3.1 The design gradient of new track should not be greater than the Ruling Gradient of the existing line between the new location and Flinders Street Station as defined in L1-CHE-MAN-010 WTT Network Configuration Governance.

10.3.2 The Maximum Design Gradients shall comply with Table 5 for the relevant Line Type, detailed in Appendix A.

10.3.3 Use of Design Gradients exceeding the Desirable Maximum and/or the Ruling Grade but meeting the Absolute Maximum Gradient shall be subject to the requirements listed in Appendix B.

10.3.4 Use of Design Gradients exceeding the Absolute Maximum Gradient but meeting the Exceptional Maximum Gradients shall be subject to the requirements listed in Appendix C, with approval by PTV and the Chief Engineer.

**Table 5: Desirable and Absolute Limits for Design Gradients**

| Track Location | Desirable Maximum | | Absolute Maximum | | Exceptional Maximum | |
|---|---|---|---|---|---|---|
| Line Type 1 | 1 in 100 | 1.0% | 1 in 40 | 2.5% | N/A | |
| Line Type 1a | 1 in 100 | 1.0% | 1 in 40 | 2.5% | 1 in 28.5 | 3.5% |
| Line Type 2 | 1 in 100 | 1.0% | 1 in 50 | 2.0% | N/A | |
| At platforms | 1 in 300 | 0.33% | 1 in 150 | 0.667% | N/A | |
| At terminal platforms at end of electrified network | 1 in 400 | 0.25% | 1 in 250 | 0.4% | N/A | |
| Sidings | 1 in 400 | 0.25% | 1 in 250 | 0.4% | N/A | |

10.3.5 Design gradients shall be compensated for horizontal curvature using the following formula:

$G_C = G_{MAX} – C$

Where

$G_C$ = Compensated Design Gradient (%)

$G_{MAX}$ = Ruling Gradient (%)

C = Curve resistance (%)

Curve resistance is calculated by:

C = 60.96 / R

Where

R = Curve radius (m)

### 10.4 Turnouts and Crossings

10.4.1 Main line turnouts and crossings shall be designed and constructed to comply with the train speed, service frequency and service patterns specified in project specific functional requirements described in the relevant MTM Final Operational Requirements and Final Impact Statement for the project. For sidings, turnouts and crossings shall comply with L1-CHE-STD-001 - MTM Requirements – Metropolitan Train Stabling.

10.4.2 Turnouts and crossings shall be of approved standard types currently in use within MTM. The positioning of turnouts and crossings in track shall ensure that all sleepers and rail lengths detailed on the approved shop drawings can be installed without modification.

10.4.3 New designs and constructions may be introduced in accordance with L1-CHE-PRO-003 - Type Approval Process for new materials within the metropolitan railway.

10.4.4 Turnouts and Crossing angles shall comply with the Chief Engineers Advice Note L1-CHE-GDL-021 for safe normal speeds through turnouts.

## 11 Level Crossings

**11.1** All new vehicle / pedestrian level crossings, maintenance access pads, or other crossing point shall be constructed using type approved removable panels. Asphalt shall not be placed on the track over sleepers.

**11.2** For existing crossings, where rails are placed in vehicle / pedestrian level crossings, maintenance access pads, or any other sealed surface built up around the rails, the rails shall be coated with bituminous paint or similar insulating material to mitigate against electrolytic corrosion. The coating is to be continuous and to be checked and made good prior to placement of the road or pedestrian crossing as corrosion may be accelerated with small areas of rail exposed.

## 12 Welded Track Construction

**12.1** Main Line track shall be designed and constructed using continuously welded rail.

**12.2** Curve and creep monuments shall be installed in accordance with MTPR 033000-13 'Welded Track Management Manual.'

## 13 Alternative Main Line Track Construction

**13.1** Alternative track constructions to concrete sleeper on ballast shall use type approved products in accordance with an agreed trackform design stated in project specific functional requirements described in the relevant MTM Final Operational Requirements and Final Impact Statement for the project.

## Appendix A: Line Type Demarcation

The Metropolitan Railway Network "5 Railway Groups" are demarcated into two Line Types network based on rolling stock and line characteristics detailed in L1-CHE-MAN-010 WTT Network Configuration Governance.

For the purpose of this Standard, the Line Types shall be used to reference the relevant design parameters at any given location on the Metropolitan Railway Network.

| Line Type | Metropolitan Railway Network Location |
|---|---|
| Type 1 | • Burnley Group (All Lines)<br>• Clifton Hill Group (All Lines)<br>• Cross City Group:<br>○ South Yarra – Sandringham<br>○ Newport – Williamstown<br>○ Altona Junction – Laverton Junction (Altona Loop)<br>• Melbourne Underground Rail Loop (MURL)<br>• Northern Group:<br>○ North Melbourne – Upfield<br>○ Newmarket Junction – Flemington Racecourse |
| Type 1a | • Melbourne Metro Rail Tunnel:<br>○ South Kensington – South Yarra |
| Type 2 | • Dandenong Group (All Lines)<br>• Cross City Group:<br>○ Flinders Street Station – Stony Point<br>○ Flinders Street Station – Werribee<br>• Northern Group:<br>○ Flinders Street Station – Craigieburn<br>○ Flinders Street Station – Sunbury |

## Appendix B: Adopting Maximum Design Gradients

The following technical requirements shall be addressed during design development and evidence provided to support the design submission. MTM may request additional information which shall be supplied prior to acceptance.

### Signal Sighting

- Ensure no signals are placed on the rising grades and positioned at least 200 metres beyond the crest of the curve.
- Theoretical and practical signal sighting assessment to be undertaken to avoid local and overall route risk arising from human factors or seasonal issues.
- Ensure local infrastructure (curves, bridges, platforms, crossing work, pedestrian and level crossings) does not impact on the sighting of signals and the capacity to avoid trains stopping on grades.
- Where a sag curve exists at the bottom of the grade, consideration is given to obstructions such as bridges on the ability of drivers to avoid a Signal Passed at Danger (SPAD).

### Metropolitan Operational Requirements

- Verify the design run time against the network service plan with an assessment of the affected section to confirm run time is not adversely impacted. For example, impacts to run-times resulting from driver behaviour approaching platforms on a “down hill” grade or ability to clearly see along the length on the platform on approach.
- Undertake Human Factors assessment of driver behaviour, which may be altered by increased braking / acceleration requirements, risk of overshooting platform at the base of a downhill gradient, changes in train performance, etc.

### Line Use Strategy

- Where there is a station adjacent to a gradient exceeding 2.0% it shall be located at the top of the grade if practical and economic.
- Provide evidence of consultation with PTV and other relevant stakeholders regarding the long-term strategy for rail traffic within the corridor. This shall include confirmation that issues raised by stakeholders have been adequately addressed.
- Demonstrate that the gradient does not adversely impact the track alignment following other future works in the corridor such as adjacent grade separations, etc. which may increase the future length of a gradient, or introduce exaggerated gradient changes.

**Maintenance of Infrastructure**

- Provide evidence that the risk of increased incidents of wheel slip / adhesion issues including impact to rail condition and maintenance requirements has been assessed and mitigation measures implemented so far as is reasonably practicable.
- Provide evidence that the impact of rail creep has been addressed and mitigation measures implemented so far as is reasonably practicable, including the need for any increased monitoring and maintenance.
- Provide evidence of the suitability of the track structure and drainage for the proposed gradient.
- Provide evidence that the rail lubrication strategy requirements have been met and all relevant interfaces are managed.

**Power System Requirements**

- Undertake a power modelling assessment to confirm the whole of life power utilisation for the corridor, including during degraded modes, is acceptable.
- Provide evidence that there is no change in operational risk associated with the power system and that the timetable can be delivered.
- Check that the overhead structure vicinity to vertical curves and platforms does not prevent the overhead conductors from achieving grading requirements and electrical clearances
- Confirm track gradients do not exceed the natural rise of the overhead system, increasing stress on components and reducing service life of the equipment and train pantographs.

**Freight, Regional & Heritage Passenger Operational Requirements**

- Undertake a rail impact study and provide evidence that V/Line, Freight, heritage and other relevant stakeholders / ARO's have been consulted as necessary to address the relevant points above. This shall include confirmation that issues raised by stakeholders have been adequately addressed.

## Appendix C: Adopting Exceptional Design Gradients

To Adopt Exceptional Design Gradient limits, the technical requirements listed in Appendix B shall be completed to provide the necessary evidence to support the design submission. Approval from PTV and the MTM Chief Engineer shall then be sought.

The approval of any Standard Waiver is dependent on the rolling stock specification for the affected section of track at Exceptional Maximum Gradient. This includes:

- Current and future freight services
- Current and future V/Line services
- Current and future MTM services
- Current Heritage operations
- Maintenance vehicles.

### Shared Use Corridors

The opportunity for other operators to market future services based on train consists documented in L1-CHE-MAN-010 WTT Network Configuration Governance provides the level of certainty that is necessary to these operators.

The designer shall provide evidence that V/Line, Freight, heritage and other relevant stakeholders / ARO's have been consulted as necessary to address the points detailed in Appendix B. This shall include confirmation that issues raised by stakeholders have been adequately addressed.

### HCMT Corridors

The Type 1a Maximum Exceptional Gradient is based on advice from PTV in relation to HCMT capability specified through requirements. Validation of such capability has not been demonstrated at this time. Consequently, a project proposing a waiver must agree with PTV how risk is to be managed if HCMT operational capability is less than the requested waiver gradient. This agreement shall be documented in any application for a waiver under the Exceptional Gradient provisions .

The Exceptional Maximum Design Gradient is restricted to locations used exclusively by HCMT rollingstock, or other rollingstock with similar agreed performance characteristics. This will be subject to a site specific risk assessment and an agreed Concept of Operations and Maintenance.

Evidence shall be provided that such locations will be accessible only by HCMT trains and using dedicated maintenance plant/machinery as required. Infrequent access for any other vehicles shall be subject to a risk assessment and acceptance by PTV and MTM.

The Exceptional Maximum Design Gradient may be increased as shown in Table 5 where rollingstock will operate in a climate controlled environment, such as a tunnel, and there is no exposure to external influences on the interface between the wheel and rail.

## Appendix D: Track Design Drawing Requirements

The Track Design Drawing Requirements apply to all projects that are producing Track Design documentation that will be used for construction. The requirements specified below are in addition to the drawings requirements specified in PTV Infrastructure Drafting Standards.

Track design documentation should include the following details:

- Coversheet including drawing index, key plan/locality plan, legend, and design notes.
- Typical cross sections of the proposed track structure shall be prepared at a scale of 1:100. As a minimum, they must include:
  - Rail size, type of fastenings, type of sleeper, minimum ballast depth, ballast shoulder and profile.
  - Details of track structure type such as capping layer, track slab, bridges/culverts, level crossings, etc.
  - Details of drainage cross fall including slope direction and grade
  - Earthwork details including embankment/cutting batters, retaining structures
  - If separate drawings are not being produced for any ground improvements works that may be required for slope stability, settlement etc. these details should be included on the typical cross sections.
  - Track centre information, clearances to adjacent infrastructure such as tracks, OHW structures, signalling infrastructure, retaining walls, platforms, over bridges, fences, handrails, etc.
  - Location and types of track drainage, combined services trenches (CSR), and any other services that are proposed to be installed with the track formation/structure. If drainage pipe sizes/types and CSR configurations (number of conduits, spacing sizes etc) are not nominated elsewhere in the design documentation, they must be nominated on the typical cross sections however the designer must be mindful of overcrowding the drawing with too much information.
  - Location of maintenance access paths
  - Any special details, such as the capping transitions at approach slabs, turnout bearers, culverts/bridges, etc.
  - Typical cross sections are required where there is a change in one of the track structure or profile.
- Plan views of the proposed track alignment shall be prepared at a scale of 1:500. Plans should be prepared so the rail alignment is rotated so that the track chainage increases from the left to the right of the drawing sheet.
- For green field projects, and other areas with limited existing infrastructure, it may be possible to show the required details at a larger scale. Alignment plans may be produced at a scale of 1:1000 with the approval of the MTM Design and Review Manager.
- As a minimum, the plans are to include the following information:
  - Changes in geometry including tangent to spiral (TS), spiral to curve (SC), tangent to curve (TC), transition to transition, curve to curve and bend points to be marked including chainage.

- Chainage markers (usually marks on the centre line) at 10m intervals with chainage text every 50m
- Alignment details (tangent length, transition length, curve length, curve radii, applied cant, cant deficiency, design speed). It is preferable to also include bearings of straights, rate of change of cant, rant of change of deficiency, and cant gradient details.
- Tracks are to be labelled (eg Up Burnley Local) and track centre information/ dimensions are to be shown.
- Location of crossing work including the last long bearer, cant reducing sleepers/plates, and any additional zero cant sleepers that may be part of the design.
- Set out details including IP coordinates. Set out coordinates should be moved to a new drawing if they cannot clearly be shown on the track alignment plans due to drawing congestion.
- Location of drainage and drainage pits, overhead structures and signal structures, combined services route, location cases, etc.
- Location of level crossings, bridges, culverts, platforms, underpasses, retaining walls, earthwork batters, fences, maintenance paths and other significant infrastructure.
- Location of existing services.
- Longitudinal and cross track drainage including pipe/channel sizes, grades, invert levels, pit locations and sizes. A pit schedule shall also be provided. If drawings are congested with information, this information should be shown on separate drawings.
- Rail reservation boundary.
- “From Melbourne” and “To Location” arrows are to be provided.
- North Arrow.

* Longitudinal sections shall be prepared with proposed levels at no less than 10m intervals and a horizontal scale of 1:500 and vertical exaggeration of 5 or 10 depending on topography. As a minimum, long sections are to include:
    - Existing rail including levels.
    - Proposed rail including levels (low rail)
    - Proposed Cant.
    - Proposed Top of Capping surface including levels at the track centreline
    - Proposed grades, grade lengths, vertical curve lengths, and curve radii of the proposed rail alignment.
    - Proposed horizontal alignment including length of straights, transition lengths, curve radii and lengths are preferred for easy reference.
    - Lift/Lower and horizontal slew information. For greenfield sites, cut and fill information shall be provided.
    - Chainages
    - Key features of the proposed rail including extents of turnouts (Including last long bearer), areas of track slab, level crossings, etc.

  - Key features that effect the design of the track including, platforms, bridges, underpasses, culverts, ground water levels, existing services (shown with correct levels).
- Cross section drawings shall be prepared with sections at not more than 20 metre intervals and at significant locations such as areas of minimum clearance.
- For green field projects, it may be possible to show the required details at a larger scale. Cross sections may be produced at interval of 50m with the approval of the MTM Design and Review Manager.
- As a minimum, cross sections are to include:
  - Existing surface including level information
  - Proposed rail levels
  - Proposed levels and slope for the Top of Capping surface
  - Proposed drainage
  - Property boundary
  - Offsets from datum line
  - Datum level
  - Platforms, retaining walls, bridges, culverts, underground services, combined service route
- Crossing work plans shall be provided for projects that include installation of new turnouts/ crossovers or compounds. The plans shall be produced at a scale of 1:250 and include:
  - Location of the last long bearer, cant reducing sleepers/plates, and any additional zero cant sleepers that may be part of the design
  - Clearly labelled set out information which identifies End of Stock Rail, Toe of Points, Intersection Point (IP), Back of Crossing (mainline), Back of Crossing (diverge), Theoretical Nose, Actual Nose.
  - Specific turnout information including reference to the manufacturers drawing number.
- A clearance diagram drawing(s) are required where the proposed track design doesn't meet clearance standards, or where track centres are less than 4.0m. For existing infrastructure, they are required when existing clearances are being reduced by the proposed track alignment. The clearance diagram is intended to provide the required detail to support the design approval including the standard waiver request. The clearance diagram shall include:
  - An extract of the plan view at a scale of 1:250 to highlight the proposed clearance infringement. The plan view should show the proposed track alignment information to enable curve and cant effect to be easily calculated. This includes the low rail level at the location of the minimum clearance. The swept path of the train (Static and Kinematic envelope based on the 3050mm wide rolling stock outline) should also be shown.
  - A cross section at the location of the minimum clearance at a scale of 1:100. This is particularly important when the clearance infringement is at a specific height (eg signal) and not continuous such as a retaining wall or OHW structure. The cross section should show the outline of the relevant clearance envelope specified in VRIOGS 001 including allowances for curve and cant effect. Where this doesn't provide sufficient justification for the clearance, the static and kinematic envelope (including curve and cant effects) of the 3050mm wide vehicle should be shown on the cross section.
  - Clear dimension to the clearance infringement, or to the adjacent track if track centres are less than 4.0m.