Engineering Standard

Track

CRN CS 210

TRACK GEOMETRY AND STABILITY

Version: 1.5

Issued: January 2021

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Document control

Revision	Date of Approval	Summary of change
1.0	August, 2011	First Issue. Includes content from the following former RIC standards: C 2108, C 2200, C 2501, C 4601, C 4610, C 4641, TS 2621, TS 3103, TS 3104, TS 3105, TS 3106, TS 3107, TS 3108, TS 3202, TS 3208, RC 4800, RTS.3640.
1.1	January, 2012	8.1.2 – Revision of Figure 12 - Permanent speed sign location; 8.2.1.1 – Correction of error in height of permanent speed sign above RL; 9.3 – Revision of Figure 14 – Kilometre post location; 12.2.3 – Correction of acceptance standard for superelevation through platforms; 12.3 – Correction of error in TCI acceptance limits
1.2	July, 2013	2.4 – New section "Definitions"; 6.1.4 – Correction of errors in Figure 5 "Compound Transition Components"; 7.4.5 – Clarification of application of clause to turnouts in sidings; 7.4.6 – Table 1 – Added limits on cant deficiency in diamond crossings; Added guidance on transition ramp limits; Table 2 – Added guidance on transition ramp limits; Change to approval requirements for turnouts in vertical curves; 7.7.2 – Replaced concrete sleepers with steel sleepers; 7.8.1 – Regrading requirements made mandatory; 7.8.2 – Separated access requirements for double track and multiple track; 8 – Replaced TOC Manual with Maximo as primary source of permanent speed information; 8.1.3 – New Section – Level Crossing Speed Signs; 8.1.4 – New Section – Conditional Level Crossing Speed Signs; 8.2.2 – New Section – 8.2.2. Placement of level crossing and conditional level crossing speed signs; 9.2 – Altered spacing of TCMs on straights (includes content of CCW 12/027 1/10/2012); 12.2.6 – Tamping attachment for off/on track plant included as a manual maintenance activity; 12.3 – Correction of error in heading in Table 12; 13.1 – Deleted Welded Track Stability Limits
1.3	June, 2016	Various – Rewording for consistency, changed "Principal Civil Engineer" to "Principal Track and Civil Engineer"; 2.2 – Corrected title of CRN CP 211; 9.2 – Changed Track Control Mark requirements to match changes to CRN CM 212 V1.2
1.4	September, 2017	C7 Table 1 - Corrected typo in Max Ea maximum limit for turnouts on class 1 track to 125mm, updated all TBA values for lower class lines, removed references to diamonds not maintained on CRN; C7.1 - Corrected table reference from 2 to 1
1.5	January, 2021	See Summary of changes below

Summary of changes from previous version

Section	Summary of change
Various	Minor formatting and grammar changes throughout; Grade represented as % throughout for consistency
Figure 6	Correct nomenclature for d'
6.3.2	Clarify minimum length of vertical curve
7.4.3.2	Inclusion of recommended applied superelevation.
7.4.6	Clarify requirement to consult Principal Rolling Stock Engineer when changing the grade
Table 1	Clarify requirement to consult Principal Rolling Stock Engineer when if compromising the ruling grade; Revise minimum curve radius for class 3 and 5 track; Revise maximum/minimum limits for Max D for Normal and HST
7.5.4	Clarify requirement to consult Principal Rolling Stock Engineer when changing the grade
Table 5	Minimum radius for wagons only in sidings increased to 120m

7.8	Inclusion of commentary for regrading or realignment of track adjacent to new work
8.1	Reworded section for clarity; Include longitudinal positional requirement for turnout speeds
8.2	Included requirement for new track designs where required to show speed sign locations
9.2	Removed duplication with CRN CM 212 and included reference for Track Control Mark placement
9.3	Updated to provide clarity the kilometre and half-kilometre posts are not be to relocated without approval from the Principal Signalling and Control Systems Engineer
11	Removal of reference to 35°C for neutral temperature

Contents

1 Scope and application

This standard establishes design requirements, acceptance standards and damage limits for track geometry, track stability and maximum speed of trains.

It is applicable to all Country Regional Network (CRN) mainline and siding tracks.

All permanent civil infrastructure shall be renewed to an approved track design, including design alignment, design rail level and transit space, including track centres and structure clearances.

2 References

2.1 Australian and International Standards

Nil

2.2 CRN Documents

CRN CS 200 - Track System

CRN CS 215 - Transit Space

CRN CS 250 - Turnouts and Special Trackwork

CRN CS 410 - Formation & Earthworks

CRN CM 203 - Track Inspection

CRN CM 212 - Survey

CRN CM 521 - Level Crossings

CRN CP 203 - Track Design

CRN CP 211 - Survey

CRN CP 213 - Track Side Signs

CRN RM 001 - Train Operating Conditions (TOC) Manual

CRN Network Rules

2.3 Other References

Nil

2.4 Definitions

Definition of terms used in this document is found in the glossary in CRN Engineering standard CRN CS 200 “Track System”.

3 Engineering authority

Design and selection of infrastructure detailed in this standard for use on the CRN may only be undertaken by persons who have been granted appropriate Engineering Authority by the Principal Track and Civil Engineer.

4 Conventions

This document contains mandatory requirements and guidelines. To aid understanding and compliance, all instances have been 'flagged' as follows:

Mandatory Requirement - SHALL be met.	**............ MR**
Guideline - preferred where practical.	***............... G***
Normal design limit. Where maintenance issues arise, maintainer acceptance is required.	**............ NL**
Maximum (or minimum) design limit. SHALL NOT be exceeded unless EXCEPTIONAL limits apply.	**............ ML**

5 Design & performance criteria

This standard has been developed in consideration of the following criteria:

- Horizontal alignment of the rails including gauge, curves and transitions.
- Vertical alignment including vertical curves and grades.
- Minimising grades and curvature.
- Rolling stock speed, response and wheelset geometry.
- Superelevation and cant deficiency requirements for both track and rolling stock.
- Terrain.
- Sighting distance requirements.

6 Horizontal and vertical alignment

Horizontal and vertical alignment shall be designed to meet the requirements specified in Section 7 using a combination of the following components. **............ MR**

The design output (frame point coordinates) for horizontal alignment shall be stated (calculated) to a minimum of 6 decimal places of a metre (0.000001). **............ MR**

Preparation, content and presentation of track design documentation and drawings shall be undertaken in accordance with the requirements of CRN Engineering specification CRN CP 203 "Track Design". **............ MR**

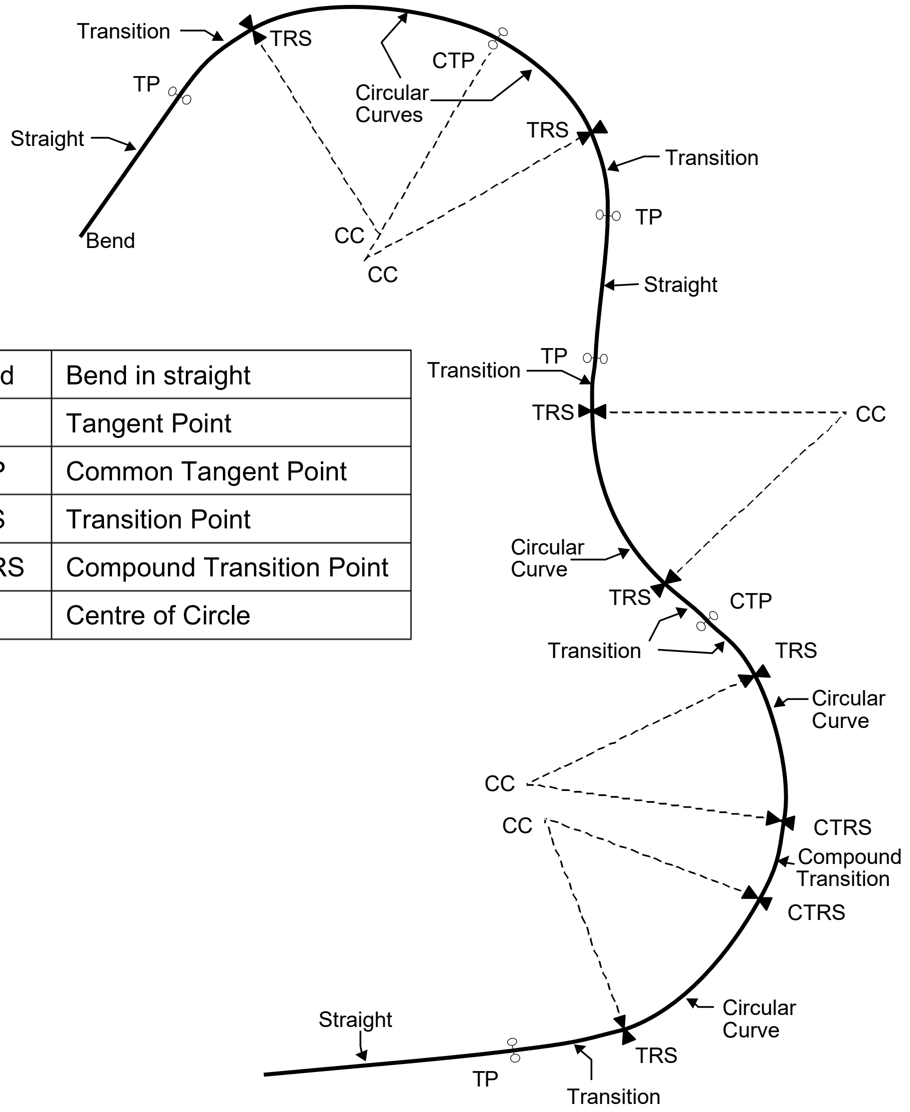
6.1 Horizontal alignment components

Horizontal alignment defines the centreline of the '4 foot' of each track.

Horizontal alignment shall be defined by a combination of any of the following individual components: **............ MR**

- Straights
- Circular curves
- Transitions
- Compound transitions.

See Figure 1 for clarification of component names, point names and various combinations of components.



Bend	Bend in straight
TP	Tangent Point
CTP	Common Tangent Point
TRS	Transition Point
CTRS	Compound Transition Point
CC	Centre of Circle

Figure 1 - Horizontal alignment component combinations

6.1.1 Straights

A straight shall be defined by a pair of tangent points (TP), a pair of bends, or a combination of both. .... **MR**

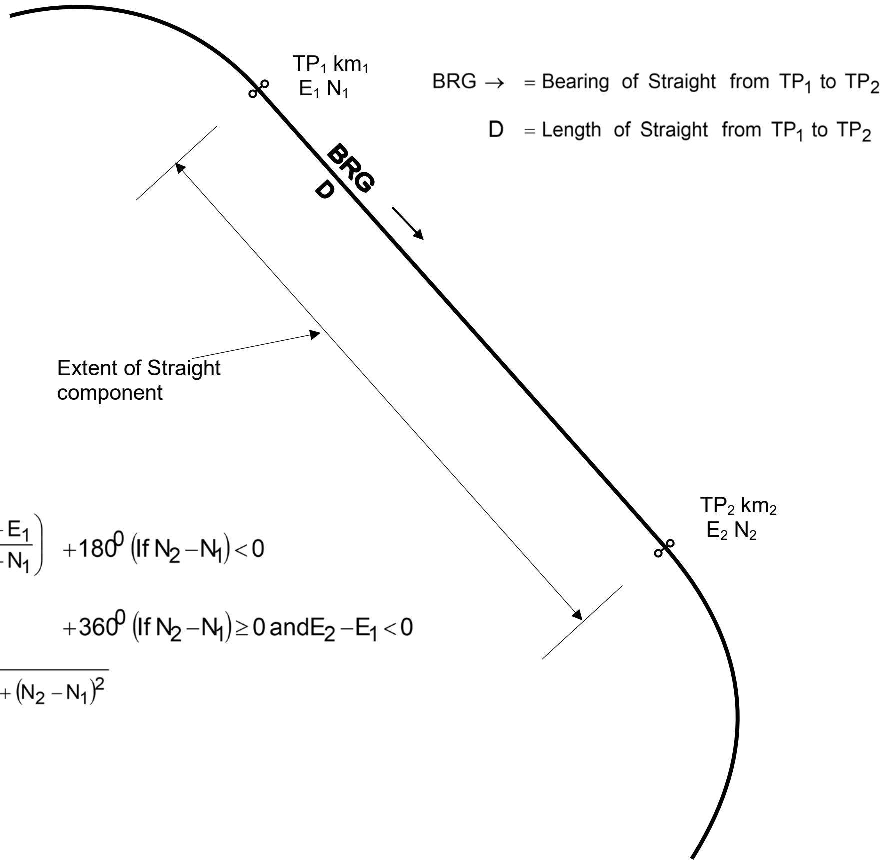
A bend is the point of intersection of two separate straights.

A bend shall be created when a change of angle occurs or where it is necessary to define the alignment of a point on the straight. .... **MR**

Each TP or bend shall have a unique coordinate set (Easting-E, Northing-N). .... **MR**

The bearing and distance of each straight are derived numbers.

See Figure 2 for the mathematical relationships for straights.



$$BRG \rightarrow = \tan^{-1}\left(\frac{E_2 - E_1}{N_2 - N_1}\right) + 180^0 \ (\text{If } N_2 - N_1) < 0$$

$$+360^0 \ (\text{If } N_2 - N_1) \geq 0 \text{ and } E_2 - E_1 < 0$$

$$D = \sqrt{(E_2 - E_1)^2 + (N_2 - N_1)^2}$$

$$km_2 = km_1 + D$$

Figure 2 - Straight component

6.1.2 Circular curves

A circular curve shall be defined by three coordinated points, two being the end points of the circular curve on the centreline and the third being the centre of circle (CC). .... **MR**

Each of the three points shall have a unique coordinate set (E, N). .... **MR**

The radius of the circular curve is a derived number and shall be the arithmetic mean of the distances calculated from each end point coordinate set to the CC coordinate set. .... **MR**

The length of the circular curve is nominated by the arc distance, shown in metres.

See Figure 3 for the mathematical relationships for circular curves.

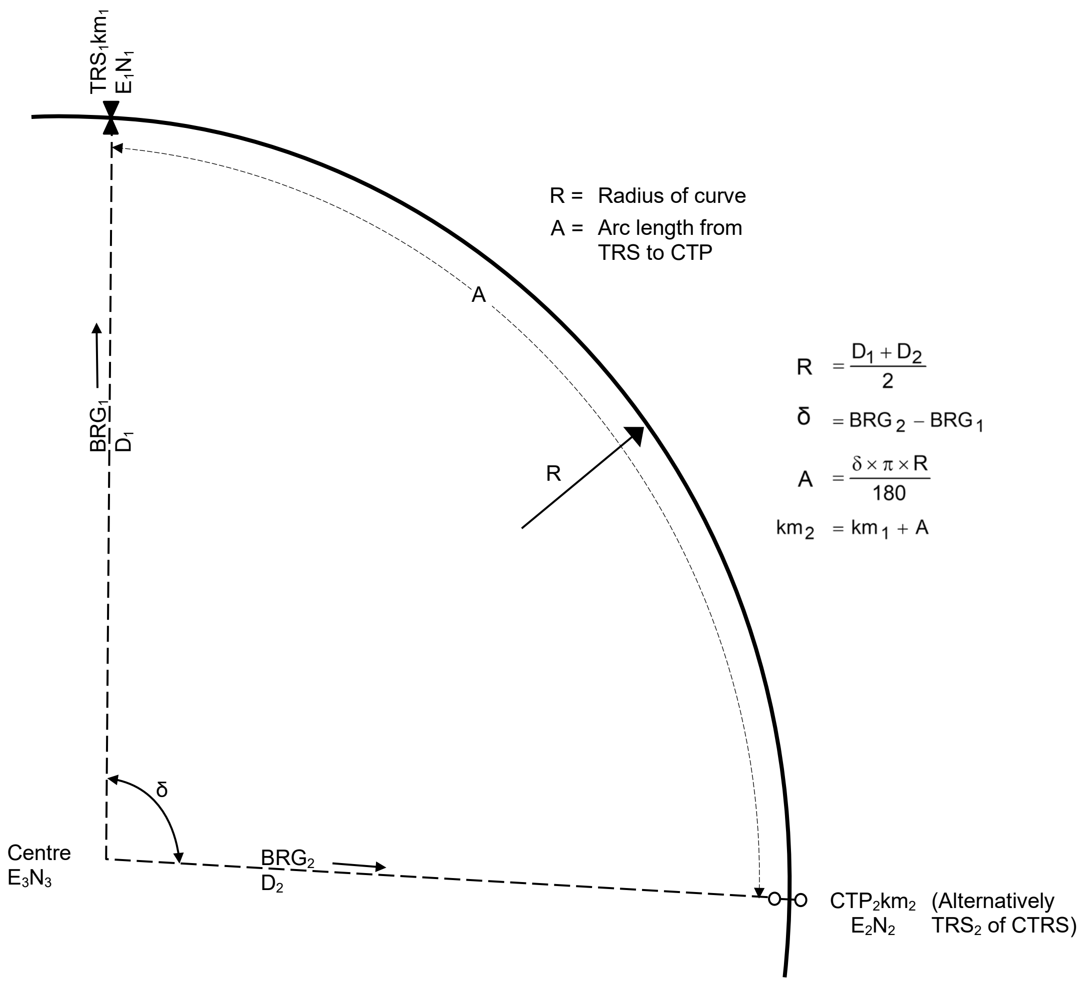


Figure 3 - Circular curve component

From coordinates of TRS1, CTP2 and centre, calculate bearing and distance as indicated.

6.1.3 Transitions

A transition is the component that joins the straight to the circular curve and is based on a cubic parabola.

The transition shall be defined by three coordinate points, being the tangent point (TP), transition point (TRS) and the centre of circle (CC). .... **MR**

Each of the three points shall have a unique coordinate set (E, N). .... **MR**

The associated radius and transition data (X_c, X', h, θ, Ø, m, L) are derived values using the three coordinate sets.

The length of the transition (L) is a derived distance. .... **MR**

See Figure 4 and Figure 5 for the mathematical relationships for transition curves.

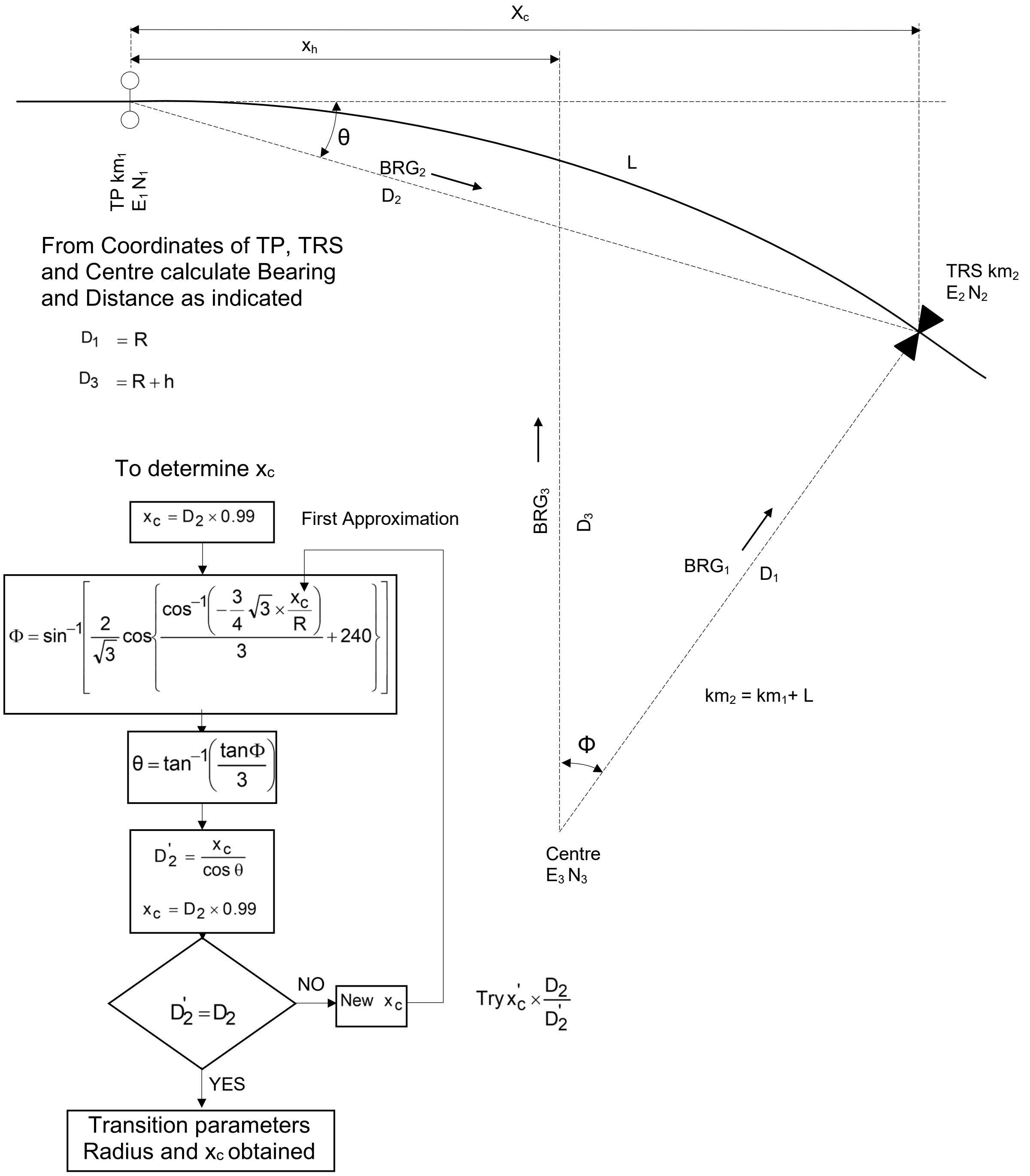


Figure 4 - Transition component

Parameters: Radius (R); Transition Identifier (x_c)

$$\Phi = \sin^{-1}\left[\frac{2}{\sqrt{3}}\cos\left\{\frac{\cos^{-1}\left(-\frac{3}{4}\sqrt{3}\times\frac{x_c}{R}\right)}{3}+240\right\}\right]$$

$$m = \left(\frac{\tan\Phi}{3{x_c}^2}\right)$$

$$y_c = m{x_c}^3$$

$$x^1 = R.\sin\Phi$$

$$h = y_c + R(\cos\Phi - 1)$$

$$\theta = \tan^{-1}\left(\frac{\tan\Phi}{3}\right)$$

$$L = x_c + \frac{9}{10}m^2{x_c}^5 - \frac{9}{8}m^4{x_c}^9 + \frac{729}{208}m^6{x_c}^{13} - \frac{32805}{2176}m^8{x_c}^{17} + \ldots\ldots\ldots$$

$$R = \frac{\left(1+9m^2{x_c}^4\right)^{3/2}}{6mx_c}$$

$$R_1 = \frac{\left(1+9m^2{x_1}^4\right)^{3/2}}{6mx_1}$$

$$x_1 = L_1 - 0.9m^2{L_1}^5 + 5.175m^4{L_1}^9 - 43.1948m^6{L_1}^{13} + 426.0564m^8{L_1}^{17}$$

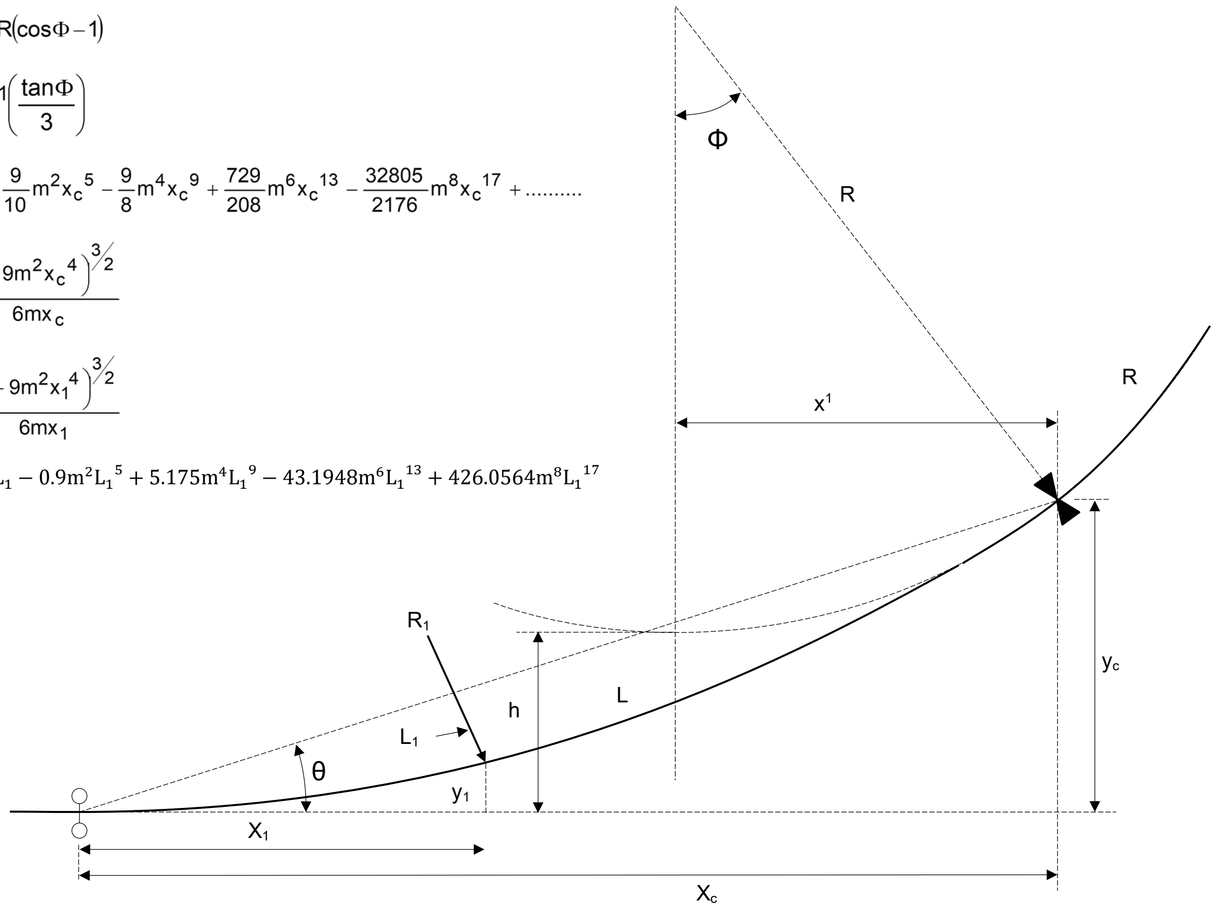


Figure 5 - Transition formulae

6.1.4 Compound transition

A compound transition is the component that joins two circular curves of different radii.

The compound transition shall be defined by four coordinated points, two being the common points joining the compound transition to the two radii (CTRS) and the other two being the respective centre of circles of each circular curve. **............ MR**

Each of the four points shall have a unique coordinate set (E, N). **............ MR**

A compound transition is a specific segment of a transition.

See Figure 6 for the mathematical relationships for compound transitions.

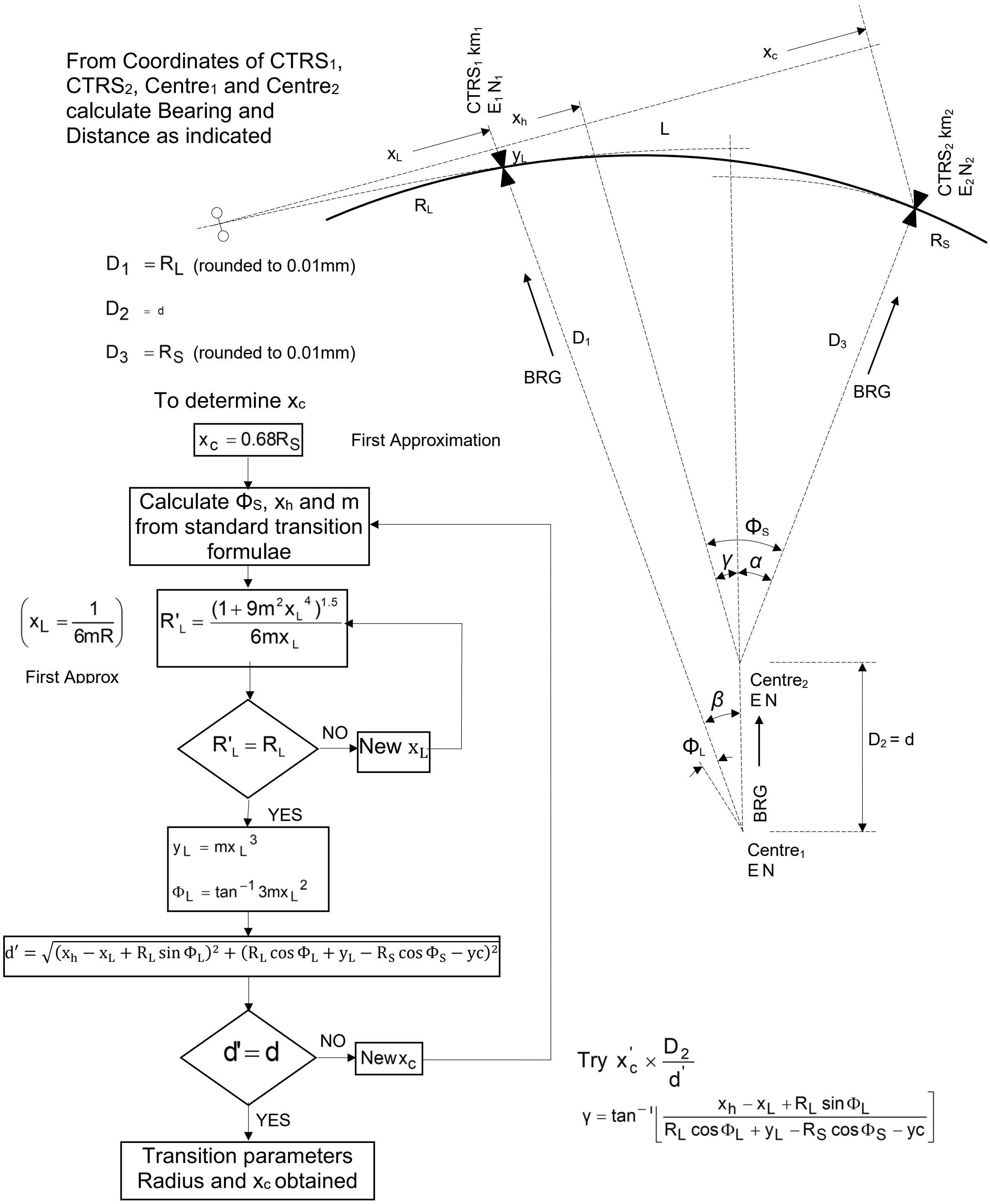


Figure 6 - Compound transition component

6.2 Location of kilometrage

6.2.1 Frame points

Each frame point (i.e. TP, TRS, CTP, CTRS, E_a point or BEND) shall be given a label called a "survey kilometrage". .... **MR**

The "survey kilometrage" is a distance measured from Sydney along the centreline '4 foot' of each track. The "survey kilometrage" 0.000km is located at the Buffer Stop at Central No.1 Platform.

The "survey kilometrage" of any frame point shall be the cumulative total from Sydney of the individual "adjusted" component lengths, each component length being derived. .... **MR**

6.2.2 Kilometrage adjustments

Kilometrage adjustments shall be incorporated to align the survey kilometrage of one track section to another. This requirement recognises the practical difficulties involved in repositioning all location markers and survey details where alignment changes result in changes to length of sections of track.

In multiple track locations, where practical, kilometrage adjustments shall be placed at the beginning of parallel straights greater than 100 metres in length to align the kilometrage of each centreline. .... ***G***

The Down track should be adopted as the through survey kilometrage. .... ***G***

The nominated survey kilometrage at this point shall be the adjusted kilometrage, i.e. the kilometrage to be carried forward. .... **MR**

6.2.3 Long and short intervals

A long or short interval shall be nominated as well as the actual length. This interval shall be located on a straight immediately before the point adjustment. .... **MR**

The length of the interval shall be limited to the distance between the last increment point and the point adjustment. .... **MR**

The length of the interval shall be such that there is only one location for any nominated kilometrage. .... **MR**

A long interval is a negative adjustment.

A short interval is a positive adjustment.

The interval shall be contained within the track to which it relates. .... **MR**

The interval should be contained wholly within a straight. .... ***G***

The straight should be >100m in length. .... ***G***

The kilometrage of a point within a long interval shall be nominated as 'the start of interval kilometrage' plus a distance e.g. in Figure 7, the end of platform kilometrage would be 43km200+24.308. .... **MR**

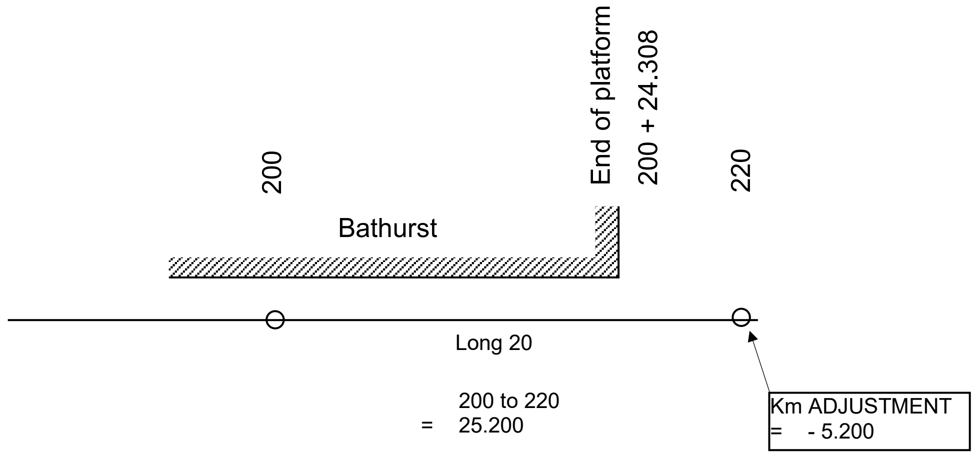


Figure 7 - Long kilometrage adjustment

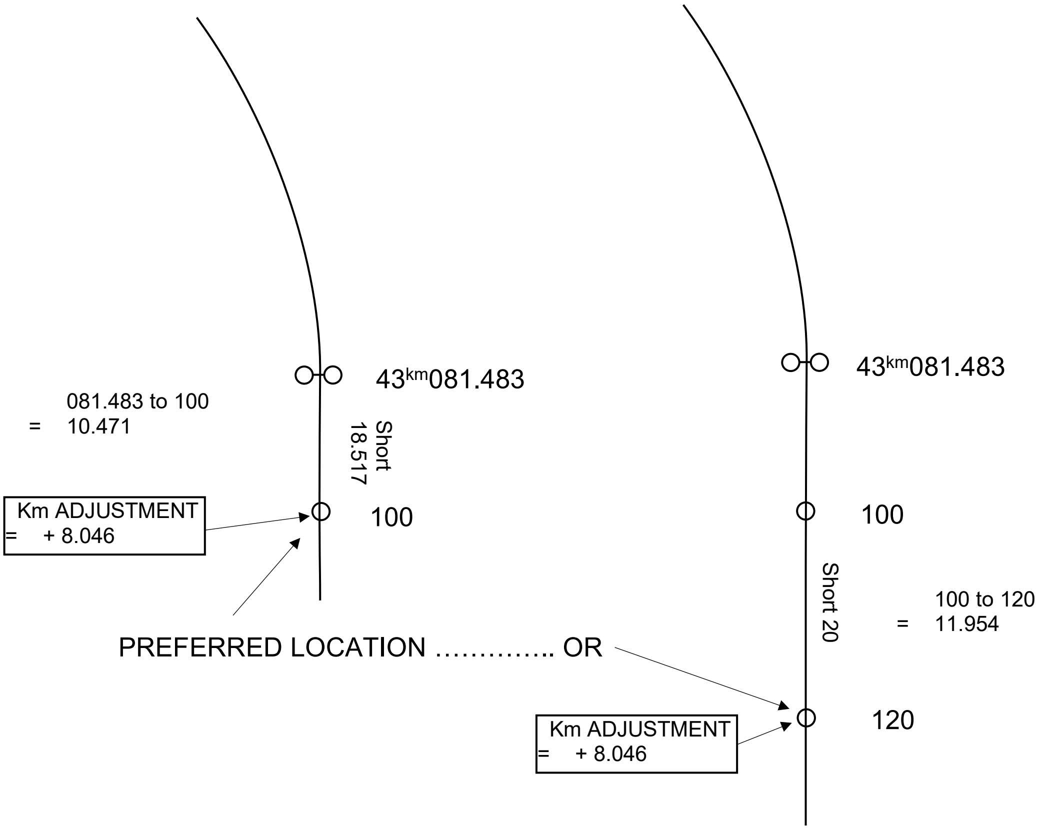


Figure 8 - Short kilometrage adjustment

6.3 Vertical Alignment Components

Vertical alignment defines the position of the low rail of each track.

Vertical alignment shall be defined as a series of straight grades connected by vertical curves (VC). **............ MR**

The parameters which define the components shall be: **............ MR**

- Intersection Point, reduced level (IPRL).
- Vertical curve, length (L_v).

6.3.1 Straight grade

Each straight grade shall be defined by a pair of terminal points called intersection points (IP), which shall be located at whole 20m kilometrage points. .... **MR**

Each IP shall have a defined reduced level (RL). .... **MR**

The 'grade' of each straight grade shall be expressed as a percentage. .... **MR**

The percentage grade shall be an exact increment of 0.005% to give an exact number of millimetre changes per 20 metres, except where kilometrage adjustment or other similar constraints occur. A grade projected from one IP shall allow the RL of the other IP to be derived to an accuracy of 0.001 of a metre. .... **MR**

6.3.2 Vertical curves

The vertical curve shall be defined by the length (L_V) and have a minimum length of 40m. .... **MR**

The vertical curve shall be based on the quadratic parabola. However in the determination of its length it shall be equated to a circular curve for convenience and practical purposes. .... **MR**

The parameters of the vertical curve are defined in Figure 9 and by the following formulae.

X = Steeper grade (%) (Note: +ve Grade = UP (Rising)

x = Flatter grade (%) -ve Grade = DOWN (Falling)

$$R_V = \frac{1}{2} V_m^2$$

$\Delta G = X + x$ OR $X - x$ if grades are in same direction

$$L_V = \frac{R_V G}{100}$$ round L_V up to an even number of 20m intervals (e.g.. 40, 60, 80,….).

$$R_V = \frac{100 L_V}{G}$$

$$Y = \frac{L_V G}{200}$$

$$Y = \frac{L_V}{2}(X + x) \text{ OR } Y = \frac{L_V}{2}(X - x)$$ if grades are in same direction

$$y = Y\left|\frac{1}{L_V}\right|^2$$

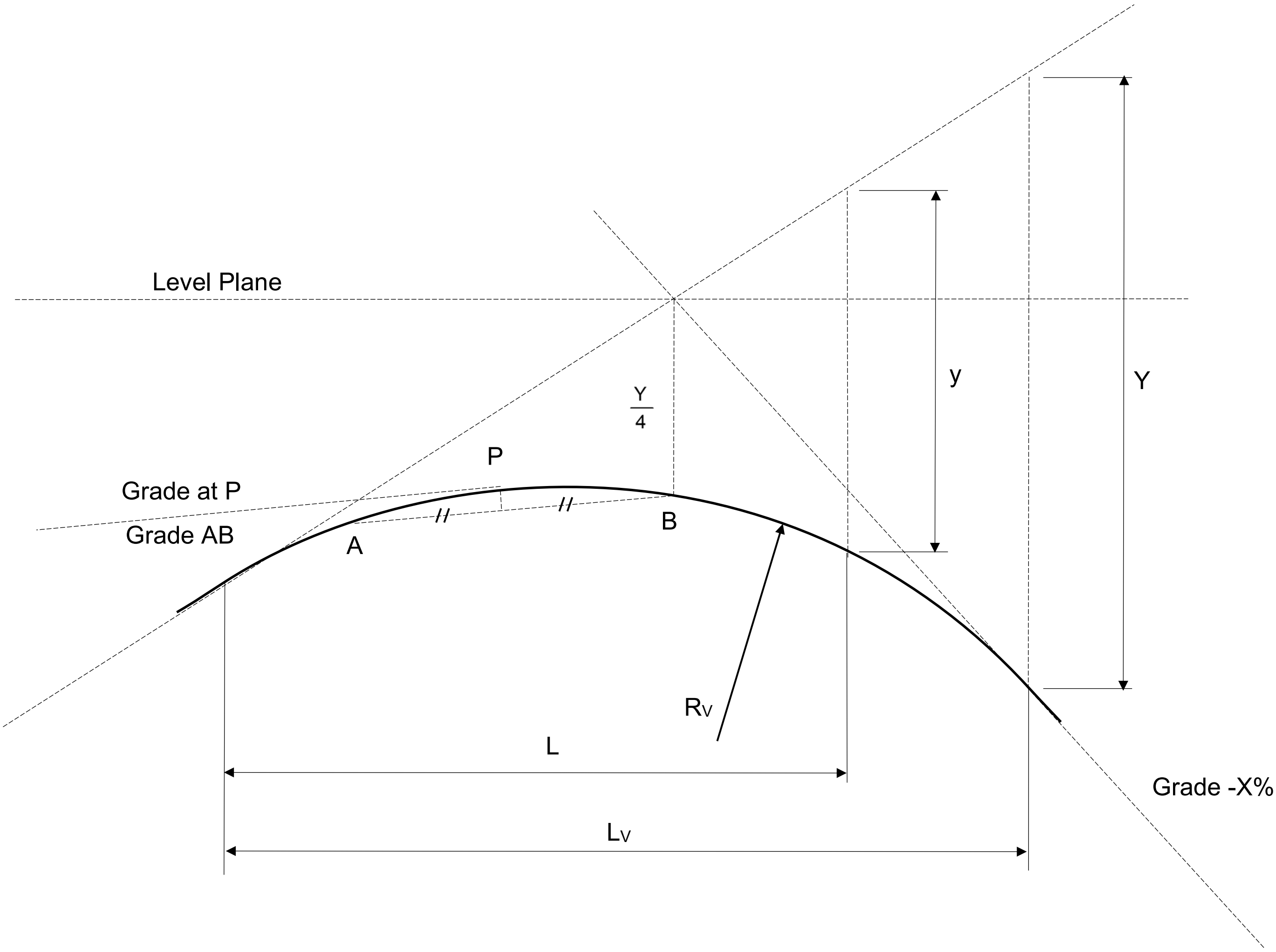


Figure 9 - Vertical curve component

7 Geometry design requirements

7.1 General

Track geometry for track in all classes of mainline and siding shall be designed to meet the limits for the track class detailed in CRN CS 200 or Table 1 using the formulae detailed in the following sections. .... **MR**

The definition of the structure of different track classifications used in this standard is detailed in CRN CS 200.

HST refers to all currently approved High-Speed Trains as detailed in CRN RM 001.

Design of multiple track shall include allowances for multiple track centres as detailed in CRN Engineering standard CRN CS 215 “Transit Space”. .... **MR**

For single lines the alignment of the centre line of the track (4 foot) is to be used for geometry design calculations. .... **MR**

When redesign of multiple tracks defined by one centre line alignment is undertaken, the geometry shall be converted to a centre line for each track. .... **MR**

This is mandatory for areas containing track componentry such as turnouts or other geometrical constraints. In other locations this requirement is optional.

7.2 Definition of design limits

7.2.1 Normal design limits

The normal design limits represent preferred engineering practice. They allow for low maintenance track. The normal design limits are found in Section 7.4 for mainline track and Section 7.5 for sidings.

Track geometry design shall conform to the Normal design limits unless otherwise approved by a person with Engineering Authority for track geometry design, following review and sign-off of maintenance impact (e.g. resourcing, additional costs, environmental effects etc.) by the Civil Maintenance Engineer. .... **MR**

7.2.2 Maximum (or minimum) design limits

The Maximum (or minimum) design Limits allow for the track to be maintained within the safety limits but may result in higher maintenance requirements and costs. The Maximum (or minimum) design limits are found in Section 7.4 for mainline track and Section 7.5 for sidings.

Track geometry design shall conform to the Maximum (or Minimum) Design Limits unless otherwise allowed by the application of Exceptional Design Limits as detailed in Section 7.2.3 below. .... **MR**

7.2.3 Exceptional design limits

Some existing infrastructure has been designed with short transitions and higher rates of change of deficiency that exceed the Maximum (or minimum) design Limits. Under controlled circumstances these Exceptional limits may be authorised by the Principal Track and Civil Engineer. The limits are described in Table 2.

These limits may only be applied in the following circumstances. .... **MR**

- It applies to existing plain track infrastructure and for new or existing tangential turnout designs.
- It applies to individual locations, each justified on a case by case basis.
- Maintenance personnel must review the ride on any sections of plain track for which exceptional limits have been applied during routine front of engine inspections (as part of Track Examination) and verify that the ride remains satisfactory at the track speed.

7.3 Design formulae

7.3.1 Abbreviations

Term	Symbol	Unit
Speed	V	km/h
Equilibrium speed	V_e	km/h
Maximum allowable speed	V_m	km/h
Radius	R	metre
Radius of turnout	R_t	metre
Bend angle	β	degrees
Applied superelevation (or cant)	E_a	millimetre
Difference in applied superelevation	ΔE_a	millimetre
Maximum design superelevation	E_m	millimetre
Equilibrium superelevation	E_e	millimetre
Superelevation ramp rate	E_r	1 in _
Superelevation deficiency	D	millimetre
Maximum superelevation deficiency	D_m	millimetre
Superelevation deficiency in bend	D_β	millimetre
Rate of change of deficiency	D_{roc}	mm/s
Difference in deficiency	ΔD	millimetre
Length of transition	L	metre
Length of superelevation ramp	L_r	metre
Grade (compensated)	G	%
Difference between two adjacent grades	ΔG	%
Vertical curve, equivalent radius	R_v	metre
Length of vertical curve	L_v	metre
Vertical acceleration	a_v	m/s^2
Nominal spacing of vehicle bogies	B_c	m

7.3.2 Bends

The relationship between the bend angle in degrees between straights (β), and speed (V) is given by: $4.85 = \frac{\beta \cdot V^2}{D_\beta \cdot B_c}$

7.3.3 Circular curves

7.3.3.1 Radius

The relationship between radius (R) and the parameters E_a, V & D is given by: $11.82 = \frac{R \cdot E_e}{V^2}$, where

$E_e = E_a + D$

7.3.3.2 Superelevation (or cant)

The relationship between applied superelevation (E_a) and the parameters R, V & D (see Radius above).

7.3.3.3 Deficiency

The relationship between deficiency (D) and the parameters R, E_a & V (see Radius above).

7.3.4 Transition curves

7.3.4.1 General

The following provisions apply to transitions from straight to curve and between similar flexure curves.

Transitions shall be as defined in Section 6.1.3.

The relationship between transition length (L) and speed (V) is given by: $3.6 = \frac{\Delta D \cdot V}{L \cdot D_{roc}}$

Except where the adopted L is less than B_c, in which case: $3.6 = \frac{\Delta D \cdot V}{B_c \cdot D_{roc}}$

This equates to a virtual transition due to the spacing of the vehicle bogies.

7.3.4.2 Superelevation

The relationship between superelevation ramp length (L_r) and superelevation parameters is given by: $1000 = \frac{E_r \cdot \Delta E_a}{L_r}$

7.3.5 Vertical curves

Vertical curves shall be as defined in Section 6.3.2.

The relationship between speed (V), vertical curve radius (R_v), & vertical acceleration (a_v) is given by: $12.96 = \frac{V^2}{a_v \cdot R_v}$

7.3.6 Calculation of speed

Determination of the design speed of trains requires the application of the following rules: .... **MR**

Calculate the maximum speed by applying the above formulae to the section of track being reviewed.

Round the speed to the nearest 1 km (e.g. 75.4 becomes 75, 75.5 becomes 76).

Since Permanent speeds are advertised in multiples of 5km/hr only, adjust the speed to the next LOWEST 5km/hr speed band (e.g. 76 becomes 75, 79 becomes 75).

7.4 Mainline geometry design

7.4.1 Gauge

Nominal track gauge is 1 435mm for all classes of track. .... **MR**

7.4.2 Bends

Bends in alignment are generally not desirable. ....*G*

The normal limit on bends between straights (β) is given in Table 1. ....**NL**

The normal limit on allowable deficiency on a bend ($D_β$) is the same as the maximum allowable limit in Table 1. ....**NL**

The maximum allowable bend between straights (β) is given in Table 1. .... **ML**

The maximum allowable deficiency on a bend ($D_β$) is given in Table 1. .... **ML**

7.4.3 Circular curves

7.4.3.1 Radius

The selection of curve radii should account for train operating speeds. Generally flat curves are more desirable than sharp curves but the requirements of platform gaps, environmental impact and maintainability also need to be considered. ....*G*

The normal limiting radius (R) is given in Table 1. ....**NL**

The minimum allowable radius (R) is given in Table 1. .... **ML**

Where radii sharper than Normal Design Limits is proposed, detailed consideration must be given to the effect of wear on wheels and rails, flanging and squeal noise; and to the requirements for lubrication and friction modification. Separate requirements may be imposed at platforms to control the platform gap. (See Section 7.7). ....**MR**

7.4.3.2 Superelevation (or cant)

The normal limit on superelevation (E_a) is the same as the maximum allowable superelevation in Table 1. ....**NL**

The maximum allowable superelevation (E_a) is given in Table 1. ....**ML**

Superelevation shall be rounded to the nearest 5mm. .... **MR**

Superelevation should be constant throughout the circular curve and zero on straights unless design constraints require variation in superelevation. ....*G*

The applied superelevation (E_a) should be specified for freight traffic at $E_a = 0.6E_e$ ....*G*

7.4.3.3 Deficiency

The normal limit on deficiency (D) is given in Table 1. ....**NL**

The maximum allowable deficiency (D) is given in Table 1. .... **ML**

7.4.3.4 Length of horizontal alignment components

The most desirable minimum straight length (in metres) between adjacent curves is given by: $\frac{V}{2}$ *subject to:* ....*G*

The minimum length of straight between adjacent curves of similar flexure is equal to B_c. ....**ML**

The minimum length of straight between reversing curves is equal to B_c. ....**ML**

The normal minimum length of a circular or transition curve is equal to B_c. .... **NL**

The maximum allowable transition curve length is: $L = 0.68R$ ....**ML**

The normal minimum length of superelevation ramp is equal to B_c. .... **NL**

If L is calculated to be less than B_c, then a transition curve is not essential .... ***G***

The normal minimum length of superelevation ramp in a non-transitioned compound curve is equal to B_c (see Figure 10). No limits apply to maximum length. .... **NL**

7.4.4 Transition curves

7.4.4.1 General

The normal limit on rate of change of deficiency (D_{roc}) is given in Table 1. ....**NL**

The maximum allowable rate of change of deficiency (D_{roc}) is given in Table 1. .... **ML**

7.4.4.2 Superelevation

Superelevation shall be applied linearly throughout L_r. ....**MR**

The normal design methods of applying superelevation for various situations are shown in Figure 10. ....**MR**

The maximum allowable superelevation ramp is related to speed through the transition but must also consider the need for the track to be maintainable to meet the base operating condition limits for track geometry, where superelevation ramp is considered a twist. Maintenance requirements must be considered for designs that exceed Normal limits. ....**MR**

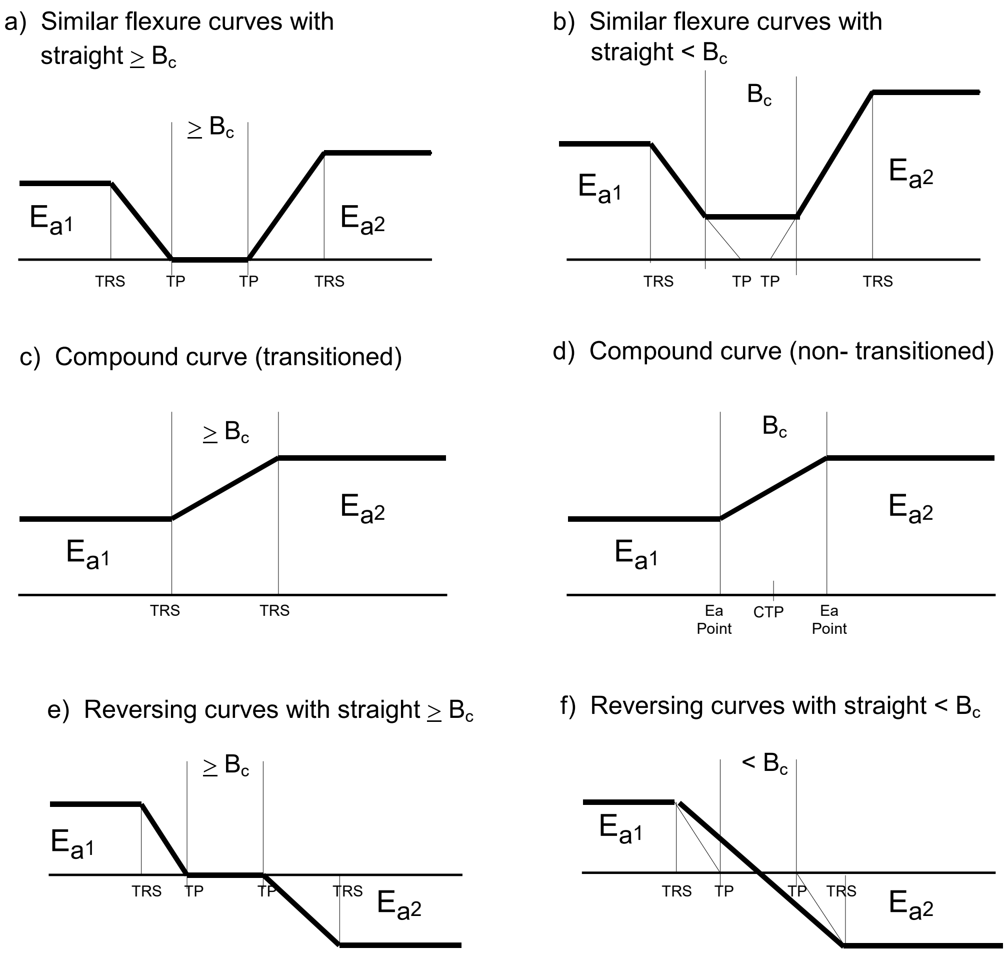


Figure 10 - Methods of applying superelevation

Note: The heavy line represents the applied superelevation through the area of the transitions.

When a curve has no transition then the superelevation shall be applied symmetrically about the geometric frame point (i.e. TP or CTP) as in case (d), above. **.............MR**

7.4.5 Vertical curves

The normal limiting vertical radius (R_v) is given in Table 1. **..............NL**

The minimum allowable vertical radius (R_v) is given in Table 1. **............. ML**

The maximum allowable vertical acceleration (a_v) in a vertical curve is given in Table 1. **............. ML**

A vertical curve is required when the grade difference is: $\Delta G \geq \frac{2600}{V^2}$ or when $\Delta G \geq 1\%$ **.............MR**

Track through turnouts and for 5m in front of switch tip shall be of constant grade (no vertical curvature). This requirement applies to turnouts on main lines and in sidings. **..............NL**

Configuration approval is required if the turnout (new or replacement) is not located on a constantly graded section of track. Turnouts may only be constructed on vertical curves following a detailed assessment of maintenance impacts and risk. **.............MR**

If turnouts are approved on vertical curves the turnout plus 5 metres of track in front of the switch tip shall have the same minimum radius (R_v) as identified in Table 1. **............. ML**

7.4.6 Grades

Track grade should be as flat as possible excepting that design of grade shall consider requirements for drainage, particularly through cuttings and platforms, as detailed below. ***................G***

The normal limits on grades are the same as the maximum limits on grades. **..............NL**

The maximum significant grade allowable in a section of track is the ruling grade for that section. Grades over short distances may be steeper than the ruling grade if it can be shown that there will be no effect on train operations (including the effects of curvature). **.............MR**

When designing grades within 0.43% of the ruling grade for that section, advice must be sought from the Principal Rolling Stock Engineer, for grade compensation. **.............MR**

(i.e. ruling grade 2%, design grade 1.7%, advice must be sought for grade compensation; ruling grade 2%, design grade 1.5%, advice for grade compensation not required)

The design grade shall not exceed the ruling grade without the approval of the Principal Rolling Stock Engineer. **.............MR**

If there is any change in the design grade, the Principal Rolling Stock Engineer should be consulted to determine if any changes to CRN TOC Manual CRN RM 001 are required ***................G***

The minimum grade in cuttings shall not be flatter than 0.5% (1 in 200) without provision for special drainage. **.............MR**

Parameter		Track Class	Normal Limits				Maximum (or Minimum) Limits			
			1	2[4]	3[5]	5	1	2[4]	3[5]	5
Max V (km/h)		Normal	115	100	100	60	115	100	60	60
		HST	160[6]	140[6]	100	80	160[6]	140[6]	100	80
Adopted B_c (m)			13	13	13	13	13	13	13	13
Max β (degrees)			1°	1°	1°	1°	1° 50'	1° 50'	1° 50'	1° 50'
Max D_β (mm)			25	25	25	25	40	40	40	40
Min R (m)			400	400	400	400	160	160	140	140
Max E_a (mm)	Mainline		125	100	75	40	125	100	75	40
	Platforms		See Section 7.7.2				See Section 7.7.2			
	T/out (Thru road) Sim		125	100	50	30	125	100	50	30
	T/out Contra		20	20	20	20	55[3]	40[3]	20[3]	20[3]
Max D (mm) (Note 1)	Plain Track	Normal	±75	±50	±40	±20	±80	±50	±40	±20
		HST	+110/-75	+75/-50	±40	±20	+110/-75	+75/-50	±40	±20
	Turnout track Conventional turnouts	Normal	75	50	40	20	75	50	40	20
		HST	100	75	40	20	110	75	40	20
	Turnout track Tangential turnouts	Normal	75	NA	NA	NA	85	NA	NA	NA
		HST	100	NA	NA	NA	110	NA	NA	NA
Max D_{roc} (mm/s)	Plain Track	Normal	35	35	35	35	55	55	55	55
		HST	55	55	45	45	65	55	55	55
	Turnout track Conventional turnouts	Normal	85	75	55	55	110	85	65	65
		HST	85	75	55	55	110	85	65	65
	Turnout track Tangential turnouts	Normal	110	110	NA	NA	135	135	NA	NA
		HST	110	110	NA	NA	135	135	NA	NA
Rate of change of superelevation E_{aroc} (mm/s)		Normal	35	35	35	35	55	55	45	40
		HST	55	55	45	35	65	65	45	40
Min E_r (1 in)			900	900	750	750	400[7]	400[7]	400[7]	400[7]
Min R_v (m)		Plain Track	1300	1300	1300	1300	1300	1300	1300	1300
		Turnouts	Constant Grade				3000	3000	3000	3000
Max a_v (m/s^2)			0.2	0.2	0.2	0.2	0.4	0.4	0.4	0.4
Grade G (compensated) (Note 2)			1.000%	1.000%	1.000%	1.000%	Ruling Grade			

Table 1 - Normal and Maximum (or minimum) design limits of basic parameters

Notes[#]

1 - The design limit for negative D applies to the normal operation of the most significant trains over the track being designed.

2 - Ruling grade must not be compromised without Principal Rolling Stock Engineer approval. See Grades 7.4.6

3 - Only allowable when maximum deficiency does not exceed 75mm on Turnout Road.

4 - Includes Class 3 track which has been plated and welded to Class 2 standard.

5 - Includes Class 5 track which has been re-railed with 53kg (Class 3G).

6 - HST Speed of 160kph subject to passenger rolling stock type (e.g. XPT or Xplorer).

7 - Consideration needs to be given to the implications for Base Operating Conditions for track geometry. Rates less than 1 in 650 will impact on track maintenance for speeds more than 60kph

		Exceptional Limits	
Parameter	**Track Class**	**1**	**2**
Max D (mm)	Passenger only	100	
Max D_{roc} (mm/s)	Normal	135	
Min E_r (1 in)		300(1)	300(1)
Grade G (compensated)		3.333%	3.333%

Table 2 - Exceptional design limits of basic parameters

Notes(#) 1 - Consideration needs to be given to the implications for Base Operating Conditions for track geometry. Rates less than 1 in 650 will impact on track maintenance for speeds more than 60kph.

7.5 Siding geometry design

All classes of sidings shall be designed to the following geometric standards. .... **MR**

The maximum design train speed on a siding is 25Km/h. If proposed speeds in a siding are > 25km/h main line geometry design standards shall apply. .... **MR**

7.5.1 Circular curves

7.5.1.1 Radius

The Normal minimum radius (R) for sidings is given in Table 3 and the minimum allowable radius (R) is given in Table 4. .... **MR**

Transitions are not required on curves in sidings. .... ***G***

The gauge shall be widened on sharp curves as detailed Table 5. .... **MR**

7.5.1.2 Superelevation

Superelevation is not required on sidings except as required to connect to a mainline turnout. .... ***G***

The maximum rate of removing mainline superelevation shall be 1 in 400. The superelevation ramp shall commence clear of turnout bearers. .... **MR**

7.5.2 Reverse curves

A desirable straight of 20m shall be provided between reverse curves ≤ 200m radius. .... **NL**

For reverse curves > 200m radius the length of straight may be reduced to 13m. .... ***G***

If, because of existing restraints, this straight cannot be economically obtained, the straight may be reduced to 10m provided it is understood that long vehicles may require shunting separately to avoid buffer locking. ....**ML**

7.5.3 Vertical curves

Vertical curves shall be provided when the grade difference is $\Delta G \geq \frac{2600}{V^2}$ or 1% (whichever is the lesser). .... **MR**

Vertical curves should be similar to adjacent mainlines. .... ***G***

The limits for curve radius shall be as detailed in Table 3 for normal design and Table 4 for minimum design. .... **MR**

7.5.4 Grade

The normal limiting Grade (G) is given in Table 3. ....**NL**

The maximum limiting Grade (G) is given in Table 4. .... **ML**

The maximum significant grade allowable in a section of track is the ruling grade for that section. Grades over short distances may be steeper than the ruling grade if it can be shown that there will be no effect on train operations (including the effects of curvature). ....**MR**

When designing grades within 0.43% of the ruling grade for that section, advice must be sought from the Principal Rolling Stock Engineer, for grade compensation. ....**MR**

(i.e. ruling grade 2%, design grade 1.7%, advice must be sought for grade compensation; ruling grade 2%, design grade 1.5%, advice for grade compensation not required)

The design grade shall not exceed the ruling grade without the approval of the Principal Rolling Stock Engineer. ....**MR**

If there is any change in the design grade, the Principal Rolling Stock Engineer should be consulted to determine if any changes to CRN TOC Manual CRN RM 001 are required ....***G***

The Mainline grade shall extend into a siding for a minimum of 15m before commencement of any vertical curve. ....**MR**

Track centres shall be widened where tracks are at different levels and grades to ensure that the designed batter slopes and formation widths are obtained for each track. If this is not possible, retaining walls and standard cess drainage shall be provided. ....**MR**

	Siding Class		
Parameter	**1**	**2**	**3**
Min Radius (R) m	200	180	180
Min Radius (R_V) m	2000	1200	1200
Max Grade (G)	0.66%		
Max Grade (G) Examination	0.66%		
Max Grade (G) Gravity shunting	1%		
Max Grade (G) Loco & Wagon coupling	3%		

Table 3 - Normal design limits for sidings

Parameter	Limit
Radius (R) m (for loco operation)	160
Radius (R) m (wagons only)	120
Min Radius (R_V) m	800
Max Grade (G) Gravity shunting	1.25%

Table 4 - Maximum (or Minimum) Design Limits for Sidings

Radius (m)	Gauge (mm)
200 - 160	1440 (Note 1)
159 - 140	1445
139 - 120	1450
119 - 100	1455

Table 5 - Gauge widening in sidings

Note 1: Gauge widening is not required on curves ≥160m radius if concrete, steel or pre-bored timber sleepers are used.

7.6 Clearance points at converging tracks

7.6.1 General

The safety clearance point between two (2) adjacent converging tracks is the point where a moving vehicle passes a stationary vehicle, on the adjacent track, with a minimum distance between vehicles of 450mm.

Clearance points are used to establish the location of catchpoints and associated insulated joints together with details with which the related signals can be located.

7.6.2 Design requirements

Use the design method detailed in CRN Engineering standard CRN CS 250 “Turnouts and Special Trackwork” to calculate the required track centres at the clearance point.

7.6.3 Protection

Clearance points are protected by:

- Catchpoints or derail devices

  The need for catchpoints shall be determined by the Principal Signal Engineer.

  The location of catchpoints and derail devices shall be established in accordance with the requirements of CRN CS 250.
- Clearance post

  A clearance post is a post provided at the safety clearance point of all turnouts not protected by signals or catchpoints to indicate the point beyond which vehicles must not be permitted to pass without proper authority. When required, the clearance board may be located at the Operations clearance point which is located at wider track centres to provide specific working conditions for operating staff.
- Insulated joints and/or Signals

The need for and location of insulated joints and signals shall be determined by the Principal Signal Engineer.

7.7 Geometry design requirements for alignment at platforms

When track alignment is being reviewed or new trackwork is being constructed, consideration needs to be given to the effects on the platform gap. Whilst the requirements address alignment, changes in track alignment and superelevation design may also necessitate small changes in track grading.

The requirements address different situations where different levels of flexibility are available to the designers.

Where a completely new corridor is being designed maximum flexibility is available allowing the location of a station and the geometry at the station to be determined to minimise the platform gap. Where a new track and platform are to be designed within an existing corridor there is much less capacity to minimise gap and where the platform and track are already fixed there is no flexibility at all.

7.7.1 Platform gap

The size of the platform gap is influenced by the following issues:

- Track structure - Concrete track requires less gap than timber or steel sleepered track.
- Track alignment – tracks on curves, especially sharp curves, will require a greater gap than tangent track.
- Changes in track alignment – changes in curvature within or near to the platform area will cause an increase in the clearance required.
- Turnouts – the presence of any turnouts within the platform area will require an additional clearance or scallop that also gives rise to an inconsistency in the platform gap.
- Superelevation – higher superelevation will require a greater gap.

7.7.2 Platform gap design requirements

7.7.2.1 New platform or track design within an existing corridor – Normal limits

The following requirements shall apply for the design of new platforms and/or new trackwork at platforms that are in an existing corridor (unless approved otherwise by the Principal Track and Civil Engineer). **.............MR**

- Turnouts prohibited in or within 20m of the platform **..............NL**
- Track curvature - minimum radius 600m **..............NL**
- Sharpening of curvature within 20m of a platform prohibited **..............NL**
- Superelevation - maximum of 60mm or up to 100mm where clearance effects are negated by coping design (overhang). **..............NL**
- Track structure - Steel sleepers. **..............NL**

7.7.2.2 New platform or track design within an existing corridor – Maximum or minimum limits

The following requirements shall apply for the design of new platforms and/or new trackwork at platforms that are in an existing corridor unless approved otherwise by the Principal Track and Civil Engineer **............ MR**

- Turnouts prohibited excepting those which affect only the end of the platform (last 15m) by no more than 10mm and for which the gap will be consistently applied for the remainder of the platform after a 1 in 20 ramp to the basic clearance. **.............ML**
- Track curvature - minimum radius 400m. **.............ML**
- No sharpening of curvature within 20m of a platform that would increase clearance requirement by more than 10mm. **.............ML**
- Superelevation - maximum of 75mm or up to 100mm where clearance effects are negated by coping design (overhang). **.............ML**
- Track structure - Steel sleepers. **.............ML**

7.7.2.3 Realignment of an existing platform

Realignment designs for existing platforms should endeavour to reduce the platform gap by considering the following effects and selecting the most effective combination that is practical to implement. Both the track alignment and the platform coping design should be considered: ....G

- *Removing or minimising the effect of turnouts.*
- *Removing or minimising the effect of changes in curvature within 20m of a platform.*
- *Reducing the superelevation.*
- *Installing concrete sleepers.*
- *Sharpening of curvature within 20m of a platform should be avoided.*

7.7.2.4 Temporary platforms

Where staging of new work requires the construction of a temporary platform, the requirements of Section 7.7.2.2 must be met unless otherwise approved by the Principal Track and Civil Engineer. ....MR

7.8 Geometry design requirements for regrading and realignment

This section sets out the geometry requirements for re-grading (adjustment of the vertical level) and re-alignment (adjustment of the horizontal position) of existing tracks.

When upgrading or reconditioning track, the approved grading shall be appropriate to the track classification. ....MR

Where a track is completely reconstructed from (and including) the formation, it shall be treated as a new construction for survey and application of standards. ....MR

Where treated as new construction it may be necessary to extend the new vertical and horizontal track design beyond the project construction limits. Those sections of track outside the project construction limits that have not been adjusted to the new design shall have TCMs placed and documented as per CRN standards and the measurement between the new TCM and the near rail recorded, existing TCMs will remain in use until instructed otherwise by the Civil Maintenance Engineer. ....MR

7.8.1 Regrading

Where design is being undertaken for re-grading the following requirements shall be considered: ....MR

- Condition of formation, and variations of existing formation level necessary to meet standards.
- The condition and depth of existing ballast and track classification to which the work is to be carried out.

The special requirements of finished level for bridges, platforms and other fixed structures shall be considered as outlined below.

- The effect of excavation or fill on the stability of adjacent structures must be reviewed by the Principal Track and Civil Engineer based on the results of an appropriate geotechnical/structural investigation. ....MR
- This applies to the footings of all structures, such as bridge abutments, piers, wingwalls, tunnels, retaining walls, platform walls, signal gantries and towers.

- When regrading past platforms, platform heights shall comply with CRN CS 215. Design approval is required for lowering of the formation level to achieve the required coping height at platforms. Provision must be made for drainage of the depressed formation area and the new track surface must conform to relevant standards. **.............MR**
- If minimum clearances cannot be obtained at overbridges and raising the overbridge is not possible, lowering the existing formation is only acceptable if provision is made for drainage of the lowered area. **.............MR**
- Where regrading is proposed in tunnels, and reconstruction of the track bed is required, the finished reconstruction is to provide for a tunnel complying with the clearances specified in CRN CS 215. **.............MR**

7.8.2 Re-alignment

Where track alignments are required to be modified to accommodate changed operating environments, the requirements of other standards shall be taken into consideration. Some of the issues that need to be considered include: **.............MR**

- Formation width; if not to standard width, shall be widened to meet the requirements of CRN Engineering standard CRN CS 410 “Formation & Earthworks”. **.............MR**
- *The provision of road access needs to be considered to permit reasonable access to all signals as well as for track maintenance purposes. In double track areas, one side shall be the prime access with special access where specifically required on the other. In multiple track areas it is desirable to provide maintenance access along alternate ‘6 foot’.* ***................G***
- *The basic centreline for the section shall be re-established and all track centres checked.* ***................G***
- In multiple track areas, the ultimate mainline track centres shall be as set out in CRN CS 215. **.............MR**
- Where structures require reconstruction or modification, provision shall be made for the ultimate track centres without requiring significant future alteration. **.............MR**

  This shall include placement of trackside structures (except platforms). The requirements of CRN CS 215 shall be met in existing and future designs. **.............MR**
- Track centres across existing underbridges shall comply with CRN CS 215. **.............MR**
- *CRN CS 215 details the requirements for upgrading existing platforms. Where the existing platform face cannot be modified to comply, it may need to be rebuilt.* ***................G***
- *Bridges that cannot be modified to comply with CRN CS 215 may need to be reconstructed or rebuilt.* ***................G***
- *Where a tunnel does not allow widening of track centres to comply with CRN CS 215, it will need to be modified to allow the passage of any vehicle conforming to the appropriate Rolling Stock Structure Gauge.* ***................G***

7.9 Changes to track geometry affecting station platforms

Where track reconstruction is proposed through existing platforms the following matters shall be resolved as part of the design: **.............MR**

- Review track alignment design to consider the platform Gap design requirements (see Section 7.7.2).
- Review what, if any, works are proposed for the platform.

DO NOT plan or undertake design, maintenance or upgrading activities that would cause the track to be non-compliant to platform height tolerances, unless a standards waiver is obtained from the Principal Track and Civil Engineer. **.............MR**

7.10 Geometry design requirements for temporary track work

Geometry design of temporary trackwork that is required for no longer than six months during staged construction of permanent works shall meet the following requirements.

Track geometry shall be designed to the maximum (or minimum) limits detailed in Sections 7.4 and 7.5, except for track at platforms, which must meet normal limits. This is also detailed in Sections 7.4 and 7.5.

Track shall be constructed to meet the maintenance limits detailed in Section 12.2.

7.11 Geometry design requirements for train-monitoring equipment

7.11.1 Electronic weighbridges and wheel-impact load detector (WILD) sites

For accurate and repeatable reading of trains passing in-motion weighbridges and WILD sites, track geometry should be consistent over the site and for a distance of 100m or more on each side of the site.

7.11.2 Other train monitoring equipment sites

No specific track geometry requirements apply for automatic equipment-identifier reader sites, Hot-box detectors or dragging equipment detectors.

8 Permanent speed of trains

Speed signs are described in CRN Network Rules.

Speed signs have a pointed left side: They have either

- black text on a white background for HST
- black text on a yellow background for other rail traffic.

A single, yellow background speed sign applies to all rail traffic.

A white background speed sign, by itself or under a yellow background speed sign, applies only to HST trains.

The locations of permanent speed signs shall be documented in JHR CRN's Asset Management System (Maximo). They shall also be documented in Train Operating Conditions (TOC) Manual for reference by operators. **............ MR**

Speed signs shall be manufactured in accordance with the requirements of CRN Engineering specification CRN CP 213 "Track Side Signs". **............ MR**

8.1 Plain track speed signs

The allowable speed of trains around curves to meet track geometry requirements shall be determined by the application of the design criteria detailed in Section 7.

Speed signs indicate the maximum allowable speed on main line track and shall be erected adjacent to the track at points of increasing or decreasing speed. .... **MR**

Where main line tracks converge (or diverge) one road shall be nominated as the "Through" road. This shall be determined in conjunction with Signal Engineering. .... **MR**

Plain track speed signs shall be applied to the Through road. Turnout speed signs where required shall be applied to the diverging movement to the "other main line".

For new work involving converging tracks, a repeater speed sign shall be placed on the joined track as close to as practical following the junction to remind drivers of the speed as illustrated in Figure 12. This requirement applies to main lines joining another main line. It does not apply to sidings, refuges and loops. .... **MR**

Plain track speed signs are illustrated in Figure 12.

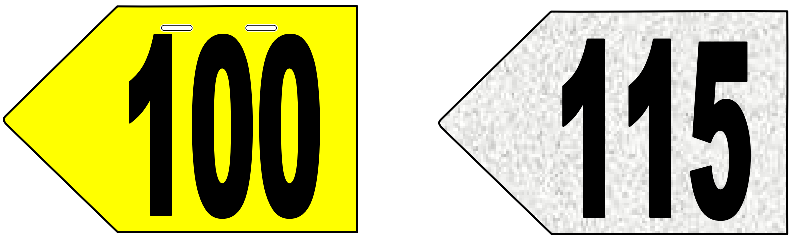


Figure 11 – Examples of pointed permanent track speed signs

8.1.1 Turnout speed signs (Normal and HST)

Turnout speed signs, placed for trains traversing the diverging route of the turnout, are described in CRN Network Rules. They are placed at some turnouts on main lines to show the maximum speed for a train travelling on the turnout track.

Turnout speed signs shall include the prefix "X". .... **MR**

Turnout speed signs are required where the default turnout speed of 25km/h is not suitable, including when the turnout is traversed in the trailing direction .... **MR**

Turnout speed signs shall be erected .... **MR**

- as close to the turnout as possible for which the turnout speed is intended, and
- within 20 metres in advance of the turnout for which the turnout speed is intended

Speed signs shall be manufactured in accordance with the requirements of CRN Engineering specification CRN CP 213 "Track Side Signs". .... **MR**

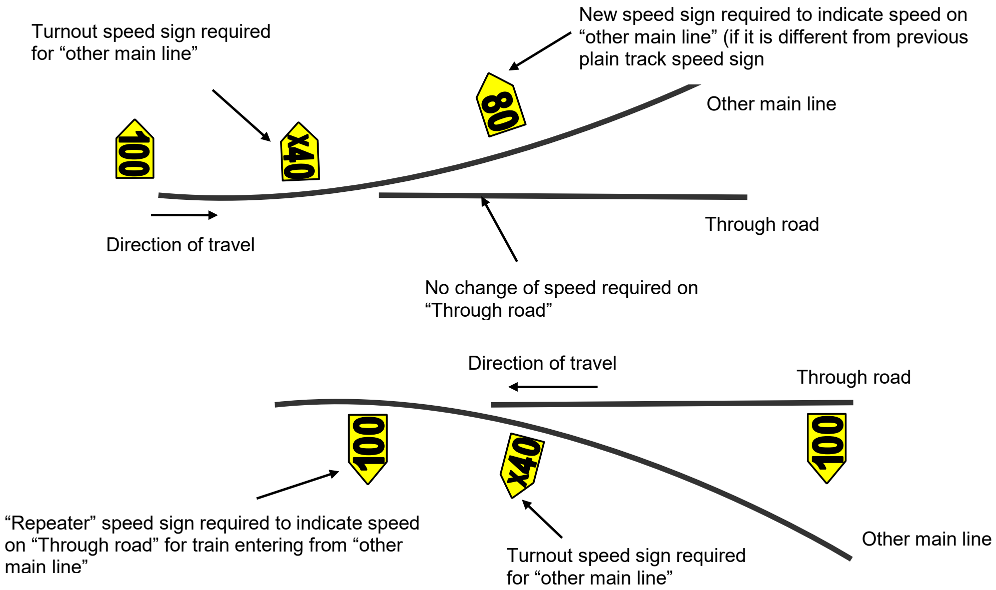


Figure 12 - Example of speed sign layout for converging/diverging roads

8.1.2 Level crossing speed signs

8.1.2.1 Application

Level crossing speed signs are placed on the approach to level crossings at locations where visibility of the level crossing is reduced and trains are required to reduce speed. Level crossing speed signs are used:

- at level crossings with passive protection when they do not comply with the sight distance standards and a risk assessment determines that a speed restriction is necessary
- at level crossings with active protection when faster train services are introduced and the track circuits are not positioned to achieve the required warning time at the faster speed.

8.1.2.2 Appearance

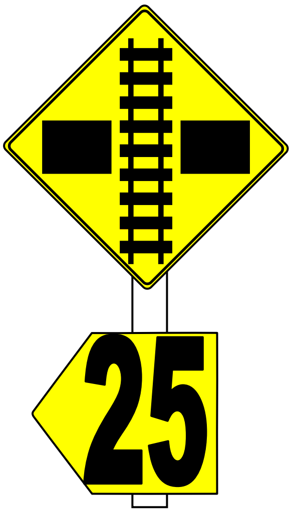
Level crossing speed signs consist of two signs secured to a single post. The upper sign diamond shaped sign with a "standard" permanent speed sign placed below.

8.1.2.3 Position of signs

For passive level crossings, position the level crossing sign at a distance from the level crossing where the sighting distance is clear.

The reduced speed is determined from CRN Engineering Manual CRN CM 521 "Level Crossings" as being the lowest speed appropriate for the sighting distance available.

For active level crossings, position the sign at the beginning of the track circuit for the level crossing. The speed reduction to be applied is the speed for which the track circuit placement was designed.



8.1.2.4 Driver's response to signs

The response to the sign is similar to permanent speed signs. The driver must reduce the speed of the train so that the reduced speed is achieved when the leading motive power unit reaches the location of the sign.

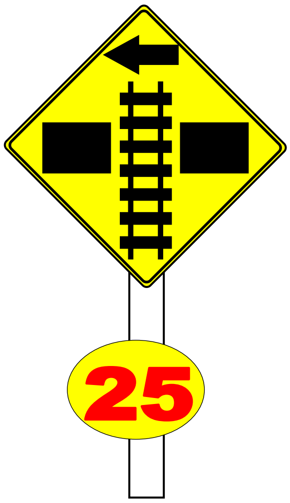
The reduced speed must be maintained until the lead power unit crosses the level crossing, at which point normal track speed may be resumed.

8.1.3 Conditional level crossing speed signs

8.1.3.1 Application

Conditional level crossing speed signs are used at level crossings when the sight distance standard cannot be met due to the presence of a train in the crossing loop. The speed restriction only applies to the affected quadrant when the loop is occupied.

8.1.3.2 Appearance



Conditional level crossing speed signs consist of two signs secured to a single post, the upper diamond shaped sign with a "conditional" speed sign placed below.

The arrow on the sign indicates the side where visibility may be reduced.

8.1.3.3 Position of signs

The "conditional level crossing sign" shall be placed on the track, at a distance from the level crossing where the sighting distance for a road vehicle driver is clear, assuming that the crossing loop is occupied.

The reduced speed is determined from CRN CM 521 as being the lowest speed appropriate for the sighting distance available.

8.1.3.4 Driver's response to signs

The driver must reduce the speed of the train so that the reduced speed is achieved when the leading motive power unit reaches the location of the sign.

If, at any point, the driver of the train can see the crossing loop and can confirm that it is not occupied, then normal line speed may be resumed, without first slowing down to the speed nominated on the speed sign.

If the crossing loop is occupied the reduced speed must be maintained until the lead power unit crosses the level crossing.

8.2 Placement rules

The following rules describe the location of speed signs relative to the track.

For new track designs, a speed sign configuration diagram is to be included as per CRN CP 203,

8.2.1 Placement of plain track, repeater and turnout speed signs

8.2.1.1 Lateral and vertical

NOTE: Lateral and vertical placement rules apply to NEW work or when signs are being repositioned. **.............MR**

Where practical, signs are to be placed in the following "standard" position." ***................G***

- *The closest part of sign shall be no closer to the gauge face of nearest running rail than 1800mm. This means that the centre of the support post, must be at least 2030mm from the gauge face of nearest running rail.*
- *The closest part of sign shall be no further than 3000mm from the gauge face of nearest running rail.*
- *The bottom of lowest sign shall be at least 1000 mm above rail level.*
- *The top of highest sign shall be no more than 3200mm above rail level.*

At locations where lateral clearances are restricted, the lateral and vertical tolerances may be reduced provided minimum transit space requirements are met. **.............MR**

8.2.1.2 Sighting

Speed signs shall be clearly visible to a driver for a minimum of 6 seconds. **.............MR**

8.2.1.3 Mounting

A speed sign shall be mounted on its own post (old rail, 50mm galvanised pipe or equivalent). ....**MR**

Signs must NOT be mounted on signal posts or signal structures. ....**MR**

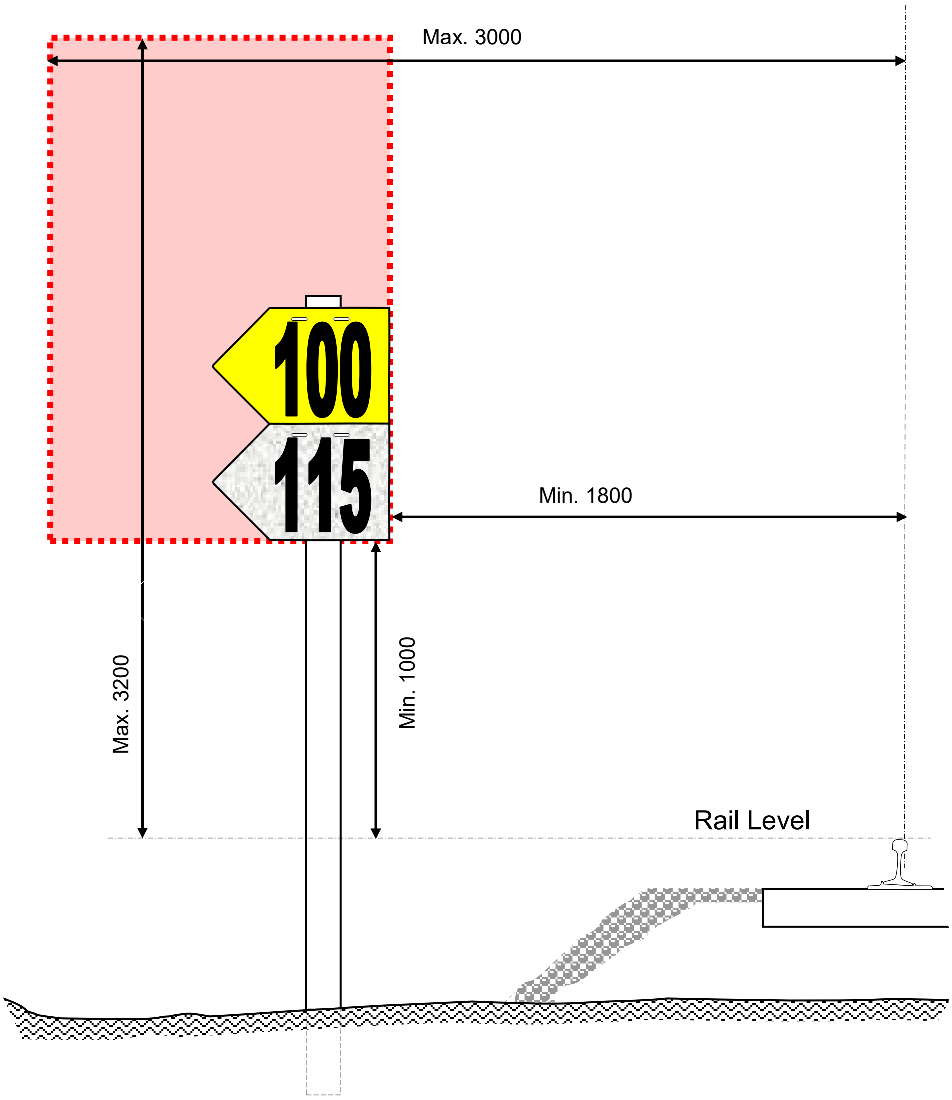


Figure 13 - Placement envelope for permanent speed signs

8.2.2 Placement of level crossing and conditional level crossing speed signs

8.2.2.1 Lateral and vertical

NOTE: Lateral and vertical placement rules apply to NEW work or when signs are being repositioned. ....**MR**

Where practical, signs are to be placed in the following "Standard" position." ....***G***

- The closest part of sign shall be no closer to the gauge face of nearest running rail than 1800mm. This means that the centre of the support post, must be at least 2225mm from the gauge face of nearest running rail.
- The closest part of sign shall be no further than 3000mm from the gauge face of nearest running rail.
- The bottom of lowest sign shall be at least 1000mm above rail level.
- The top of highest sign shall be no more than 3200mm above rail level.

At locations where lateral clearances are restricted, the lateral and vertical tolerances may be reduced provided minimum transit space requirements are met. **.............MR**

8.2.2.2 Sighting

Speed signs shall be clearly visible to a driver for a minimum of 6 seconds. **.............MR**

8.2.2.3 Mounting

A Speed sign shall be mounted on its own post (old rail, 50mm galvanised pipe or equivalent). **.............MR**

Signs must NOT be mounted on signal posts or signal structures. **.............MR**

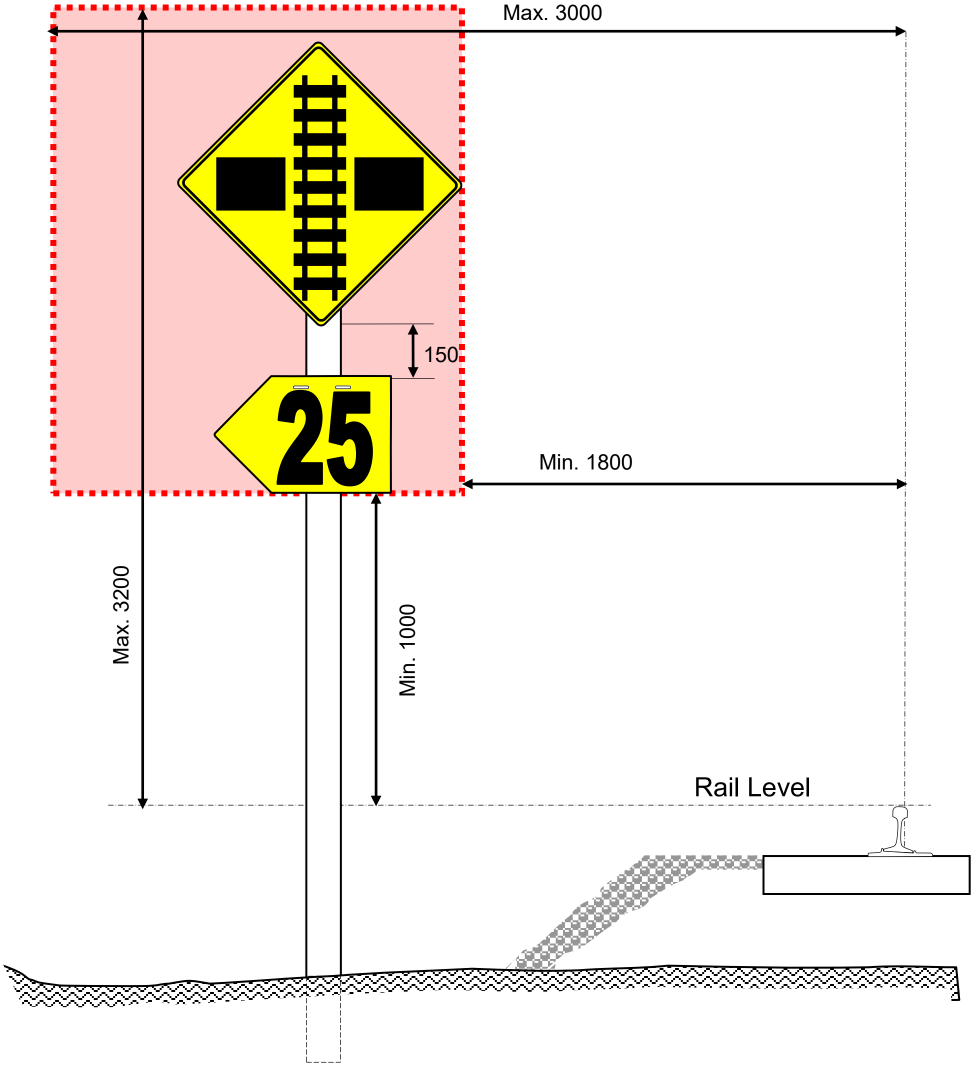


Figure 14 - Placement envelope for level crossing speed signs

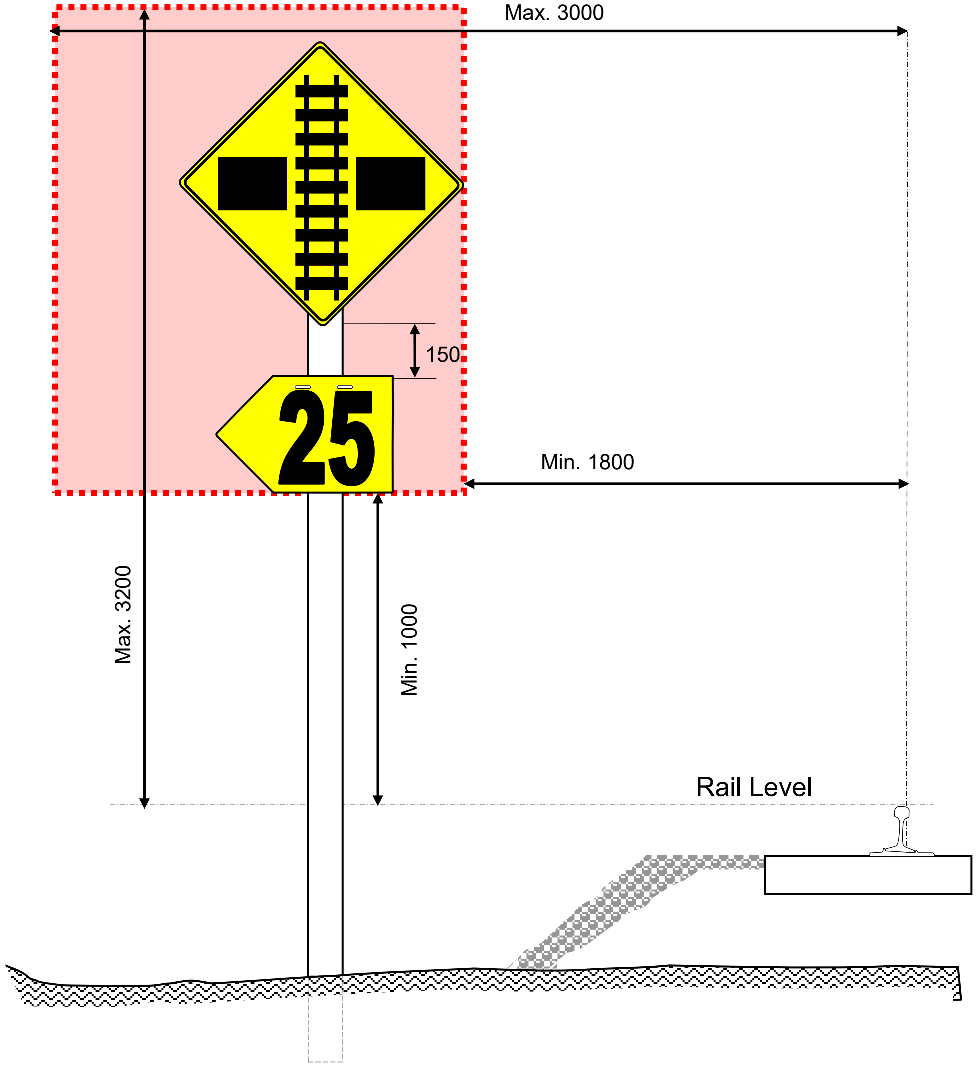


Figure 15 - Placement envelope for conditional level crossing speed signs

9 Survey control requirements

9.1 General

The location of track infrastructure shall be established by Track Control. **.............MR**

Track Control shall be established, based on JHR CRN Survey Control. **.............MR**

All surveys for CRN purposes shall be established using Map Grid of Australia (MGA) and Australian Height Datum (AHD). Alternative systems shall only be used with the approval of the Principal Track and Civil Engineer. **.............MR**

All surveys shall be conducted in accordance with CRN Engineering specification CRN CP 211 "Survey". **.............MR**

Surveys for railway purposes have exacting accuracy requirements and therefore have enhanced checking requirements.

9.2 Track Control standard marking

Track Control Marks to define alignment and grade shall be placed in accordance with CRN CM 212 . ...MR

Track Control Marks should be placed, as far as is practical, on stable permanent structures adjacent to the tracks. *................G*

Where standards of accuracy are not nominated in the design, all marks shall be placed to an accuracy, relative to adjacent marks, of at least twice the accuracy standards defined in Section 12.1.1 for track construction standards. ....MR

Each Track Control Mark (TCM) shall be referenced by a label containing, at least, the following information: ....MR

- Track referenced
- Kilometrage of TCM to 1mm (e.g. 49km 357.345m)
- Design Track Centres from referenced track to adjacent track (if applicable)
- Design superelevation of referenced track (mm)
- Horizontal offset from TCM to design-running face of nearest rail of referenced track (mm)
- Vertical offset from TCM to design low (datum) rail of referenced track (mm).

9.3 Kilometre posts

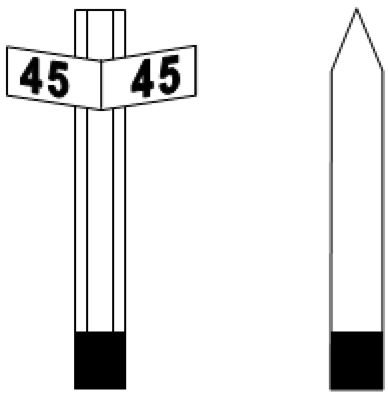


Figure 16 – Kilometre and half-kilometre posts

The location of kilometre and half-kilometre posts shall be established and documented in track designs. The location should be as close as is reasonably practicable to the design location of the km and ½ km points ....MR

Kilometre and half-kilometre posts shall be manufactured in accordance with CRN CP 213, ...MR

Where alignment designs relate to existing track on which kilometre and half-kilometre posts have been established;

- No alterations in longitudinal location are to be undertaken without approval from the Principal Signalling and Control Systems Engineer ....MR
- Lateral placement shall to be reviewed to meet the requirements of Figure 17 ....MR

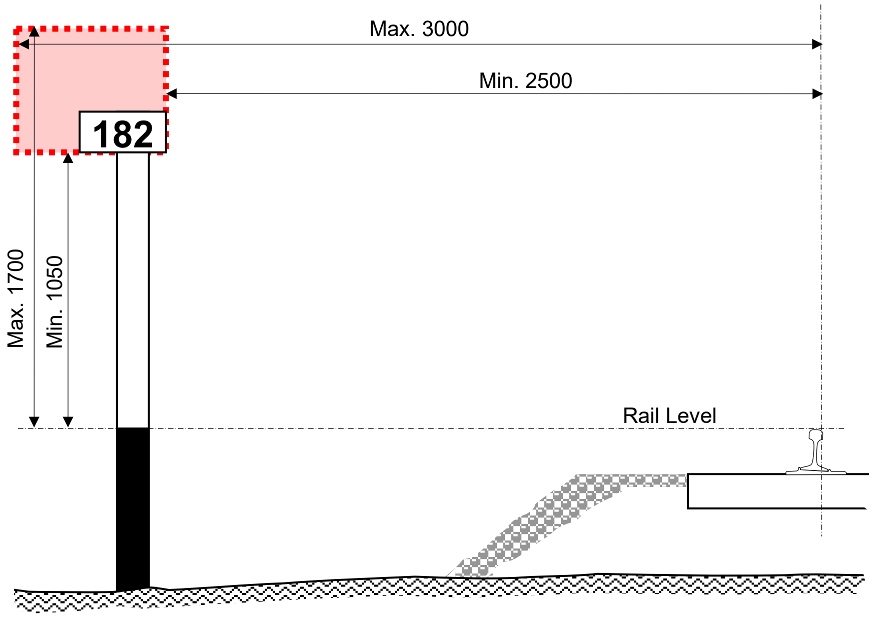


Figure 17 – Lateral placement of kilometre posts

9.4 Measurement of kilometrage

9.4.1 Authorised surveyors

Surveyors with appropriate engineering authority are responsible for the precise location of Track Control Marks and other features. They have authority to locate infrastructure using means other than the nearest Track Control Mark and they are the only people who can place, amend or relocate Track Control Marks.

9.4.2 For non- surveyors

When precisely locating the kilometrage of an item of infrastructure, measurements shall be taken from the kilometrage displayed on the nearest Track Control Mark.

Where Track Control Marks are not available approximate locations can be determined from kilometre and half-kilometre pegs. Only use these markers for approximate location of track features or when no other reference is available as these locations are not precisely located.

Where a survey plaque or kilometre post is used, the location should be described by kilometrage (i.e. by using the decimal point e.g. 35.316Km).

10 Trackside signage

The Civil Maintenance Engineer shall authorise the placement of all types of freestanding signage within 4 metres of any track centre to ensure that signs do not interfere with track maintenance.

Signs shall be mounted on old rail posts, 50mm galvanised pipe or equivalent, and shall be founded in concrete at least 750mm below ground level.

Any sign that needs to be read by drivers should be placed so that the instruction on the sign is visible for at least 6 seconds prior to the point of intended action.

11 Track stability

The track structure capacity to resist the effects of neutral temperature error, depends on sleeper type, curve radius, fastening torsional restraint, ballast quality (angularity and compaction) and quantity in the cribs and shoulders.

The design of new track geometry and track structure, and the reconstruction and maintenance of existing track shall meet the following track stability requirements.

- Rail shall be laid and adjusted to maintain the rail-neutral temperature.
- Rail shall be laid and adjusted at ambient temperature in tunnel environments (i.e. more than 50m in from portals).
- Track structure design shall be capable of providing resistance to lateral movement for the rail temperature range established in CRN CS 200 when subject to the curving forces and dynamic loads imparted by the axle load / speed combination for the relevant Track Class detailed in CRN CS 200, in circumstances where rail adjustment varies from neutral temperature by ± 20°C.
- Track structure design shall be capable of providing resistance to longitudinal movement of rail and rail/sleeper system due to traction and grade effects.

12 Acceptance standards

Manual measurements detailed in this section shall be taken using the methods detailed in CRN Engineering manual CRN CM 203 “Track Inspection”.

12.1 Construction and upgrading for plain track

This section specifies the track geometry requirements for the construction and renewal of trackwork. Gauge requirements are based on new rails. Where second hand rails are used then an appropriate allowance is to be made for rail wear. **.............MR**

The track material shall be to the standards detailed in CRN CS 200. **.............MR**

Where interfaces exist between new construction and existing track appropriate variations in tolerances are acceptable. These will depend on the time the interface will exist between stages of renewal activity, the track speed, traffic etc. They may not exceed the maintenance acceptance levels for unevenness specified in Table 10 or the Base Operating limits for track geometry for the relevant track speed specified in CRN CM 203. **.............MR**

12.1.1 Accuracy to survey

Survey marks shall be provided as specified in Section 9.2. The survey marks, and the information provided, will form the primary source of information for assessing compliance. **............ MR**

Installed tracks shall conform to the basic surveyed design within the tolerances for alignment and level detailed in Table 6. **............ MR**

	Main line				Sidings
Track Class	1	2	3	5	All Classes
Alignment					
Alignment at platforms	± 6				NA
Alignment general	±10	±15	±15		±15
Mid-ordinate from 20m overlapping chords (5m overlap)	±5	±7	±8		±8
Alignment at restricted clearance locations (1)	±10				±10
Variation in alignment between stations up to 20m apart	±10	±15	±15		±15
Superelevation					
Superelevation through platforms	±5				NA
Superelevation	±5	±5	±5	±5	±5
Twist – variation from design (3m) (2)	±5	±6	±7.5		±7.5
Track Surface					
Height at platform relative to design rail level	-0 to +25				NA
Height at other restricted height clearance locations relative to design rail level	-0 to +50				-0 to +50
General height (open track) relative to design rail level	±25	±50	±50		±50
Variation in level between stations up to 20m apart	±15				±15
Rate of change of uniform surface 20m chord	10	12	14		14
Rate of change of uniform surface 6.5m chord	5	6	7		7
Wide Gauge	5	6	6	NA	6
Tight Gauge	-3	-3	-3	NA	-3
Gauge variation in 2m	5	6	7	NA	7

Table 6 - Construction survey acceptance limits

Note
1. Where separate construction tolerances have been supplied as part of a Transit Space Infringement Approval of these will take precedence.
2 Subject to maximum rate of change of 1 in 300.
3 Note: Measurement convention (+ means track is lower than design rail level) – see Figure 18 below.

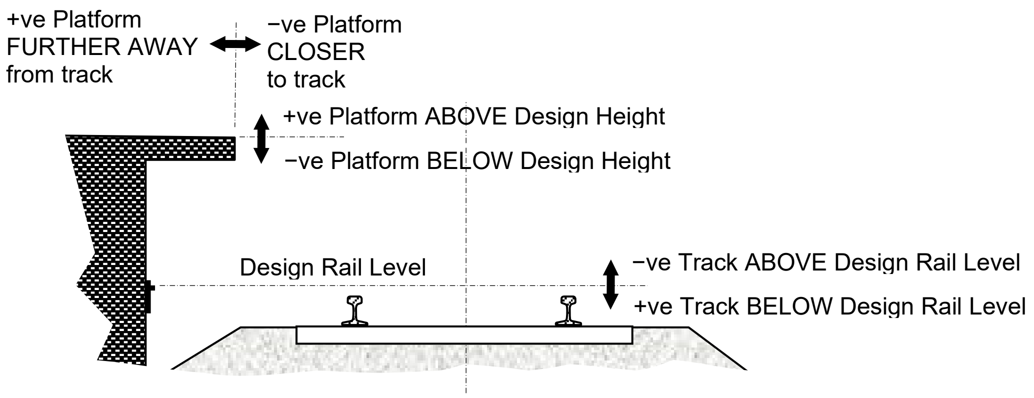


Figure 18 – Measurement conventions

12.2 Maintenance

12.2.1 General

This section details the minimum standard of track geometry that is to be achieved at the completion of the different types of maintenance activities. ....MR

Maintenance of geometric alignment on ballasted track may be carried out by mechanised surfacing or by manual maintenance (fettling). ....*G*

Criteria have been specified for compliance to survey, and for track unevenness depending on the nature of the work (manual or mechanised) and the specific site conditions. Separate requirements have been specified for maintenance activities affecting track gauge. ....*G*

12.2.2 Gauge of track

The limits in Table 7 shall be applied when new sleepers are installed (at each sleeper) or track is cross bored or regauged. ....MR

		Main line	Sidings
Gauge			
Variation to design gauge	Wide	5	5
	Tight (including head flow)	5	5
		Limiting tight gauge 1430mm	
Variation in 1m (due to rail wear)		2	2
maximum deviation at a discontinuity (e.g. a joint)		1	1

Table 7 - Maintenance acceptance limits for gauge

Where gauge widening has been applied on curves by design, the limit applies to the widened design gauge. ....MR

Rail play is not permitted except for small amounts arising from construction tolerances (e.g. 1mm between insulator and foot of rail). ....MR

Work shall be carried out to correct “foot gauge” ± 5mm. ....MR

Rail Cant		Rail Size (kg/m)			
		47	50	53	60
1 in 20	Plain Track	1390	1391	1373	1374
Zero	In Turnouts	1379	1379	1360	1360

Table 8 – Foot gauge

12.2.3 Accuracy to survey

Track on which maintenance work has been undertaken shall conform to the basic surveyed design within the tolerances for alignment and level detailed in Table 9. .... MR

Variation from design		Main line				Sidings
	Track Class	1	2	3	5	All Classes
Alignment						
Alignment at platforms		±15				NA
Alignment at restricted clearance locations (Note 1)		±10				±10
Alignment general		±15				±25
Superelevation						
Superelevation through platforms		±6				NA
Superelevation		6	6	8	10	±10
Track Surface						
Height at platform		− 10 to + 25				NA
Height at other restricted height clearance locations		− 10 to + 25				− 10 to + 25
General height, only applicable to mechanised resurfacing		+75/ -125				+50/ +150 (Note 2)

Table 9 - Maintenance survey acceptance limits

Note 1. Where separate construction tolerances have been supplied as part of a Transit Space Infringement Approval, these will take precedence.

Note 2. Note: Measurement convention (+ means track is lower than design rail level) – see Figure 18.

12.2.4 Unevenness

Track on which maintenance work has been undertaken shall conform to the limits of track unevenness detailed in Table 10. **.............MR**

	Main line				Sidings		
	Track Class				Siding Class		
	1	2	3	5	1	2	3
Line							
Tangent Mid-ordinate (mm) from overlapping chords and maximum versine (mm) for 8m chord with 2m overlap	1	2	2	3	3	3	4
Curve (Note 1) Mid-ordinate variation (mm) in successive overlapping chords for 8m chord with 2m overlap	2	2	3	4	4	4	7
Twist							
Track twist over 2m	6	6	8	10	10	10	10
Track twist over 14m	12	12	16	20	20	20	20
Track Surface							
Mid-ordinate of 6m chord	6	8	10	10	10	10	10

Table 10 - Maintenance Acceptance limits

Note 1. Where the track being assessed is within a transition, the designed variation in superelevation (i.e. a designed twist) shall be considered when determining compliance.

Note 2. Irrespective of any allowances in the table above, the Base Operating limits for track geometry for the relevant track speed specified in CRN CM 203 shall not be exceeded.

12.2.5 Mechanised surfacing

Where mechanised surfacing is undertaken track geometry shall conform to the basic surveyed design within the tolerances for alignment and level detailed in Table 9. ....**MR**

In addition, a visual examination shall be undertaken to confirm geometry is visually smooth. If visible deviations are evident then the anomaly shall be checked as follows: ....**MR**

Alignment use overlapping chords as per Table 10.

Surface use overlapping chords or a "Level" to determine compliance to Table 10.

Superelevation shall be checked against the tolerances in Table 9 at the following locations:

- At all geometry change points including TP, TRS, CTP, CTRS, Ea points.
- At all surveyed locations.
- At no more than 20m intervals on track of consistent curvature.
- At no more than 5m intervals on track with changing curvature (e.g. transitions).
- At any location where any visible deviation in rail surface is evident.

12.2.6 Manual maintenance

Where manual maintenance activities are undertaken (including use of tamping attachment for off/on track plant) track geometry shall conform to the unevenness criteria detailed in Table 10 and the following survey acceptance criteria from Table 9. ....**MR**

- Track height at platforms and restricted height locations
- Track height to design for longer sections of track (more than 30m) at the nearest survey reference points
- Superelevation at 2m intervals through the worksite and for 14m either side.

Track twist shall be checked for 2m and 14m chord lengths against Twist criteria detailed in Table 10. ....**MR**

On multiple tracks with centres less than 4 000mm, where variations in the superelevation roll the vehicles towards each other, the sum of the variations in superelevation shall not exceed 12mm. ....**MR**

12.3 Track Condition Indices

This section details limiting Track Condition Indices (TCI) to be met at the completion of construction, renewal and maintenance work. ....**MR**

Construction and renewal limits apply where new rails and sleepers have been installed.

Track is to be evaluated over half-kilometre lengths excluding turnouts. ....**MR**

The individual parameter TCI must not be greater than that shown in Table 11. ....**MR**

Indices – Construction and renewal					
	Top	**Twist**	**Gauge**	**Line**	**Total**
All classes					
Tangent Track and curves ≥ 800 radius	8	7	5	8	28
Curved Track >240m but < 800m radius	8	8	5	9	30
Turnouts	Not applicable				
Indices - Maintenance (following resurfacing)					
Class 1					
Tangent Track and curves ≥ 800 radius	12	11	9	11	43
Curved Track >240m but < 800m radius	12	11	11	13	47
Class 2, 3 Welded and 3G					
Tangent Track and curves ≥ 800 radius	13	12	10	12	47
Curved Track >240m but < 800m radius	13	13	12	14	52
Class 3					
Tangent Track and curves ≥ 800 radius	15	13	10	13	51
Curved Track >240m but < 800m radius	15	14	14	15	58
Class 5					
Tangent Track and curves ≥ 800 radius	15	13	10	14	52
Curved Track >240m but < 800m radius	15	15	15	17	62
Turnouts (all Classes)	Not applicable				

Table 11 - Track Condition Index limits

12.3.1 Track Code maintenance targets

Track Class	T.C.I. Target
1	45
2, 3 Welded 3G	48
3 Loose	54
5	57

Table 12 - Track Code maintenance targets

13 Damage limits

13.1 Track geometry limits

To be determined.