UGL REGIONAL LINX

GENERAL INTERFACE REQUIREMENTS FOR ROLLING STOCK

CRN-STD-ROL-713026361-493

CRN RS 008

LINKING COMMUNITIES. CONNECTING CUSTOMERS.

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Document Control

Function	Position	Name	Date
Approver	A&E Manager	Lucio Favotto	03.06.2022

Revision	Issue Date	Revision Description
2.1	09.11.2021	UGLRL Operational Standards Template applied
3.0	03.06.2022	Sections 9,10,11 updated.

Summary of changes from previous version

Section	Summary of change
All	Note 1 added to section 9 (also applied to sections 10 and 11)

1 Introduction

This document is a supporting standard to each of the following rolling stock minimum operating standards and covers those interface issues that are common across the various vehicle/rolling stock types.

- Locomotives CRN RS 001
- Freight vehicles CRN RS 002
- Locomotive hauled passenger vehicles CRN RS 003
- Multiple unit trains CRN RS 004
- Rail bound infrastructure maintenance vehicles CRN RS 005
- Road/rail infrastructure maintenance vehicles CRN RS 006

These interface requirements, in the form of minimum standards pertaining to vehicles operating on the New South Wales Country Regional Network (CRN), have been established to ensure that such vehicles are compatible with the CRN infrastructure and operation. The following are typical examples where infrastructure and rolling stock interface with each other.

- Dimensional interface requirements allow for vehicles to operate on the track without fouling bridges, tunnels and structures or passing rolling stock.
- Requirements for vehicle dynamics are provided to ensure that vehicles do not cause undue damage to infrastructure or have an increased risk of derailment.
- Some requirements allow for vehicles belonging to different operators to be coupled and operate together, where necessary, to clear a track section in the case of vehicle or train failure.
- Performance requirements enable different vehicle types to operate safely together on the same track system. For example, vehicle and/or train braking performance must be compatible with the current signalling systems.

2 Rolling Stock Outline Requirements

There are a number of different Authorised Rolling Stock Outlines permitted to operate on the CRN. Each track section is categorised for the operation of one or more Authorised Rolling Stock Outlines as detailed in the CRN Train Operating Conditions (TOC) Manual. Only vehicles conforming to one of the Authorised Rolling Stock Outlines for a particular track section, is permitted to operate unrestricted on that section.

A register of authorised vehicles (CRN Train Operating Conditions (TOC) Manual) is maintained by UGLRL, the Operations Manager and Maintainer of the CRN. This TOC register contains details of all vehicle types that are authorised to operate on the CRN.

All vehicles listed in the CRN Train Operating Conditions Manual, either comply with the Rolling Stock Outline requirements for unrestricted operation, or are identified by an exception note for restricted operation.

2.1 Standard Rolling Stock Outlines

2.1.1 General

The Standard Rolling Stock Outlines are based on those outlines applicable to existing vehicles that have been operating on particular track corridors. Historically, vehicles operating on the CRN have been constructed to comply with the New South Wales Narrow Non-Electric Rolling Stock Outline, but in some cases, with a number of allowable controlled infringements. New Standard Rolling Stock Outlines have been developed such that no infringements are permitted other than those cases detailed in Section 2.4.2 below.

Table 1 contains a list of Rolling Stock Outlines that are authorised for operation on the NSW CRN, and the outlines on which each is based. No other rolling stock outlines are permitted unless authorised by the CRN Manager.

Refer to Civil Standard CRN CS 215 Appendix 1, for specific rolling stock outline corridor access. Refer to the CRN TOC Manual General Instruction Pages Section 5 – Loading Restrictions for loose load and container height limits.

An allowable infringement for rubber tyres on road/rail vehicles is detailed CRN Standard CRN RS 006.

Outline Name	Outline Width Basis	Figure No
CRN Narrow Non-Electric	Narrow based	1
CRN Narrow Container	Narrow based	2
CRN Narrow Square	Narrow based	3
CRN Intersystem	Narrow based	4
CRN Narrow Hopper	Narrow based	5

Table 1 – CRN Rolling Stock Outlines

2.1.2 Description

For vehicles to conform to the envelope requirements a particular Standard Rolling Stock Outline, there are certain dimensional requirements that must be met:

The vehicle must be within the specified longitudinal dimensional proportions of the relevant Standard Rolling Stock Outline and not exceed that outline at any cross section, under the following conditions:

- New wheel diameter together with tare spring height and the vehicle packed to compensate for future wheel wear, where applicable.
- Condemned wheel diameter, combined with a solid suspension (including fully deflated air springs, where applicable).
- Bottom discharge hopper doors and other loading/unloading equipment when open.
- The following rolling stock outlines are relevant to the CRN:

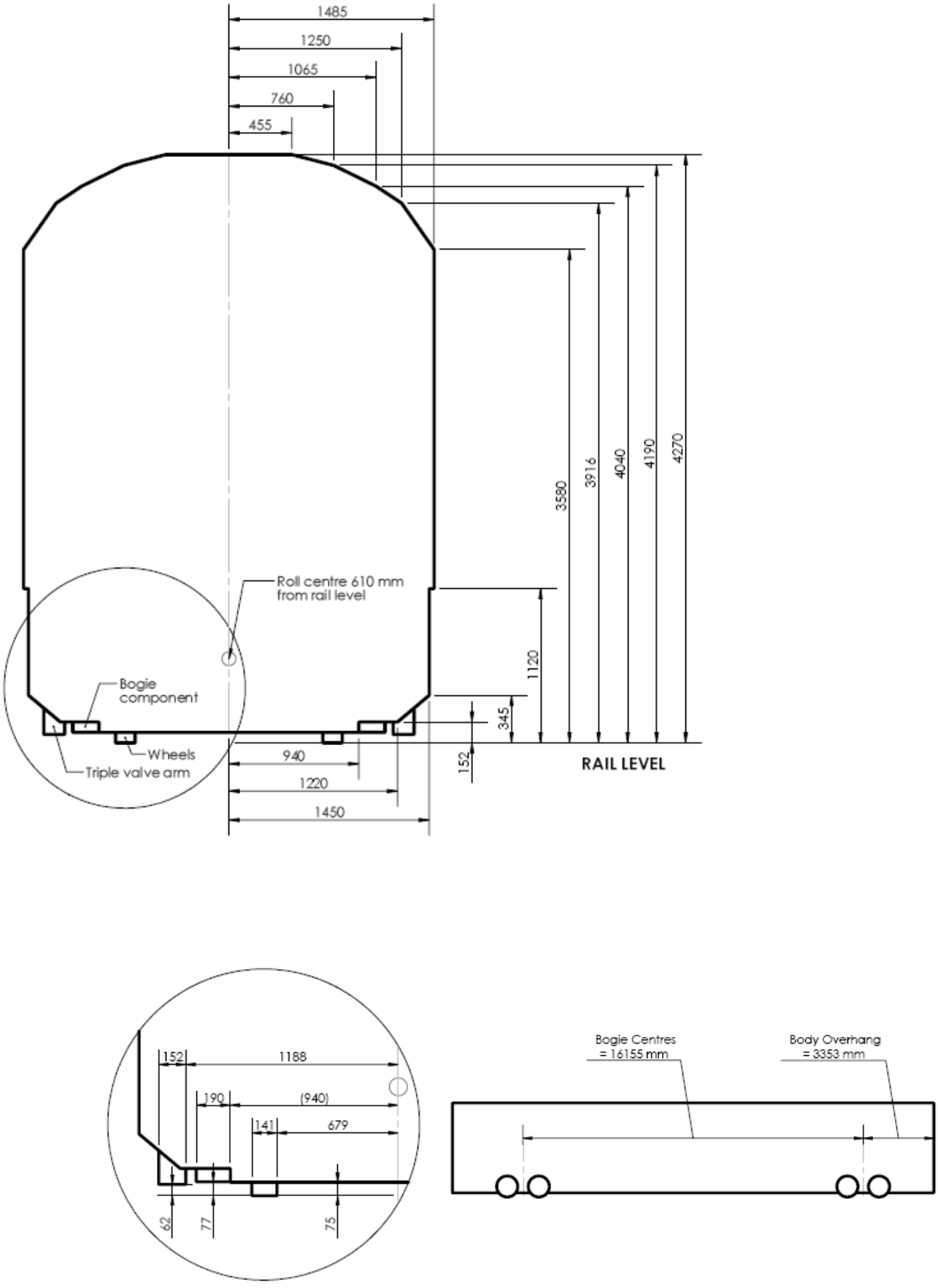


Figure 1 – CRN Narrow Non-Electric" Rolling Stock Outline Dimensions

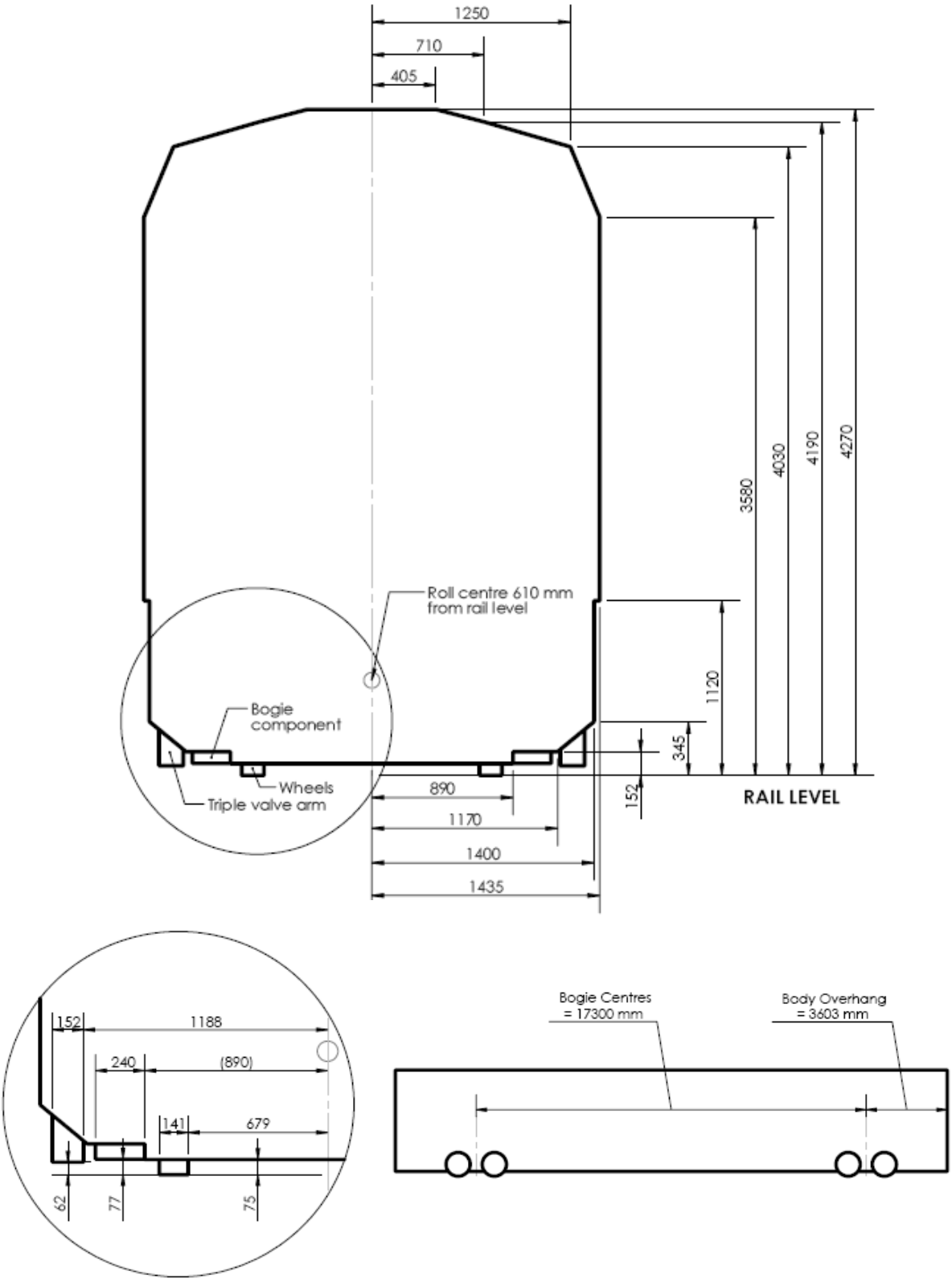


Figure 2 – CRN "Narrow Container" Rolling Stock Outline Dimensions

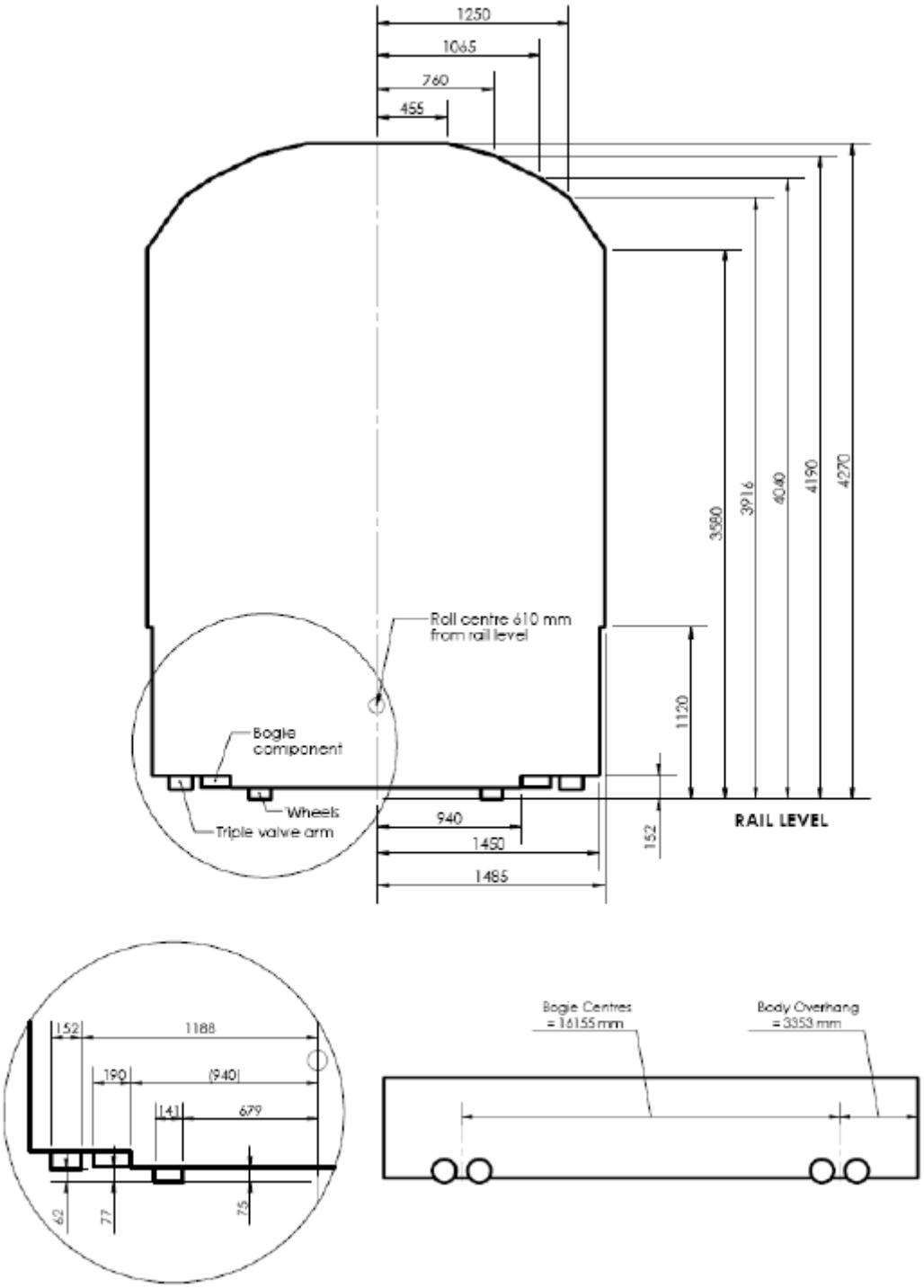


Figure 3 – CRN "Narrow Square" Rolling Stock Outline Dimensions

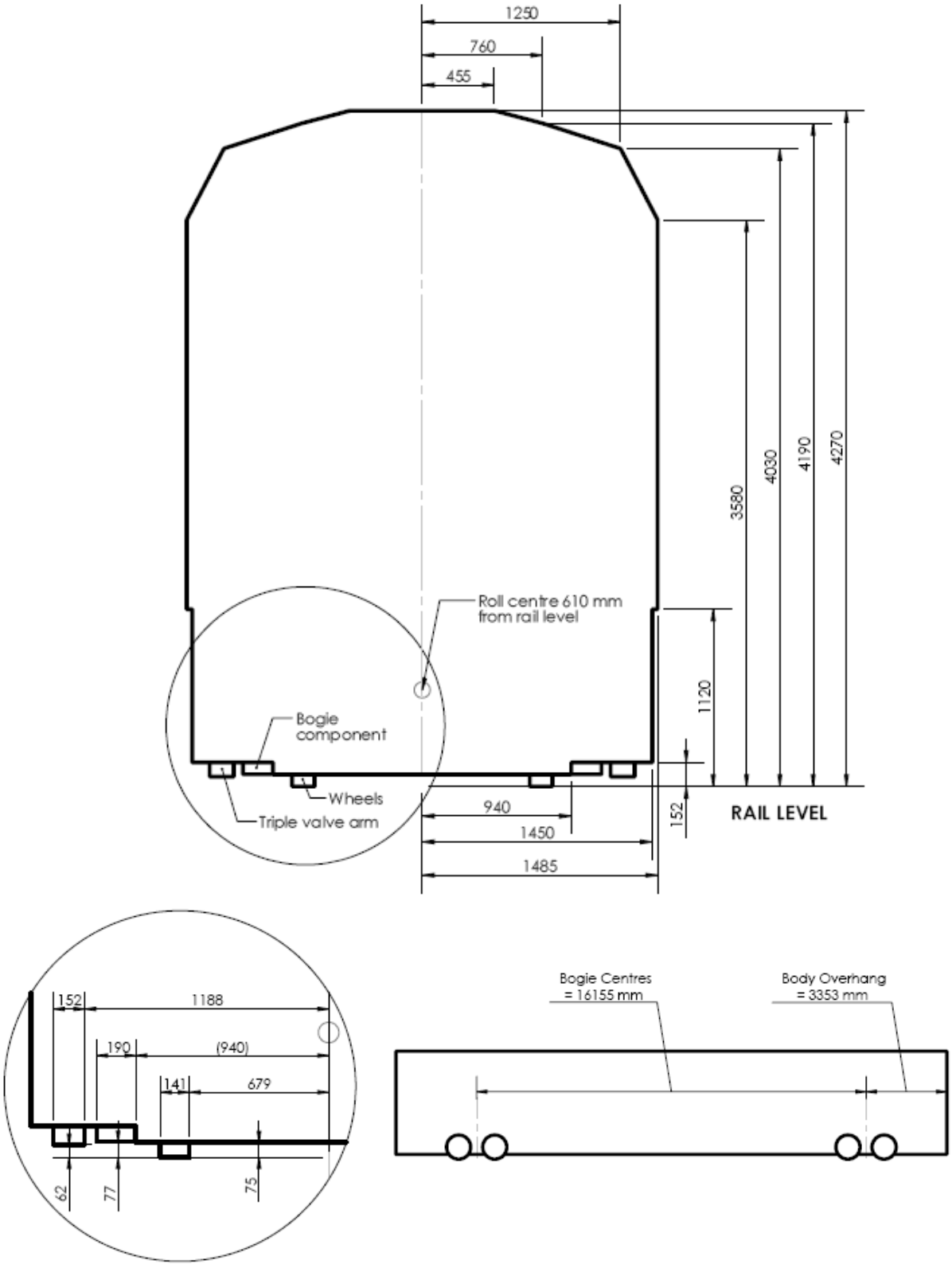


Figure 4 – CRN "Intersystem" Rolling Stock Outline Dimensions

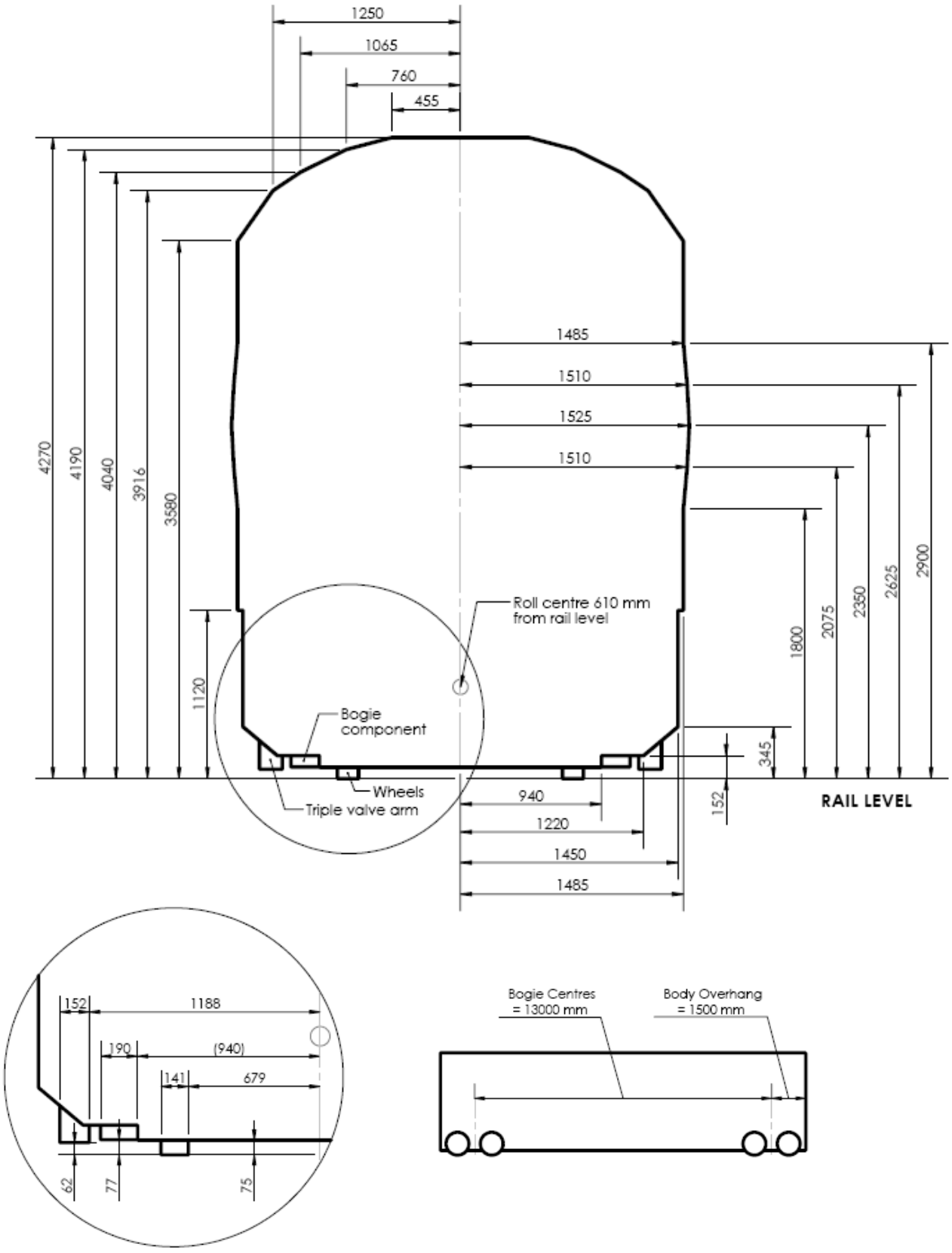


Figure 5 – CRN "Narrow Hopper" Rolling Stock Outline Dimensions

2.2 Kinematic Rolling Stock Outline

The kinematic rolling stock outline is the cross-sectional envelope produced by the applicable rolling stock outline, displaced through maximum body roll, lateral movements and vertical bounce.

The roll of the vehicle body is measured about the vehicle roll centre located on the vehicle centre line which is perpendicular to the rail plane. The vehicle roll centre, for calculation purposes, is located 610 mm above the rail plane, however, it is possible that some suspension types may produce body roll about a different roll centre height.

The lateral displacement of the vehicle body is measured with respect to the vertical centre of the wheelsets. This lateral displacement is made up of all possible movements, including, but not limited to:

- Bogie centre pin clearance
- Secondary suspension lateral clearance
- Primary suspension lateral clearance

Note: On the CRN a kinematic lateral displacement of up to +/- 60 mm is permitted within the vehicle components between the vehicle body and the worn wheel and the maximum permitted roll angle is +/- 2 degrees about the roll centre located 610 mm above rail. Reference CRN Transit Space Standard CRN CS 215.

2.3 Equivalent Swept Path Rolling Stock Outlines

2.3.1 General

The Equivalent Swept Path Rolling Stock Outline is that volumetric shape generated by the lateral displacement (throw) of a vehicle body centre and ends relative to the track centreline, during curve negotiation for a vehicle with the applicable Standard Rolling Stock Outline proportions.

This means that a vehicle may be designed with:

- larger tolerances and/or
- a different roll centre height and/or
- longer bogie centres or
- a longer body overhang,

than that of the Standard Rolling Stock Outline. However to achieve this, the vehicle will require a smaller cross-section.

Note: No part of a vehicle can have a larger cross section than that of the applicable standard rolling stock outline, other than where detailed in Section 2.5.2 below (Expendable Items).

Warning

Reducing a vehicle kinematics cannot be used to compensate for the vehicle exceeding the allowable static rolling stock outline.

also

Reducing the vehicle longitudinal proportions cannot be used to compensate for a wider vehicle body.

2.4 Special Load Outline Conditions

2.4.1 General

Vehicles that exceed the rolling stock outlines for a particular route may be permitted to travel under special conditions, such as, restrictions on passing other vehicles or warnings to public on platforms.

2.4.2 Authority

The conditions for the operation of out of gauge vehicles on the CRN will be issued by the Owner/Manager of the network.

2.4.3 Special Conditions

Special conditions for the operation of particular vehicle/loads may be published in the CRN Train Operating Conditions.

2.5 Rolling Stock and Loading Infringements

2.5.1 General

The authorised Rolling Stock Outline for any track section can be infringed in two (2) ways. These infringements are as follows:

- Expendable items
- Out of gauge loads

Some existing vehicles may be operating outside of the requirements of this standard. This is a legacy of the past approvals, and must be controlled in order to minimise risk.

Note: Vehicles having outline infringements must have a Network Manager Design Exemption Certificate for continued operation or a Train Operating Conditions (TOC) waiver for a one off movement.

2.5.2 Expendable Items

Some parts (generally items of equipment attached to the exterior) of vehicles project beyond the Rolling Stock Outline. These items can only be permitted if they are considered, and treated as, Expendable Items. This means that they are in an area of the transit space resulting in an acceptable risk of infringement. By their nature they must have low consequences in the event of contact at speed with infrastructure or other vehicles.

The following are some examples of potentially expendable items:

- Locomotive side mirrors
- Guard’s blue lights
- External speakers
- Handrails (in the designated handrail area only)
- External plug doors
- Periscopes
- Radio antennae
- Roof guttering

It is the responsibility of vehicle owner/operators to ensure that expendable items are constructed and maintained such that, in the event of contact with the infrastructure or other vehicles, they will not cause damage to the infrastructure or other vehicles, injury to employees or public, or result in an unsafe operating condition.

New expendable items cannot be introduced, or existing items modified, such that they occupy an area not already used by a similar expendable item, without the approval of the CRN Manager.

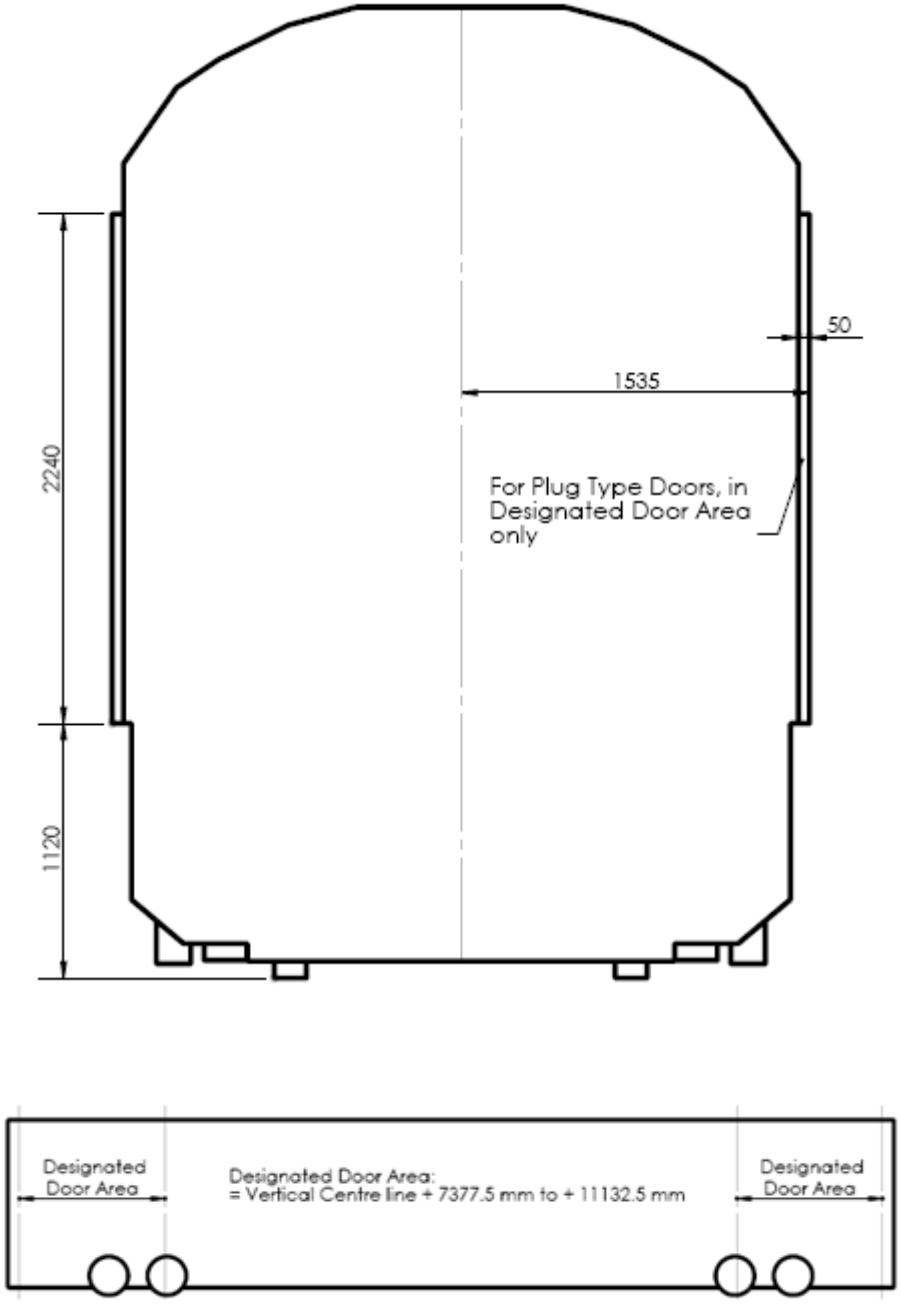


Figure 6 – "Existing Foul Load Infringement – CRN Narrow-Non Electric"

Rolling Stock Outline Dimensions

2.5.3 Out of Gauge Loads

Loads that do not conform to any of the Rolling Stock Outlines in this standard are termed "Out of Gauge Loads".

Authority to move any "out of gauge" load can only be granted by the Network Owner/Manager.

Out of gauge load movements are treated as specific movements and special operating conditions will apply. These special conditions will be determined by the Network Owner/Manager.

Because of the unique dimensions of each out of gauge load, the suitability of a proposed route will have to be determined for each movement. Special and out of gauge loads are usually accompanied by a representative of the Network Owner/Manager.

2.5.4 Passenger vehicle plug doors

Passenger vehicles fitted with external plug type doors that can fail in the open condition, resulting in the vehicle being foul of the authorised rolling stock outline are categorised as a foul load infringement.

The position of plug type doors must be in the designated door areas as shown figure 6.

2.6 Physical interface requirements

2.6.1 General

Portions of vehicles that are required to physically interface with Infrastructure are permitted to be outside the Rolling Stock Outline. These items can only be approved by the Network Manager.

Items currently forming a physical interface include:

- Trip Valve Arms (Fitted on some vehicles but not required for operation on the CRN)
- External plug doors interfacing with platforms.

2.7 Platform clearances

For platform clearances refer to the CRN Transit Space Standard – CRN CS 215.

3 Track and axle load limit requirements

3.1 Axle Load Limits

Wheel and axle loading and axle spacings are important in terms of infrastructure protection, particularly from a vehicle balance and bridge loading viewpoint.

Vehicles shall be weighed prior to entering service to ensure the vehicle weight and weight distribution is within specified limits.

3.2 When the weigh test must be performed

A weigh test shall be performed on rolling stock for each of the following occasions:

3.2.1 Acceptance testing of new or substantially modified vehicles

New vehicles covers newly constructed rolling stock or rolling stock that is new to the NSW rail network.

Substantially modified vehicles include any existing vehicle modified such that the total vehicle mass has been altered, or the vehicle mass distribution has changed.

All vehicle types shall normally be weighed in the service tare condition, however In the case of locomotives, passenger cars or track maintenance vehicles, the tare condition shall include full supplies such as water, sand fuel, oil, etc.

In the case of bulk commodity vehicles, the vehicle shall also be loaded to the full volumetric capacity with the highest density commodity proposed to be carried in the vehicle, to ensure that the vehicle does not exceed the agreed maximum axle load. Refer to Section 3.4.

3.2.2 Derailment damage

Any vehicle which has become derailed and is suspected of having sustained damage, or has had equipment removed as a consequence of a derailment, which may alter the wheel load distribution

shall be weighed to confirm that the wheel load distribution is within acceptable limits before the vehicle is released into traffic.

The CRN Manager reserves the right to request and have a weigh test carried out by the owner/operator where, in the manager's opinion there is doubt as to the vehicle's wheel load distribution.

3.3 When the weigh test is recommended

A weigh test is recommended on each of the following occasions:

3.3.1 Bogie change on locomotives and passenger rolling stock

Locomotives and passenger vehicles having undergone a bogie change should be subject to a weigh test to confirm that the wheel load distribution is within acceptable limits, as determined by the formulae in CRN Standard, CRN-RS 012, before the vehicle is released into traffic.

3.3.2 Removal / replacement, modification, or adjustment of suspension equipment.

Locomotives and Passenger Rolling Stock should be weighed if the suspension equipment (including primary/secondary springs, air springs, levelling valves, torsion bars, and spring packing) have been removed/replaced, modified or adjusted, to confirm that the wheel load distribution is within acceptable limits, as determined by the formulae in CRN Standard, CRN RS 012, before the vehicle is released into traffic.

3.3.3 Investigation for overloading

Any vehicle which is suspected of being excessively or unevenly loaded should be weighed to confirm the wheel load distribution and where necessary, determine appropriate operating conditions.

3.3.4 Investigation of derailment cause

It may be appropriate in some derailment investigations, to weigh the vehicle involved to determine if wheel load distribution was a contributing factor in the incident.

Note: In the case of freight vehicles it is possible that the load may have shifted during the derailment.

3.4 Maximum axle load

The maximum axle load for any vehicle operating on the CRN shall be as agreed between the Network Manager and the owner/operator, considering the type of vehicle proposed, vehicle operating conditions and the area of operation. Refer to Table 3.

3.5 P/D ratio

In determining operating conditions, the CRN Manager will consider the maximum P/D ratio, (the ratio of maximum static wheel load to minimum [worn] wheel diameter).

Where it is proposed to operate vehicles having P/D ratio's outside these limits, approval must be obtained from the CRN Manager.

The maximum allowable P/D ratios for operation of worn wheels on the CRN are as follows:

Area of Operation	Maximum P/D Ratio (t/m)
Unlimited track Class	12.66
Selected Class 1 track	15.13

Table 2 – Accepted Wheel P/D Ratios

Refer to Table 3 for currently approved bogie/wheel load/wheel diameter combinations for new wheels.

Track classes are shown in the CRN Train Operating Conditions Manual, Section 1, Route Standards.

Wagon Type	Side Bearer Type	Max Axle Load Tonnes	New Wheel Diameter mm	Speed km/h	Track Class	Comments
Cartainer wagon	CCSB	16	737	115	Class 1 or better	19 tonne axle load approved for a limited number of services
All types	Gap Side Bearer	19-20	840-920	80		Reduced speed over all lower class track (See TOC Manual)
Super freighter	CCSB	19		115		Reduced speed over some lower class track (See TOC Manual)
		19.25	920	115		Applies to dual sprung bogies Reduced speed over some lower class track (See TOC Manual)
		21	840	100		Reduced speed over Class 2 track with 2 mm wheel tread hollowing limit
		23		80		Reduced speed over Class 2 track with 2 mm wheel tread hollowing limit
Steel traffic	Gap Side Bearer	23	840	80	Class 1 or better	Reduced speed over Class 2 track with 2 mm wheel tread hollowing limit
Coal traffic	Gap Side Bearer	25		65		Coal working
Super freighter	Gap + large centre pivot	19.25		115		Reduced speed over all lower class track (See TOC Manual)
	CCSB		920			
Grain traffic		20.25		80		
		25		80		
Super freighter		19.25	840	115		
Coal traffic		25	920	80		Coal working

Table 3 - Approved vehicle/axle load/wheel diameter/speed combinations

Note on Table 3:

All applications with axle loads exceeding 19 tonnes and/or wheel diameters with less than 840 mm are subject to traffic density considerations as part of the vehicle approval process.

4 Vehicle wheel unloading limit requirements

4.1 Twist test requirements

The vehicle, and in particular, the bogie or suspension shall be capable of accommodating the track twist conditions specified herein with the loss of absolutely no more than 60% of the static wheel load on the rail for any wheel. For vehicles fitted with a centre plate pivot, the body centre plate shall have no less than 14 mm engagement with the bogie centre casting at any point, under the twist configuration specified in this Standard.

A track twist test using a certified weighbridge, or other approved load measuring device, and adopting the test procedures detailed below shall be used to verify compliance with the above requirements.

4.2 When a twist test is required

A twist test shall be conducted on all vehicle types before they will be approved to operate on the CRN.

A twist test shall also be performed on any vehicle where the torsional stiffness of the vehicle has changed due to any of the following:

- An increase in suspension spring rates
- An increase in bogie frame torsional stiffness
- A reduction in minimum side bearer clearance
- A modification from gap side bearer to constant contact side bearer.
- An increase in side bearer preload,(where applicable)
- An increase in underframe/body torsional stiffness
- A change in vehicle equipment, and/or mass distribution.

All vehicle types or modified versions thereof, including vehicles for test purposes, shall meet the requirements of this standard before any movement of such vehicles occurs on the CRN, other than in the confines of yards.

When the twist test is a part of a new vehicle acceptance requirement and there are more than 10 vehicles of the same type being supplied, if the results of a twist test on the first vehicle tested exceeds 58% wheel unloading then 1 in 10 vehicles thereafter shall be twist tested to verify consistency in the vehicle design.

The CRN Manager reserves the right to request and have a twist test carried out by the owner/operator where, in the Manager's opinion, there is doubt as to a vehicle's twist capability.

Vehicles equipped with standard three piece bogies having the standard 10-14 mm gapped side bearers, with the exception of torsionally stiff vehicles; such as tank vehicles; and high centre of gravity vehicles, may be exempt from a static vehicle twist test for operational speeds up to 80 km/h, subject to written approval from the CRN Manager. Torsionally stiff and high centre of gravity vehicles may still require a twist test to confirm their acceptance.

Vehicles with a centre pivoting axle or bogie at one end, that essentially creates a three (3) point suspension, may not require a twist test.

5 Vehicle/bogie operating clearance requirements

When designing and constructing bogie vehicles it is essential that sufficient operating clearance be provided between the vehicle underframe structural components, as well as underframe mounted equipment, and the vehicle bogie, which needs to rotate beneath the vehicle body in order to accommodate curve negotiation.

Whilst the clearances can be investigated by using CAD layouts there is significant advantage in simulating the 3D view by physically rotating the car body about its bogie centre and checking actual clearances.

Vehicle/bogie clearances can be assessed by simulating the bogie rotation using a traverser or crane to move the opposite end of the vehicle body laterally.

Refer to Figures 7 and 8 for the method of calculating the lateral displacement.

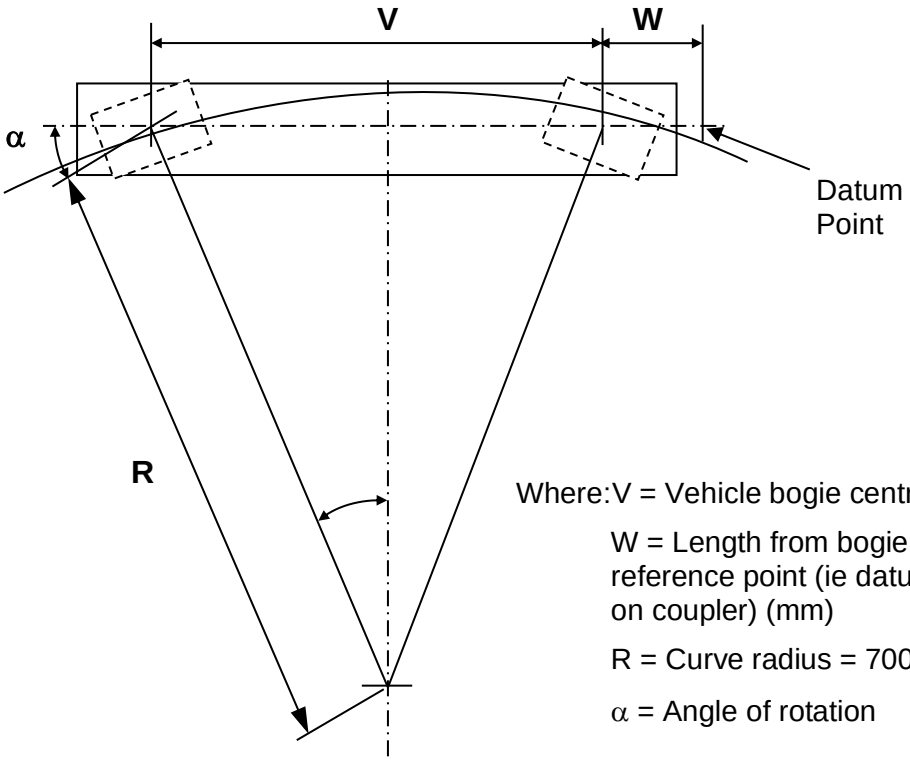


Figure 7 – Bogie swing test geometry

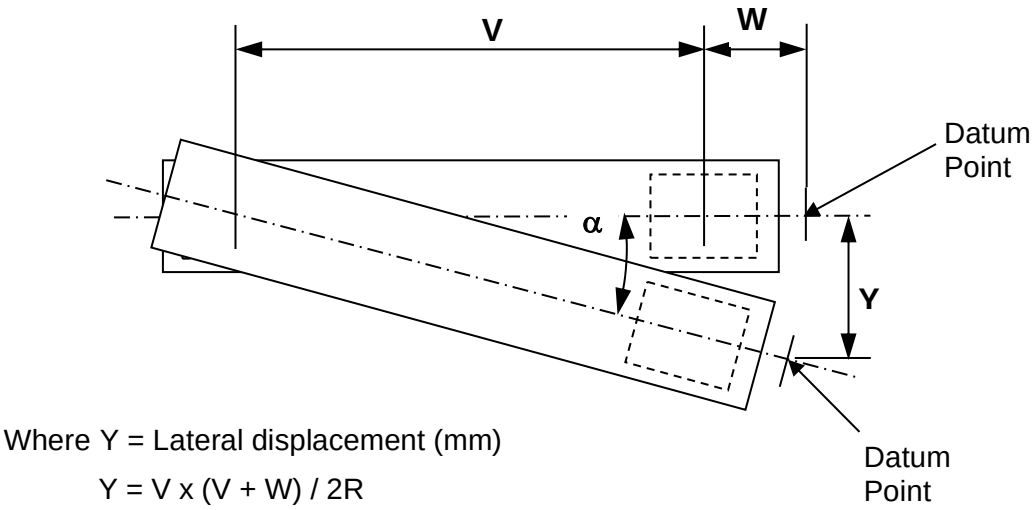


Figure 8 – Calculation of lateral displacement

In order to check actual clearances the vehicle body has to be displaced such that it is in its worst possible position relative to the bogie and underframe components. To this end, the suspension must be simulated in its solid condition or the tare to solid spring deflection must be included as necessary vertical clearance over and above normal running clearance

In order to cater for extreme rotational conditions the vehicle body is normally rotated such that it simulates the vehicle on a 70 metre radius curve. Under these circumstances the lateral or rotational clearance to any equipment need be minimal because the actual minimum in-service track curvature is 100 metres radius. There may be curves within yards and sidings as small as 90 metres radius but the vehicle dynamics in this case would be negligible and thus the clearance requirements would be minimal.

6 Vehicle/vehicle operating clearance requirements

6.1 General

The operating clearance between adjacent vehicles is an important safety consideration. During curve negotiation the ends of vehicles move relative to each other. Two adjacent vehicles are tethered together by their couplers and during curve negotiation the ends of the vehicles are drawn together. Insufficient clearance or vehicle separation will cause binding. It is important also to consider inter-vehicle connections such as brake hoses, control jumper couplings, gangway beams, gangway diaphragms, etc to ensure there is no possible interference, binding or chafing.

All vehicles shall be capable of successfully negotiating:

- A horizontal simple curve of 100m radius whilst coupled to a base vehicle (see the definition in CRN Standard CRN RS 010, Section 6.5), with a total lateral coupler offset (from the vehicle centreline) of 90mm at the coupler line; the vehicle path shall be through the curve from tangent track.
- A reverse horizontal curve of 120m radius, without transition between the two curves, while coupled to an identical vehicle.
- A vertical both convex and concave curve of 300 metres radius.

These curve radii are tighter than those which vehicles would normally be required to negotiate in service and are designed to ensure adequate clearance is available.

For test requirements refer to CRN Standard CRN 010 Section 6.

6.2 Vehicle end equipment

For compatibility between rolling stock required to operate over the CRN, the location of end brake pipe equipment on locomotive hauled vehicles shall be generally in accordance with that shown in the relevant vehicle standard as listed below, unless otherwise approved by the CRN Manager.

- Locomotives CRN RS 001
- Freight vehicles CRN RS 002
- Locomotive hauled passenger vehicles CRN RS 003
- Multiple unit trains CRN RS 004
- Rail bound infrastructure maintenance vehicles CRN RS 005

Where vehicles are fitted with drawbars, buffers, buffer beams, gangway beams, or transition lugs, those items shall be compatible in height and loading and under conditions of curving or vehicle dynamics they must not be capable of fouling or locking together with those on adjacent vehicles.

Gangway diaphragms fitted to the ends of vehicles must be compatible with adjacent coupled vehicles to ensure they do not foul or interlock with each other. The use of coupler mounted

gangway and diaphragm equipment on passenger vehicles is preferred because it is less likely to cause fouling between adjacent vehicles.

Refer to CRN Standard CRN RS 010 Section 6 for static vehicle/vehicle swing test requirements.

For vehicles fitted with main reservoir and/or independent brake the type and location of hoses should be such that they couple with locomotives and other locomotive hauled vehicles.

For multiple unit locomotive coupling compatibility, the location of end equipment on locomotives shall be generally in accordance with that shown in CRN Standard CRN RS 001.

6.3 Couplers

6.3.1 6.3.1 Standard automatic knuckle coupler

All new or substantially modified locomotives and locomotive hauled vehicles shall be fitted with automatic couplers generally in accordance with that shown in Figure 9.

Automatic knuckle couplings shall have the No. 10A contour to AAR Standard S-106,

Coupler lengths shall be in accordance with the dimensions shown in Figure 14 and chosen to ensure that the coupler length is commensurate with the length of the vehicle in order to minimise the lateral coupler force component when negotiating curves coupled to a vehicle complying with the base vehicle dimensions. Refer to CRN Standard CRN RS 010 Section 6.5 for the base vehicle dimensions.

Coupler material shall be cast steel to in accordance with AAR Specification M-201 Grade E - with the impact test at 0°C acceptable

or alternatively

AS 2074 Grade L6B2 - with a Charpy impact test at 0°C to AS 1544, Part 2, 3 tests are required, with an average impact energy of 27J minimum, and no individual test shall be less than 20J

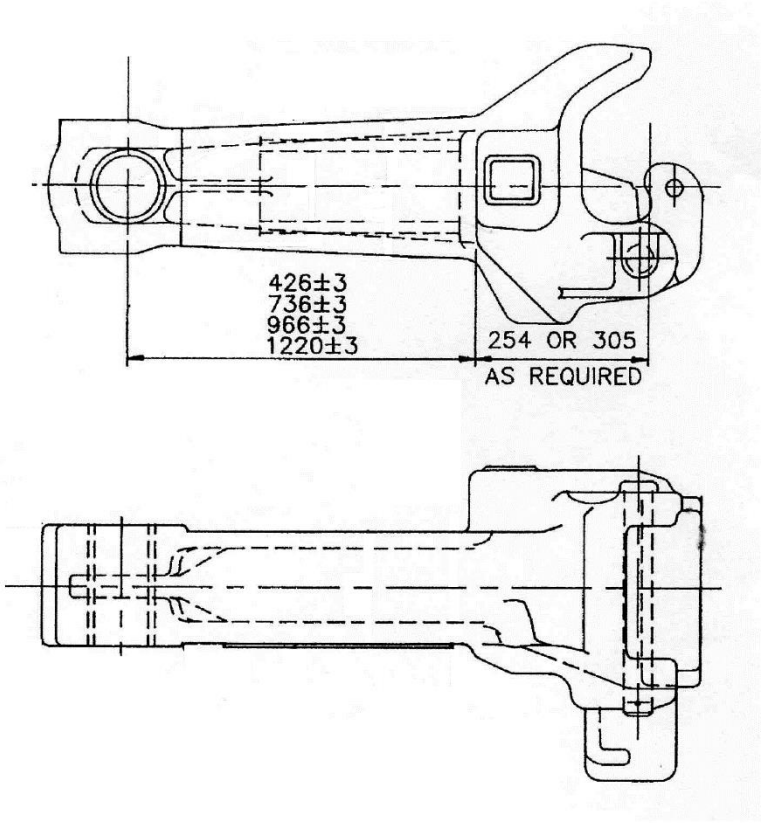


Figure 9 – Standard knuckle coupler with bottom shelf

Note: The optimum coupler length for a specific vehicle length can be determined using the criteria specified in section 6.5 below.

6.3.2 Other automatic knuckle coupler applications

All vehicles, except tank cars used for the conveyance of dangerous goods in bulk, shall conform to the coupler dimensional requirements of Figure 9, with a bottom shelf.

Tank cars used for the conveyance of dangerous goods in bulk shall be fitted with couplers conforming to the dimensions of Figure 9 but with both top and bottom shelves (double shelf type).

Special purpose couplers for rotary-dump operations etc may be fitted where required. These couplers shall comply with all relevant aspects of this section and AAR requirements, with the impact and Charpy tests as specified in Section 6.3.1.

6.3.3 Uncoupling equipment

The uncoupling mechanism shall be designed to prevent it being damage when loading, unloading or coupling vehicles. The uncoupling equipment shall be readily accessible from the corner of the vehicle without the need for personnel to stand between that and the adjacent vehicle. Uncoupling equipment shall be designed to prevent unintended uncoupling of vehicles whilst operating in service.

Uncoupling equipment on locomotives shall be accessible from either side of the locomotive.

6.3.4 Non-standard, combined or multifunction couplers

Vehicles with non-standard couplings, combined or multi-function couplings shall be compatible with similar vehicles with which they must operate. On terminal end vehicles, emergency couplings must be provided to interface mechanically with the standard AAR 10A contoured coupler as well as with brake pipe and main reservoir air brake coupling hoses.

Vehicle couplings and end equipment shall be designed to enable vehicles with the same coupling system to be readily coupled together on a minimum curve radius of 200 metres.

6.3.5 Rigid drawbars

Rigid drawbars are permitted, which permanently connect two (2) or more vehicles together where the need for vehicle separation in service is not required.

The drawbar ends and shank dimensions shall be designed to provide vertical flexibility to adequately cater for differences in vehicle heights, loading and dynamics.

The drawbar length shall be chosen to be commensurate with the length of the vehicle and shall comply with the following vehicle design parameters in order to minimise lateral force components during curve negotiation and also to maintain adequate vehicle separation to minimise concentrated bridge loading.

L/V ratio of the design vehicle shall not exceed 0.82 under the following conditions:

- Draft/Buff force of 890 kN
- The design vehicle coupled between two (2) AAR base vehicles
- The design vehicle positioned on a horizontal curve of 165 m radius
- The design vehicle shall be in the tare condition.
- The drawbar and components shall be designed to withstand longitudinal buff and draft forces equivalent to those of the couplers.

6.3.6 Slackless drawbars

Slackless drawbars are permitted, to permanently connect two (2) or more vehicles together where the need for vehicle separation in service is not required and where there is a need to minimise train slack.

The slackless drawbar shall connect to each vehicle with an assembly incorporating components for load transfer and self adjustment of wear induced slack, without draft gear.

The drawbar shall be designed to permit movement in the vertical and lateral planes.

The length of the drawbar shall be selected to comply with the parameters specified in Clause 6.3.5 above.

The slackless drawbar and components shall be designed to withstand longitudinal buff and draft forces equivalent to those of the couplers.

A suitable means shall be provided to prevent the slack control system from binding, which can compromise curve negotiation.

6.3.7 Articulated connector

Articulated connectors are used to permanently couple adjacent vehicle platforms which share a common bogie and form part of an articulated multi-pack vehicle.

The connectors shall consist of inter-connecting male and female components, each permanently attached to the end structure of the vehicle platforms. The two components shall be permanently coupled at assembly by means of a vertical pin with positive retention.

The connector shall be designed to permit rotation in the longitudinal, vertical and lateral planes, with sufficient internal clearance to permit the vehicle to be lifted clear of the bogie.

Longitudinal buff forces shall be transmitted by direct contact between the mating components; draft forces shall be transmitted through the connecting pins.

The connector assembly shall incorporate components for load transfer and self-adjustment of wear induced slack.

The female component shall incorporate a spigot, equivalent to a body centre plate, to mate with the bogie centre plate and include provision for a bogie centre pin.

The minimum capacity for angular rotation when installed shall be:

- Vertical plane (concave and convex) : ± 7°30' (for undulations and lifting)
- Horizontal plane : ± 18° (for curving)
- Lateral roll : ± 5° (for twist)

The connector and components shall be designed to withstand longitudinal buff and draft forces exceeding that of the coupler/draft gear rating, without failure.

6.4 Draft gear

All drawgear shall be equipped with draft gear of sufficient energy absorption capacity to withstand longitudinal buff and draft forces equivalent to those of the couplers and shock loading due to train dynamic forces.

6.5 Coupler/drawbar swing

Automatic coupler/drawbar swing should be sufficient to permit negotiation of minimum design curve radii without binding in the headstock coupler/drawbar opening and in the case of couplers, allow for coupling to vehicles with short or long overhangs and to couple on minimum curves.

6.6 Coupler height

Coupler heights shall be within the following limits:

Locomotives:

- New condition, full provisions — 880 to 900 mm.
- In service condition — 840 to 900 mm.

Freight vehicles:

- New condition — 870 to 915 mm.
- In service condition — 780 to 915 mm.

Passenger vehicles:

- XPT — 875 to 915 mm.
- Xplorer/Endeavour. — 905 +/- 1 mm.

Note: Multifunction couplers must be maintained level

7 Static brake performance requirements

7.1 Introduction

Static brake performance must be checked to ensure correct functionality prior to any rail vehicle being permitted to travel on the CRN.

Static brake checks include the following, where applicable, for each type of vehicle and in some cases, each individual vehicle.

- Measurement of brake block force and calculation of net brake ratio
- Single car air test
- Parking/hand brake holding test on a grade
- Static brake valve operation test

- Operation of Driver Safety Systems

For specific static brake requirements applying to the different vehicle types, refer to:

- Locomotives CRN RS 001
- Freight vehicles CRN RS 002
- Locomotive hauled passenger vehicles CRN RS 003
- Multiple unit trains CRN RS 004
- Rail bound infrastructure maintenance vehicles CRN RS 005
- Road/rail infrastructure maintenance vehicles CRN RS 006

7.2 When a static brake check is required

All vehicles shall successfully meet the following static brake requirements in order to gain approval to operate on the CRN.

- New vehicles shall be type tested for compliance prior to any on-track testing.
- Existing vehicles, new to NSW, shall be type tested or original type test results submitted for assessment prior to operation on the CRN or evidence.
- Any vehicle where modifications have been made to the brake system, including change of brake block or disc pad types, change of control equipment type shall undergo static brake tests prior to entering service.
- Following any alteration to brake rigging ratios or brake cylinder size or pressures , the brake block forces shall be re-measured to reconfirm the net brake ratio.
- Following any vehicle maintenance and/or inspection a static brake valve operational test shall be conducted on all locomotives, multiple unit trains and rail bound infrastructure maintenance vehicles prior to the vehicle being permitted to move on the CRN.

The CRN Manager reserves the right to request and have a static brake test carried out by the owner/operator where, in the Manager's opinion, there is doubt as to the vehicle's braking capability.

7.3 Net brake ratio

A net brake ratio shall be determined for all locomotive and locomotive hauled vehicle types. The net brake ratio shall be determined by dividing the sum of the actual measured brake block forces by the total vehicle weight at rail, for both tare and gross mass conditions. The hand/parking brake net brake ratio shall also be recorded.

Net brake ratios are specified for locomotives and locomotive hauled vehicles in the appropriate standard for that type of vehicle.

- Locomotives CRN RS 001
- Freight vehicles CRN RS 002
- Locomotive hauled passenger vehicles CRN RS 003

7.4 Single car air test

All locomotive hauled freight and passenger vehicle brake systems shall be regularly maintained and a single car test conducted on the automatic brake system to confirm the correct brake operation, in accordance with operator's maintenance and inspection procedures.

During the single car test, the following items would normally be verified:-

Test No	Test	Allowable limits
1	brake pipe leakage	20 kPa/minute maximum
2	main reservoir leakage	10 kPa/minute maximum
3	sensitivity on application	brakes remain applied for over 60 seconds
4	sensitivity on release	brakes release within 30 sec
5	accelerated release operation (where fitted)	sudden increase in BP pressure
6	grade control valve operation (where fitted)	50 – 70 kPa BC pressure maintained in HP Delayed release in IP
7	load compensation operation (where fitted)	higher pressure in “loaded”
8	slack adjuster operation	Adjust as required
9	brake cylinder leakage	10 kPa/5 minute maximum
10	auxiliary reservoir leakback	nil leakage
11	main reservoir leakback	10 kPa/minute maximum
12	independent brake (where fitted) double check valve leakage independent brake over automatic brake independent control pipe leakage	nil leakage allowed

Table 4 - Test criteria in single car air test

A single car test shall also be conducted on a vehicle after the replacement of any major air brake equipment which is likely to affect the sensitivity of the brake system.

Any vehicle having skidded wheels (class 2 repeat offender, class 3 or greater) or scaled wheels (class 4 or greater) shall be given a single car test to confirm correct brake operation, prior to release into service.

Locomotives that are to be hauled dead attached or for the purpose of assisting on the rear of a train, or within a train consist, shall undergo a single car test to verify the sensitivity of the brake equipment for compatibility with other locomotive hauled vehicles.

7.5 Brake block/pad requirements

Vehicles fitted with brake blocks or disc pads shall comply with the following requirements.

Due to the variation in friction characteristics between the different types of wheel tread brake blocks, they shall be designed such that they are not interchangeable.

The brake block type shall be compatible with the vehicle wheel design/material.

Brake blocks and disc pads shall not contain asbestos fibre or any other asbestos product.

7.5.1 Composite brake blocks

The following table showing the coefficient of friction of composite brake blocks and disc pads is provided as a guide:

Composition brake block/pad type	Dynamic coefficient of friction

Low friction	0.2 maximum
Medium friction	0.2 to 0.25
High friction	0.25 minimum

Table 5 - Coefficient of dynamic friction for composite brake blocks/pads

High friction brake blocks shall comply with the latest revision of AAR Manual of Standards, specification M-926.

7.5.2 Cast iron insert composite brake blocks

Cast iron insert composition brake blocks may be used on locomotives.

The application of cast iron insert composition brake blocks to other vehicles shall be subject to the approval of the CRN Manager.

7.5.3 Cast iron brake blocks

Cast iron brake blocks are commonly used on locomotives and some other vehicles such as XPT power cars, some Indian Pacific cars and vehicles with tyred wheels.

Cast iron brake blocks may be used for wheel conditioning and should be replaced by a composition brake block as soon as practical. Cast iron brake blocks may be used to remove minor tread defects such as class 1 skids and class 1 scale.

Composition brake blocks are preferred to that of cast iron.

7.5.4 Abrasive brake blocks

Abrasive brake blocks shall only be used to remove minor wheel and tread irregularities.

Full thickness abrasive brake blocks shall not be used on a vehicle in service.

Brake blocks with a thin layer of abrasive material may be fitted to a vehicle and enter normal service.

7.5.5 Noise limits

Noise emitted during braking, usually caused by the wheel or any other associated component resonating shall not exceed the limits specified in Section 14 herein.

Noise emission tests shall be conducted on a complete train consist, braking at various normal running speeds.

Noise tests shall be conducted:

- on new trains with different combinations of brake rigging and brake block or disc pad material to that already in service.
- when the material composition of brake blocks or disc pads is altered.

The CRN Manager reserves the right to request and have noise emission tests carried out by the owner/operator where, in the manager's opinion, there is doubt to the vehicle/train complying with the noise limits specified in Section 14.

8 Safety equipment performance requirements

8.1 Introduction

All rail bound self-powered vehicles operating on the NSW rail network shall be fitted with a driver safety system in accordance with the requirements of CRN Standard CRN RS 013 – Driver Safety Systems.

8.2 Driver safety systems

Driver safety systems shall include but be not limited to the following equipment:

- Vigilance control to monitor driver alertness/attentiveness.
- Driver enable system to monitor driver functionality.
- Tripgear to catch vehicles at locations where automatic train stops are installed.
- ATP (Automatic Train Protection) system to monitor and control vehicles in line with infrastructure requirements.
- Driver's emergency cock
- Lights
- Horns

8.2.1 Alternate safety systems

Where other types of Driver Safety Systems are fitted to rolling stock, the operation of those systems shall be tested in accordance with manufacturer's procedures to ensure compatibility with the NSW rail network. Operators and/or owners shall have procedures to test the operation of any Driver Safety Systems.

8.3 Lights

The following are the minimum requirements for rail vehicle safety lighting

8.3.1 Headlights

All locomotives, rail bound infrastructure maintenance vehicles and self-propelled multiple unit trains shall have a white headlight fitted at any leading end. The headlight/s shall have a peak intensity of at least 200,000 candela.

The peak intensity requirement shall also comply if devices to protect / diffuse the headlights are required while in service.

Headlights on new and modified vehicles shall be at least 2.3 metres above rail and the centreline of each headlight beam should be aimed at a centre point on the track at least 240 m ahead and in front of the headlight.

Headlights shall have dimming capability.

8.3.2 Tail and marker lights

All locomotives, rail bound infrastructure maintenance vehicles and self-propelled multiple unit trains shall have white marker lights and red marker lights fitted to leading and trailing ends, respectively, mounted as high and as wide as practical. Any vehicle or multiple unit train that has bi-directional capability shall have white and red marker lights at each end with provision for selective switching.

For normal on-track operation the leading or driving end shall display white marker lights and the trailing end (last vehicle) shall display red marker lights. Vehicles operating in a possession worksite shall display white marker lights at both ends.

Locomotive hauled vehicles shall be fitted with red marker lights at each trailing end.

Each marker or tail light shall have a luminous intensity of at least 0.75 candela.

8.3.3 Visibility or ditch lights

All locomotives, rail bound infrastructure maintenance vehicles and self-propelled multiple unit trains shall have two (2) visibility or ditch lights installed between 600 and 1200 mm above rail.

The lights shall be positioned at least 1500 mm apart and angled horizontally such that the centre of each light beam intersects the track centreline within the range of 7.5 to 15 degrees.

Each ditch light shall have a luminous intensity of at least 20,000 candela.

8.3.4 Flashing lights or beacons

All self-propelled infrastructure maintenance vehicles shall be fitted with an amber or orange flashing beacon.

The beacon shall be roof mounted or on a high prominent location so that the beacon light is visible from all sides. More than one beacon may be required on some vehicles in order to meet this requirement.

Each beacon shall have a luminous intensity of at least 18,000 candela. The flash frequency of the beacon/s shall be between 40 and 180 flashes per minute.

Refer to the following individual vehicle standard for vehicle specific requirements.

- Rail bound infrastructure maintenance vehicles CRN RS 005
- Road/rail infrastructure maintenance vehicles CRN RS 006

8.3.5 Additional lights

Additional lighting shall be provided on locomotives, locomotive hauled vehicles, infrastructure maintenance vehicles and multiple unit trains to illuminate steps, couplers, walkways, etc, where appropriate for personnel safety.

8.4 Horns

Horns shall be checked for compliance with that specified in Table 5 below.

	Main horn	Low horn
Stationary	200 m in front	100 m in front
External noise limit	88 dB(A) min	85 dB(A) min 90 dB(A) max
Driver's cab internal noise limit	85 dB(A) max	85 dB(A) max

Table 5 – Horn minimum and maximum noise levels

9 Locomotive signal visibility requirements

Signal sighting is an important safety aspect of crew cab design and must be considered when positioning the driver and controls as well as the frontal shape of the vehicle. The driver should normally be seated on the left hand side of the vehicle or to the left of the vehicle centreline and when seated, shall have direct line of sight to the following signalling equipment.

Note 1: Where compliance with this section is affected by vehicle design or operation (including 'Long End Leading' configuration), operators will be required to demonstrate that they have managed the risks SFAIRP as part of CRN certification. This could include- but is not necessarily limited to- considering how gradients and curves affect visibility on the desired route, considering alternative routes, implementing speed controls, additional cab-based observers, vision enhancement (e.g. cameras) and operating a vehicle in the direction offering greatest visibility.

9.1 Dwarf or ground based signalling equipment

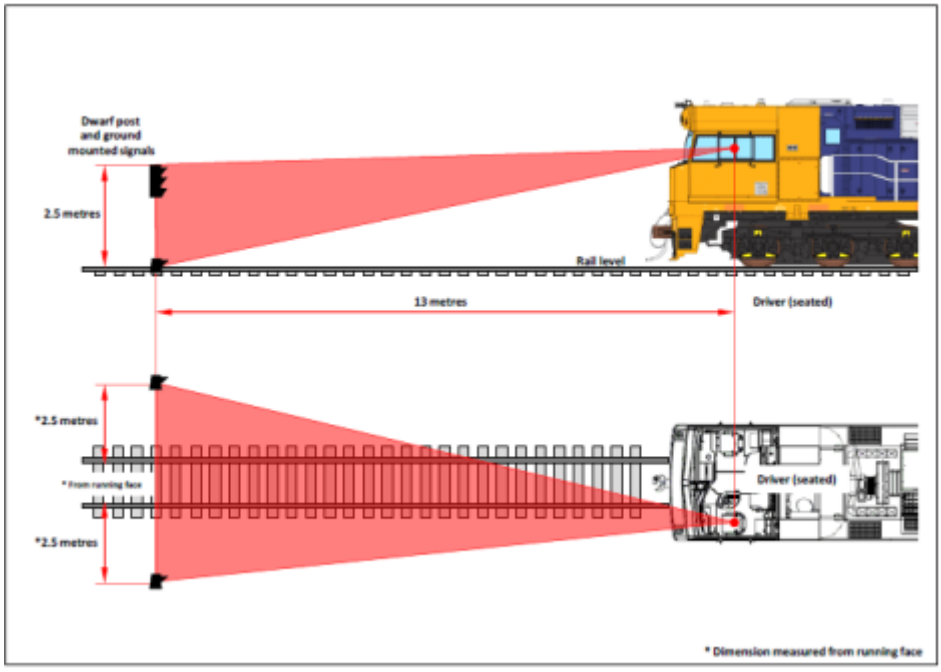


Figure 10 – Seated signal visibility for dwarf and ground mounted signals

Dwarf or ground signalling equipment located at all distances greater than 13 metres from the driver's eye position to a height of 2.5 metres above rail and to a width of 2.5 metres from the adjacent rail running face on either side of the track. Refer to Figure 10.

9.2 High or gantry signalling equipment

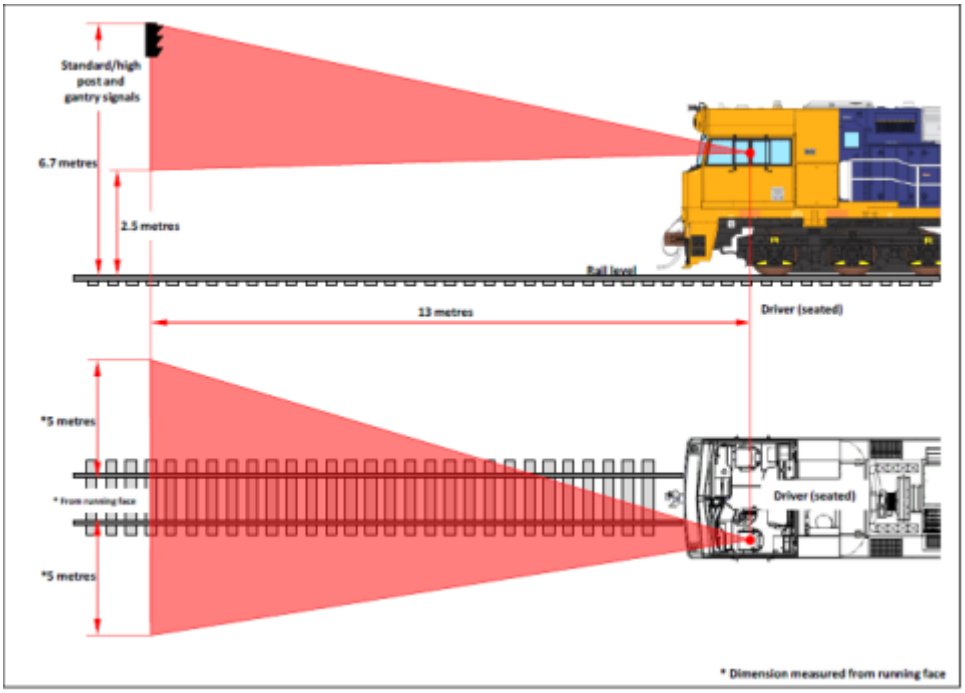


Figure 11 - Seated signal visibility for standard, high post and gantry mounted signals

High or gantry signalling equipment located at all distances greater than 13 metres from the driver's eye position at 2.5 metres up to a normal height of 6.7 metres above rail level and within a width of 5 metres from the adjacent rail running face on either side of the track. Refer to Figure 11.

9.3 Driver standing visibility

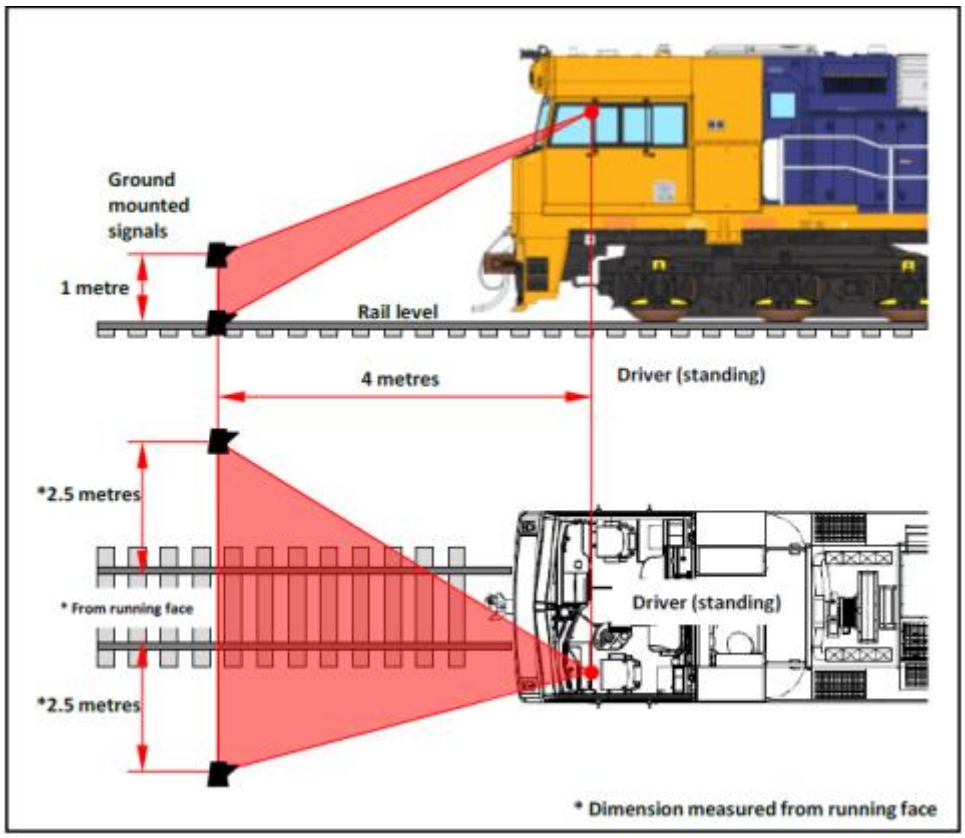


Figure 12 – Standing signal visibility for ground mount signals

The driver in a standing position shall have direct line of sight to dwarf and ground signalling equipment located at all distances greater than 4 metres from the driver's eye position, up to 1 metre above rail and to a width of 2.5 metres from the adjacent rail running face on either side of the track. Refer to Figure 12.

10 Diesel multiple unit (DMU) signal visibility

10.1 Dwarf or ground based signalling equipment

The driver of DMU rolling stock shall have a direct line of sight to ground mounted signals located at rail level to a height of 1 metre above rail level, at all distances greater than 2.5 metres from the driver's eye position while in the standing position. This field of view shall be seen to a width of 1 metre from the adjacent rail running face on either side of the track. Refer to Figure 13.

Please also refer to Note 1 in section 9.

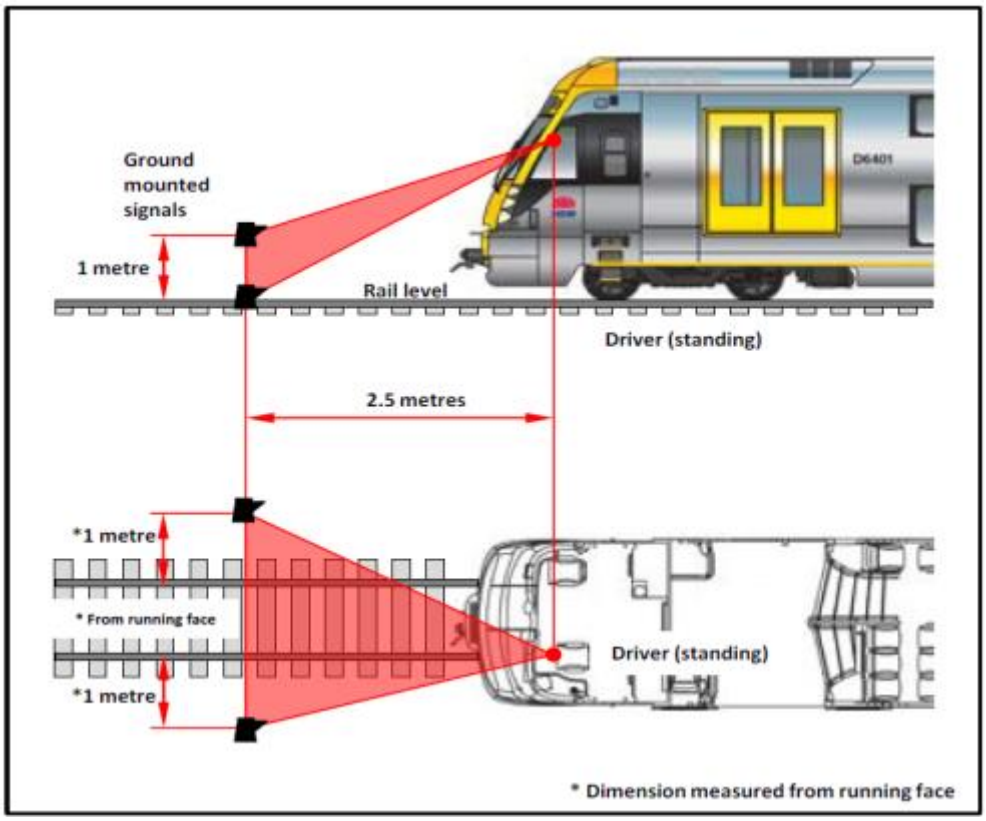


Figure 13 – Standing DMU signal visibility for ground mounted signals

10.2 High or gantry signalling equipment

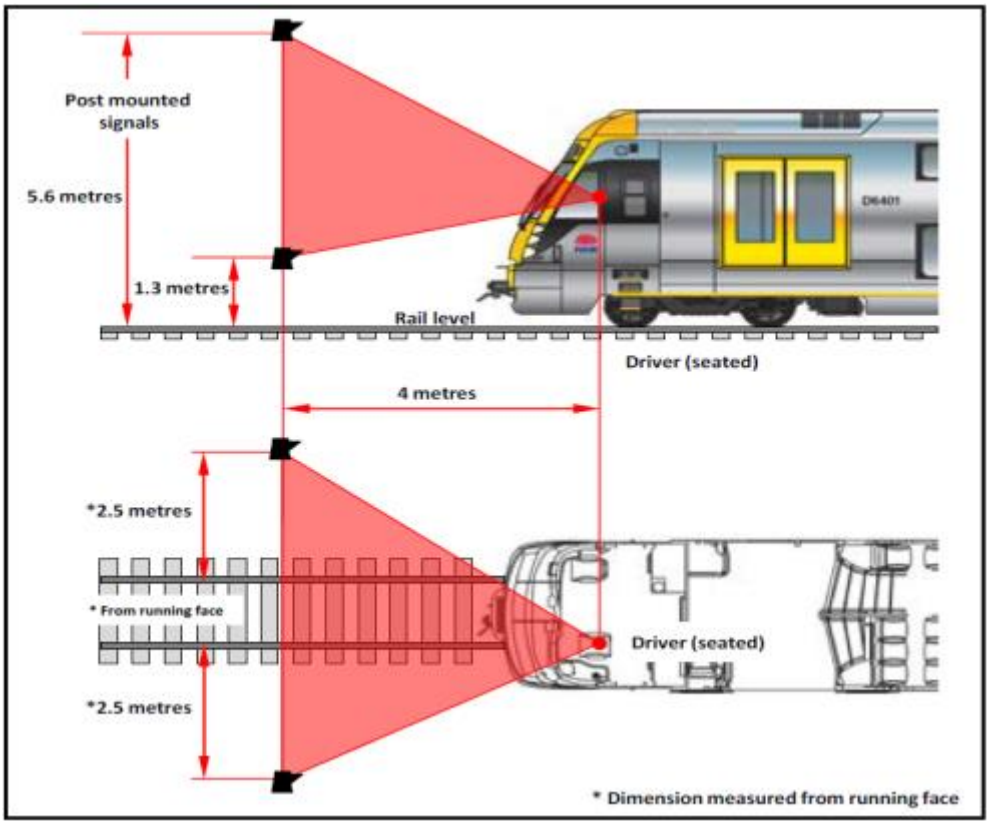


Figure 14 – Seated DMU signal visibility high post and gantry mounted signals

The driver shall have a direct line of sight to post or gantry mounted signals located 1.3 metres to a height of 5.6 metres above rail level, located at all distances greater than 4 metres from the driver's eye position while in the seated position. This field of view shall be seen to a width of 2.5 metres from the adjacent rail running face on either side of the track. Refer to Figure 14.

11 Rail bound infrastructure maintenance vehicles

The signal sighting requirements for rail bound infrastructure maintenance vehicles shall meet the requirements specified in either Section 9 or Section 10 depending on the vehicle crew cab configuration. Crew cabs with the driver/operator's position on the vehicle centreline or to the right of the vehicle centerline shall still meet the signal sighting requirements specified herein.

Please also refer to Note 1 in section 9.

12 Alternate driving positions

In the case of vehicles where the driver is not seated at the front of the vehicle, such as in locomotives running long end leading, steam locomotives, or some track maintenance vehicles the driver must be accompanied by a second person who is qualified in safeworking and has the appropriate road knowledge.

Vehicles not complying with the requirements specified in Sections 9, 10 and 11 will require an assessment and approval before being accepted for operation on the CRN.

13 Electrical safety requirements

13.1 Introduction

Vehicles that may or intend to operate within electrified traction areas must meet the electrical safety requirements as specified herein.

Vehicles having roof access and/or elevating equipment such as a platform, jib or boom, that are intended for operation under any electric overhead wiring, shall display suitable high voltage “Danger” warning signage on a near vertical surface adjacent to roof access points and controls associated with elevating equipment.

Vehicles having elevated platforms, jibs or booms shall also be fitted with height limiting controls to prevent unintended elevation of equipment.

The above requirements apply to all existing, new or modified vehicles where:

- equipment can come into contact with overhead wiring or be within 3 metres of the overhead wiring.
- personnel operating the vehicle, can come within contact with overhead wiring or be within 1 metre of the overhead wiring.

An electrical safety inspection is not required where vehicles only operate outside of electrified areas. Vehicles that fail the electrical safety inspection will be restricted to operation outside of electrified areas.

13.2 When an electrical safety inspection is required

All new or modified vehicles that may be required to operate under overhead electrical wiring, must be inspected and display the appropriate “Danger” warning signs as shown below.

An electrical safety inspection is designed to ensure that vehicles required to operate under overhead wires are safe in the following areas:

- There is adequate clearance between the vehicle and the overhead wiring.
- Moving parts, such as cranes and elevating platforms, are secured in a locked position while the vehicle is in travelling mode.
- There is adequate signage warning personnel not to climb on the vehicle when under the overhead wiring.

13.3 Safety labels

The safety labels shall be made from retro-reflective self-adhesive material and generally comply with those shown in Figure 15 below, and be located on a surface where they will be clearly visible to vehicle operating personnel and contrast well with the background colour of the vehicle.

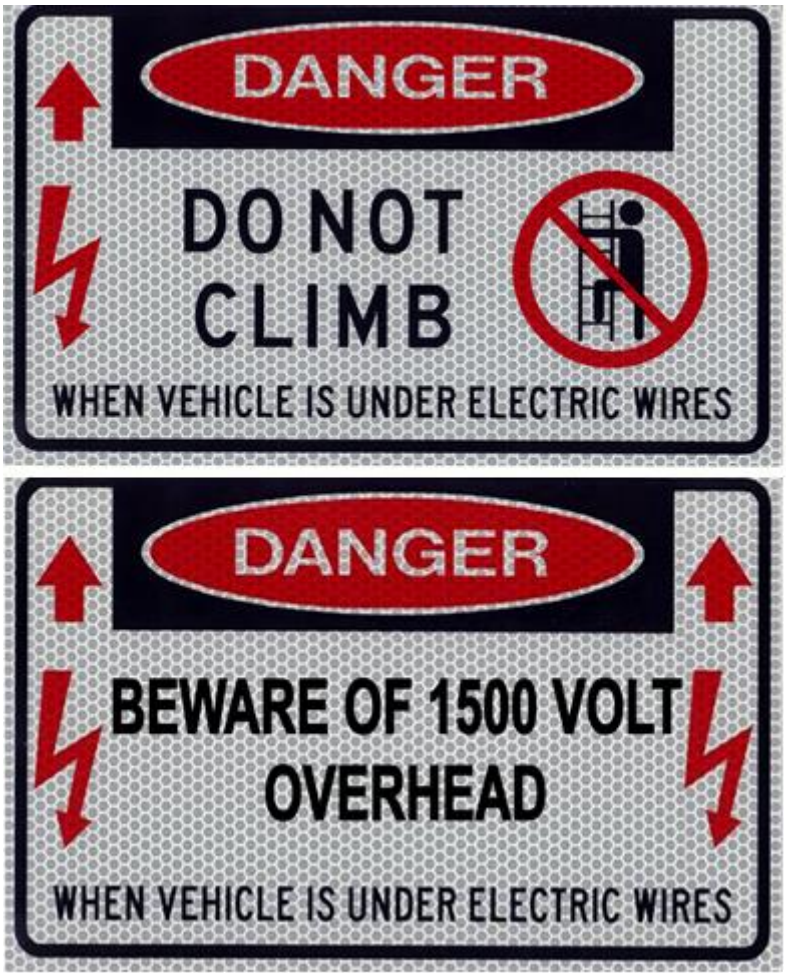


Figure 15 –Electrical "Danger" label samples

14 AEI tag requirements

All rail-bound vehicles operating on the CRN shall be fitted with automatic equipment identification (AEI) tags. The re-use of used AEI tags is not permitted.

The AEI tags shall be in accordance with the requirements specified CRN Standard CRN RS 014.

Road/rail vehicles and infrastructure maintenance vehicles that are transported or operate between worksites, by road, do not require AEI tags.

15 Reflective delineators

Reflective delineators or reflectors are mandatory equipment on all rail vehicles to facilitate night recognition of rail vehicles by motorists and other road users, particularly at road crossings.

Reflective delineators shall be fitted to vertical or near-vertical surfaces of the vehicle's permanent structure, preferably on the sole-bar, side-sill or boundary members.

Reflective delineators shall be manufactured from retro-reflective material which complies with the requirements of AN/NZS 1906, latest revision. Retro-reflectivity shall be to Class 1A.

The material shall be applied with a high strength pressure adhesive backing ready for application to bare or pre-painted surfaces.

Reflective delineators shall be cut or stamped from rolls so that the orientation marks are in the vertical direction when the reflective delineators are applied to the vehicle sides.

15.1 Locomotives, passenger, freight and rail bound infrastructure maintenance vehicles

Reflective delineators shall be applied to each side of each vehicle such that the edge closest to the vehicle end is still not more than 500 mm from the end of the vehicle underframe or sub-sills. Additional reflective delineators shall be applied between these, preferably at equal intervals, so that the centre-to-centre distance between adjacent delineators is not less than 2.5 metres and not more than 5 metres. The intervals shall be as close to equal as is practicable within the constraints imposed by the vehicle structure.

The preferred vertical location of reflective delineators or reflectors is between 900 mm and 1200 mm above rail level, but shall not be less than 800 mm nor more than 2000 mm above rail level (all heights are at tare in new condition). On any vehicle side, all reflective delineators should be positioned as near as practicable to the same height above rail level where permitted by the vehicle structure.

The design of new vehicles shall provide for the application of reflective delineators having the largest possible dimensions within the limits given below, and for reflective delineators to be located as close as possible to the preferred positions and spacing.

Reflective delineators shall be rectangular strips or panels, whose height shall be within the limits of 75 to 150 mm, and whose length shall be not less than 350 mm nor more than 500 mm.

Wherever possible, the length of reflective delineators whose height is 100 mm or less shall be at least 450 mm

The preferred colour of reflective delineators is white, with yellow as an acceptable alternative.

15.2 Road/rail vehicles

All road-rail vehicles shall be fitted with reflective zebra stripes. The stripes shall be fitted to the sides of the vehicle body, nominally at a height between 400 mm and 1500mm above ground level.

Vehicles with body lengths less than 2500 mm shall have continuous striping.

Vehicles greater than 2500 mm may have spot striping at a maximum spacing of 1000mm between stripes. Placement shall highlight the extremities of the vehicle.

The width of the continuous reflective zebra stripe material shall nominally be 100 mm. Spot striping shall have a minimum area of 0.025 m2 and a minimum length of 250mm.

The zebra stripes shall be at 45 degrees to the horizontal with a minimum width of 50 mm.

Zebra stripes shall consist of any contrasting colours, but **shall not** include the **colours red or green.**

In addition to the above requirement, outriggers, support legs, stabiliser legs, and similar, which have the potential to protrude outside of the rolling stock outline, shall be highlighted with yellow and black reflective striping.

15.3 Maintenance requirements

The presence, integrity and light reflective properties of reflective delineators are critical to their function as safety devices. Accordingly, the cleaning of reflective delineators, the checking of their attachment to the vehicle and the replacement of damaged or missing reflective delineators shall be included as a routine task in all scheduled and corrective maintenance functions.

Similarly, all train inspections shall include a check on the presence and condition of reflective delineators. Vehicles shall be green-carded for attention if there are two or more reflective delineators missing from any side of a vehicle. Reflective delineators shall not be damaged or obscured by graffiti, contamination, loading, restraining equipment or other accessories.

16 Vehicle recovery interface requirements

16.1 General

To ensure vehicles are recovered with minimal consequential damage and delay following an incident, such as a derailment, they should be equipped for, or have attachments suitable for use with the recovery equipment used by the Emergency Response Groups.

It is the owner/operator's responsibility to have incident recovery plans in place.

16.2 Lifting brackets and towing fixtures

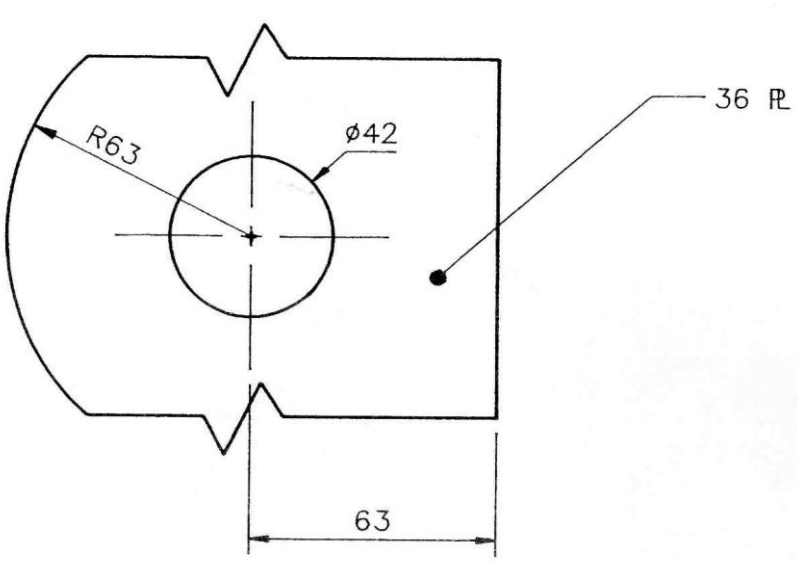


Figure 16– Lifting bracket basic dimensions

All vehicles should be fitted with facilities for towing in emergencies. Two (2) emergency towing fixtures shall be attached to each headstock. Refer to Figure 17.

16.3 Specialised recovery equipment

Vehicle owner/operators shall familiarise themselves with vehicle recovery equipment such as jacks and other lifting appliances. This may entail actually trialling the equipment prior to vehicle commissioning and acceptance tests in order to ensure that the vehicle is recoverable in the event of an incident during on-track tests.

Figure 18 – Pony bogie application

In the event of broken wheel, broken axle, seized bearing or seized drive train the standard recovery method and transportation by rail requires the use of a pony bogie as shown in Figure 18.

It is the Owner/operator's responsibility to become familiar with the pony bogie and its application as used by the relevant Emergency Response Group.

17 Environmental interface requirements

17.1 General

All vehicles shall comply with all relevant legislative environmental requirements, including those relating to exhaust emissions, noise, waste removal and handling of fuel.

Vehicle owner/operators must consult with the Environmental Protection Authority (EPA) and the CRN Manager on the environmental standards that do or will apply to a vehicle type, and shall demonstrate compliance with the appropriate standards and regulations thereby nominated, prior to operation of the vehicle on the CRN.

Owners/operators shall minimise all relevant environmental problems generated from rail vehicles with the BATNEEC (Best Available Techniques Not Entailing Excessive Costs) principle.

Owners/operators must comply with the CRN Environment Protection Licence with respect to the operation and maintenance of all plant and equipment.

17.2 Noise

All rail vehicles should comply with the noise requirements of the Protection of the Environment Operations Act 1997 as amended and the objectives of the Environment Protection Licence.

17.2.1 Locomotives

The CRN Manager must seek approval from the EPA prior to permitting the operation on the CRN for:

- a class or type of "locomotive, whether new or existing, that has not previously operated on the NSW rail network; or
- an existing locomotive that has been "substantially modified" since it was last used on the NSW rail network.

Note: If the owner/operator of a vehicle falls within either of the definitions of "locomotive" or "substantially modified" below, the owner/operator must comply with condition L6 of the CRN Manager's Environment Protection Licence.

17.2.2 Definitions

The EPA defines a "locomotive" as:

"A powered vehicle, primarily intended for hauling freight and/or passenger rolling stock or a rail vehicle comprising part of a diesel-multiple unit train, but does not include:

- a vehicle used for maintenance of track or other infrastructure, or
- a vehicle used or intended to be solely for heritage purposes."

Note: Diesel hydraulic DMU's (eg Xplorer Railcars) and diesel locomotives are captured by the above EPA definition.

EPA defines "substantially modified" as:

The major upgrading, replacement, restructuring or reconfiguration of one or more of the principal noise-emitting components of a locomotive, including where applicable:

- the combustion engine
- the engine exhaust system
- the traction system, including traction motors and gearboxes
- the electrical supply system, including alternators, inverters and control equipment
- cooling systems, and
- the dynamic braking system

but, does not include the routine maintenance of the locomotive.

A "non-locomotive" is defined as anything other than a "locomotive" and includes:

- a bogie/wheelset as part of either a freight or passenger train
- a rail vehicle comprising part of a multiple unit train (eg DMU trailer car)
- a vehicle used for maintenance of track or other infrastructure
- a vehicle used or intended to be solely for heritage purposes

Examples of non-locomotives include the XPT and DMU trailer cars, ballast cleaner, rail grinder, tamper, regulator, road/rail vehicle, etc.

17.2.3 Noise emissions

Noise emissions shall not exceed 85 dB(A) MAX pass by for new or existing vehicles, when operating at a speed of 80 km/h and measured at 15 metres from the track centreline in accordance with the conditions as specified in Australian Standard 2377, Methods for the Measurement of Airborne Sound from Rail Bound Vehicles. Where wheel tread defects are present (as defined in CRN Standard CRN RS 015 - Wheel Defect Standard), and result in non-compliance with the 85 dB(A) limit, this limit does not apply.

Additionally, all external noise must be non-tonal. In the context of this clause, for external noise to be considered non-tonal, the sound pressure level in each unweighted (linear) one-third octave band does not exceed the level of the adjacent bands on both sides by:

- 5 dB if the centre frequency of the band containing the tone is above 400 Hz: and
- 8 dB if the centre frequency of the band containing the tone is between 160 and 400 Hz, inclusively: and

- 15 dB if the centre frequency of the band containing the tone is below 160 Hz.

All external noise must not exhibit an undue low-frequency component. To comply with this requirement, linear noise levels must not exceed the A-weighted noise levels by more than 15 dB.

The results of noise tests must be submitted on the standard noise test reporting form. Refer to the following documents:

- Report Requirements for Locomotive Noise tests CRN RS-017
- EPA Locomotive Approval Declaration Form CRN RF 008
- Noise Test Data Recording Form CRN RF 009
- Locomotive Noise Test Recording Spreadsheet.xls CRN RF 010

17.3 Vibration

Ground borne vibrations shall not exceed 3 mm/sec at 15 metres from the track centreline on Class 1 track, in accordance with the requirements of DIN 4150 Part 3, with vehicle operating at any speed within their operational range and at any loading. The test vehicles and test site shall be free of wheel tread and rail head defects and mechanical track joints.

17.4 Exhaust emissions

Vehicle exhaust emissions shall comply with the requirements of the Protection of the Environment Operations Act 2002 as amended.

Exhaust emissions from new or re-engined rolling stock should comply with the relevant requirements of European Directive 2004/26/EC, or US EPA Standard 40 CFR 92.

The emissions requirement for locomotives in EU Directive 2004/26/EC valid until 1st January 2012 are Stage IIIA limits, referenced in Annex I, section 4(b), table entitled ‘Engines for propulsion of locomotives’.

The emissions requirements for locomotives in US EPA Standard 40 CFR 92 are Tier 2 limits, referenced in table A8.3.

Revised US EPA locomotive emissions standards were proposed in April 2007.

Operators shall use diesel fuels compliant to Fuel Standard (Automotive Diesel) Determination 2001, as amended.

The use of low sulphur diesel fuels in order to reduce levels of sulphur dioxide emissions and facilitate the future use of exhaust after-treatment equipment should be encouraged.

17.5 Waste management requirements

Locomotives and passenger rolling stock shall comply with all the requirements of the Protection of the Environment Operations Act 2002 as amended in relation to the discharge, intentional or otherwise, of wastes on the rail corridor.

Owner/operators shall have positive means to prevent spillages (for example: fuel, oil or coolant) plus manage, contain and clean-up all environmental incidents resulting from their activities to ensure compliance with all requirements of the Protection of the Environment Operations Act 2002 as amended.

Locomotives and rolling stock that are provided with toilets shall be provided with holding tanks and decanting facilities. The toilet system shall not discharge untreated waste to track.

Owner/operators of existing locomotives and passenger vehicles which are fitted with toilets that discharge untreated waste to track shall develop an agreed program to retrofit such vehicles with holding tanks and decanting facilities.

17.6 Vehicle attachments and loading

All vehicle attachments, such as generator sets, refrigeration units, LPG cylinders and air conditioning units, shall meet all relevant environmental requirements addressed elsewhere in this Standard and shall comply with the requirements of the Protection of the Environment Operations Act 2002.

All vehicle loads, such as dangerous goods, containers fitted with refrigeration units and generator sets, shall meet all appropriate regulatory requirements.

Owners/Operators of fuel tanks for self-contained generator sets, in-line refuelling and refrigeration units fitted to vehicles or containers shall have positive means to prevent spillages (for example: fuel, oil or coolant) plus manage, contain and clean-up all environmental incidents resulting from their activities.

Vehicle owner/operators shall ensure that vehicles used for the transportation of environmentally hazardous loads or loads which present an environmental risk when spilt, are designed, manufactured, operated and maintained in order to prevent load spillage.

17.7 Ecologically sustainable development

Owners/operators shall ensure that their rolling stock is designed, manufactured, operated and maintained in accordance with the principles of Ecologically Sustainable Development as defined in the Protection of the Environment Administration Act 1991 and in accordance with the Ecologically Sustainable Development strategies of the CRN manager's Environmental Management System.

Owners/operators shall, when designing new rolling stock or substantially modifying existing rolling stock, identify options for maximising energy efficiency and material reuse and recycling, and minimising non-renewable resource consumption, waste generation, water and energy consumption, and greenhouse gas emissions, and shall complement these options wherever possible.

Owners/operators shall periodically review the environmental impacts resulting from the operation and maintenance of their rolling stock in line with the principles of Ecologically Sustainable Development.

18 Kinematic rolling stock outline requirements

18.1 Vehicle body roll and lateral displacement limit requirements

The kinematic outline requirements are designed to ensure the vehicle remains within the kinematic envelope during its operation. There is an allowance for kinematic displacement of the static rolling stock outline and the vehicle shall remain within that allowance under all conditions of on track dynamics. Refer to Section 2.1.3 for displacement limits.

The static displacement check is designed to determine the vehicle roll and lateral displacement coefficients under simulated lateral acceleration created during curve negotiation. The simulated superelevation applied to the vehicle represents a cant deficiency of 160 mm or a lateral acceleration of 0.1g acting on the vehicle at its centre of gravity.

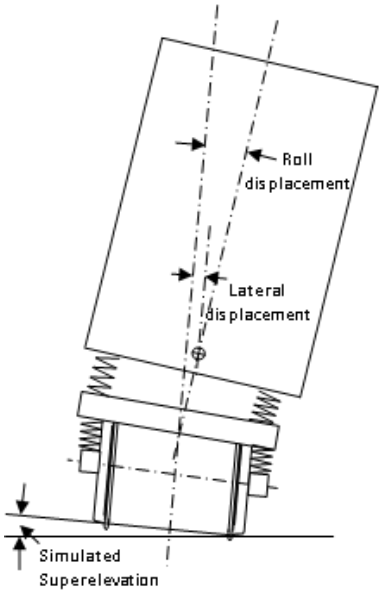


Figure 17 – Simulated cant deficiency

Some rail vehicles have a suspension system made up of various components which individually have load/deflection characteristics but in combination, they are quite complex. The purpose of this test is to plot the angular roll and lateral displacement of the vehicle body with respect to the track centre and rail plane.

Refer to CRN Standard CRN RS 010, Section 15 for test requirements.

18.2 When a kinematic outline test is required

A kinematic outline test shall be conducted on all vehicle types in order to gain approval to operate on the CRN.

The CRN Manager reserves the right to request and have a kinematic outline test carried out by the owner/operator on any vehicle for the following reasons:

- A modification to the vehicle suspension characteristics
- An increase in the vehicle centre of gravity height
- A change in wheel profile
- A change in bogie type
- A change in vehicle operating conditions
- Any vehicle modification which may affect the vehicle roll and/or lateral ride performance
- Where, in the CRN Manager's opinion, there is suspected infringement of the kinematic rolling stock outline.

18.3 Kinematic outline test requirements

The kinematic outline dynamic test can be conducted in conjunction with the ride performance test and as with the ride test the test speeds shall be incrementally increased whilst the performance parameters are monitored as required in CRN Standard CRN RS 010, Section 1.3.4.

The vehicle shall be instrumented to determine roll relative to the rail plane and the lateral displacement of the vehicle body relative to the wheels. Refer to Section 2.2 for displacement limits.

The loading of the vehicle for test purposes shall be such as to give the maximum expected centre of gravity height above rail.

The test shall be conducted with the vehicle negotiating an agreed test track site with 'x' per cent of the vehicle design cant deficiency.

Where 'x' = 160 % for freight vehicles

'x' = 145 % for passenger vehicles and locomotives.

The worst condition of roll and the worst condition of lateral displacement determined above shall be used in assessing vehicle compliance with the kinematic rolling stock outline requirements.

19 Signal compatibility requirements

19.1 General

All vehicles and trains operating on the CRN shall satisfactorily operate all NSW existing signalling systems or work under block working conditions. Refer to CRN Standard CRN SD 026, Signal Design Principles - Rolling Stock Interface Requirements.

To ensure the safe operation of all trains within the signalling limits, train braking performance shall not be less than the braking performances specified below.

19.2 When a signal compatibility test is required

The signal compatibility test shall be conducted on all vehicle types, excluding locomotive hauled vehicles, in order to gain approval to operate on the NSW rail network.

A signal compatibility test shall be conducted on any vehicle that has failed to operate track circuits.

19.3 Train detection

Tests shall be conducted to ensure that the vehicle/train is effectively detected by the signalling system. The types of signalling systems in use in NSW are described in CRN Standard CRN SD 026, Signal Design Principles - Rolling Stock Interface Requirements.

Track maintenance vehicles and road/rail vehicles which operate under special operating conditions do not need to shunt the signalling systems.

Refer CRN Standard CRN RS 001 for requirements relating to de-sanding equipment.

Light engines, when travelling as a single unit or as a double consist, and one or two car DMU trains must travel under block working conditions on lines that are nominated in the CRN Train Operation Conditions (TOC) manual as requiring such restrictions.

Refer to CRN Standard CRN SD 026, Signal Design Principles - Rolling Stock Interface Requirements for Signal Compatibility Tests.

19.4 Signal interference

Tests shall be conducted on vehicles/trains to measure for possible vehicle generated electrical and/or magnetic disturbance effects in signalling track circuits, track side processor based signalling systems/equipment, telecommunication cables and line side telecommunications systems

Refer to CRN Standard CRN SD 026, Signal Design Principles - Rolling Stock Interface Requirements, for Signal and Communication System Interference Tests.

19.5 Train braking requirements

The spacing of signals on the CRN is determined by the braking characteristics of an average train for the terrain and track speeds relevant to the signal location.

Refer to CRN Standard CRN SD 003, Signal Design Principles – Braking Distance.

The braking performance of all new multiple unit trains shall comply with the minimum requirements in CRN Standard CRN RS 004.

All vehicles must be maintained in a condition such that their braking performance, as tested and initially accepted, is maintained for the life of the vehicle.

Trains with stopping distances exceeding these limits must be driven at reduced speeds to provide the ability to stop within the signalling distances.

At some locations 'advisory speed signs' have been displayed for XPT/Xplorer/Endeavour trains, express trains and freight trains exceeding 1150 metres in length. This is to ensure that these trains have sufficient distance to enable them to stop within the required signal spacing.

19.6 Train stops

Signal train stops are not used on the CRN, however self-powered vehicles such as Xplorer and XPT passenger trains do carry trip valve equipment and travel into electrified areas where train stops are installed, therefore they must be catered for in vehicle design.

20 Signal and communication requirements

20.1 Introduction

Vehicles having electric traction or electrical equipment operating, have the potential to cause interference with the operation of trackside signalling and communication equipment.

Interference can be in the form of radio frequencies and/or magnetic fields which if strong enough can cause false or phantom indications in signalling and radio equipment. Electro-magnetic influences also have the potential to affect life support systems such as pacemakers.

The CRN Manager reserves the right to request a signal and communication system interference test be conducted on any vehicle that is suspected of interfering with signalling or communications equipment.

20.2 Interference tests

Interference tests shall be conducted in accordance with the requirements specified in CRN Standard CRN SD 026, Signal Design Principles - Rolling Stock Interface Requirements.

21 Brake performance requirements

21.1 Introduction

Brake performance is a measure of a vehicle or train's capability to stop safely to meet either a defined stopping distance or deceleration requirements.

Self-propelled vehicles, such as locomotives, and multiple unit trains are usually tested to determine their safe braking distance under normal full service, as well as, emergency brake applications. It is possible to also measure the deceleration of the vehicles during stopping distance tests, using an accelerometer.

Brake performance testing can also be carried out on locomotive hauled trains of varying lengths, to determine the effects of train length on stopping distances. Refer to Appendix 3 for typical stopping distance curves for various train types.

For specific brake performance requirements for the different vehicle types refer to the following relevant standard for those vehicles:

- Locomotives — CRN RS 001
- Freight vehicles — CRN RS 002

- Locomotive hauled passenger vehicles CRN RS 003
- Multiple unit trains CRN RS 004
- Rail bound infrastructure maintenance vehicles CRN RS 005
- Road/rail infrastructure maintenance vehicles CRN RS 006

21.2 When a brake performance test is required

Brake performance tests shall be conducted on all self-propelled vehicles and multiple unit trains in order to gain approval to operate on the CRN.

Hauled vehicles, such as freight vehicles, are difficult to test in terms of stopping distance unless they are assembled into a unit train consist and tested as a complete train. As single vehicle it is necessary to obtain a representative measurement of brake performance using brake percentage or net brake ratio. Refer to the CRN Standard CRN RS 010, Section 7.2 for the net brake percentage test. The individual vehicle standards specify their net brake percentage limits.

A brake performance test shall also be conducted on such vehicles following any modifications to the braking system, including any change in brake block material, before entering service on the CRN.

The CRN Manager reserves the right to request and have brake performance tests carried out by the owner/operator where, in the CRN Manager's opinion, there is doubt as to the braking capability a train or individual vehicle.

22 Ride Performance Requirements

22.1 Introduction

A ride performance test is designed to ensure vehicle compatibility with the track and to establish the optimum vehicle operating conditions to provide minimum damage to the track and meet acceptable train pathing requirements.

The following vehicle ride performance parameters are the minimum requirement for all rolling stock operating on the CRN.

22.2 When a ride performance test is required

A ride performance test shall be conducted on all vehicle types in order to gain approval to operate on the CRN.

The CRN Manager reserves the right to request and have a ride performance test carried out by the owner/operator on any vehicle for the following reasons:

- Modification to the suspension characteristics
- Change in the bogie rotational resistance
- Change in the wheel profile
- Change in bogie type
- Change in vehicle operating conditions
- Any vehicle modification which may affect the vehicle ride performance
- A significant change in the vehicle tare mass
- Where, in the CRN Manager's opinion, there is suspected poor ride performance

Vehicles equipped with standard three piece bogies having the standard 10-14 mm gapped side bearers, with the exception of torsionally stiff vehicles, such as tank vehicles and high centre of gravity vehicles, may be exempt from a ride performance test for operational speeds up to 80

km/h, subject to written approval from the CRN Manager. Torsionally stiff and high centre of gravity vehicles may still require a ride test to confirm their acceptance.

22.3 Base ride performance requirements

The base ride performance requirement for all rolling stock operating on the CRN is based on the accepted performance for freight vehicles.

Ride performance shall be measured using vertical and lateral accelerometers positioned on the vehicle body/underframe, as near as possible to the trailing bogie centre.

All measured accelerations shall be filtered at 10 Hz low pass.

Average acceleration shall be taken as the mean peak acceleration measured about the zero axis. The mean peak acceleration shall be calculated from the 10 Hz low pass filtered acceleration.

Sustained hunting is not permitted. Hunting is defined as sinusoidal lateral oscillations of the wheelset, resulting in greater than 0.5 Hz lateral vehicle body accelerations measured at the bogie centre of greater than 0.35g sustained for 10 seconds or longer.

The base ride performance requirements for all vehicle types operating on the CRN shall be as follows:

Parameter	Limit	Test Speed
Maximum lateral acceleration	+/- 0.5g	110% design
Average lateral acceleration	+/- 0.35g	110% design
Maximum vertical acceleration	+/- 0.8g	110% design
Average vertical acceleration	+/- 0.5g	110% design

Table 6 - Base ride performance test requirements

For vehicles, such as locomotives, equipped with vibration isolated cabs, the base ride performance specified shall be measured using accelerometers positioned outside the cab, but as near as possible to the trailing bogie centre.

22.4 Recommended ride performance requirements

In the interests of crew/passenger comfort and safety, the ride quality specified below is recommended.

Vehicle Type	Speed (km/h)	Vertical Ride Index	Lateral Ride Index
Locomotives	Maximum design speed	3.2	3.0
Track Maintenance Vehicle	Maximum design speed	3.2	3.0
Passenger Vehicles	Maximum design speed	2.5	2.5

Table 7 – Recommended Ride quality

These recommended ride performance requirements are in addition to the base ride performance requirements specified above.

The ride index values are recommended for wheels up to the fully worn condition.

For vehicles, such as locomotives and track maintenance vehicles, with vibration isolated cabs, it is recommended that the comfort ride index be measured using accelerometers positioned inside the cab, as close as possible to the bogie centre.

In this case, sustained bogie hunting is not permitted. Bogie hunting shall be defined as sinusoidal lateral oscillations of the wheelset resulting in greater than 0.5 Hz sinusoidal lateral body accelerations measured at the bogie centre of greater than 0.15 g sustained for 10 seconds or longer.

For bogies equipped with air springs, the above ride performance also applies for vehicles with deflated air springs. A reduction in design speed may be required to achieve this.

22.5 Ride index algorithm

Ride index shall be calculated in accordance with the algorithm specified below:

The ride index algorithm is implemented as follows: Acceleration data is weighted by the function:

$$R_i = 7.07\ (Vi)0.1$$

where the i-th value refers to the peak amplitude of a frequency component derived from a Fast Fourier Transform FFT analyser.

The function Vi is defined as follows:

Frequency Range (Hz)	Vi (Vertical)	Vi (Lateral)
0 – 6 6 – 20 20+	0.32 fa3 400 a3/f3 a3/f	4.32 a3 650 a3/ f3 a3/f

Table 8 – Ride index factors

where f = frequency, (Hz), a = amplitude, g peak (1 g = 9.81 m/s2)

The total ride index is calculated from the i values by:

$$RI_{total} = [\square \quad (RI_i)10]0.1$$

Notes:

Frequency analysis will utilise FFT analysis of at least 400 lines with 0.25 Hz resolution. Data shall be averaged over 32 averages to minimise statistical error. 16 averages are acceptable for comparative evaluations only.

Analysis shall be restricted to the 0.5 to 50 Hz band.

Weighting filters implementing the above weightings are acceptable provided:

- integration is performed over 10-15 second periods.
- the integrated values are recorded over at least 3 km of track and reported as a mean and sample variance.

Data for analysis shall come from samples at substantially constant speed (variance ± 5 km/h).

23 Vehicle pitch and bounce requirements

23.1 Introduction

Vehicle and even bogie pitch and bounce can occur when vertical track irregularities or perturbations exist in a regular repeating pattern which will excite a vehicle suspension when it is travelling at the critical speed for that excitation. The cyclic disturbance may cause resonant behaviour in the vehicle suspension which can result in high vertical displacement amplitudes. Such behaviour can result in derailment.

Testing vehicles over typical track at various incrementally increasing speeds can determine that particular vehicle critical speeds for pitch and bounce. Such tests also determine if the vehicle

suspension is adequately damped to control vehicle oscillations created during pitch and bounce events.

The pitch and bounce test is usually conducted using vertical accelerometers positioned on the vehicle body over each bogie centre. There are additional means of assessing the actual effects of pitch and bounce by measuring wheel loads with an instrumented (strain gauged) wheel.

23.2 When a pitch and bounce test is required

The CRN Manager reserves the right to request and have a pitch and bounce test carried out by the owner/operator on any vehicle for the following reasons:

- A new vehicle type
- A modification to the vehicle suspension characteristics
- A change in bogie type
- A change in vehicle operating conditions
- Any vehicle modification which may affect the vehicle vertical ride performance
- Where, in the CRN Manager's opinion, there is suspected poor vertical or resonant ride performance.

23.3 Pitch and bounce test limits

The pitch and bounce test performance requirements for all vehicle types operating on the CRN shall be as follows:

Parameter	Limit	Test speed
Maximum vertical acceleration	+/-0.8g	Up to 110% of design
Average vertical acceleration	+/-0.5g	Up to 110% of design
Minimum vertical wheel load	10% of static	Up to 110% of design

Table 9 - Pitch and bounce acceleration limits

Where an instrumented wheelset is not available to measure vertical wheel forces, the vertical acceleration in the table 6 shall be taken as the test limit.

23.4 Simulation of pitch and bounce test

As an alternative to conducting the pitch and bounce test, a computer-simulated test may be acceptable provided the simulation is validated by comparing the computer model of a representative vehicle ride results with that of an on-track ride test using the actual modelled vehicle.

24 Traction performance requirements

24.1 Introduction

Proven traction performance of locomotives is an important aspect of operating a reliable rail operation. Train pathing and timetabling is dependent on locomotive reliability, particularly when the locomotive is hauling the ruling load for the maximum gradients. If the locomotive is overloaded for the grade or has insufficient adhesion to apply the necessary tractive effort then the locomotive will lose speed or fail completely, thus blocking the track.

A locomotive that cannot provide sufficient tractive effort for the grade is at risk of producing uncontrolled wheel spin with consequential rail damage being the result.

In order to set maximum locomotive loads to take advantage of the locomotive's available adhesion it is necessary to conduct load tests on a ruling grade. Such test shall be conducted

under simulated wet weather conditions and be monitored by a representative of the Network Manager.

24.2 Traction performance acceptance criteria

- The test train shall not exceed the scheduled running time for the section under test, as published in the Train Operating Conditions (TOC) Manual.
- The minimum speed of the test train shall not be less than 10 km/h at any time during the test.
- There shall not be any uncontrolled wheel slip during the test. Uncontrolled wheel slip is any wheel slip as indicated in the locomotive cab, not including wheel creep.
- Traction motor currents shall not exceed their short time ratings during the test.
- The locomotive/s shall demonstrate that it/they can haul the specified trailing load in accordance with this acceptance criteria and test conditions on at least one occasion. If any doubt exists as to the locomotives' performance, the test conditions or acceptance criteria being met, then the locomotive will not be accepted until there is no doubt as to its compliance with this test criteria under the specified conditions.
- Traction performance test data recorded during tests on another network may be accepted for traction evaluation purposes.

25 Vehicle structural requirements

25.1 Introduction

Vehicle structural tests are carried out on vehicles to investigate and confirm that they have the structural capacity to perform their intended use in rail operations and can be recovered in the event of a derailment without incurring addition damage as a consequence of lifting or jacking for the purpose of re-railing.

Structural integrity tests are optional for an owner/operator, however the CRN Manager reserves the right to request and have a vehicle tested by the owner/operator, where, in the CRN Manager's opinion, there is doubt or adverse evidence questioning the structural integrity of the vehicle.

25.2 Jacking point vertical load test

Jacking the vehicle is a common means of lifting the vehicle in the field, particularly in the event of a minor derailment where there is minimal damage to running gear. Incident management teams are equipped with jacking equipment to meet this need. Fully loaded vehicles must therefore be capable of being lifted at the headstock or beneath the coupler without incurring structural damage.

A vertically upward force to prove the structural integrity of the vehicle frame shall be applied to the coupler head immediately adjacent to the striker face of the draft gear body, or jacking point, at one end of the vehicle, sufficient in magnitude to lift the fully loaded vehicle free of the bogie nearest the applied load, and held for sixty seconds.

A load of +/- 225 kN shall be applied in the vertical plane at the coupler head as near as possible to the pulling face and held for 60 seconds in both directions.

Platforms of articulated vehicles, that are not the end units of an articulated vehicle, do not need to be tested, as they do not have any bogie overhang.

25.3 Static end compression test

The single vehicle impact may be performed as an alternative to this test.

A longitudinal compressive end load of 4500 kN shall be applied to the couplers and held for sixty seconds minimum. The load shall be applied over an area equal to the contact area between the draft lugs and draft gear. The vehicle as tested shall simulate an axially loaded beam having ball

end restraints ie the loading fixture shall be constrained from lateral and vertical motion. See Figure 18.

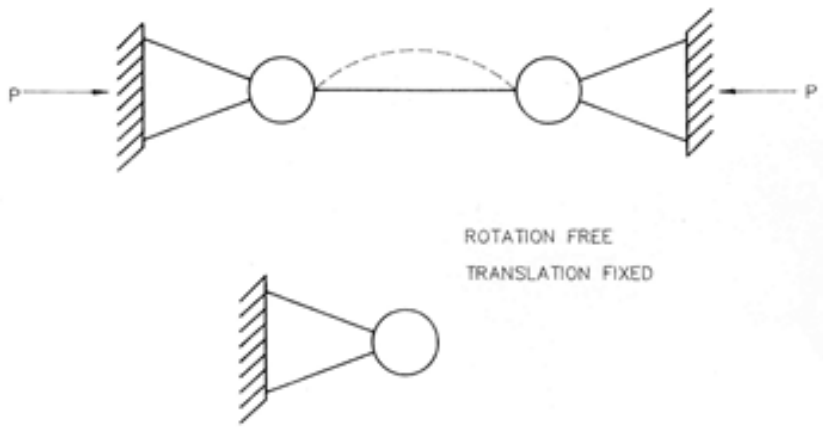


Figure 18 - Loading fixtures for static end compression

The vehicle shall be tested under the adverse stress conditions (empty and/or loaded) and shall withstand the applied loads without permanent deformation of any component.

25.4 Single vehicle impact test

Where a single car impact test is required, the test vehicle shall be loaded to its maximum gross mass on rail and impacted by a rake of vehicles, consisting of three 50 tonne nominal capacity open or hopper cars. These cars shall be loaded to their allowable maximum gross mass on rail with sand or other granular material, and should be equipped with AAR M 901E rubber-friction draft gear or equivalent at the striking end. A metal plate may be placed on top of the granular material to stop load shift.

The test vehicle shall be stationary at the start of each test with the handbrake and air-brake released. It shall be located between, but not in contact with, the striking consist described above and a similar consist used as a buffer. The hand-brake on the buffer vehicle furthest from the vehicle under test shall be firmly applied. No restraint other than the handbrake on the last vehicle shall be used. The track shall, therefore, be level.

A series of impacts shall be made on tangent track by the striking consist starting at 10 km/h. The speed should be increased in small increments of approximately 3 km/h. For freight vehicles the impacts shall continue until either a coupler force of 5500 kN or a speed of 22 km/h has been reached, whichever occurs first. For other vehicles, the vehicle owner or operator shall specify the maximum coupler force and maximum impact speed.

A vehicle consisting of two or more permanently coupled units shall also undergo impact testing as outlined above with the struck unit of the test vehicle being empty for a two-unit vehicle, or with the first two units being empty for a three (or more) unit vehicle.

26 P2 force wheel impact requirements

P2 force is a measure of the vertical impact force imparted by the rail wheel on a dipped joint or vertical track defect. Such a force is created by the unsprung mass of the wheel, axle and other attachments such as an axlebox, brake disc, traction gear case and a portion of the traction motor in the case of an axle hung motor.

Below is a calculation method for estimating the P2 force.

The results of a P2 force calculation shall be submitted, using the algorithm shown below and including the relevant track constants shown in the table below, and at the maximum proposed design speed for the vehicle.

Track Class	Max P2 force Locomotives (kN)	Max P2 force other rolling stock (kN)	Equivalent Track Stiffness Kt (MN/m)	Equivalent Track Damping Ct (kNs/m)	Equivalent Track Mass Mt (kg)
1XC	295	230	117	56	338
1X	295	230	117	56	151
1C	295	230	110	52.5	310
1	295	230	110	52.5	135
2	230	230	100	48	117
3	200	200	95.8	45.9	106
4	180	180	90.3	43.2	95
5	130	130	83.6	40	85

Table 10 – Permitted Maximum P2 Force for Tack Classes

$$P2 = P_0 + 2\alpha.V \times \left[\frac{M_u}{M_u + M_t}\right]^{0.5} \times \left[1 - \frac{C_t\,\pi}{4\,[K_t\,(M_u + M_t)]^{0.5}}\right] \times [Kt\,M_u]^{0.5}$$

Where,

P2 = Vertical Impact Force (kN)

P_0 = Vehicle static wheel load (kN)

M_u = Vehicle unsprung mass per wheel (kg)

2α= Total joint angle, 0.014 radians

V = Vehicle velocity (m/s)

K_t = Equivalent track stiffness (MN/m)

C_t = Equivalent track damping (kNs/m)

M_t = Equivalent track mass (kg)

27 Vehicle curve stability requirements

27.1 Introduction

Curve stability is an inherent problem when rail vehicles negotiate a curve under traction or buffing in-train forces. Extreme coupler angles can result from the combination of long and short vehicles coupled together. Such angles create both longitudinal and lateral coupler forces acting on the vehicles through their coupler pivot points. Therefore in-train tensile or draw forces tend to pull the vehicles towards the inside of the curve (low rail), tending to try and string line the train to form a chord across the curve. Compressive of buff forces tend to push the vehicles towards the outside of the curve (high rail) introducing higher wheel flange climbing forces over and above the normal leading wheel flanging forces.

If the dynamic in-train forces are high enough a light axle load vehicle can be literally lifted or pinched to the point where it jumps over the high rail.

Curve stability problems are more prone to happen with long/short vehicle combinations and/or where empty/tare vehicles are marshalled towards the front of a freight train. Operators should

have specific marshalling rules which prevent excessive train load from being marshalled behind such vehicle combinations and lightly loaded vehicles.

27.2 Curve stability tests

These tests are optional for an owner/operator, however the CRN Manager reserves the right to request and have a vehicle tested by the owner/operator, where, in the CRN Manager's opinion, there is doubt or adverse evidence questioning the vehicle proportions and geometry.

Refer to CRN Standard CRN RS 010 Section 24 for curve stability test requirements.

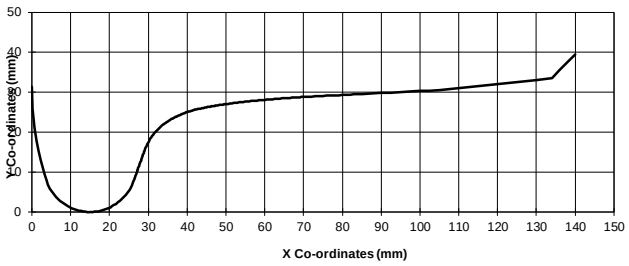
Appendix 1 CRN Rolling Stock Glossary

Agreed	Agreed between the Owner/Operator and the CRN Manager.
Approved	Approved by the CRN Manager.
Authorised person	Person authorised to travel in the cab of an infrastructure maintenance vehicle/train and stop the vehicle/train in the event of an emergency.
Cant deficiency	The difference in superelevation between: that required to balance the actual vehicle centrifugal force due to curve negotiation such that there is equal wheel loading on the high and low rail, (equilibrium or balancing speed), and the actual superelevation existing in the curve. Cant deficiency is a function of superelevation, curve radius and vehicle speed.
Continuous tractive effort	The tangential force that can be applied at the wheel/rail interface by a self powered vehicle for an indefinite period without causing wheel spin or overheating of the traction equipment.
Curved wheel web	Wheel web or plate which is domed such that its cross section is curved.
Design speed	The maximum speed at which a vehicle is expected to operate on the CRN.
Flat top trolley or trailer	A small non-powered infrastructure maintenance vehicle which is used for conveying tools and equipment along the track and which can be easily removed from the track.
Freight Train	A train predominantly consisting of freight vehicles.
Full supplies, Fully provisioned	Locomotive with all equipment and full of fuel, oil, water, coolant and sand.
Handbrake	A mechanical device provided on a train/vehicle in order to secure the train or an individual vehicle so as to prevent it from moving. Note: Where the term “handbrake” is used, it will also mean “parking brake”.
Heritage vehicle	Locomotive, passenger vehicle, freight vehicle or trolley that has historical significance and/or is not used in regular revenue service but used in special interest operations, such as steam tours.
Infrastructure maintenance vehicle	A rail bound self propelled vehicle which is used to carry out inspection and/or maintenance on railway infrastructure. Some of these vehicles may be removed from the railway track by the use of special take-offs or portable turnouts.
Light locomotive	One or more locomotives coupled together without hauled vehicles attached.
Locomotive	A self propelled vehicle, powered by any form of energy, which does not convey passengers or freight but which is used to move one or more other vehicles thus forming a train.
Multiple unit train	A distributed power train made up of similar electric or diesel powered vehicles and non-powered vehicles operating as a unit.
Net brake ratio	The ratio of the sum of the actual measured brake block forces divided by the total vehicle weight.
On-track infrastructure maintenance vehicle	Any infrastructure maintenance vehicle which operates exclusively on railway track.

Overhead wiring vehicle	An infrastructure maintenance vehicle with an elevating platform or equipped for maintenance of the overhead traction wiring system.
Power car	A self propelled vehicle, which may or may not convey passengers and/or freight, and operates in conjunction with similar vehicles in a multiple unit consist.
Quadricycle	A small self propelled rail-bound track vehicle which can be easily removed from the track.
Qualified worker	A worker certified as competent to carry out the relevant task.
Rail-bound infrastructure maintenance vehicle	An on-track infrastructure maintenance vehicle that cannot be removed from track without the use of a heavy crane. These vehicles are transferred around the network by rail.
Road/rail vehicle	Any type of track vehicle which can travel on either road or rail and can readily transfer from one mode of operation to the other.
Rolling Stock Exemption Certificate	A Certificate issued to a vehicle owner/operator covering vehicle non-conformances which are technically acceptable. These certificates remain in place for the life of the vehicle.
Rolling Stock Standards Waiver	A Waiver issued for a vehicle covering non-conformances that are deemed acceptable for a limited time period, until corrected.
Starting tractive effort	The tangential force applied at the wheel/rail interface that can be applied by self powered vehicle, to move itself and its trailing load from a stationary state without causing excessive wheel slip.
Straight wheel web	Wheel web consisting of a flat plate with no curvature such that its cross section is straight. Used primarily with wheel cheek mounted disc brakes
S-plate wheel	Wheel with a web such that its cross section forms an S shape, designed to provide low wheel rim stresses
Substantially modified vehicle	Vehicle modified to accommodate its use for a different purpose. Vehicle undergoing major refurbishment with updated equipment which can alter the braking, traction or suspension system performance. Vehicle being moved with equipment removed resulting in a reduction of vehicle mass that could alter the vehicle performance. Vehicle modified such that it may be incompatible with the infrastructure.
TOC Waiver	An authority issued for the movement of a vehicle for which there are no published operating conditions, or for which the operating conditions are different from those published in the CRN Train operating Conditions Manual.
Track maintenance vehicle	Infrastructure maintenance vehicle used for the maintenance, construction or inspection of track.
Train	One or more rail vehicles operating singularly or coupled together, hauled or self powered and capable of operating track signal circuits

Appendix 2 Wheel Profiles

WPR 2000 full flange wheel profile for a 140 mm wide wheel

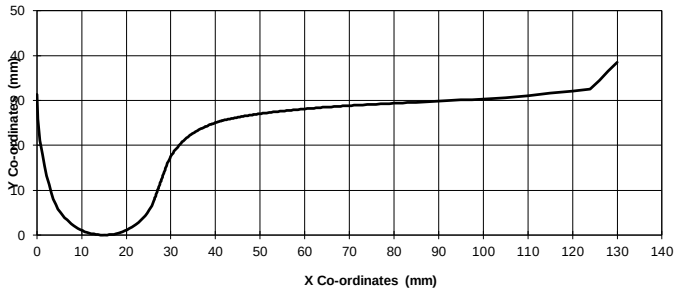


X	Y	X	Y	X	Y	X	Y	X	Y	X	Y
0	31.365	19.7	0.959	28.9	15.104	38.75	24.576	48.75	26.864	67	28.642
0.2	25.855	20.2	1.185	29	15.374	39	24.673	49	26.901	67.5	28.674
0.7	21.074	20.7	1.44	29.25	15.99	39.25	24.767	49.25	26.937	68	28.705
1.2	17.913	21.2	1.726	29.5	16.538	39.5	24.858	49.5	26.972	68.5	28.736
1.7	15.38	21.7	2.045	29.75	17.034	39.75	24.946	49.75	27.007	69	28.766
2.2	13.211	22.2	2.4	30	17.489	40	25.032	50	27.041	69.5	28.795
2.7	11.287	22.7	2.796	30.25	17.91	40.25	25.114	50.25	27.075	70	28.832
3.2	9.544	23.2	3.239	30.5	18.302	40.5	25.194	50.5	27.108	70.5	28.851
3.7	7.961	23.7	3.735	30.75	18.669	40.75	25.271	51	27.172	71	28.878
4.2	6.769	24.2	4.295	31	19.014	41	25.345	51.5	27.233	72	28.929
4.7	5.843	24.7	4.935	31.25	19.339	41.25	25.416	52	27.292	73	28.979
5.2	5.075	25.2	5.679	31.5	19.647	41.5	25.484	52.5	27.351	74	29.029
5.7	4.416	25.7	6.568	31.75	19.939	41.75	25.55	53	27.409	75	29.079
6.2	3.842	26.2	7.686	32	20.217	42	25.613	53.5	27.465	76	29.129
6.7	3.333	26.3	7.961	32.25	20.481	42.25	25.673	54	27.521	77	29.179
7.2	2.881	26.4	8.236	32.5	20.733	42.5	25.731	54.5	27.575	78	29.229
7.7	2.476	26.5	8.51	32.75	20.973	42.75	25.786	55	27.629	79	29.279
8.2	2.113	26.6	8.785	33	21.202	43	25.839	55.5	27.682	80	29.329
8.7	1.787	26.7	9.06	33.25	21.422	43.25	25.891	56	27.733	81	29.379
9.2	1.495	26.8	9.335	33.5	21.632	43.5	25.942	56.5	27.784	82	29.429
9.7	1.234	26.9	9.609	33.75	21.833	43.75	25.992	57	27.834	83	29.479
10.2	1.002	27	9.884	34	22.025	44	26.042	57.5	27.883	84	29.529
10.7	0.797	27.1	10.159	34.25	22.209	44.25	26.091	58	27.93	85	29.579
11.2	0.618	27.2	10.434	34.5	22.385	44.5	26.14	58.5	27.977	87.5	29.704
11.7	0.463	27.3	10.708	34.75	22.554	44.75	26.188	59	28.023	90	29.829
12.2	0.331	27.4	10.983	35	22.716	45	26.235	59.5	28.068	92.5	29.954
12.7	0.222	27.5	11.258	35.25	22.87	45.25	26.281	60	28.112	95	30.079
13.2	0.136	27.6	11.533	35.5	23.019	45.5	26.327	60.5	28.155	97.5	30.204
13.7	0.071	27.7	11.807	35.75	23.16	45.75	26.372	61	28.197	100	30.329
14.2	0.027	27.8	12.082	36	23.297	46	26.417	61.5	28.238	102.5	30.454
14.7	0.004	27.9	12.357	36.25	23.43	46.25	26.461	62	28.279	105	30.579
15.2	0.002	28	12.632	36.5	23.56	46.5	26.504	62.5	23.318	110	31.079
15.7	0.02	28.1	12.906	36.75	23.868	46.75	26.547	63	28.357	115	31.579
16.2	0.06	28.2	13.181	37	23.808	47	26.589	63.5	28.396	120	32.079
16.7	0.121	28.3	13.456	37.25	23.928	47.25	26.63	64	28.433	125	32.579
17.2	0.203	28.4	13.731	37.5	24.044	47.5	26.671	64.5	28.47	130	33.079
17.7	0.308	28.5	14.005	37.75	24.156	47.75	26.711	65	28.506	134	33.479
18.2	0.435	28.6	14.28	38	24.266	48	26.75	65.5	28.541	136	35.479
18.7	0.585	28.7	14.555	38.25	24.372	48.25	26.789	66	28.575	138	37.479
19.2	0.759	28.8	14.83	38.5	24.476	48.5	26.827	66.5	28.609	140	39.479

WPR 2000 7/8 flange wheel profile for a 140 mm wide wheel

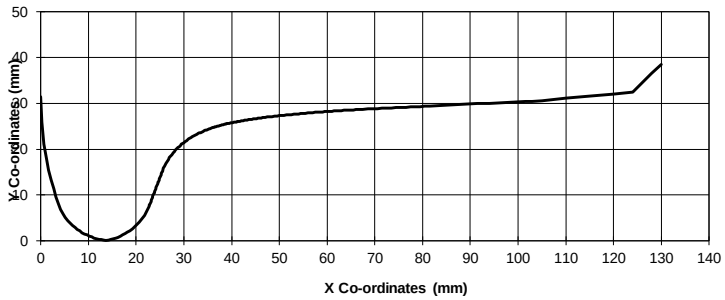
X	Y	X	Y	X	Y	X	Y	X	Y	X	Y
0	31.365	19.7	3.064	27	18.127	37	25.019	47	26.933	67	28.676
0.2	25.855	20.2	3.56	27.25	18.494	37.25	25.096	47.5	26.997	67.5	28.703
0.7	21.074	20.7	4.12	27.5	18.839	37.5	25.17	48	27.058	68.5	28.754
1.2	17.913	21.2	4.76	27.75	19.164	37.75	25.241	48.5	27.117	69.5	28.804
1.7	15.38	21.7	5.504	28	19.472	38	25.309	49	27.176	70.5	28.854
2.2	13.211	22.2	6.393	28.25	19.764	38.25	25.375	49.5	27.234	71.5	28.904
2.7	11.287	22.7	7.511	28.5	20.042	38.5	25.438	50	27.29	72.5	28.954
3.2	9.544	22.8	7.786	28.75	20.306	38.75	25.498	50.5	27.346	73.5	29.004
3.7	7.961	22.9	8.061	29	20.558	39	25.556	51	27.4	74.5	29.054
4.2	6.769	23	8.335	29.25	20.798	39.25	25.611	51.5	27.454	75.5	29.104
4.7	5.843	23.1	8.61	29.5	21.027	39.5	25.664	52	27.507	76.5	29.154
5.2	5.075	23.2	8.885	29.75	21.247	39.75	25.716	52.5	27.558	77.5	29.204
5.7	4.416	23.3	9.16	30	21.457	40	25.767	53	27.609	78.5	29.254
6.2	3.842	23.4	9.434	30.25	21.658	40.25	25.817	53.5	27.659	79.5	29.304
6.7	3.333	23.5	9.709	30.5	21.85	40.5	25.867	54	27.708	80.5	29.354
7.2	2.881	23.6	9.984	30.75	22.034	40.75	25.916	54.5	27.755	81.5	29.404
7.7	2.476	23.7	10.259	31	22.21	41	25.965	55	27.802	84	29.529
8.2	2.113	23.8	10.533	31.25	22.379	41.25	26.013	55.5	27.848	86.5	29.654
8.7	1.787	23.9	10.808	31.5	22.541	41.5	26.06	56	27.893	89	29.779
9.2	1.495	24	11.083	31.75	22.695	41.75	26.106	56.5	27.937	91.5	29.904
9.7	1.234	24.1	11.358	32	22.844	42	26.152	57	27.98	94	30.029
10.2	1.002	24.2	11.632	32.25	22.985	42.25	26.197	57.5	28.022	96.5	30.154
10.7	0.797	24.3	11.907	32.5	23.122	42.5	26.242	58	28.063	99	30.279
11.2	0.618	24.4	12.182	32.75	23.255	42.75	26.286	58.5	28.104	101.5	30.404
11.7	0.463	24.5	12.457	33	23.385	43	26.329	59	28.143	103	30.479
12.2	0.331	24.6	12.731	33.25	23.511	43.25	26.372	59.5	28.182	105	30.579
12.7	0.222	24.7	13.006	33.5	23.633	43.5	26.414	60	28.221	110	31.079
13.2	0.136	24.8	13.281	33.75	23.753	43.75	26.455	60.5	28.258	115	31.579
13.7	0.071	24.9	13.556	34	23.869	44	26.496	61	28.295	120	32.079
14.2	0.133	25	13.83	34.25	23.981	44.25	26.536	61.5	28.331	125	32.579
14.7	0.26	25.1	14.105	34.5	24.091	44.5	26.575	62	28.366	130	33.079
15.2	0.41	25.2	14.38	34.75	24.197	44.75	26.614	62.5	28.4	134	33.479
15.7	0.584	25.3	14.655	35	24.301	45	26.652	63	28.434	136	35.479
16.2	0.784	25.4	14.929	35.25	24.401	45.25	26.689	63.5	28.467	138	37.479
16.7	1.01	25.5	15.199	35.5	24.498	45.5	26.726	64	28.499	140	39.479
17.2	1.265	25.75	15.815	35.75	24.592	45.75	26.762	64.5	28.53		
17.7	1.551	26	16.363	36	24.683	46	26.797	65	28.561		
18.2	1.87	26.25	16.859	36.25	24.771	46.25	26.832	65.5	28.591		
18.7	2.225	26.5	17.314	36.5	24.857	46.5	26.866	66	28.62		
19.2	2.621	26.75	17.735	36.75	24.939	46.75	26.9	66.5	28.648		

WPR 2000 full flange wheel profile for a 130 mm wide wheel



X	Y	X	Y	X	Y	X	Y	X	Y	X	Y
0	31.365	19.7	0.959	28.9	15.104	38.75	24.576	48.75	26.864	67	28.642
0.2	25.855	20.2	1.185	29	15.374	39	24.673	49	26.901	67.5	28.674
0.7	21.074	20.7	1.44	29.25	15.99	39.25	24.767	49.25	26.937	68	28.705
1.2	17.913	21.2	1.726	29.5	16.538	39.5	24.858	49.5	26.972	68.5	28.736
1.7	15.38	21.7	2.045	29.75	17.034	39.75	24.946	49.75	27.007	69	28.766
2.2	13.211	22.2	2.4	30	17.489	40	25.032	50	27.041	69.5	28.795
2.7	11.287	22.7	2.796	30.25	17.91	40.25	25.114	50.25	27.075	70	28.823
3.2	9.544	23.2	3.239	30.5	18.302	40.5	25.194	50.5	27.108	70.5	28.851
3.7	7.961	23.7	3.735	30.75	18.669	40.75	25.271	51	27.172	71	28.878
4.2	6.769	24.2	4.295	31	19.014	41	25.345	51.5	27.233	72	28.929
4.7	5.843	24.7	4.935	31.25	19.339	41.25	25.416	52	27.292	73	28.979
5.2	5.075	25.2	5.679	31.5	19.647	41.5	25.484	52.5	27.351	74	29.029
5.7	4.416	25.7	6.568	31.75	19.939	41.75	25.55	53	27.409	75	29.079
6.2	3.842	26.2	7.686	32	20.217	42	25.613	53.5	27.465	76	29.129
6.7	3.333	26.3	7.961	32.25	20.481	42.25	25.673	54	27.521	77	29.179
7.2	2.881	26.4	8.236	32.5	20.733	42.5	25.731	54.5	27.575	78	29.229
7.7	2.476	26.5	8.51	32.75	20.973	42.75	25.786	55	27.629	79	29.279
8.2	2.113	26.6	8.785	33	21.202	43	25.839	55.5	27.682	80	29.329
8.7	1.787	26.7	9.06	33.25	21.422	43.25	25.891	56	27.733	81	29.379
9.2	1.495	26.8	9.335	33.5	21.632	43.5	25.942	56.5	27.784	82	29.429
9.7	1.234	26.9	9.609	33.75	21.833	43.75	25.992	57	27.834	83	29.479
10.2	1.002	27	9.884	34	22.025	44	26.042	57.5	27.883	84	29.529
10.7	0.797	27.1	10.159	34.25	22.209	44.25	26.091	58	27.93	85	29.579
11.2	0.618	27.2	10.434	34.5	22.385	44.5	26.14	58.5	27.977	87.5	29.704
11.7	0.463	27.3	10.708	34.75	22.554	44.75	26.188	59	28.023	90	29.829
12.2	0.331	27.04	10.983	35	22.716	45	26.235	59.5	28.068	92.5	29.954
12.7	0.222	27.5	11.258	35.25	22.87	45.25	26.281	60	28.112	95	30.079
13.2	0.136	27.6	11.533	35.5	23.019	45.5	26.327	60.5	28.155	97.5	30.204
13.7	0.071	27.7	11.807	35.75	23.16	45.75	26.372	61	28.197	100	30.329
14.2	0.027	27.8	12.082	36	23.297	46	26.417	61.5	28.238	102.5	30.454
14.7	0.004	27.9	12.357	36.25	23.43	46.25	26.461	62	28.279	105	30.579
15.2	0.002	28	12.632	36.5	23.56	46.5	26.504	62.5	28.318	110	31.079
15.7	0.02	28.1	12.906	36.75	23.686	46.75	26.547	63	28.357	115	31.579
16.2	0.06	28.2	13.181	37	23.808	47	26.589	63.5	28.396	120	32.079
16.7	0.121	28.3	13.456	37.25	23.928	47.25	26.63	64	28.433	124	32.479
17.2	0.203	28.4	13.731	37.5	24.044	47.5	26.671	64.5	28.47	126	34.479
17.7	0.308	28.5	14.005	37.75	24.156	47.75	26.711	65	28.506	128	36.479
18.2	0.435	28.6	14.28	38	24.266	48	26.75	65.5	28.541	130	39.479
18.7	0.585	28.7	14.555	38.25	24.372	48.25	26.789	66	28.575		
19.2	0.759	28.8	14.83	38.5	24.476	48.5	26.827	66.5	28.609		

WPR 2000 7/8 flange wheel profile for a 130 mm wide wheel

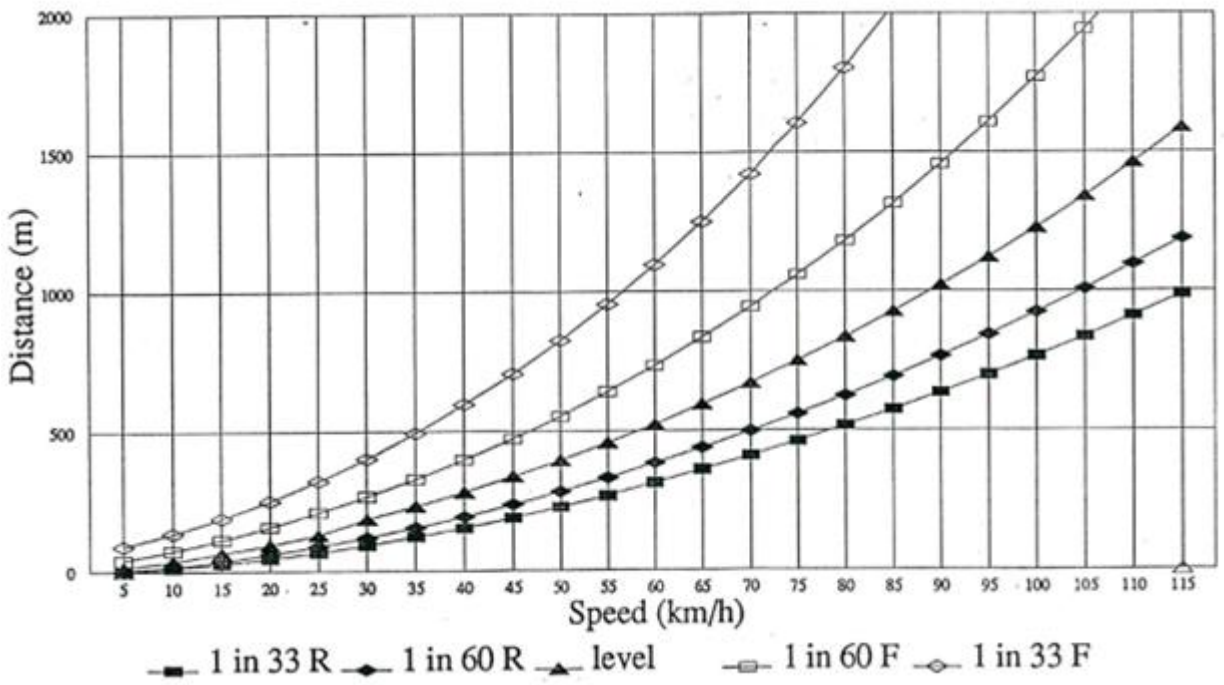


X	Y	X	Y	X	Y	X	Y	X	Y	X	Y
0	31.365	19.7	3.064	27	18.127	37	25.019	47	26.933	67	28.676
0.2	25.855	20.2	3.56	27.25	18.494	37.25	25.096	47.5	26.997	67.5	28.703
0.7	21.074	20.7	4.12	27.5	18.839	37.5	25.17	48	27.058	68.5	28.754
1.2	17.913	21.2	4.76	27.75	19.164	37.75	25.241	48.5	27.117	69.5	28.804
1.7	15.38	21.7	5.504	28	19.472	38	25.309	49	27.176	70.5	28.854
2.2	13.211	22.2	6.393	28.25	19.764	38.25	25.375	49.5	27.234	71.5	28.904
2.7	11.287	22.7	7.511	28.5	20.042	38.5	25.438	50	27.29	72.5	28.954
3.2	9.544	22.8	7.786	28.75	20.306	38.75	25.498	50.5	27.346	73.5	29.004
3.7	7.961	22.9	8.061	29	20.558	39	25.556	51	27.4	74.5	29.054
4.2	6.769	23	8.335	29.25	20.798	39.25	25.611	51.5	27.454	75.5	29.104
4.7	5.843	23.1	8.61	29.5	21.027	39.5	25.664	52	27.507	76.5	29.154
5.2	5.075	23.2	8.885	29.75	21.247	39.75	25.716	52.5	27.558	77.5	29.204
5.7	4.416	23.3	9.16	30	21.457	40	25.767	53	27.609	78.5	29.254
6.2	3.842	23.4	9.434	30.25	21.658	40.25	25.817	53.5	27.659	79.5	29.304
6.7	3.333	23.5	9.709	30.5	21.85	40.5	25.867	54	27.708	80.5	29.354
7.2	2.881	23.6	9.984	30.75	22.034	40.75	25.916	54.5	27.755	81.5	29.404
7.7	2.476	23.7	10.259	31	22.21	41	25.965	55	27.802	84	29.529
8.2	2.113	23.8	10.533	31.25	22.379	41.25	26.013	55.5	27.848	86.5	29.654
8.7	1.787	23.9	10.808	31.5	22.541	41.5	26.06	56	27.893	89	29.779
9.2	1.495	24	11.083	31.75	22.695	41.75	26.106	56.5	27.937	91.5	29.904
9.7	1.234	24.1	11.358	32	22.844	42	26.152	57	27.98	94	30.029
10.2	1.002	24.2	11.632	32.25	22.985	42.25	26.197	57.5	28.022	96.5	30.154
10.7	0.797	24.3	11.907	32.5	23.122	42.5	26.242	58	28.063	99	30.279
11.2	0.618	24.4	12.182	32.75	23.255	42.75	26.286	58.5	28.104	101.5	30.404
11.7	0.463	24.5	12.457	33	23.385	43	26.329	59	28.143	103	30.479
12.2	0.331	24.6	12.731	33.25	23.511	43.25	26.372	59.5	28.182	105	30.579
12.7	0.222	24.7	13.006	33.5	23.633	43.5	26.414	60	28.221	110	31.079
13.2	0.136	24.8	13.281	33.75	23.753	43.75	26.455	60.5	28.258	115	31.579
13.7	0.071	24.9	13.556	34	23.869	44	26.496	61	28.295	120	32.079
14.2	0.133	25	13.83	34.25	23.981	44.25	26.536	61.5	28.331	124	32.479
14.7	0.26	25.1	14.105	34.5	24.091	44.5	26.575	62	28.366	126	34.479
15.2	0.41	25.2	14.38	34.75	24.197	44.75	26.614	62.5	28.4	128	36.479
15.7	0.584	25.3	14.655	35	24.301	45	26.652	63	28.434	130	38.479
16.2	0.784	25.4	14.929	35.25	24.401	45.25	26.689	63.5	28.467		
16.7	1.01	25.5	15.199	35.5	24.498	45.5	26.726	64	28.499		
17.2	1.265	25.75	15.815	35.75	24.592	45.75	26.762	64.5	28.53		
17.7	1.551	26	16.363	36	24.683	46	26.797	65	28.561		
18.2	1.87	26.25	16.859	36.25	24.771	46.25	26.832	65.5	28.591		
18.7	2.225	26.5	17.314	36.5	24.857	46.5	26.866	66	28.62		
19.2	2.621	26.75	17.735	36.75	24.939	46.75	26.9	66.5	28.648		

Appendix 3 Train Stopping Distance Curves

GW 16 Brake Stopping Distance Curves

for a 680 metre 1500 tonne Intermodal Train



GW30 Brake Stopping Distance Curves

For a 1280 metre 2760 tonne Intermodal Train