SECTION 1

CIVIL

CONTENTS

1.2.2.2 Requirements for Steel and Concrete Sleepers

1.2.2.2.1 Rail fastenings for concrete sleepers shall be a resilient fastening system complying with AS1085 and approved by the Rail System concerned.

1.2.2.2.2 Steel sleepers may be designed and installed to utilise either a resilient or non-resilient fastening system.

1.2.2.3 Requirements for Timber Sleepers

Timber sleepered track may utilise either resilient or non-resilient fastenings approved by the Rail System.

1.2.3 SLEEPERS

1.2.3.1 Specification

Timber, steel and concrete sleepers shall comply with the relevant Australian Standard and Rail System specifications:

Concrete Sleepers to AS 1085.14
Steel Sleepers to AS 1085 (draft)
Timber Sleepers to Australian Standard O97/1963

1.2.4 BALLAST

1.2.4.1 Specification

Ballast shall comply with the Rail System specification. The specification shall take into account technical and economic considerations, and material availability.

1.3 DESIGN STANDARDS

1.3.1 GAUGE

1.3.1.1 Measurement of Gauge

Gauge shall be measured 16 mm below the top of the rail with an accurate combination track gauge or an equivalent appliance.

1.3.1.2 Nominal Gauge

The nominal gauge for all classes of track shall be:

Narrow gauge	1067 mm
Standard gauge	1435 mm
Broad gauge	1600 mm

1.3.1.3 Gauge Widening on Sharp Curves

1.3.1.3.1 Gauge widening on sharp curves shall be provided on timber sleepered track and, where practicable, on concrete and steel sleepered track.

1.3.1.3.2 Where appropriate on timber sleepered track, gauge widening may be provided only on main lines and not in sidings.

1.3.1.3.3 Where provided, gauge widening shall be as set out in Table 1.1. Gauge widening on 1067 mm nominal gauge track shall be as specified by the Rail System.

TABLE 1.1
MAXIMUM GAUGE WIDENING ON CURVES (mm)

Nominal Gauge (mm)	Curve Radius (m)	
	> 200	≤200
1435	0	+3
1600	0	+3

1.3.1.3.4 On very sharp curves, additional gauge widening may be provided to suit vehicle characteristics, as specified by the Rail System.

1.3.1.4 Gauge in Turnouts

1.3.1.4.1 Track gauge for the straight road and the turnout road shall be the relevant open track gauge.

1.3.1.4.2 Guard rail gauge, from the crossing nose to the guard rail face, shall be the open track gauge less the guard rail gap (see 1.3.3.3).

1.3.2 CURVES

1.3.2.1 Notation

The following symbols are used in this section:

A_d	=	unbalanced lateral acceleration (m/s^2)
$A'_d(t)$	=	rate of change of unbalanced lateral acceleration (m/s^3)
D	=	superelevation deficiency (mm)
E_a	=	applied superelevation (mm)
$E'_a(t)$	=	rate of change of applied superelevation (mm/s)
E_t	=	total superelevation required for equilibrium at v_m (mm)

g	=	acceleration due to gravity (9.81 m/s^2)
L	=	length of transition (m)
R	=	curve radius (m)
S	=	distance between centres of rails(mm)
V	=	maximum velocity through a curve (km/h)
v_e	=	equilibrium velocity through a curve (m/s)
v_m	=	maximum velocity through a curve (m/s)

Note: S = 1670 mm for Broad gauge tracks
= 1500 mm for Standard gauge tracks
= 1132 mm for Narrow gauge tracks

1.3.2.2 Design Curve Radii

1.3.2.2.1 Minimum curve radii are specified in table 1.2.

1.3.2.2.2 Main line curves shall normally be designed with at least the desirable minimum radius, unless physical, economic or operating factors make consideration of sharper radii appropriate.

1.3.2.2.3 Siding curves shall whenever possible be designed with at least the desirable minimum radius. Curves with a radius less than the normal minimum shall not be used unless track, rolling stock and operating aspects are specifically considered and approved by the Rail System for each case.

1.3.2.2.4 In all cases, minimum curve radii shall be selected taking into account train operating speeds.

TABLE 1.2
MINIMUM CURVE RADII

Gauge (mm)	Main Lines Desirable (m)	Sidings	
		Desirable (m)	Normal (m)
1067	300	160	100 *
1435	800	250	150 *
1600	1000	300	150 *

* Note that intersystem rolling stock is designed to negotiate a curve of 100 m minimum radius. Where there are special circumstances the normal curve radius in sidings may be reduced subject to specific operating and engineering approval by the Rail System for each individual case.

1.3.2.3 Design Superelevations and Transition Lengths

The superelevations and transition lengths to be applied on curves shall be in accordance with standards established by the Rail System, based on the principles set out in sub-sections 1.3.2.4, 1.3.2.5 and 1.3.2.6.

1.3.2.4 Superelevation (or Cant)

1.3.2.4.1 Superelevation for any curve shall be found from the following expression:

$$E_t = E_a + D = \frac{Sv_m^2}{gR}$$

1.3.2.4.2 The applied superelevation (E_a) is a compromise value, because of the need to operate different traffics at varying speeds. Equilibrium speed (v_e) occurs when the lateral acceleration (v_e^2/R) is balanced by the superelevation applied. At speeds higher than equilibrium, there will be an unbalanced component of lateral acceleration because of a deficiency (D) in the amount of superelevation required at that speed.

1.3.2.4.3 Unbalanced lateral acceleration $A_d (m/s^2)$ can be determined from either:

$$A_d = \frac{V_m^2}{R} - \frac{g E_a}{S}$$

or

$$A_d = \frac{g D}{S}$$

1.3.2.4.4 The following combinations of applied superelevation (E_a) and deficiency (D) provide a guide for typical track sections carrying passenger and freight traffic:

$E_a = 0.60 (E_a + D)$ for $V < 120$ km/h
$E_a = 0.55 (E_a + D)$ for $120 < V \leq 160$ km/h
$E_a = 0.50 (E_a + D)$ for $160 < V \leq 200$ km/h

1.3.2.4.5 Limits to be adopted in the establishment of superelevation and curve speed standards shall not exceed those set out in table 1.3.

TABLE 1.3
LIMITS FOR THE DESIGN OF SUPERELEVATION

Limit	Normal	Exceptional
Applied Superelevation E_a (mm)*	150	
Superelevation Deficiency D (mm)*	80	130
Unbalanced Lateral Acceleration $A_d (m/s^2)$	0.52	0.85

Normal: Limits for new construction and existing tracks

Exceptional: Limits to be applied only after rolling stock characteristics have been verified.

* Limits applicable to standard gauge. Values for other track gauges shall be determined as a ratio of the distances (S) between the centres of the rails, e.g. applied superelevation for broad gauge is given by:

$$E_a(bg) = E_a(sg) \frac{S(bg)}{S(sg)}$$

Where: (bg) = broad gauge
(sg) = standard gauge

1.3.2.4.6 The effects of superelevation on the track structure shall be checked by use of the ROA Rail Selection Module computer program.

1.3.2.5 Transitions

1.3.2.5.1 Transitions, based on a cubic spiral, shall normally be provided at the entry and exit of each circular curve, and between curves of different radii, in order to maintain specified maximum or desirable rates of change in applied superelevation and unbalanced radial acceleration.

1.3.2.5.2 Where a transition cannot be provided, a virtual transition length equal to the bogie centres of the vehicle under consideration shall be used for the purpose of the calculations herein.

1.3.2.5.3 The applied superelevation and deficiency shall be developed entirely over the length of the transition.

1.3.2.5.4 The rate of change of applied superelevation $E'_a(t)$ shall not exceed the following values for Standard Gauge track:

Normal (limit for new construction):	35 mm/s
Maximum (limit generally applicable to existing tracks):	55 mm/s
Exceptional (limit to be applied only after rollingstock characteristics have been verified):	70 mm/s

Values for other track gauges shall be determined as a ratio of the distances (S) between the centres of the rail, e.g. for narrow gauge:

$$E_a'(t)(ng) = E_a'(t)(sg)\frac{S(ng)}{S(sg)}$$

Where: (sg) = standard gauge
(ng) = narrow gauge

1.3.2.5.5 The rate of change of unbalanced acceleration A'd(t) shall not exceed the following values:

Normal (limit for new construction)	0.16 m/s^3
Maximum (limit generally applicable to existing tracks):	0.36 m/s^3
Exceptional (limit to be applied only after rolling stock characteristics have been verified):	0.50 m/s^3

1.3.2.5.6 Transition length (L) shall be based on the greater of the following:

$$L = \frac{v_m E_a}{E_a'(t)}$$

or

$$L = \frac{A_d v_m}{A'_d}$$

1.3.2.5.7 The applied superelevation gradient shall not exceed the equivalent of 1:400 for standard gauge.

1.3.2.6 Selection of Superelevation and Speed

1.3.2.6.1 In applying the criteria specified in sub-sections 1.3.2.4 and 1.3.2.5, selection of superelevation and authorised speed for a curve must result in the following criteria being met:

(a) Applied superelevation (E_a) and superelevation deficiency (D) (and hence unbalanced lateral acceleration (A_d)) must be within the limits prescribed in table 1.3.

(b) The transitions must be of sufficient length to ensure that the rate of change of applied superelevation ($E'_a(t)$) does not exceed the limits prescribed in clause 1.3.2.5.4.

(c) The transitions must be of sufficient length to ensure that the rate of change of unbalanced lateral acceleration ($A'_d(t)$) does not exceed the limits prescribed in clause 1.3.2.5.5.

1.3.2.6.2 The maximum allowable speed (v_m) for the curve is:

$$v_m = \left[\frac{(E_a + D)}{S} gR\right]^{\frac{1}{2}}$$

$$= \frac{E'_a(t) L}{E_a}$$

$$= \frac{A'_d(t) L}{A_d}$$

Also:

$$v_m = \left[gR \frac{E'_a(t) L}{S} + R A'_d(t) L\right]^{\frac{1}{3}}$$

1.3.2.7 Reverse Curves

1.3.2.7.1 A straight between reverse curves shall have a minimum length of 20 metres.

1.3.2.7.2 A straight between reverse curves shall have a desirable length of V/2 metres.

1.3.2.7.3 Where the minimum length of straight is not possible, the superelevation shall vary continuously from one direction to the other with the transition curves extended so that they join.

1.3.2.8 Transitions Within Compound Curves

In compound curves, transitions shall be provided between any change of radius where the rate of change of unbalanced lateral acceleration or superelevation development exceed the recommended values, calculated using a virtual transition length equivalent to the bogie centre spacing for the vehicle under consideration.

1.3.3 TURNOUTS

1.3.3.1 Radius

Desirable minimum curved road radii for turnouts in the main line are:

Gauge (mm)	Minimum Curve Radius (m)
1067	100
1435	160
1600	200

1.3.3.2 Superelevation Deficiency

The maximum super-elevation deficiency on the turnout road for the maximum diverging road speed shall be:

Gauge (mm)	Maximum Superelevation Deficiency (mm)
1067	55
1435	75
1600	85

1.3.3.3 Flangeway and Guard Rail Gaps

1.3.3.3.1 Standard Flangeway and guard rail gaps shall be within the range of 43 to 45 mm for all rail sections.

1.3.3.4 Wheel Back-to-Back

1.3.3.4.1 The wheel back to back dimensions used for turnout design shall be 1522 to 1525 mm for 1600 mm gauge track, and 1357 to 1360 mm for 1435 mm gauge track.
For 1067 gauge track, the nominal wheel back-to-back shall be 990 mm to 992 mm, or as determined by the rail System.
Note that the adoption of the AAR-1B wheel profile is under consideration, with a nominal back-to-back dimension of 1346 mm to 1349 mm for 1435 mm gauge track and an equivalent dimension for 1600 mm gauge, and this will possibly impact on the flange-way dimensions and turnout design.

1.3.3.4.2 In applying these criteria, the dimension used shall be based on the actual vehicle back-to-back, the new and worn wheel flange thickness, and the wheel width of all rollingstock operating over the crossing. The actual track gauge, and the guard and flangeway widths, shall also be taken into account in determining this turnout design parameter.

1.3.3.5 **Crossing Nose Profile**

The nose profile shall be designed for the range of new and worn wheels operating on the Rail System.

1.3.4 **VERTICAL CURVES**

1.3.4.1 Vertical curves shall be used whenever there is grade difference equal to or greater than 0.20% (1 in 500 grade) and shall be a circular arc.

1.3.4.2 The minimum length of a vertical curve shall be 15 m between tangent points.

1.3.4.3 The desirable minimum radius shall be as given by:

$R_v = 0.5\,V^2$

where:

R_v = desirable minimum radius (m)

V = maximum velocity (km/h)

1.3.4.5 The minimum vertical curve radius shall be based on a rate of change of 0.02 m per 20 m chord.

1.3.4.6 Minimum radii shall be in accordance with table 1.4.

TABLE 1.4
MINIMUM VERTICAL CURVE RADII

Line Speed (km/hr)	Desirable Radius Minimum (m)	Absolute Minimum Radius	
		Sags (m)	Summits (m)
160	12800	5000	3200
120	7200	3200	2000
100	8000	3000	2000
80	3200	1200	1000
<80	1800	600	400

1.3.5 BRIDGES

1.3.5.1 Bridge loadings and the analysis and design of structural components shall comply with the Australian and New Zealand Railway Conferences Railway Bridge Design Manual, 1974.

1.3.5.2 Bridge design shall consider the maximum vehicle axle loads proposed for the route. Refer to Section 6.2 for bogie axle loads.

1.4 CONSTRUCTION TOLERANCES

1.4.1 GAUGE IN OPEN TRACK

Open track shall be constructed to a gauge tolerance of +3 mm, -0.

1.4.2 GAUGE IN TURNOUTS

1.4.2.1 Track within turnouts shall be constructed to a tolerance of +2 mm, -0.

1.4.2.2 The guard rail gauge within turnouts shall be constructed to a tolerance of +0 mm, -3 mm.

1.5 STRUCTURE CLEARANCES

1.5.1 EXISTING STRUCTURES

1.5.1.1 Section 18 of this Manual specifies the following maximum rolling stock outlines which may operate over existing lines:

(a) Unrestricted Plate A

(b) Alternate Unrestricted Plate B

(c) Principal Plate C

(d) Alternate Principal Plate D

(e) Interim Plate E

1.5.1.2 Section 1.6, Line Section Classification, classifies line sections according to the maximum rolling stock outline which can be accommodated with existing structures.

1.5.1.3 Structure clearance requirements for existing operations shall be as specified by the Rail System concerned. Note that vehicles conforming to the Interim Outline Pate E cannot operate within existing electrified networks.

1.5.2 FUTURE STRUCTURES

1.5.2.1 The Ultimate Maximum Rolling Stock Outline, Plate F is defined at Section 18, diagram 18-6.

1.5.2.2 All new or substantially modified structures constructed over or adjacent to existing and new intersystem and major intrastate routes shall conform to the following structural clearance outlines:

(a) Diagram 1-1: Ultimate Minimum Structure Outline - Straight Track

(b) Diagram 1-2: Ultimate Minimum Structure Outline - for Curves > 300m radius

(c) Diagram 1-3: Ultimate Minimum Structure Outline - for Curves < 300m radius

These diagrams are applicable to both standard and broad gauge lines.

1.5.2.3 The derivation of the above outlines is specified in Appendix 1 to this section. The outlines do not provide for the additional clearances required for the overhead catenary if electric traction is to be provided.

1.5.2.4 Infringement of Clearances

The structure outline shown on each diagram is the minimum acceptable, unless the Rail System determines, using technical principles contained in Appendix 1, that more stringent track tolerances will be maintained or other factors apply and that the alternative structural clearances are therefore acceptable for operation of vehicles conforming to the Ultimate Maximum Rolling Stock Outline.

1.5.2.5 Provision of Additional Clearance

1.5.2.5.1 The structural clearances shown on the diagrams are based on rollingstock operating requirements. Additional clearance for maintenance access, staff safety and the like shall be provided as specified by the Rail System.

1.5.2.5.2 Adjacent to tracks fitted with guard rails, the structure gauge may be widened by the extra width required to accommodate a vehicle running against the guard rail, to provide protection to the structure in the event of a derailment.

1.5.2.6 Curve Transitions

For the purpose of calculating the structure outline for a curve transition, the transition shall be considered to have the minimum radius of any circular curve to which it is joined. In the event that a circular curve is non-transitioned, the structure outline appropriate to the circular curve must be maintained for a minimum distance of 25 metres beyond the curve.

1.5.2.7 Spacing of Adjacent Tracks

1.5.2.7.1 Clearances, derived from the principles set out in this section, shall be provided to allow rollingstock to cross or pass on adjacent lines, crossing loops or sidings.

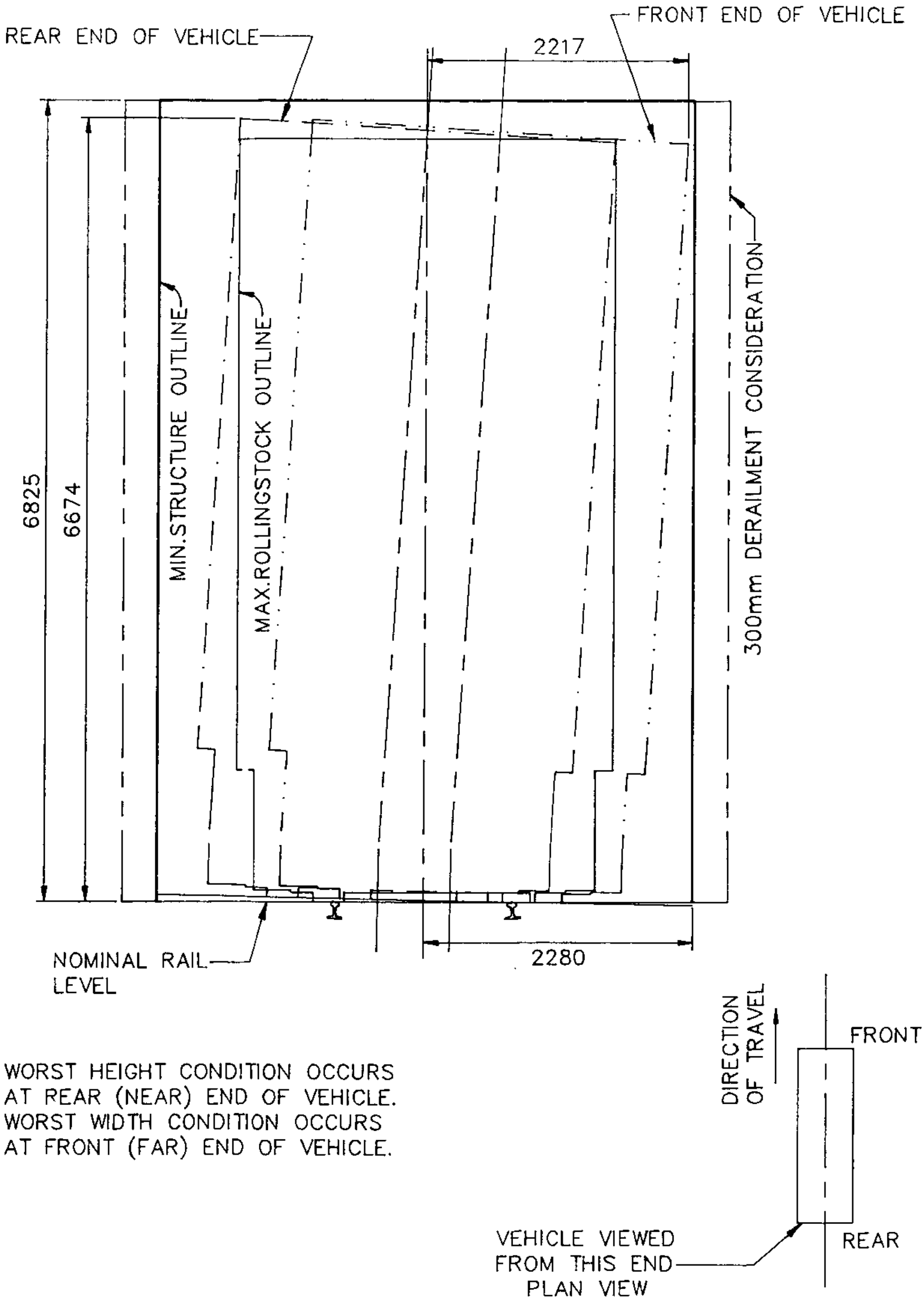
1.5.2.7.2 The specific clearance standards to be provided shall be established by the Rail System.

1.5.2.8 Other Routes

On routes where the 'Ultimate' future rollingstock outline is not being provided for, future clearance requirements shall be as determined by the Rail System.

DIAGRAM 1-1

ULTIMATE MINIMUM STRUCTURE OUTLINE - STRAIGHT TRACK



WORST HEIGHT CONDITION OCCURS AT REAR (NEAR) END OF VEHICLE. WORST WIDTH CONDITION OCCURS AT FRONT (FAR) END OF VEHICLE.

DIAGRAM 1-2

ULTIMATE MINIMUM STRUCTURE OUTLINE - FOR CURVES > 300m RADIUS

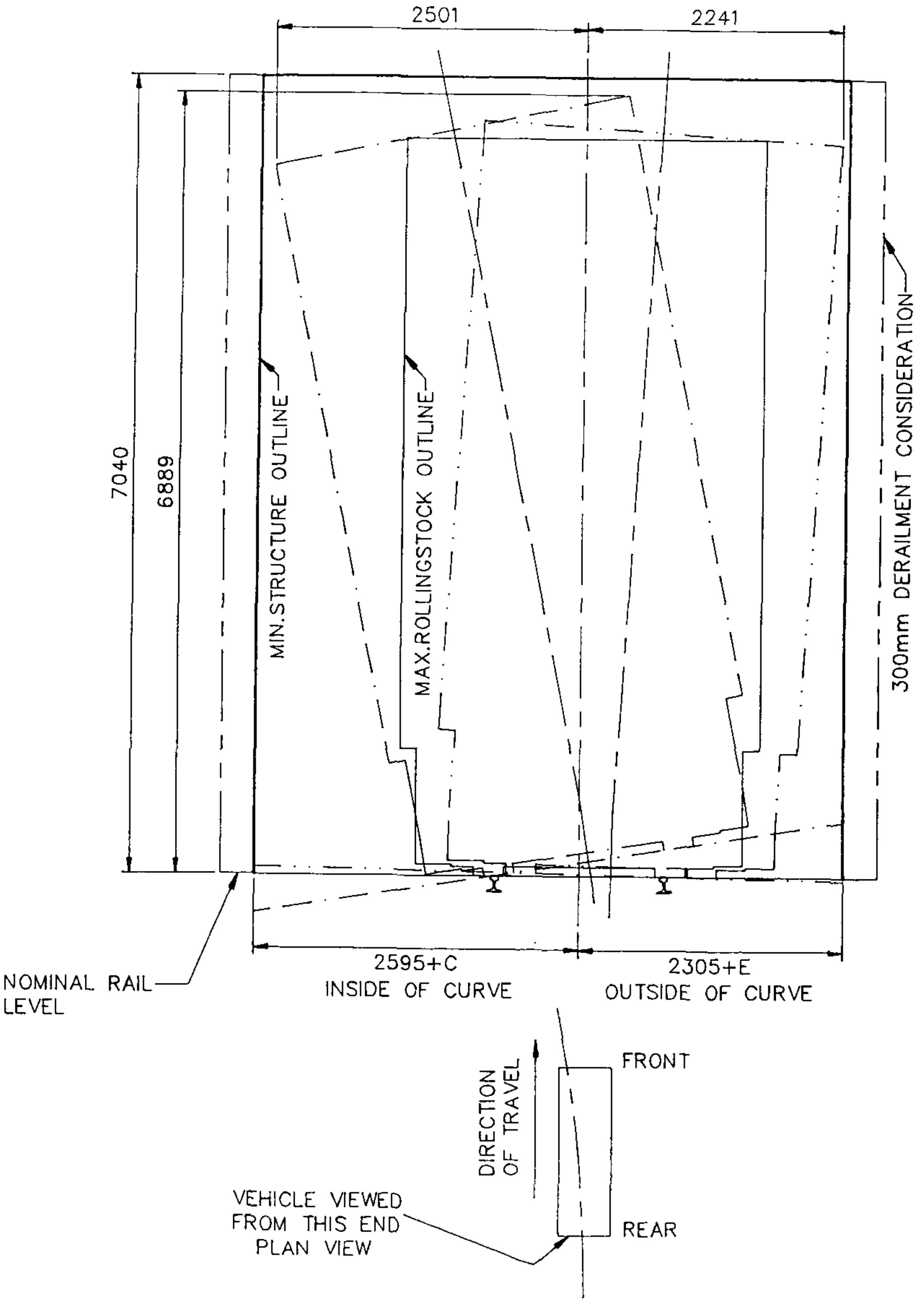
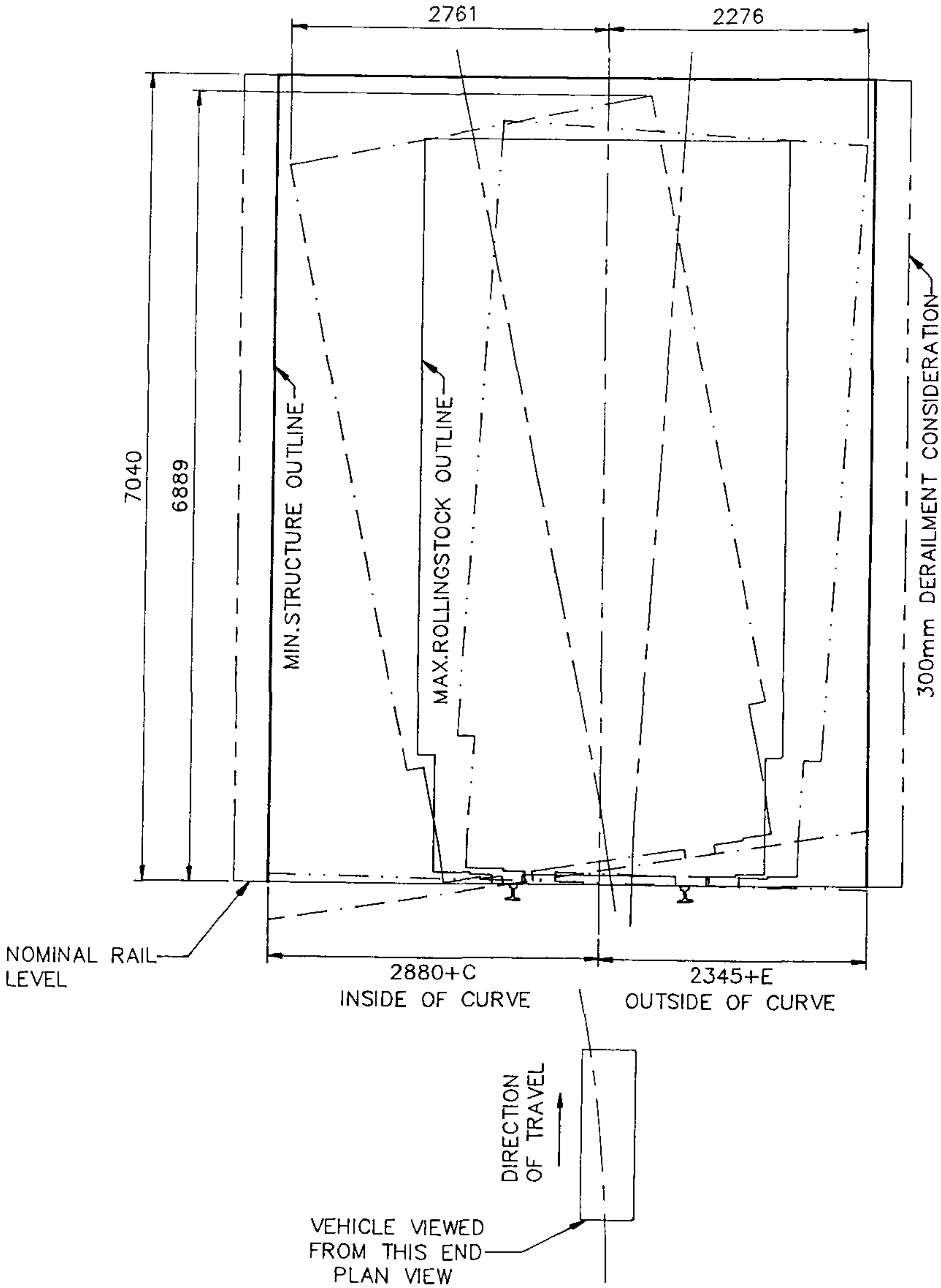


DIAGRAM 1-3

ULTIMATE MINIMUM STRUCTURE OUTLINE - FOR CURVES < 300m RADIUS



1.6 LINE SECTION CLASSIFICATIONS

1.6.1 GENERAL

1.6.1.1 Inter-system routes, principal intra-system routes and branch and local lines which may carry inter-system traffic, shall be classified in accordance with this section

1.6.1.2 The purpose of the classification is to enable ready identification of principal operating parameters.

1.6.2 CLASSIFICATION SYSTEM

1.6.2.1 General

Classification shall be by listing the following parameters:

Line section
Rail system
Authorised rollingstock outline for operating clearance
Normal maximum operating speed for nominated axle loads
Special-condition operating speeds for nominated axle loads

1.6.2.2 Line Section

Line section shall specify the start and end locations, eg. Tarcoola - Alice Springs.

1.6.2.3 Rail System

Rail systems shall be identified by the following code:

QR Queensland Railways
SRA State Rail Authority of New South Wales
PTC Public Transport Corporation (Victoria)
AN Australian National Railways Commission
W Western Australian Government Railways.
R National Rail Corporation

1.6.2.4 Normal Maximum Speeds for Nominated Axle Loads

Normal maximum operating speed (km/h) for the given axle load (t) shall be the normal train speed authorised over that line section for freight traffic, applicable to freight vehicles approved for operation at speeds of 100 km/hr or above in express freight traffic e.g Superfreighters, Westliners, etc. The stated speed shall be that which is generally applicable over the route, ignoring local restrictions. Axle load shall be that applied to freight vehicles and not necessarily to locomotives.

1.6.2.5 Special Axle Load and Speed

Special operating speeds are shown in the table in parentheses, and shall be for other freight traffic. This may be for higher speed lower axle load traffic, or for vehicles not approved for operation at speeds of 100 km/hr, e.g vehicles classified as 'X' or 'F'. Axle load shall be that applied to vehicles and not necessarily to locomotives.

NOTE: Where a nominated axle load is not permitted over a line section, it shall be indicated in the speed column of table 1.5 as NP (not permitted).

1.6.2.6 **Authorised Rollingstock Outline**

The authorised rollingstock (vehicle) outline shall be designated by the following code:

A = Unrestricted and Alternate Unrestricted Outlines, Plates A and B

C = Principal and Alternate Principal Outline, Plates C and D.

E = Interim Maximum Outline, Plate E.

F = Ultimate Maximum Outline, Plate F.

1.6.2.7 **Example**

Albury - Dynon[1], PTC[2], C[3],100[4], 100[5], 90[6], 70[7], NP[8]

[1] Track Section
[2] Rail System
[3] Authorised Rollingstock Outline.
[4] Normal Operating Speed, 19 t. Axle Load
[5] Normal Operating Speed, 20 t. Axle Load
[6] Normal Operating Speed, 21 t. Axle Load
[7] Normal Operating Speed, 23 t. Axle Load
[8] Normal Operating Speed, 25 t. Axle Load

Note that the normal operating speed shown in the table is that which is permitted for high speed freight trains with appropriate vehicle-bogie combinations e.g. Superfreighter, Westliner, etc. Speeds shown in parentheses (80) are those applicable to vehicles not suitable for high speed operation. Lower speeds may be imposed over some sections because of reasons other than vehicle characteristics.

1.6.2.8 **Classification Listings**

Line section classifications are listed in Table 1.5 overleaf.

TABLE 1.5
LINE SECTION CLASSIFICATIONS

LINE SECTION	SYSTEM	VEHICLE OUTLINE S'n. 18	AXLE LOAD IN TONNES				
			19	20	21	23	25
BRISBANE - SYDNEY - MELBOURNE CORRIDOR			**MAXIMUM OPERATING SPEED - KM/HR**				
Brisbane - Sydney	SRA	C	115 (90)	115	115		
Sydney - Albury	SRA	C	100				
Albury - Dynon, S.G.	PTC	C	80/90*/ 100*	80			
SYDNEY - ADELAIDE - PERTH CORRIDOR							
Sydney - Goobang J'n.	SRA	C					
Goobang J'n. - Broken Hill	SRA	E					
Broken Hill - Crystal Brook	AN	E	110(80)	110(80)	110(80)	80	
Adelaide - Kalgoorlie	AN	E	110(80)	110(80)	110(80)	80	
Kalgoorlie - Koolyanobbing	W	E	90		80		
Koolyanobbing - Avon	W	E	90		90	80	
Avon - Cockburn (up)	W	E	80		80	70	
Avon - Cockburn (down)	W	E	80		80	40	
Cockburn - Leighton	W	E	80		80	40	
Midland - Perth Terminal	W	C	60				
MELBOURNE - ADELAIDE CORRIDOR							
Melbourne - Geelong	PTC	A	80	80			
Geelong - Maroona	PTC	A	80	80			
Melbourne - Ballarat - Ararat	PTC	A	80(90*)	80			
Maroona - Wolseley	PTC	A	90(100*)	80			
Wolseley - Adelaide	AN	C	100(80)	100(80)	100(80)	80(80)	
NEW SOUTH WALES INTRASTATE							
Cootamundra - Forbes	SRA						
Forbes - Goobang J'n.	SRA						
and similar routes for example	SRA						
VICTORIA INTRASTATE							
Melbourne - Albury (broad gauge)	PTC	A	80	80			
Geelong - Ballarat	PTC	A	80	80			
Maroona - Portland	PTC	A	80	80			
Dynon-Long Island	PTC	A	65	65			
SOUTH AUSTRALIA INTRASTATE							
Port Augusta - Whyalla	AN	E	80	80	80	60	-
Tarcoola - Alice Springs	AN	E	100 (80)	100 (80)	100 (80)	80(80)	

* = Specially authorised vehicles

1.7 DERIVATION OF ULTIMATE MINIMUM STRUCTURE OUTLINE

1.7.1. ROLLING STOCK OUTLINE

The ultimate rolling stock outline used in the calculation of the Ultimate minimum structure outline diagrams is defined in section 18 of this manual. Calculation of the structure gauge is based on a vehicle length of 25.9 m and a bogie centre distance of 18.3 m.Vehicles with dimensions greater than this have reduced width to compensate for increased centre and end throw on a curve with a radius of 100 m.

1.7.2. VEHICLE AND TRACK TOLERANCES

This sub-section describes the vehicle and track tolerances which are assumed in calculation of the ultimate minimum structure outline.

1.7.2.1 Vehicle Clearances at Condemning Level

A lateral translation of the vehicle centre pivot of ±40 mm is used due to clearances in and wear of vehicle components. This assumes the vehicle components are in a condemnable condition.

1.7.2.2 Wheel/Rail Clearances

A lateral movement of ±20 mm is assumed at the vehicle centre-pivot due to the clearance between a flange condemned wheel and a new rail. The basis on which this assumption is made is detailed in Diagram 1-4. The wheel is considered condemned when the flange thickness reaches 20 mm.

1.7.2.3 Rail Side Wear

The assumed rail side wear tolerances for the purposes of calculating structure clearances are given in Table 1.6. The +25 mm allowance in curve is based on ROA Rail System limits for rail side wear. A ±5 mm limit is set on straight track to allow for side wear due to cyclic lateral vehicle movements.

TABLE 1.6
RAIL SIDE WEAR (mm)

Straight	Curves >300 m Radius	Curves ≤300 m Radius
+5 -5	+25 -5	+25 -5

Note: +ve implies wear to the gauge side of the outer rail in curves.
-ve implies wear to the gauge side of the inner rail in curves.

1.7.2.4 Gauge Widening in Sharp Curves

Gauge widening in sharp curves is permitted by movement of the inner rail towards the field side. The assumed widening tolerances for the purposes of calculating the structure clearance are set out in Table 1.7 below. The gauge widening values are based on Rail System standards for main line tracks.

TABLE 1.7
GAUGE WIDENING (mm)

Straight	Curves >300 m Radius	Curves ≤300 m Radius
+0 -0	+0 -0	+0 -15

Note: +ve implies widening by movement of the outer rail in curves.
-ve implies widening by movement of the inner rail in curves.

1.7.2.5 Wide Gauge Tolerances

The assumed wide gauge tolerances for the purpose of calculating the structure outline are given in Table 1.8 below. The values are based on Rail System standards for main line tracks.

TABLE 1.8
WIDE GAUGE TOLERANCES (mm)

Straight	Curves >300 m Radius	Curves ≤300 m Radius
+20	+20	+25

Note: +ve implies widening of gauge.

1.7.2.6 Vehicle Carbody Roll

A maximum carbody roll of ±2.5 degrees relative to the track lateral plane is permitted. This roll has been imposed on the vehicle at a height of 440 mm above rail level. The 440 mm rotation height is based on the distance from nominal rail level to the top of the secondary spring nests at working height for a low level 3-piece bogie.

1.7.2.7 Centre and End Throw of the Vehicle in Curves

For the purpose of calculating structure clearances on curves, the centre (C) and end (E) throw for a vehicle may be calculated using the following formulae:

$$C = R - \left(R^2 - \frac{B^2}{4}\right)^{½}$$

or approximately

$$C = \frac{B^2}{8R}$$

$$E = \left(R^2 + H^2 + BH\right)^{½} - R$$

or approximately

$$E = \frac{L^2 - B^2}{8R}$$

where:

B *is the distance between vehicle centre pivots*
L *is the distance over the vehicle headstocks*
R *is the actual minimum curve radius*
H $= ½(L - B)$

C is maximised when B is at a maximum (B_{max}), and E is maximised when both B *and* H are at their maximum (B_{max} *and* H_{max} respectively).

B_{max} = 18300 mm
H_{max} = 3800 mm

For these values of B_{max} and H_{max}, the centre and end throw can be considered to be equal, and this has been used as the basis for the development of the Ultimate Maximum Rolling Stock Outline. There are no specific maximum values for the vehicle bogie centres and end overhang; these are limited by the L/V requirements and practical considerations.

C and *E* have been calculated for a range of actual curve radii (R) and are listed in Table 1.9 and illustrated in Diagram 1-5 for quick reference.

TABLE 1.9
CENTRE AND END THROW

Curve Radius (R) (m)	Centre Throw (C) (mm)	End Throw (E) (mm)
50	840	840
100	420	420
200	210	210
300	140	140
400	105	105
600	70	70
800	52	52
1000	42	42
1200	35	35

Note: B = 18300 mm and L = 25900 mm used in Table 1.9

1.7.2.8 **Track Alignment**

1.7.2.8.1 **Variation of Track Centreline From Design**

The assumed maximum variation in horizontal alignment from the design horizontal alignment is defined in Table 1.10. The values in Table 1.10 relate to open track only, that is, which passes under or next to a structure. The allowance for tight curves is relaxed to allow for push out and pull in due to temperature variations and the like.

TABLE 1.10
VARIATION FROM DESIGN CENTRELINE (mm)

Tangent	Curves >300 m Radius	Curves ≤300 m Radius
+50 -50	+50 -50	+75 -75

Note: +ve implies variation towards the outside of a curve.
-ve implies variation towards the inside of a curve.

1.7.2.8.2 **Alignment Versine**

A horizontal alignment versine of 20 mm on a 10 m chord length is assumed for the purposes of calculating structure clearance. This value is based on Rail System standards for main line tracks.

1.7.2.9 **Superelevation**

The maximum design superelevation permitted on a curve is assumed in all cases to be 150 mm. This allows for possible future increases in superelevation on existing curves.

1.7.2.10 **Cross-Level Variation**

The maximum cross-level variation from design is ±30 mm. This value is based on Rail System standards for main line tracks.

1.7.2.11 **Summary**

The vehicle and track tolerances assumed in the determination of the ultimate minimum structure outlines are summarised in Table 1.11.

TABLE 1.11
SUMMARY OF VEHICLE AND TRACK TOLERANCES

Tolerance	Straight Track	Curves >300 m Radius	Curves ≤300 m Radius
(a) Total vehicle clearances at condemning level (inc wheel/rail clearance)	+60 mm -60 mm	+60 mm -60 mm	+60 mm -60 mm
(b) Rail side wear	+5 mm -5 mm	+25 mm -5 mm	+25 mm -5 mm
(c) Gauge widening	+0 mm -0 mm	+0 mm -0 mm	+0 mm -15 mm
(d) Wide gauge tolerances	+20 mm -20 mm	+20 mm -20 mm	+25 mm -25 mm
(a) +b +c +d	+85 mm -85 mm	+105 mm -85 mm	+110 mm -105 mm
(e) Vehicle body roll	+2.5° -2.5°	+2.5° -2.5°	+2.5° -2.5°
(f) Vehicle centre and end throw	0 mm	Refer to text	Refer to text
(g) Track centreline align Either side of design centreline	+50 mm -50 mm	+50 mm -50 mm	+75 mm -75 mm
(h) Track alignment versine on a 10 m chord, ie variation from design versine	20 mm	20 mm	20 mm
(i) Superelevation	0 mm 0 mm	0 mm -150 mm	0 mm -150 mm
(j) Cross level variation from design	+30 mm -30 mm	+30 mm -30 mm	+30 mm -30 mm

Note: +ve values imply possible movement of the vehicle to the outside of the curve.

1.7.2.12 **Service Tolerances**

The lateral structure clearances have been increased by 10% in Diagrams 1-1 to 1-3 to allow for variations in all of the above tolerances which may occur due to normal maintenance procedures, as well as to provide for clearance between the vehicle in its worst configuration and the structure.

1.7.3. VERTICAL CLEARANCES

A vertical clearance of 150 mm is assumed in Diagrams 1-1 to 1-3, between the highest point on the vehicle in its laterally (i.e. items from Table 1.11) displaced position and the minimum structure outline. This is to allow for bounce and pitch of the vehicle body as well as for track tolerances in the vertical direction.

The vertical height of the structure outline in Diagrams 1-1 to 1-3 is measured from the nominal rail level *(i.e. rail level before consideration of superelevation and cross-level variations). The Rail System* must ensure that track level is maintained at or below that indicated in Diagrams 1-1 to 1-3

1.7.4. DERIVATION OF THE DISPLACED VEHICLE OUTLINES

1.7.4.1 Straight Track

To produce the displaced vehicle outlines, a series of translations and rotations are made to the nominal static rollingstock outline based on the vehicle and track tolerances set out in Table 1.11. The process which is used to determine the worst displaced vehicle outlines is as follows for the straight track case:

(a) Apply cant variation of +30 mm to the left rail.

(b) Apply +2.5° *roll to the vehicle at a height of 440 mm above rail level.*

(c) Rotate the vehicle in yaw an amount which accounts for items (a), (b), (c), and (d) in Table 1.11. This effectively takes up all vehicle lateral clearances as well as the lateral clearances between wheels and rails.

(d) Translate vehicle +50 mm to the right to account for track centreline offset.

(e) Rotate vehicle about the axis through the front centre pivot to account for an alignment versine of 20 mm on a 10 metre chord length.

(f) Apply 10% additional clearance for service tolerances.

1.7.4.2 Curved Track

To produce the displaced vehicle outlines a series of translations and rotations are made to the nominal static rollingstock outline based on the vehicle and track tolerances set out in Table 1.11. The process which is used to determine the worst displaced vehicle outlines is as follows for the curved track cases:

(a) Apply cant variation of ±30 mm to the track.

(b) Apply ±2.5° roll to the vehicle at a height of 440 mm above rail level.

(c) Rotate the vehicle in yaw an amount which accounts for items (a), (b), (c), and (d) in Table 1.11. This effectively takes up all vehicle lateral clearances as well as the lateral clearances between wheels and rails.

(d) *Translate vehicle ±50 mm (±75 mm) to account for track centreline offset* on curves >300 m (≤300 m) radius.

(e) Rotate vehicle about the axis through the front centre pivot to account for an alignment versine of 20 mm on a 10 m chord length.

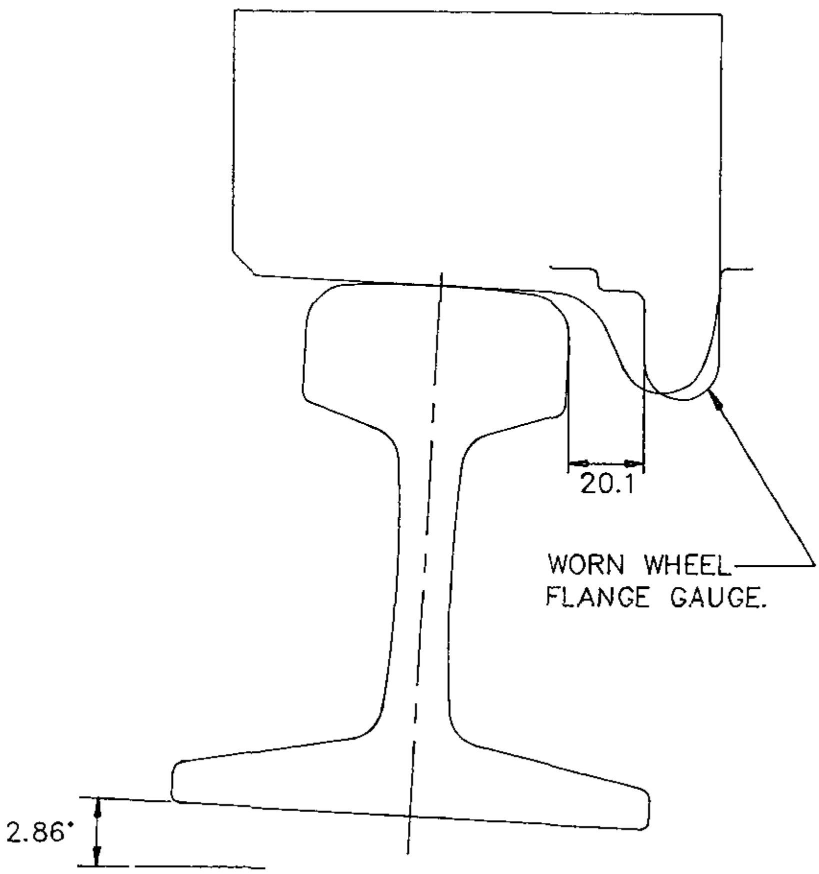
(f) Apply 150 mm (0 mm) superelevation to track for inside (outside) curve clearances.

(g) Apply 10% additional clearance for service tolerances.

(h) Apply clearances for centre (C) and end (E) throw for the inside and outside of curves respectively.

DIAGRAM 1-4

WHEEL/RAIL CLEARANCES



ASSUMPTIONS: NEW 47kg A.S. RAIL ON 1:20 INCLINE.
GAUGE 1435mm.
WHEEL PROFILE ANZR NEW WHEEL.
WHEEL BACK TO BACK MEASUREMENT 1357mm.
WORN WHEEL FLANGE GAUGE, SEE SECTION 17

DIAGRAM 1-5

CENTRE AND END THROW OF THE VEHICLE IN CURVES