TRACK AND CIVIL INFRASTRUCTURE

CODE OF PRACTICE

VOLUME THREE - TRAM SYSTEM [CP3]

STRUCTURAL CLEARANCES

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1.0 PURPOSE AND SCOPE

1.1 PURPOSE

The purpose of this part is to set standards to ensure that:

a) the construction or maintenance of tracks and structures shall enable trams or tram-type vehicles to travel along tram tracks at the line speed with clearances between vehicles and adjacent structures or between vehicles on adjacent tracks which are safe; and

b) if the prescribed clearances are compromised:

   1) appropriate restrictions shall be imposed on tram movements to maintain safety; and

   2) actions shall be taken to ensure affected track or structures are restored to a safe standard.

1.2 PRINCIPLES

This part complies with the principles set out in the "Code of Practice for the Defined Interstate Rail Network", volume 4, part 2, section 7.

1.3 SCOPE

This part specifies general procedures for:

a) the design and rating of lineside structures to provide adequate clearances between them and tram movements on adjacent tramway tracks;

b) the design and rating of tracks at minimum centres to provide adequate clearance; and

c) the monitoring and maintenance of clearances and infringements.

1.4 REFERENCES

1.4.1 TransAdelaide documents

a) **CP3**

CP-TS-972: Part 2, Structure and application
CP-TS-973: Part 3, Infrastructure management and principles
CP-TS-976: Part 6, Track geometry

b) **Infrastructure Services Management Procedure Manual**

CPRD/PRC/046 Records Management.

1.4.2 Industry codes of practice

Code of Practice for the Defined Interstate Rail Network, volume 4 (Track, Civil and Electrical Infrastructure), part 2 (Infrastructure Principles), section 7: Clearances.

1.4.3 TransAdelaide drawings

200-A2-2003-104: Tram system – maximum static rolling stock outline
301-A2-2003-102: Tram system – minimum structure outline

2.0 DESIGN AND RATING

2.1 APPLICATION OF CLEARANCES

The design and rating of clearances applies to clearances between

a) rolling stock and structures; and

b) rolling stock on adjacent tracks.

2.2 ADDITIONAL CLEARANCES

Structure outlines detailed in this section are provided for the safe operation of rolling stock and the passage of trams. Where required, additional clearances should be provided for:

a) access or egress (emergency or otherwise);

b) people, plant or equipment;

c) projection of parts of the human body from rolling stock;

d) derailed rolling stock (where practicable);

e) health and safety reasons;

f) service requirements;

g) maintenance activities; and

h) future clearance upgrades.

2.3 DETERMINATION OF CLEARANCE STANDARDS

For the everyday use of the standard clearance diagrams, it is considered that the development of clearance standards, their basis and the derivation of these diagrams is not necessarily of consideration and these determinations and background calculations are included as Appendices 1 to 4 to this part of the Code of Practice as a record only.

2.4 AIR GAP

To ensure adequate clearances between rolling stock and structures, or rolling stock on adjacent tracks, monitoring and maintenance of track position is based on the “air gap”. The “air gap” is defined as follows:

a) at a specific location, the shortest distance between a structure and the maximum kinematic rolling stock outline;

b) at a specific location, the shortest distance between the maximum kinematic rolling stock outlines on two adjacent tracks.

Note: The maximum kinematic rolling stock outline is defined in Appendix 4.

2.5 INFRINGEMENTS

Except where the cost of removing an infringement is uneconomically high and it does not present any danger to tram operations or personnel, measures should be taken to remove infringements where:

a) existing structures infringe the minimum structure outline, or

b) track centres infringe the minimum standard track centres,

3.0 MINIMUM STRUCTURE OUTLINE

3.1 ALL NEW STRUCTURES

a) All new structures built adjacent to TransAdelaide's tracks shall comply with drawing No. 301-A2-2003-102 (Tram system – minimum structure outline).

b) On curves, additional horizontal clearance shall be provided in accordance with the drawing in sub-clause (a).

c) Where track is wide to gauge, the centreline of the track shall be considered to be 0.717m behind the gauge face of the near rail for the purposes of measuring horizontal distances to adjacent structures or parallel tracks.

d) For measuring horizontal and vertical distances to adjacent structures or parallel tracks, on canted track, the vertical centreline of the track shall be considered to be at right angles to the plane of the running surface of the two rails.

3.2 ALLOWABLE INFRINGEMENTS

a) Existing structures, which do not comply with the minimum structure outline or are not listed as allowable infringements of the minimum structure outline shall be recorded as follows:

1) A separate schedule shall be maintained listing all infringements, which infringe the horizontal clearance by no more than 100mm;

2) A separate schedule and an accurate drawing shall be maintained showing all other infringements. ***SCHEDULES TO BE PREPARED***

b) For structures that infringe the standards as in sub-clause (a), it may also be necessary for more stringent track geometry standards to apply to compensate for the reduced clearances. The schedules shall indicate where this requirement applies.

4.0 MAXIMUM STATIC ROLLING STOCK OUTLINE

4.1 ROLLING STOCK OWNED BY TRANSADELAIDE

All rolling stock owned and operated by TransAdelaide shall comply with drawing number 200-A2-2003-104 (Tram system – maximum static rolling stock outline).

4.2 ROLLING STOCK OWNED BY OTHERS

Rolling stock owned by other than TransAdelaide and operating over TransAdelaide infrastructure shall comply with the drawing in sub-section 4.1. If it does not comply, it shall be considered as infringing the maximum static rolling stock outline and will be subject to the provisions of sub-section 7.7 and CP-TS-972 (Structure and application).

5.0 CLEARANCES BETWEEN ROLLING STOCK ON ADJACENT TRACKS

5.1 MINIMUM TRACK CENTRES

The minimum track centres between parallel rail tracks on running lines or sidings shall be sufficient to give a clearance between the maximum kinematic rolling stock outline on each track of not less than 300mm under all conditions. For example, if the maximum kinematic rolling stock outline is 3.555m wide the minimum track centres on tangent track would be 3.855m.

5.2 PREFERRED TRACK CENTRES

The preferred minimum track centres on all new work or remodelling of track layouts shall be:

a) 3.8m for in-street tracks; and

b) 4.0m elsewhere;

but shall not be less than specified in sub-section 5.1.

5.3 PERMANENT REDUCED TRACK CENTRES

5.3.1 A separate schedule shall be maintained listing where existing straight track and track on parallel curves with track centres permanently less than that prescribed in sub-section 5.1 infringe the required standard. ***RECORD TO BE PREPARED***

5.3.2 For tracks that infringe the standards as in sub-section 5.1, it may also be necessary for more stringent track geometry standards than shown in CP-TS-976 (Track geometry) to be applied to compensate for the reduced track centres. The schedule (see clause 5.3.1) shall indicate where this requirement applies and the limits on deterioration with speed limits where applicable.

6.0 MONITORING AND MAINTENANCE

6.1 INSPECTIONS AND ASSESSMENT

Inspections, assessment and maintenance actions shall include the specific conditions shown in table 6.1:

Table 6.1: Structural clearance inspections, assessment and actions

Type of inspection	Specific actions or conditions to observe
Scheduled inspections	
Walking inspections	a) Identify visually obvious clearance infringements and report any structure or adjacent track that is damaged, unsound or of changed geometry. A sharp lookout should be kept for clearance infringements and conditions (i.e. indicators of infringements) including the following: 1) track obstructions; 2) changes in track or structure location since previous inspection; 3) visible markings or damage to structures; 4) horizontal and vertical alignment past structures; 5) evidence of recent or current movement; 6) fouling point discs are not visible, conspicuous or performing the function intended. b) Intervals between walking inspections shall not exceed 31 days.
General inspections	a) Identify non-compliance with the clearance standards at locations on the clearance schedules in sub-sections 3.2 and 5.3 and report the following (terms are defined in Appendix 3, clause A3.1(b): 1) structures infringing the maintenance intervention standard; 2) structures infringing the base operating standard; 3) adjacent tracks infringing the maintenance intervention standard; 4) adjacent tracks infringing the base operating standard; b) These inspections should identify locations of clearance degradation requiring action and determine the need for further specialist inspection. c) Frequency of general inspections shall be in accordance with sub-section 6.2.
Detailed inspections, including infringements for “gauging”	a) As for general inspections but including detailed measurement of structures or tracks infringing the clearance requirements. b) All infringements listed in paragraph 3.2 shall be “gauged” at intervals not exceeding 26 weeks. To “gauge” a structure, the distance and height shall be measured from the gauge face of the nearest rail of the adjacent track. Infringements are to comply with paragraph 3.2(b).
Unscheduled inspections	To be undertaken following a defined event affecting the clearances or a report of a suspected infringement of the required clearances from a TransAdelaide worker, Traffic Operator or a member of the public.
Assessment and maintenance action	Assessment and method of assessment shall be in accordance with CP-TS-973 (Infrastructure management and principles). Inspection results shall be assessed to determine whether the structure or track centres infringe the standards. For maintenance action see sub-section 6.3.

6.2 GENERAL INSPECTIONS – FREQUENCY AND TASKS

a) General inspections of clearances should be carried out in a manner and at an interval appropriate to the location, rates of deterioration and other local factors (e.g. track type), and in any case at intervals not greater than those detailed below. At locations of restricted clearance, the frequency of general inspection should be increased.

b) A general inspection including determination of the available clearances should also be carried out when there are suspected defects following work affecting the location of tracks or structures or defects are identified from walking inspections.

c) The scheduled inspections should include the tasks of the walking inspections in addition to measurement of the following:

   1) clearance from datum points to specific locations;

   2) distance between track centrelines (including fouling clearances at turnouts);

   3) track super-elevation if specified on datum;

   4) track curvature if specified on datum.

d) A general inspection frequency regime should be specified. The inspection frequency regime should take into account the associated level of risk at the clearance location.

e) If the clearance standards adopted are based on section 2.0 (Design and rating), i.e. a total air gap of 300mm or greater is provided, the following rates of scheduled general inspections should apply:

   1) If the structure is outside the structure outline, scheduled general inspections are not necessary.

   2) If the structure is between the maintenance intervention standard and the structure outline, scheduled general inspections should be carried out at intervals not exceeding six (6) years.

   3) If the structure infringes the maintenance intervention standard, scheduled general inspections should be carried at intervals not exceeding one (1) year.

6.3 MAINTENANCE ACTION AND RESPONSE

6.3.1 General

The results of inspections should be assessed to determine whether the structure (or the maximum kinematic outline on adjacent tracks) infringes the maintenance intervention or base operating standard for clearances and action taken as described in clauses 6.3.2 and 6.3.3.

6.3.2 Infringement of the maintenance intervention standard

Where the maintenance intervention standard is infringed either:

a) action should be taken to restore the clearances such that the maintenance intervention standard is no longer infringed, with clearances monitored until this action is completed; or

b) approval from the Rail Network Manager should be given to register the clearance location as a permanent infringement of the maintenance intervention standard following detailed clearance assessment; and

c) the increased rate of general inspection specified in sub-section 6.2 should be met.

6.3.3 Infringement of the base operating standard

Where the base operating standard is infringed either:

a) action should be taken, prior to the passage of the next tram, to restore the clearances such that the base operating standard is no longer infringed. If this action does not restore clearances such that the maintenance intervention standard is not infringed then the action specified in clause 6.3.2 shall be implemented.

b) Or, restrictions should be applied to tram operations, prior to the passage of the next tram, until action can be taken to restore clearances. Assessment of an appropriate restriction is to be carried out using the general procedures defined in CP-TS-976 (Track geometry).

6.3.4 Permanent infringements of the base operating standard

a) Where permanent infringement of the base operating standard for clearances has been permitted, the results of inspections should be assessed to determine whether the track tolerances used to specify the clearance standards (see Appendix 3) have been exceeded. This may be achieved using datum markers on structures, however where this is not the case, the relative position of track and structure, or track and adjacent track, should be checked against the clearance standard.

b) Where the track tolerances have been exceeded, either:

   1) action should be taken prior to the passage of the next tram, to restore the track position such that the track tolerances are not exceeded; or

   2) restrictions should be applied to tram operations, prior to the passage of the next tram, until action can be taken to restore the track position. Assessment of an appropriate restriction is to be carried out using the general procedures defined in Appendix 3.

7.0OUT OF GAUGE VEHICLES OR LOADS

7.1 DEFINITION OF AN OUT OF GAUGE VEHICLE OR LOAD

Any vehicle or a load on a vehicle where any part of the profile of the load or vehicle falls outside the profile shown on TransAdelaide drawing number 200-A2-2003-104 (Tram system maximum static rolling stock outline) is to be treated as an out of gauge load.

7.2 INFORMATION TO BE PROVIDED

Whenever a request is made to carry an out of gauge load over TransAdelaide tram tracks the following information shall be provided:

a) a full description of the vehicle or load including the name, address and telephone number of the consignor;

b) full dimensional data such as width from centreline and distances above rail level of every part of the out of gauge vehicle or load which exceeds the static rolling stock outline;

c) the type of vehicle, no. of the vehicle and diagram of the rolling stock;

d) the exact route and timetabling proposed for the vehicle or load;

e) the weight and distribution of the vehicle or load;

f) the method used to secure the load and an estimate of any anticipated relative movement between the load and the vehicle.

7.3 ASSESSMENT

7.3.1 Diagrams of infringements of structure outline

The schedule of infringements of the structure outline in accordance with sub-sections 3.2 and 5.3 shall be taken into account when checking out-of-gauge vehicles or loads.

7.3.2 Plotting on diagram of infringements

For the route proposed, a plot of the out of gauge vehicle or load shall be made on the appropriate diagram (or diagrams), taking into account any additional clearance required on curves or any anticipated movement of the load.

7.4 TOLERANCES

Where clearances are initially determined to be less than 300mm, the effects of track geometry and rolling stock behaviour as listed in clauses 7.4.1 and 7.4.2 are to be taken into account.

7.4.1 Effect of track irregularities on clearances

a) Additional clearances [as in (b)] shall be allowed for track irregularities where these are otherwise unknown. If the use of these figures leads to less than acceptable clearances then it may be necessary to take actual measurements on site.

b) The additional clearances are calculated in accordance with the parameters shown in Appendix 3.

7.4.2 **Effect of rolling stock dynamics on clearances**

a) Additional clearances [as in (b)] shall be allowed for lateral translation, body roll, bounce and wheel clearance for rolling stock moving at normal speed. If the use of these figures leads to less than acceptable clearances, then it may be necessary to impose a speed restriction on the movement past the structure, which is foul.

b) The additional clearances are calculated in accordance with the parameters shown in appendix 3.

7.5 MINIMUM CLEARANCES

When deciding the necessary action to take after determining the minimum clearance between load and all structures on the route as required by sub-section 7.4, the following criteria shall influence the restrictions placed on the movement:

a) The minimum clearance to any structure above platform level where normal speed is permissible shall be 125mm.

b) The minimum side clearance at or below platform level where normal speed is permissible shall be be 75mm.

c) Less clearance than these would require a speed restriction. Clearances as little as 10mm are permissible if the movement is made at 5km/hr and piloted.

7.6 ISSUE OF INSTRUCTIONS

Instructions for the passage of the out of gauge vehicles or loads shall include the following:

a) any special route required to avoid fouling close structures;

b) speed restrictions past close structures;

c) any instructions regarding piloting past close structures;

d) any instructions regarding the need to stop and check load for movement prior to passing a close structure;

e) speed restrictions past passenger platforms if a load overhangs the platform;

f) speed restrictions if axle loading is excessive;

g) timetabling of the movement.

7.7 NON-TRANSADELAIDE ROLLING STOCK OUTSIDE THE STATIC ROLLING STOCK OUTLINE

Non-TransAdelaide rolling stock to travel over TransAdelaide tracks which is outside of the static rolling stock outline shall be considered as an out of gauge load and instructions issued accordingly.

8.0 DOCUMENTATION

8.1 SCHEDULES OF INFRINGEMENTS

Schedules shall be maintained of:

a) allowable infringements of the structure outline in accordance with sub-clause 3.2; and

b) allowable infringements of track centre standards in accordance with sub-clause 5.3.

SCHEDULES TO BE PREPARED

8.2 OUT OF GAUGE VEHICLES OR LOADS

Records of all requests for out of gauge vehicles or loads and instructions issued shall be kept in accordance with CPRD/PRC/046 Records Management.

8.3 INSPECTION REPORTS

All inspection reports shall be maintained in accordance with CPRD/PRC/046 Records Management.

A1.0 APPENDIX 1: BACKGROUND CALCULATIONS TO THE DERIVATION OF THE MINIMUM STRUCTURE OUTLINE

A1.1 BASIS OF MINIMUM STRUCTURE OUTLINE

The derivation of the minimum structure outline is based on the Code of Practice for the Defined Interstate Rail Network, volume 4, part 2, section 7.

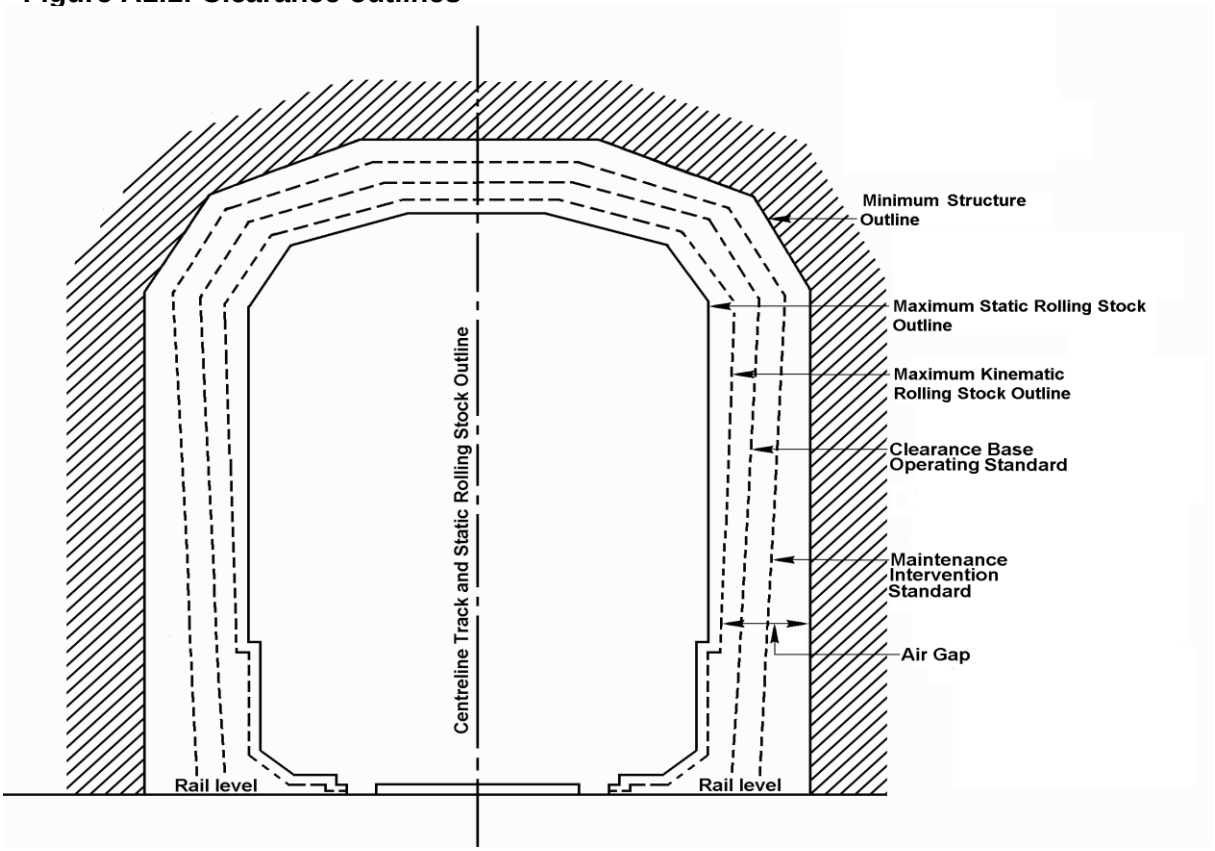
A1.2 CLEARANCE OUTLINES

Outlines relevant to the determination of clearance standards are shown in table A1.1 and illustrated in figure A1.1:

Table A1.1: Clearance outlines

Standard outline	Derivation
Maximum static rolling stock outline	drawing no. 200-A3-2003-104
Maximum kinematic rolling stock outline	derived from the static rolling stock outline as described in clause A2.4.
Base operating standard	derived from the maximum kinematic rolling stock outline as described in clause A2.5.
Maintenance intervention standard	derived from the base operating standard as described in clause A2.6.
Minimum structure outline	derived from the maintenance intervention standard as described in clause A2.7.

Figure A1.1: Clearance outlines



A2.0 APPENDIX 2: DETERMINATION OF CLEARANCE STANDARDS

A2.1 VEHICLE SWEPT PATH

The centre throw (versine) and end throw of rolling stock on curved track shall be calculated as follows:

a) centre throw (in mm) = $\frac{B^2}{8.R}$, where B = bogie centres (in mm); R = radius of curve (in mm).

b) end throw (in mm) = $\frac{\left(L^2\right)-\left(B^2\right)}{8.R}$, where L = length of vehicle over vehicle body (in mm); B = bogie centres (in mm); R = radius of curve (in mm).

c) Where in (b), a vehicle has unequal overhang from the bogie centres to the ends of the body (at each end), the length L will be taken as equal to twice the greater of the two overhang lengths added to the bogie centres; i.e. if the length of the two overhangs is O_1 and O_2 , and $O_1 > O_2$, then $L = B + 2 \times O_1$.

A2.2 TRACK TOLERANCES

Additional clearance shall be allowed for the following track tolerances:

a) rail side wear;

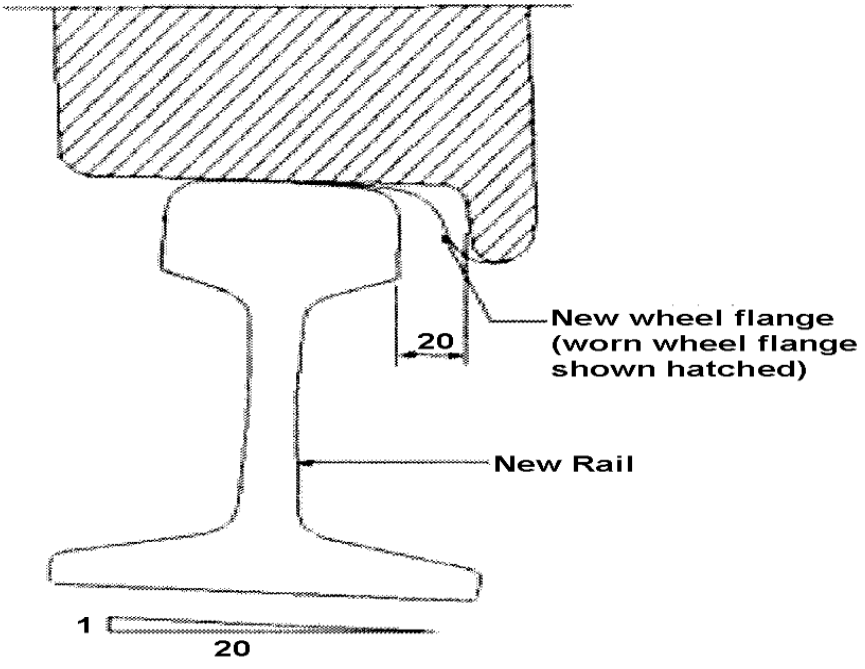
b) wide gauge, either due to track deterioration or by design;

c) track horizontal or vertical misalignment;

d) cross-level/cant variation from design;

A2.3 DYNAMIC ROLLING STOCK TOLERANCES

Figure A2.1: Effect of worn wheel flanges



Additional clearance shall be allowed for the following dynamic rolling stock tolerances:

a) lateral displacement of the vehicle, including the effect of side worn wheel flanges (see figure A2.1);

b) angular displacement due to body roll;

c) upward displacement due to body bounce.

A2.4 MAXIMUM KINEMATIC ROLLING STOCK OUTLINE

The maximum kinematic rolling stock outline is derived by enlarging the static rolling stock outline by applying the following in order:

a) horizontal translation due to horizontal vehicle displacement tolerances, wheel clearance, rail side wear, gauge widening of track and centre and end throw of vehicles on curved track;

b) vertical displacement tolerance due to vehicle bounce tolerance;

c) angular displacement due to track cross-level tolerances around the track centre;

d) angular displacement due to track cross-level tolerances around the left hand and right hand rail;

e) angular displacement due to body roll tolerance about the vehicle roll centre;

f) horizontal and vertical displacement due to track alignment and vertical alignment tolerances.

A2.5 BASE OPERATING STANDARD

The base operating standard shall be produced by adding the minimum allowable air gap to the maximum kinematic rolling stock outline.

A2.6 MAINTENANCE INTERVENTION STANDARD

Additional clearances shall be added to the base operating standard to determine the maintenance intervention standard. The maintenance intervention standard should provide for correction of structures or tracks before the base operating standard is infringed.

A2.7 MINIMUM STRUCTURE OUTLINE

Additional clearances shall be added to the maintenance intervention standard to define the minimum structure outline or track centre standards. The additional clearances added shall be sufficient that scheduled inspections are not considered necessary for structures (or track centres) which fall outside this outline.

A3.0 APPENDIX 3: CLEARANCE MANAGEMENT PRACTICES

A3.1 ROLLING STOCK AND STRUCTURE OUTLINE STANDARDS

a) To the rolling stock outline in table A1.1, the corresponding structure outline is derived by applying the following:
   1) dynamic rolling stock limits from table A3.1.
   2) track tolerances from table A3.2
   3) 130mm and 0 mm cant elevation to provide for clearances on the inside and outside rail respectively of curved track.
   4) for curves centre and end swings shall be calculated using the actual radius of the curve.
   5) 100mm air gap.

b) The other clearance outlines specified in table A1.1 should be determined as follows:
   1) a maintenance intervention standard 100mm inside the adopted structure outline.
   2) a base operating standard 200mm inside the adopted structure outline.
   3) a maximum kinematic rolling stock outline 300mm inside the adopted structure outline.

Table A3.1: Dynamic rolling stock limits

FACTOR	ASSUMED LIMITS
Lateral translation (see note 1)	± 40mm
Body roll (see note 2)	± 2º about a roll centre 610mm above rail level or ± 2.5º about a roll centre 440mm above rail level
Bounce (see note 3)	+ 50mm
Wheel clearance – worn wheel to new rail (see note 1)	± 20mm (see figure 2.2)

Notes:

1) ± means linear displacement parallel to the plane of the top of the rails to each side of the rolling stock outline.
2) ± means angular displacement clockwise and anti-clockwise about the roll centre of the rolling stock centreline.
3) + means upward linear displacement normal to the plane of the top of the rails.

Table A3.2: Track tolerances

FACTOR	Assumed tolerances in mm (see note 1)		
	Straight track	>300m radius	<300m radius
Rail side wear (see note 2)	± 5	+25. –5	+25. -5
Gauge widening (see note 2)	± 0	± 0	+0, -15
Gauge from 1 435mm (see note 2)	± 20	± 20	± 25
Track misalignment – from design (see note 3)	± 50	± 50	± 75
Cross level – displacement from design (see note 4)	± 30	± 30	± 30
Rail level displacement (see note 5)	± 100	± 100	± 100

Notes:

1) These geometry tolerances are intended for the purpose of calculating clearances only.
2) On straight track, ± means linear displacement parallel to the plane of the top of the rails to each side of the design centreline of the track.

   On curved track, + means linear displacement to the outside of the curve and – means linear displacement to the inside of the curve parallel to the plane of the tops of the rails.
3) On straight track, ± means horizontal linear displacement each side of the design centreline of the track. On curved track, + means horizontal displacement to the outside of the curve and – means horizontal linear displacement to the inside of the curve.
4) ± means vertical displacement of the left and right rails respectively resulting in a clockwise and an anti-clockwise rotation of the track in the vertical plane normal to the track.
5) ± means vertical linear displacement above (+) and below (-) design rail level.

A4.0 APPENDIX 4: CALCULATIONS

A4.1 MAXIMUM KINEMATIC ROLLING STOCK OUTLINE

A4.1.1 The static rolling stock outline has been drawn to allow for;

a) existing rolling stock (i.e. "H" type);

b) a width that provides for any future tram designs up to 2 650 wide;

c) a pantograph 1 720mm wide

A4.1.2 The kinematic rolling stock outline is derived by adding to the dimensions of the static rolling stock outline, the movements encountered by the rolling stock while in motion. (The outline is developed for straight track and additional allowances for curves are considered later.) These consist of the following:

a) Horizontal:

Lateral translation of the vehicle body = 40mm

Wheel clearance = 20mm

Rail side wear = 5mm

Gauge widening (deliberate as well as wear and tear) = nil + 20

Track alignment = 50mm

TOTAL = 135mm

b) Vertical:

Bounce = 50mm (upwards)

Rail level due to wear and tear = 100mm (upwards and downwards)

TOTAL = 150mm (up) and 100mm (down)

c) Additional horizontal translation due to rotational effects:

Body roll, obtained by multiplying the height above or below the roll centre height by the angle of roll in radians (for 2º = 0.034906 and for 2.5º = 0.043633 (see table A4.1)

Table A4.1: Rotational effects

Height above rail level	Effect of 2º body roll; roll centre 610mm above rail (R_1 = 0.034906)	Effect of 2.5º body roll; roll centre 440mm above rail (R_2 = 0.043633)	Maximum horizontal displacement
150	610-150 x R_1 = 16	440-150 x R_2 = 13	16
3 600	3600-610 x R_1 = 104	3600-440 x R_2 = 139	139
5 500	5500-610 x R_1 = 171	5500-440 x R_2 = 221	221

d) Cant imperfections of up to 30mm, obtained by multiplying by the height above rail level by (30 ÷ 1435)

Table A4.2: Cant effect

Height above rail level	Cant Effect
150	3
3 600	76
5 500	115

A4.1.3 The total additional clearances required are given in the table:

Table A4.3: Additional clearances

Height above rail level	Horizontal movement			
	From A4.1.2 (a)	From A4.1.2 (c)		Total
		Body roll	Cant def.	
150	135	16	3	154
3 600	135	139	76	350
5 500	135	221	115	471

A4.1.4 The following table gives the co-ordinates for the kinematic rolling stock outline, with the X axis at rail level and Y axis, the vertical centreline of the track:

Table A4.4: Co-ordinates of maximum kinematic rolling stock outline

Y co-ordinate	X co-ordinate	X co-ordinate + 300mm
150	1 325 + 154 = 1 479	1 779
3 600	1 325 + 350 = 1 675	1 975
5 500	860 + 471 = 1 331	1 631

A4.2 DERIVED MINIMUM STRUCTURE OUTLINE - WIDTH

The derived minimum structure outline is obtained by adding a 300mm wide envelope around the kinematic rolling stock outline (see column 3 of table A4.4). As the new minimum structure outline will be vertical from rail level to the point of maximum width it is only necessary to consider points at the widest point and above.

The maximum width of the kinematic rolling stock outline is at co-ordinates (3 580, 1 675). Therefore, the derived minimum structure outline will be 1 675 + 300 wide at this point = 1 975(from centreline, or 3 950 total width).

The extension to allow for the pantograph will require a maximum width of 1 331 + 300 = 1 631 (from centerline, or 3 262 total width).

A4.3 DERIVED MINIMUM STRUCTURE OUTLINE - HEIGHT

As the new minimum structure outline will be vertical from rail level to the point of maximum height it is only necessary to consider the top of the rolling stock outline.

The maximum height is required to clear the pantograph, but as this is flexible it is proposed to retain the existing height which has proven satisfactory (for existing work) but adopt a height of 6 000 for all new work.

A4.4 NEW MINIMUM STRUCTURE OUTLINE

The new minimum structure outline is basically similar to the previous minimum structure outline.

A4.5 NEW MINIMUM TRACK CENTRES

The new minimum track centres equals the kinematic rolling stock width plus 300mm equals 1 675 x 2 + 300 = 3 650, however the preferred minimum track centres are 4 000m. The minimum track centres may be reduced to 3 650 in a tight situation. Where the track is fixed and unable to move sideways the track centres may be reduced even more. With in-street track laid in concrete, it is considered that gauge widening, track misalignment and gauge effect may be considered as zero. In addition the cant effect will be considerably reduced to (say) 5mm maximum cant variation. The

maximum kinetic rolling stock outline can be reduced by 2 x (70 + 76 + 63) = 418mm, the track centres can be reduced to 3 650 – 418 = 3 232. A figure of 3 200 in Jetty Road, Glenelg has been adopted, by imposing a speed restriction on the movement of rolling stock to reduce the effect of body roll to the minimum.

A4.6 ADDITIONAL CLEARANCE ON CURVES

The minimum structure outline has been derived for straight track. On curves, allowance must be made for additional clearances for rail side wear, gauge widening and extra track misalignment allowance. In addition allowance has to be made for end swing and versine of the longest vehicles. Note that the "H" class trams are tapered at the ends so that the endswing on curves never exceeds the versine. The formula for deriving the latter allowances is given in sub-section A2.1

The longest vehicles on TransAdelaide are the "H" Class trams, which have the following dimensions:

Bogie centre = 9 450mm

Applying the formulae gives the following results:

Versine = $(9\ 450)^2 \div (8 \times R)$ = 11162812.5 ÷ curve radius (in millimeters)

Table A4.5 gives the value of the versine and endswing for various radii of curves:

Table A4.5: Versines and endswings for various radii curves

Curve radius	Versine	All up (see note 1)
18m	620	685mm
20	558 (say 560)	623 (say 625)
30	372 (say 375)	437 (say 440)
40	279 (say 280)	344 (say 345)
50	223 (say 225)	288 (say 290)
60	186 (say 190)	251 (say 255)
70	159 (say 160)	224 (say 225)
80	139 (say 140)	204 (say 205)
90	124(say 60)	189 (say 190)
100	112(say 50)	177 (say 180)
150	75 (say 40)	140
200	56	121 (say 125)
300	38	103 (say 105)
400	28	48 (say 50)
500	23	43 (say 45)
1000	12	32 (say 35)

Note 1: To the values in columns two or three must be added 20mm for curves over 300m radius and 65mm for curves under or equal to 300m radius to make the values in column four. These additional clearances are to allow for the additional movement of rolling stock on curves and are derived by subtracting the values in column 2 from the values in columns 3 and 4 of table A3.2.