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Australian STANDARD®

Rolling Stock Outlines

RISSB
RAIL INDUSTRY SAFETY AND STANDARDS BOARD

Rolling Stock Standard

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Development of the standard was undertaken in accordance with RISSB's accredited process, which includes an independent validation.

RISSB wishes to acknowledge the positive contribution of subject matter experts in the development of this standard. Their efforts ranged from membership of the Development Group through to individuals providing comment on a draft of the standard during the open review.

I commend this standard to the Australasian Rail Industry as it represents industry good practice and has been developed through a rigorous process.

Paul Daly
Chief Executive Officer
Rail Industry Safety and Standards Board

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1 Introduction

1.1 Purpose

This document describes requirements for determining whether rolling stock conforms to reference rolling stock outlines that are contained within this document.

The main purpose of the requirements is to maintain an acceptable clearance between rolling stock and fixed structures and between passing trains.

1.2 Scope

This document applies to new and modified rolling stock that is to operate on a network, also to existing rolling stock where it is proposed to operate it on a different network.

This document applies to passenger; locomotive; infrastructure maintenance and freight rolling stock.

The document applies to the design, construction and maintenance of rolling stock under all conditions of loading.

The scope of this standard is to describe the permissible outlines of rolling stock relative to the centre of the track, and how conformance to those outlines is to be demonstrated.

Infrastructure related requirements for rail wear, track tolerances, structure outlines, etc. plus the magnitude of clearances between vehicles and structures, between passing vehicles, electrical clearances, etc. Are all treated in infrastructure standards.

Operation of rolling stock is not covered.

Rolling stock used on light rail, cane railway and monorail networks are not covered.

This document does not control the outline of any freight loads that are carried by rolling stock - refer to section 7.

Operation of infrastructure maintenance rolling stock is not covered.

1.3 Compliance

There are two types of control contained within RISSB Standards:

(a) mandatory requirements

(b) recommended requirements

Each of these types of control address hazards that are deemed to require controls on the basis of existing Australian and international Codes of Practice and Standards.

A **mandatory** requirement is a requirement that the standard provides as the only way of treating the hazard.

Mandatory requirements are identified within the text by the term shall.

A **recommended** requirement is one where the standard recognises that there are limitations to the universal application of the requirement and that there may be circumstances where the control cannot be applied or that other controls may be appropriate or satisfactory, subject to agreement with the Rolling Stock Operator, Rail Infrastructure Manager and/or Rail Safety Regulator.

Recommended clauses are mandatory unless the RIM or RSO can demonstrate a better method of controlling the risk.

Recommended requirements are to be considered when compliance with the standards is being assessed.

Recommended requirements are identified within the text by the term should.

Hazards addressed by this standard are included in an appendix. Refer to the RISSB website for the latest Hazard Register Guideline: www.rissb.com.au

1.4 Informative references

The following referenced documents are used by this Standard for information only:

(a) AS 4292 Railway safety management

(b) AS 7501 Railway rolling stock - Rolling stock certification

(c) RISSB Code of Practice for Loading of Rail Freight

1.5 Definitions

ARL: Abbreviation for "Above Rail Level", as used in dimensions for height measured from top of rails, perpendicular to the plane of the rails.

Body Roll: The angular translation of the body cross-section relative to the plane of the rails that may be expected to occur in response to cant excess, cant deficiency and/or track irregularities.

Bounce: The vertical translation of the vehicle body relative to the rails that may be expected to occur in response to track irregularities.

Cane Railway Network: A railway system dedicated to hauling harvested sugar cane from farms to a raw sugar factory. Typically 610mm gauge.

Cant: The height difference, at a common location, measured in millimetres, between the running surfaces of both rails. Also known as superelevation.

Cant Deficiency: The extent by which the cant on curved track is less than that required for the gravitational force component acting parallel with the rails towards the inside of the curve to exactly counterbalance the centrifugal force acting on a vehicle towards the outside of the curve in the same plane (also known as 'superelevation deficiency').

Cant Excess: The extent by which the cant on curved track exceeds that required for the gravitational force component acting parallel with the rails towards the inside of the curve to exactly counterbalance the centrifugal force acting on a vehicle towards the outside of the curve in the same plane (also known as 'superelevation excess'). It equates to a negative value of cant deficiency.

Centre Throw: The curve throw towards the inside of a horizontal curve at the vehicle centre which is the position of maximum inwards curve throw for a uniform vehicle.

Cowcatcher: An extension of vehicle body underneath the headstock at a cab end to deflect large obstacles from the track, also known as a 'pilot'.

Curve Throw: The extent to which a transverse cross-section of a vehicle is displaced inwards or outwards from the track centreline on a perfectly aligned horizontal curve, or upwards and downwards on a perfectly aligned vertical curve, for zero cant and excluding dynamic effects.

End Throw: The curve throw towards the outside of a horizontal curve at the vehicle end which is the position of maximum outwards curve throw for a uniform vehicle.

Expendable Item: A feature on rolling stock that exceeds the required rolling stock outline but is considered acceptable by both Operator and Rail Infrastructure Manager due to the low consequence if struck.

Freight Rolling Stock: Hauled rolling stock used to transport goods, materials etc.

Infrastructure Maintenance Rolling Stock: Track machines and road rail vehicles. Also known as on track vehicles.

Kinematic Outline: A two-dimensional shape that consists of the static outline plus the maximum permitted allowance for vertical bounce upwards plus lateral translation and body roll in response to a steady-state cant deficiency force at maximum permitted cant deficiency (or the maximum installed cant) and dynamic movements in response to track irregularity.[1]

Light Rail Network: A passenger-carrying railway system operating with trams or other similar shorter length, lower speed and lower axle-load self-propelled vehicles. Typically used in urban areas and often having a shared right-of-way with road traffic.

Locomotive Rolling Stock: Self-propelled, non-passenger-carrying railway vehicles used for hauling other (typically freight or passenger) rolling stock.

Loading Outline: An outline drawing or specification that describes the maximum permissible load dimensions.[2]

Maximum Designed Cant Deficiency: The cant deficiency that the vehicle has been designed to operate with under normal operating conditions.

Maximum Test Cant Deficiency: The cant deficiency that the vehicle would operate under testing conditions, this is greater than the design cant deficiency.

Maximum Installed Cant: The maximum track cant that exists on the routes over which the Vehicle will operate.

Maximum Kinematic Outline: A two-dimensional shape that consists of the kinematic outline, wheel clearance and all track tolerances including rail wear.[3]

Maximum Lateral Translation: Maximum lateral movement experienced by the vehicle under the conditions of maximum test cant deficiency including (where applicable) secondary lateral suspension, primary lateral suspension, bogie-axle box lateral clearances, centre plate lateral clearances, etc. but not including wheel to rail lateral clearances, wheel flange wear or rail side wear and not including any body roll or bogie roll.

Maximum Static Height: The case of a stationary vehicle in minimum tare condition (i.e. no fuel, sand, water, etc.) that is in a service ready condition and gives the maximum height above rail.

Minimum Static Height: The case of a stationary vehicle in the fully loaded condition (i.e. with the suspension fully compressed to “solid”) that is in a service ready condition to give the minimum height above rail. The suspension fully compressed to the “solid” condition is whichever of the below occurs first:

- Suspension travel limited by consuming available bumpstop clearances.
- Suspension travel limited by coil springs reaching solid height.

[1] Note: the kinematic outline excludes curve throw and all track tolerances.
[2] Note that the loading outline may be different to, and in some cases bigger than, the reference rolling stock outline.
Note also that containers are considered as loads that are controlled by the loading outline rather than the reference rolling stock outline.
[3] Not typically used in rolling stock assessment.

- Suspension travel limited by spring nest stiffness tending toward an infinite value.

Monorail Network: A passenger-carrying system in which vehicles travel over a single broad beam (rather than two narrow rails connected by sleepers as with conventional railway rolling stock).

Obstacle Deflector. An extension of vehicle body underneath the headstock at a cab end to deflect large obstacles from the track.

Out of Gauge Loads: A vehicle load that does not conform to the relevant loading outline.

Out of Gauge Rolling Stock: Any vehicle that does not conform to a reference rolling stock outline applicable to a particular route.

Passenger Rolling Stock: Rolling stock carrying people and facilities for these people. Excludes locomotive and infrastructure maintenance rolling stock.

Rail Infrastructure Manager (also known as Track Manager): the person who has effective control and management of the rail infrastructure, whether or not the person—

(a) owns the rail infrastructure; or

(b) has a statutory or contractual right to use the rail infrastructure or to control, or provide, access to it.

Reference Kinematic Outline: The kinematic outline of a reference vehicle.

Reference Rolling Stock Outline: The three-dimensional size of a reference vehicle. This consists of three specific parts, the reference static outline, reference kinematic outline and reference swept outline.

Reference Static Outline: The static outline of a reference vehicle.

Reference Swept Outline: The swept outline of a reference vehicle.

Reference Vehicle: A vehicle whose rolling stock outline has been accepted by the rail infrastructure manager as being clear to operate over a defined route.

Regulator: A government body responsible for ensuring compliance with particular laws, acts, regulations etc., e.g. rail safety regulator.

Road-Rail Vehicle: A vehicle that can travel on a road and can also travel on rail by use of a rail wheel guidance system.

Rolling Stock: Any vehicle that operates on, or intends to operate on, or uses a railway track, including any loading on such a vehicle, but excluding a vehicle designed for both on- and off-track use when not operating on the track. Rolling stock is a collective term for a large range of rail vehicles of various types, including locomotives, freight wagons, passenger cars, track machines and road-rail vehicles.

Rolling Stock Operator: a person who has effective control and management of the operation or movement of rolling stock on rail infrastructure for a railway, but does not include a person by reason only that the person drives the rolling stock or controls the network or the network signals.

Rolling Stock Outline: A generic term for the three-dimensional size of a railway vehicle including its movements that consists of three specific parts, the static outline, basic kinematic outline and swept kinematic outline.

Routine Test: A test conducted on every vehicle that will be registered to operate.

Shall: The word "shall" indicates that a statement is mandatory for the applicable vehicles.

Should: Indicates a recommendation.

Static Outline: An outline drawing or specification of a notional vehicle cross-section, or item of vehicle equipment, which prescribes permissible rolling stock dimensions under specified conditions of load and suspension translations in vertical directions. The static outline will have an associated kinematic outline and swept outline.

Sway: The translation of any point on the vehicle body in a direction parallel to the plane of the rails that arises as a result of a combination of lateral translation and body roll on the vehicle suspension.

Swept Outline: The swept outline is the static outline of the vehicle in plan view, including the inner and outer curve throw on a 100m radius horizontal curve.

Track Machine: A flange wheeled vehicle used for infrastructure maintenance, construction and inspections. Separate to freight rolling stock (e.g. wagons used for carrying rail, sleepers, spoil, ballast etc.) and road rail vehicles.

Type Test: A test conducted on one vehicle that is typical of all vehicles.

Vehicle(s): Generically used to denote a means of transportation, and specifically used to denote single item(s) of rolling stock (e.g. individual locomotives, carriages or wagons).

Vertical Swept Outline: The vertical swept outline is a two-dimensional cross-section for the vehicle that consists of the static outline, plus the upper and lower vertical curve throw produced by the vehicle on a humped or dipped vertical curve.

Wheel Clearance: For a wheelset positioned on the centreline of the track, the wheel clearance is the lateral distance between one fully worn wheel flange and the adjacent new rail.

Wheel guard: A deflector mounted in front of the leading wheels of a vehicle to deflect small objects from the rails, also known as 'lifeguards' or 'guard-irons'.

2 Principles of Rolling Stock Outlines

2.1 General

The maximum permitted size of rolling stock varies for different routes in Australia.

In order for a vehicle to be permitted to operate over a defined route, it will need to be demonstrated that its rolling stock outline does not exceed that of a reference vehicle, or the combined rolling stock outlines of more than one reference vehicle, as nominated by the Rail Infrastructure Manager.

Alternatively, with the agreement of the Rail Infrastructure Manager, a reference vehicle can be any other vehicle that has a history of operating with safe clearances over the required route.

The Rail Infrastructure Manager is responsible for specifying the appropriate reference rolling stock outline for each route.

The Rolling Stock Operator is responsible for ensuring that their rolling stock complies with the appropriate reference rolling stock outline.

An alternative method is that known as "absolute gauging" whereby the rolling stock, including its kinematic movements and curve throw, is shown to have acceptable clearances to absolute

measurements of the structures along a route, and acceptable clearances to all other types of passing rolling stock on adjacent track(s), at every position along the route; however, details of absolute gauging is outside of the scope of this standard.

2.2 Rolling Stock Outlines

A rolling stock outline consists of four parts:

- static outline
- kinematic outline
- swept outline
- vertical swept outline.

2.2.1 Static Outline

The static outline, as shown in Figure 1, is the maximum permitted two-dimensional envelope that a stationary vehicle must always satisfy.

The static outline is defined by a dimensioned drawing nominated by the Rail Infrastructure Manager.

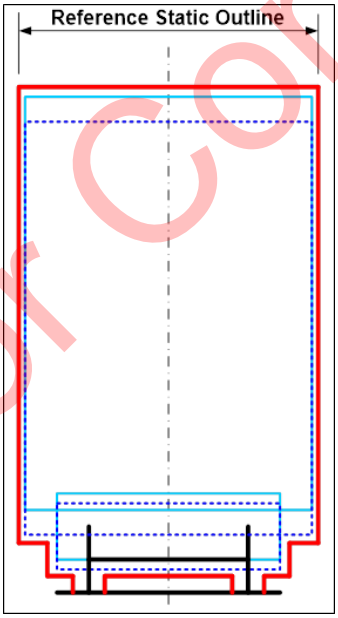


Figure 1 – Static Outline[4].

2.2.2 Kinematic Outline

The kinematic outline, as shown in Figure 2, consists of

- the static outline, and
- the maximum permitted allowance for vertical bounce upwards, and

[4] Note: The solid light blue line represents the outline of the vehicle in maximum static height condition;
The dotted dark blue line represents the vehicle in minimum static height condition;
The red solid line represents the reference static outline.
This figure is for illustrative purposes only.

- lateral translation and body roll in response to a steady-state cant deficiency force at maximum permitted cant deficiency (or the maximum installed cant), and
- dynamic movements in response to track irregularity.

The kinematic outline is usually defined by movements that are applied to the static outline in vertical, lateral and roll translation, but may be defined by another dimensioned drawing.

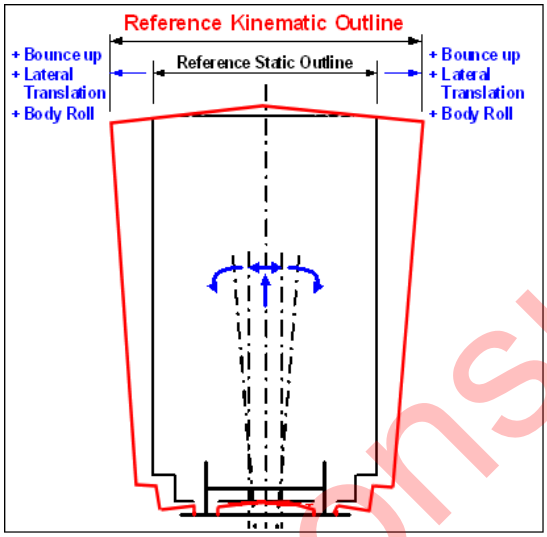


Figure 2 – Kinematic Outline[5]

The reference kinematic outlines are each produced as a result of moving the corresponding reference static outline through the lateral translation (in the plane of the rail level), body roll and bounce upwards movements detailed in Appendix A.

Note that bounce is applied upwards but not downwards.[6]

Note that the reference static outline is not moved through the lateral allowance for wheel clearance given in Appendix A as the reference kinematic outline does not include this; this is listed for information only.

2.2.3 Swept Outline

The swept outline consists of the static outline plus the inner and outer curve throw produced by the vehicle on a 100m radius horizontal curve, as shown in Figure 3.

The body length and bogie spacing (as detailed in the reference vehicles in Appendix A) will define the curve throws produced. Refer to Equation 1 and Equation 2 on page 19.

[5] The black outline represents the reference static outline; the red outline represents the reference kinematic outline that is obtained by applying the defined lateral, roll and bounce upwards movements to the reference static outline. The dotted black line shows lateral translation and body roll against the vehicle centre line.
This figure is for illustrative purposes only.

[6] Downwards bounce is accounted for in the static outline in considering the suspension 'solid' in the minimum static height condition.

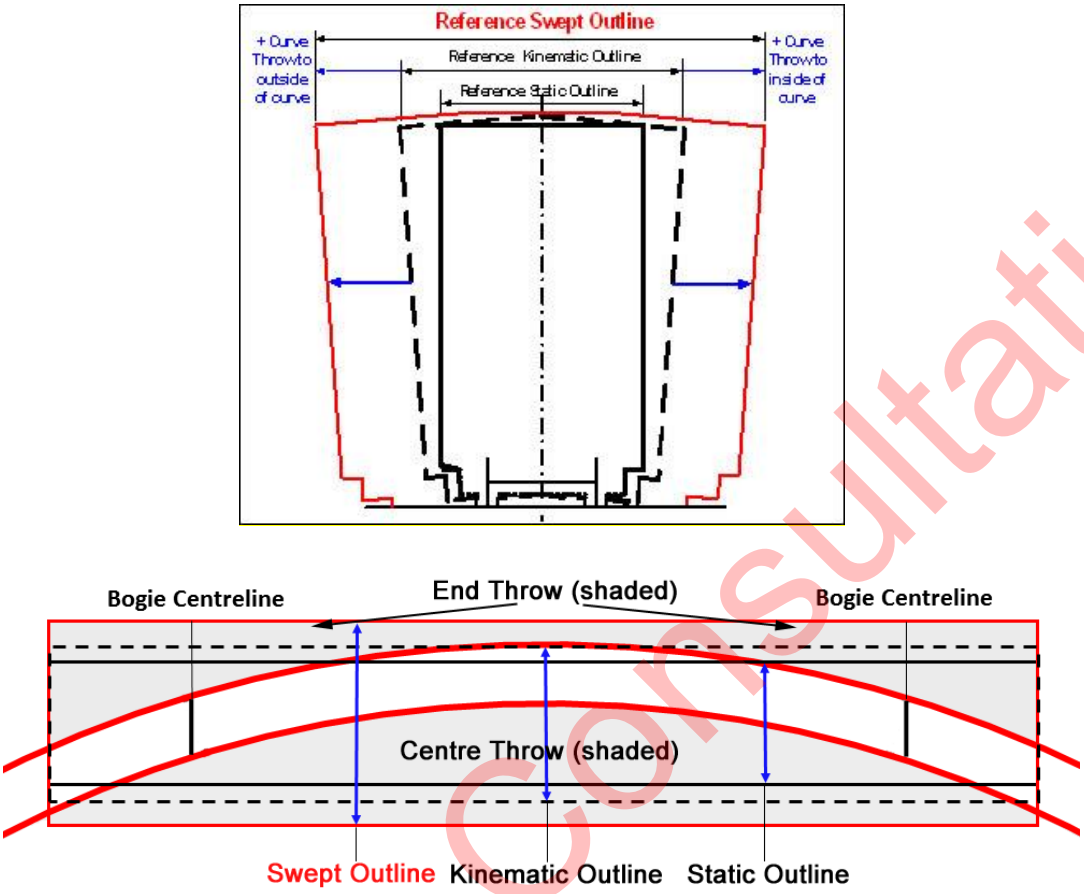
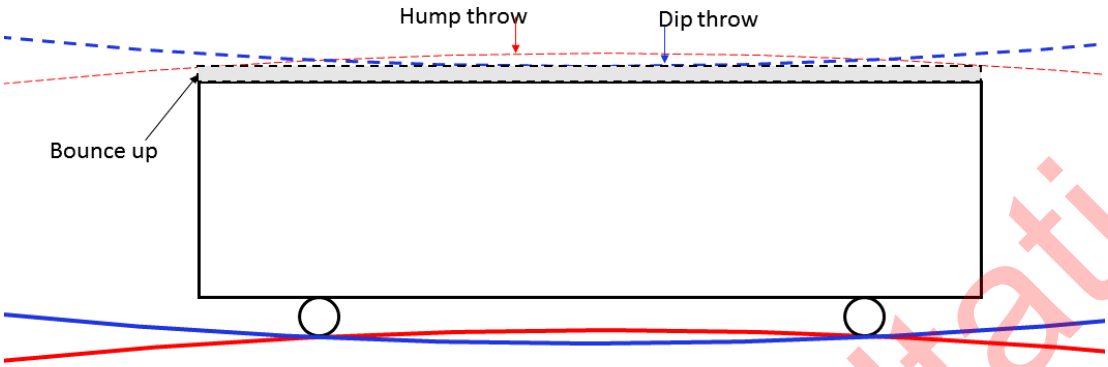


Figure 3 – Swept Outline[7]

2.2.4 Vertical Swept Outline

The vertical swept outline consists of the static outline, plus bounce upwards, plus the upper and lower vertical curve throw produced by the vehicle on a humped or dipped vertical curve, as shown in Figure 4.

[7] This figure is for illustrative purposes only.



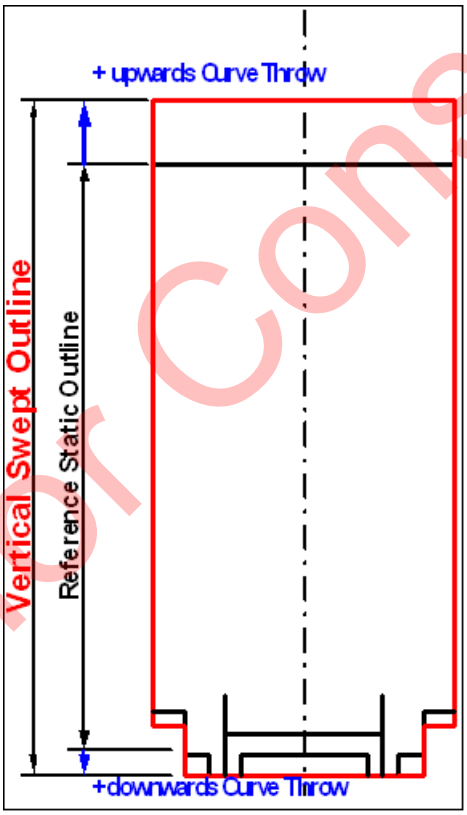


Figure 4 – Vertical Swept Outline[8]

2.3 Reference Vehicles

This standard has defined 37 reference vehicles with their associated rolling stock outlines, based on those used by rail infrastructure managers at the time of this standard's development.[9]

A reference vehicle defines:

(a) The static outline, via a dimensioned drawing.

[8] This figure is for illustrative purposes only.
[9] Organisations wishing to add new reference vehicles to this standard should contact RISSB.

(b) The maximum permissible vertical, lateral and roll translations, plus the position of the roll centre, to calculate the permissible kinematic outline[10]

(c) The maximum body length and bogie spacing to calculate the permissible swept outline.

Advice shall be obtained from the Rail Infrastructure Manager as to the appropriate reference rolling stock outline, or outlines, applicable for the routes on which a new, or modified vehicle is proposed to operate.[11] 3.12, 9.17, 32.7

Rolling stock should conform to the applicable reference rolling stock outlines as advised by the Rail Infrastructure Manager. 3.12, 9.17, 32.4, 32.7

Non-conformances may be permitted with approval from the Rail Infrastructure Manager but operating restrictions may be applied.

A design for a new or modified vehicle may have actual dimensions and characteristics that differ from but remain within the reference vehicle static, kinematic and swept outlines.

For example (subject to agreement by the Rail Infrastructure Manager):

(a) The new vehicle may be longer and thinner than the reference rolling stock outline such that its smaller static cross-section offsets the larger curve throws due to its length and the reference swept outline is still met.

(b) A vehicle, such as an active tilting train, may have greater lateral and roll movements than allowed for by the reference kinematic outline, so it may be designed with a smaller static cross-section to offset the greater kinematic movements such that the reference kinematic outline can be met.

(c) A vehicle could be designed with non-uniform cross-section (tapered ends, for instance) in order to be able to maximise its cross-section and length within the limits permitted by the reference static outline and reference swept outline, as long as the reference kinematic outline is still met.[12]

A design for a new, or modified, vehicle is permitted to have dimensions that use the features of more than one reference rolling stock outline, providing the overall combined rolling stock outline is not exceeded.[13]

3 Assessment of Rolling Stock Outlines

When a new or modified, vehicle is designed its dimensions and characteristics shall be assessed against the appropriate reference vehicle and its outlines.[14] 3.12, 9.17, 32.4, 32.8, 32.21, 32.33, 32.37

A new or modified vehicle may comply with a reference vehicle either

- Completely, including lengths and tolerances, or
- Fit within the swept path of the reference outline, and tolerances on tangent and curves on a 100m radius.

[10] Where applicable: Reference Vehicle 35 does not have a defined kinematic outline.
[11] Advice sought from the Rail Infrastructure Manager at the earliest possible stage in the vehicle design should avoid abortive work and delays.
[12] Note that the width of the vehicle cannot exceed the width of the reference static outline.
[13] For example, if a route is clear for two reference vehicles, where one has a wider body and the other is taller, it is permissible for a new vehicle to make use of both of these features.
[14] The Rail Infrastructure Manager can confirm the appropriate reference vehicle.

3.1 Conformance to a reference vehicle

The first stage of assessment of conformance of a new or modified vehicle to a reference vehicle is made at design stage by calculation, and includes:

(a) Identifying the appropriate reference rolling stock outline/s;[15]

(b) Calculating the static, kinematic and swept outlines of the rolling stock

(c) Ensuring the rolling stock outlines are within the outlines of the reference vehicle/s.

The second stage is undertaken on completion of the vehicle build or modification and is made by physical test to confirm that the outlines have been achieved. Refer to Section 5, Outline Physical Testing. Physical testing consists of:

(a) Physical measurement of the static outline of every vehicle produced.

(b) Physical measurement of the vertical, lateral and roll movements of the vehicle on its suspension under defined input conditions on a sample vehicle from the batch produced. Refer to Section 5.3.

3.1.1 Conformance to Static Outlines

For rolling stock to comply with a reference static outline, its dimensions shall not exceed the reference static outline at any position around the perimeter of the cross section under the defined conditions of: 3.12, 9.17, 32.10, 32.11, 32.12, 32.40, 32.43, 32.44, 32.45

(a) Maximum static height; 32.10, 32.19

(b) Minimum static height. 32.11, 32.40, 32.43, 32.44, 32.45

In making an assessment of conformance of a vehicle to a reference static outline, the vehicle wheelset is assumed to remain fixed at the centreline of the track and no account needs to be taken of wheelset lateral translation relative to the track.

The assessment shall include rolling stock build and maintenance tolerances. 32.4, 32.40, 32.43, 32.45

3.1.2 Conformance to Kinematic Outlines

For rolling stock to comply with a reference kinematic outline, its kinematic outline shall not exceed the reference kinematic outline at any position around the perimeter of the cross section under the combined conditions of:[16] 3.12, 9.17, 32.4, 32.8, 32.21, 32.33, 32.37

(a) Maximum lateral translation; 32.8, 32.37

(b) Vehicle body roll relative to the wheelset in response to a steady-state cant deficiency force at the maximum design test cant deficiency for the vehicle, or the maximum installed cant, plus an allowance for dynamic movements in response to track irregularity, whichever is the greater value; 32.8, 32.37

(c) Vehicle body bounce upwards. 32.8, 32.37

[15] The Rail Infrastructure Manager can confirm the appropriate reference rolling stock outline.
The reference rolling stock outline should consist of the vehicle dimensions and all relevant allowances for suspension movements, wheel wear, curve throw, etc. as defined in this standard.

[16] These requirements control maximum basic kinematic outline under conditions of maximum cant deficiency or maximum cant excess only. They do not control the size of the basic kinematic outline under other conditions such as lesser cant deficiency or cant excess, or straight track.

For vehicles with air springs, the reference kinematic outline is to be met with air springs inflated and deflated.

For vehicles with active suspension, for example tilting trains: 32.8, 32.14, 32.45

(a) The additional movements due to the active system are to be taken into account and are not to exceed the reference kinematic outline. 32.8

(b) There should be suitable controls such that the effect of failure of the active system does not cause exceedance of the reference kinematic outline. 32.8, 32.9, 32.14

In order to retain safe clearances it may be necessary to make an assessment of the effects of cross-winds, or pressure pulses from passing trains, on the vehicle's kinematic outline, particularly on high-sided and/or lightweight vehicles on exposed routes.

There should be suitable controls such that the effect of component failures do not cause exceedance of the kinematic outline. 32.9, 32.45

The assessment shall include rolling stock build and maintenance tolerances. 32.4, 32.40, 32.43, 32.45

In making an assessment of conformance of a vehicle's kinematic outline with a reference kinematic outline, the vehicle wheelset is assumed to remain fixed at the centreline of the track and no account needs to be taken of wheelset lateral translation relative to the track, wheel flange wear or rail side wear.[17]

Kinematic calculations for the vehicle shall use the actual roll centre height and kinematic tolerances applicable to the vehicle design. For example, the reference kinematic outlines specify heights at which the body roll allowance is applied, typically 440mm, 610mm or 1100mm above rail level. These roll centre heights are for the reference kinematic outline and are not to be assumed for the vehicle. 32.4, 32.8

3.1.3 Conformance to Swept Outlines

For rolling stock to comply with a reference swept outline the following requirements shall be met: 3.12, 32.4, 9.17, 9.25

(a) The vehicle's swept outline shall not exceed the reference swept outline at any position around the vehicle on level track for horizontal curves down to 100m radius; 32.4, 9.25

(b) The vertical swept outline shall not exceed the vertical swept outline of the reference vehicle at any position around the vehicle on straight track for vertical curves (humped or dipped) down to 300m radius; 32.10, 32.11, 32.19

(c) The vertical swept outline for the vehicle shall not drop below rail level at any position around the vehicle on straight track for vertical curves (humped or dipped) down to 300m radius. 32.11

Below is the method for calculation of curve throw.

Consider the vehicle on a curve of constant radius, where:

(a) Curve radius = R

(b) Body length = L

(c) Bogie centres = B

[17] The Rail Infrastructure Manager accounts for wheel-rail movement, track tolerances and clearances.

The end throw, ET, is given by Equation 1.

$$ET = \frac{[L^2 - B^2]}{8R}$$

Equation 1 – End throw for a uniform vehicle[18]

The centre throw, CT, is given by Equation 2.

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

Equation 2 – Centre throw for a uniform vehicle[19]

3.2 Maintenance

The vehicle shall be maintained to the dimensions and tolerances of the static outline and kinematic outline. 3.12, 3.39, 9.17, 32.4, 32.5, 32.40, 32.43

4 Specific Items

4.1 Wheels

The area of the static outline marked 'for wheels only' also represents the kinematic outline and swept outline for wheel-related equipment such as wheel guards, derail catch bars and sanding equipment.

The static outline of wheel-related equipment at minimum static height shall be above rail level. 3.12, 32.4, 32.11

4.2 Expendable Items

A part of a vehicle that is outside of the reference rolling stock outline but has low consequences in the event of an infringement can be treated as an expendable item.

Any proposed expendable Items shall be agreed with the Rail Infrastructure Manager. 3.12, 9.17, 32.4, 32.23

Examples of items that could be expendable items include:

- mirrors;
- warning lights;
- speakers;
- periscopes;
- antennae;
- roof gutters.

For vehicles conforming to RISSB reference RISSB Reference Vehicle 27 new expendable items, or existing expendable items that are modified, shall occupy an area already used by similar expendable items as shown in Appendix B, Figure B 1. 3.12, 9.17, 32.4, 32.23

[18] This equation omits the effect of throw due to bogie wheelbase.
[19] This equation omits the effect of throw due to bogie wheelbase.

4.3 Cowcatchers

A cowcatcher is expected to deflect a sleeper that has been maliciously placed across the track.

Cowcatchers shall be height adjustable so height above rail can account for underframe manufacturing tolerances and also be re-established during service life.

The installed height of the cowcatcher shall:

- Satisfy the applicable rolling stock outlines, and
- Consider the rolling stock in its Minimum Static Height condition, and
- Consider its longitudinal position, taking into consideration the effect of vertical curves (sags) permitted by the Rail Infrastructure Manager.

The Rail Infrastructure Manager may have specific guidance regarding cowcatcher height above rail.

4.4 AWS & APC Receiver Heads

The Rail Infrastructure Manager may have specific guidance regarding the installation height ARL of AWS and APC receiver heads.

4.5 Pantographs

For pantographs in their lowered position all parts of the pantograph and associated equipment shall not exceed the appropriate static outline as described in Appendix A. 3.12, 32.4

The RISSB pantograph outlines given in Appendix B.2 show the pantograph static outline up to maximum working height.

The pantograph head profile shall conform to the dimensions of the appropriate pantograph static outline as described in Appendix B.2.[20] 3.12, 3.39, 3.45, 32.4

The pantograph head position along the vehicle shall not exceed the dimensions of the appropriate pantograph static outline as described in Appendix B.2.[21] 3.12, 3.53, 32.4

4.6 Trip Valve Arms

Some of the rolling stock outlines include an extension of the outline for trip valve arms.

Trip valve arms, where fitted, shall conform to the dimensions specified in Appendix A under maximum static height and minimum static height conditions. 3.12, 32.4

No other items shall occupy the area designated for trip valve arms.

4.7 Doors

Vehicles conforming to RISSB Reference Vehicle 21 or RISSB Reference Vehicle 27 that have plug-type doors that when failed in the open position exceed the relevant reference static outline, but do not exceed the dimensions detailed in Appendix B, Figure B 6 or Figure B 7 respectively, may be able to operate under special operating conditions.

Except for the conditions in section 4.2, empty freight rolling stock with bottom discharge doors in the open position shall not exceed the reference static outline under the conditions of wheels at condemned diameter, maximum permissible wear in bogie centre plates and other wear

[20] The Rail Infrastructure Manager can confirm the appropriate pantograph outline to use.
[21] The Rail Infrastructure Manager may impose requirements on location of pantographs with respect to bogie centres of the vehicle.

surfaces which may reduce clearance to rail, suspension spring height in wagon tare condition and allowance for bounce downwards.[22] 3.11, 3.12, 32.4, 32.11, 32.29

Freight rolling stock with bottom discharge doors during discharge at an applicable load receiving site for the type of wagons may have doors that exceed the reference static outline but shall not drop below rail level in the minimum height condition.[23] 3.11, 3.12, 32.4, 32.11, 32.29

5 Outline Physical Testing

5.1 General

A physical test shall be conducted to ensure that the vehicle conforms to the reference rolling stock outline.[24] 3.12, 9.17, 32.1, 32.4, 32.10, 32.11, 32.12, 32.19, 32.40, 32.43, 32.44, 32.45

Generally, the sort of vehicle modifications that might impact on the kinematic outline would be suspension modifications, increase in vehicle centre of gravity height, change in bogie type or change in operating conditions (e.g. change in load, speed or cant deficiency).

The static outline test is a routine test, unless physical measurements of a representative number of vehicles and technical argument over control of tolerances can demonstrate that the vehicles cannot be expected to exceed to reference static outline.[25]

The kinematic outline test is a type test.

The swept outline test is a type test.

5.2 Static Outline Test

Static outline test measurements shall be made on straight and level track. 3.12, 9.17, 32.1, 32.4

Static outline test measurements shall be made relative to the track centreline and the rail head level. 3.12, 9.17, 32.1, 32.4

The vehicle shall be measured in the maximum height condition and in the minimum height condition. 3.12, 9.17, 32.4, 32.10, 32.11, 32.19

One method for the static outline test is to measure the clearance between the vehicle profile and a constructed check profile.

It is suggested that before the test commences a check is made to ensure that the vehicle body is sitting centrally within the range of its lateral suspension travel and between the rails, and the vehicle centred if necessary.

Some aspects of the vehicle maximum height condition such as vehicle packed to compensate for future wheel wear or a container vehicle loaded with empty containers may be simulated by adding or subtracting the appropriate allowances from the measured dimensions, or by lowering the check profile by an appropriate amount.

Some aspects of the vehicle minimum height condition such as springs fully compressed to bumpstops, condemned wheels and worn surfaces may be simulated by adding or subtracting

[22] Except during discharge, doors would normally be closed. Doors inadvertently in the open position are to remain within gauge while stationary or during travel.
[23] During discharge at a dumping station, the freight rolling stock is in a controlled environment specific to the type of freight rolling stock and exceedance of the reference static outline is confined to the dumping station.
[24] This includes the reference static outline, reference kinematic outline and reference swept outline.
[25] It is anticipated that some measurements will be required on all vehicles, i.e. the routine test for the static outline will be a simplified version of the type test for the static outline.

the appropriate allowances from the measured dimensions, or by raising the check profile by an appropriate amount.

Vehicles with attachments such as cranes and elevated platforms shall be measured in the travelling condition. 3.12, 9.17, 32.1, 32.4

5.3 Kinematic Outline Tests

5.3.1 General

Design calculations shall be made to calculate the kinematic outline for the vehicle. 3.12, 9.17, 32.4, 32.8, 32.21, 32.33, 32.37

The design calculations should include vehicle movements due to maximum installed cant, cant deficiency and dynamic response of the vehicle to track irregularities. 3.12, 9.17, 32.4, 32.8, 32.37

Where design calculations show that the kinematic outline has 100mm or more clearance to the reference kinematic outline at all points around the vehicle cross-section, taking into account any body width reductions that are required to conform to the reference kinematic outline, then physical type tests for kinematic outline are not required.[26]

Where design calculations show that there is less than 100mm clearance to the reference kinematic outline at any point around the vehicle, physical type tests shall be undertaken to verify the design calculations. 3.12, 9.17, 32.4

The body roll relative to the wheelset plane and lateral translation of the body relative to the wheelset centreline shall be measured during the kinematic outline test. 3.12, 9.17, 32.4

The vehicle undergoing kinematic outline testing shall be assessed in the load condition that gives maximum sway.[27] 3.12, 9.17, 32.4, 32.8

The physical kinematic outline test may be a static kinematic sway test where one side of the stationary vehicle is lifted to simulate standing on maximum installed cant (see section 5.3.2) or a dynamic kinematic track test where the vehicle is tested negotiating curves at speed (see section 5.3.3).

The results of the physical tests made (whether static or dynamic tests) shall be compared to the results of the design calculations for the corresponding case. 3.12, 9.17, 32.4

Where the results of the physical tests and design calculations do not align, further tests and/or analysis may be required until the design calculations are verified, i.e. the results of the design calculations replicate the results of the physical tests undertaken.

Once the design calculation process is verified by testing, the design calculations are used to find whether the vehicle's kinematic outline exceeds the reference kinematic outline.

Physical type tests for kinematic outline are not required for infrastructure maintenance rolling stock having a mass exceeding 5 tonnes with a maximum operating speed of less than 30 km/h, or for infrastructure maintenance rolling stock of less than 5 tonnes with a maximum operating speed of less than 50 km/h.[28]

5.3.2 Kinematic Sway - Static Test

The vehicle shall be tested on straight and level track. 3.12, 9.17, 32.4

[26] Vehicles where the candidate kinematic outline is well inside the reference kinematic outline are exempt from a physical kinematic outline test.
[27] Generally, this would be the fully loaded condition.
[28] Generally, low speed track machines should not require a kinematic outline test.

It is suggested that before the test commences a check is made to ensure that the vehicle body is sitting centrally within the range of its lateral suspension travel and the vehicle centred if necessary.

The vehicle shall be raised on one side to simulate the maximum installed cant, or maximum cant deficiency plus an allowance for dynamic movements in response to track irregularity, that the vehicle will experience in operation, whichever is the greater value.[29] 3.12, 9.17, 32.4, 32.8

Gauge	Maximum test cant
Narrow	105 mm
Standard	160 mm
Broad	190 mm

Table 1 - Maximum test cant per gauge

Cant shall be applied equally to all wheelsets of the vehicle during the kinematic sway static test.[30] 3.12, 9.17, 32.4, 32.8

The vehicle undergoing a kinematic sway static test shall be lifted in increments up to the maximum cant on one side, then lowered gently in increments to the level condition, then repeated by lifting on the opposite side of the vehicle. 3.12, 9.17, 32.4, 32.8

By lifting both sides the complete hysteresis curve of lateral and roll movement versus applied cant will be recorded.

After lifting the vehicle in each direction it may be necessary to lift the vehicle in the first direction again for a small cant input in order to close the hysteresis curve.

It is suggested that the measurements of vehicle lateral translation and body roll are recorded during the test such that any arising errors can be identified during the test.[31]

It is usual to measure the displacement of (at least) two positions on the body, at different heights, relative to the position of the vehicle wheelset.

These results may then be analysed to provide body roll and lateral translation of the body relative to the wheelset.

Where vehicles are fitted with air springs they shall be fully inflated and levelling valves shall be isolated such that the air springs neither inflate nor deflate for the duration of the kinematic static test. 3.12, 9.17, 32.4, 32.8

Note that the air system may need to be made specially 'air tight' for the test vehicle to remain inflated for the duration of the test with air spring levelling valves isolated.

5.3.3 Kinematic Sway - Dynamic Test

The kinematic sway dynamic test shall be made over a test site that is representative of the routes on which the vehicle would be operating in terms of track irregularity and permits

[29] Maximum installed cant gives the largest sway to the inside of the curve. Maximum cant deficiency, plus dynamic movements due to the vehicle speed and track irregularities, give the largest sway to the outside of the curve. The kinematic sway static test simulates the greater of these.
[30] Refer to Appendix C for description of a sway test.
[31] This allows the hysteresis curve to be observed during the test and any discontinuities in results may be investigated that may be due to instrumentation, the vehicle characteristics or the test conditions.

operation of the test vehicle to the maximum speed and cant deficiency required for the test. 3.12, 9.17, 32.4, 32.8

Dynamic cant deficiency needs to be tested taking into consideration the maximum design cant deficiency for the vehicle and accounting for track irregularities and associated vehicle roll inertia, including when entering the curve. This could be achieved by testing at 145% of maximum designed cant deficiency.

The kinematic sway dynamic test shall include: 3.12, 9.17, 32.4, 32.8

(a) The vehicle curving at maximum cant deficiency at a speed as close as possible to the maximum speed for the vehicle.[32] 3.12, 9.17, 32.4, 32.8

(b) The vehicle stationary on maximum installed cant.[33] 3.12, 9.17, 32.4, 32

It is usual to measure the vertical and lateral translation of the primary and secondary suspension.

These results may then be analysed to provide body roll and lateral translation of the body relative to the wheelset.

5.4 Swept Outline Test

Vehicle length, body overhangs and bogie centres shall be measured to ensure that they conform to the swept outline dimensions. 3.12, 32.4, 9.17, 9.25

6 Out of Gauge Rolling Stock

Out of gauge rolling stock may be permitted to operate by the Rail Infrastructure Manager, but may have operational constraints, limitations or special conditions placed upon it.

Where a track machine operates with equipment outside the static, kinematic or swept outline such as lifting jibs, elevated platforms, etc., there shall be a means of ensuring that it is not driven in travel mode with this equipment exceeding any of the static, kinematic or swept outlines.[34] 3.12, 9.17, 32.4, 32.35, 32.36

7 Loads

Loading outlines and out of gauge loads are outside of the scope of this standard and reference should be made to the relevant documents for each network; for example the RISSB Code of Practice for Loading of Rail Freight.

The loading outline for loose, non-rigid or flexible loads is typically smaller than the applicable rolling stock (static) outline for a route.

The loading outline for rigid loads may be smaller or larger than the applicable rolling stock (static) outline for defined routes on some networks.

[32] The perfect test curve is where curve radius, installed cant and line speed permit the candidate vehicle to curve at maximum cant deficiency and maximum speed simultaneously. The minimum requirement is that the test curve should permit maximum cant deficiency and it is preferably that line speed is not less than 75% of the maximum speed of the candidate vehicle. Testing in excess of line speed is not intended.
[33] This test is required since the maximum installed cant is often greater than the maximum permitted cant deficiency.
[34] Within a possession, in work mode, it is sometimes necessary to travel with equipment outside the static, kinematic or swept outlines.

8 Records

Test records shall be kept for each vehicle. 32.4

Any out of gauge items shall be dimensioned. 45.34

Appendix A Reference Rolling Stock Outlines

Note: Wheel clearances are for information only to allow Rail Infrastructure Managers to make assessments of suitable structure outlines. Rail Infrastructure Managers will also make allowances for rail wear, track tolerances, safe clearances, etc.

A.1 RISSB Reference Vehicle 1

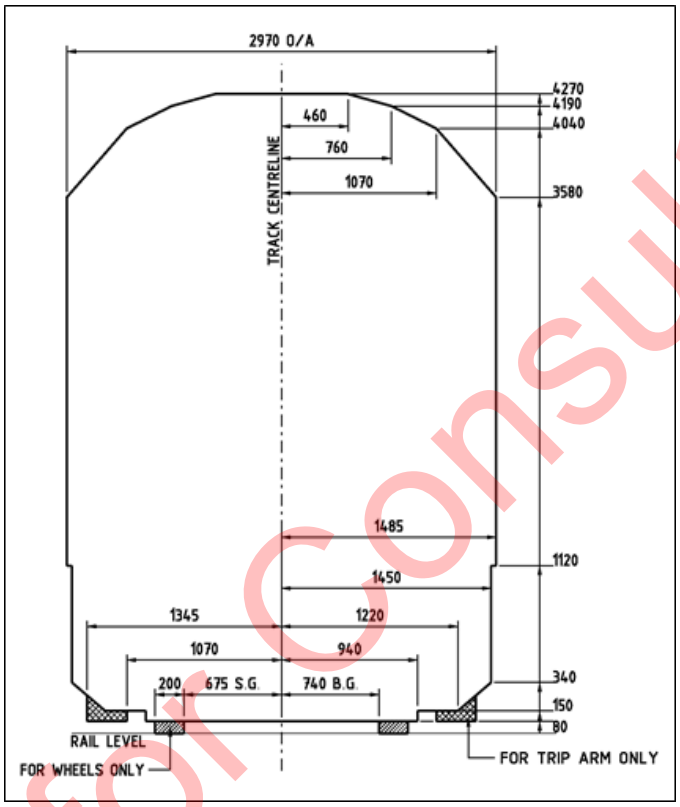


Figure A 1 - Static rolling stock outline dimensions for RISSB reference vehicle 1.

RISSB Reference Vehicle 1	Lateral Translation +/- (mm)	Body Roll		Bounce (Upwards Only) (mm)	Wheel Clearance +/- (mm)
		Angle +/- (degrees)	Point of Rotation ARL (mm)		
Interstate Plate A	40	2.0	610	50	20

Table A 1 - Kinematic outline translations for RISSB reference vehicle 1.

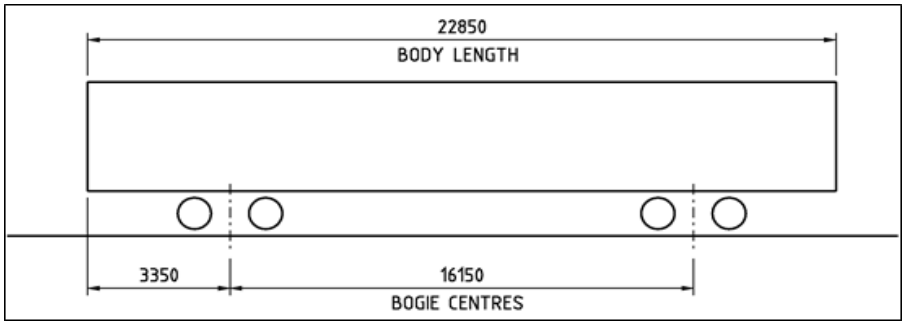


Figure A 2 - Swept outline vehicle dimensions for RISSB reference vehicle 1.

A.2 RISSB Reference Vehicle 2

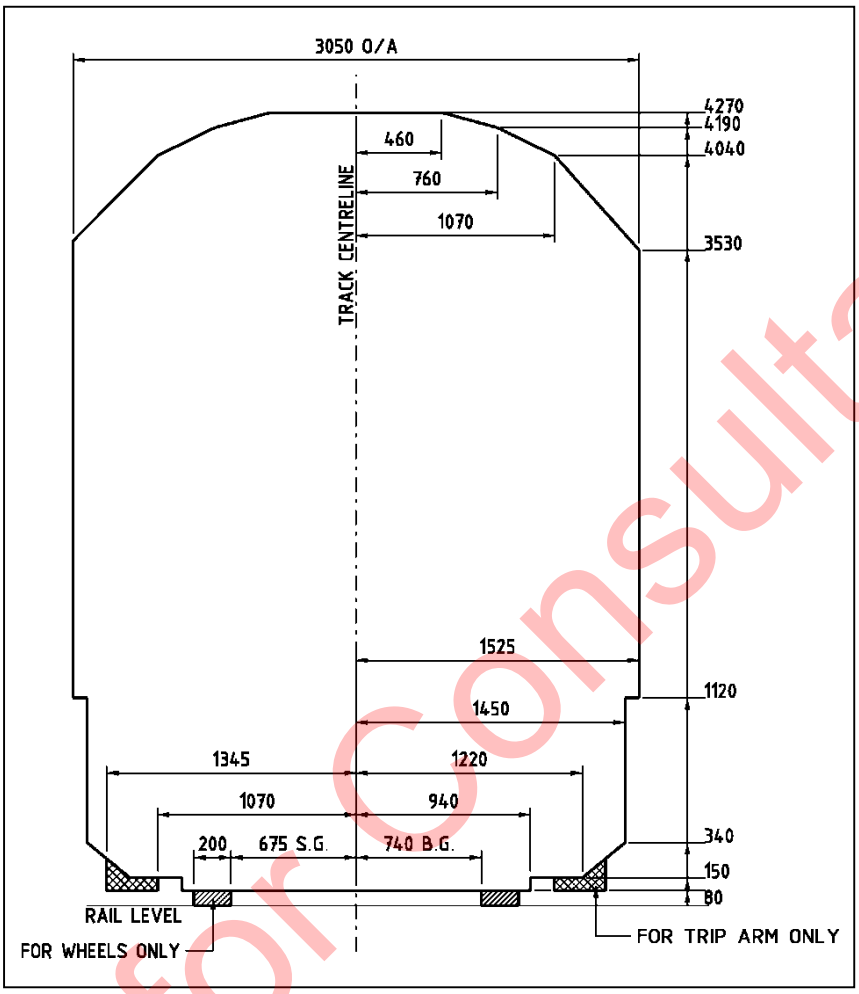


Figure A 3 - Static rolling stock outline dimensions for RISSB reference vehicle 2.

RISSB Reference Vehicle 2	Lateral Translation +/- (mm)	Body Roll		Bounce (Upwards Only) (mm)	Wheel Clearance +/- (mm)
		Angle +/- (degrees)	Point of Rotation ARL (mm)		
Interstate Plate B	40	2.0	610	50	20

Table A 2 - Kinematic outline translations for RISSB reference vehicle 2.

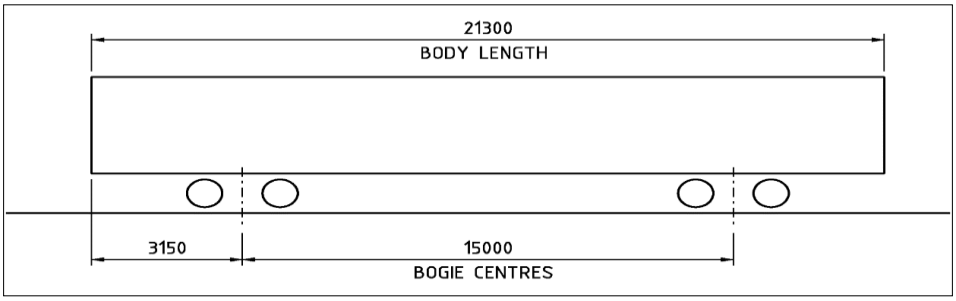


Figure A 4 - Swept outline vehicle dimensions for RISSB reference vehicle 2.

A.3 RISSB Reference Vehicle 3

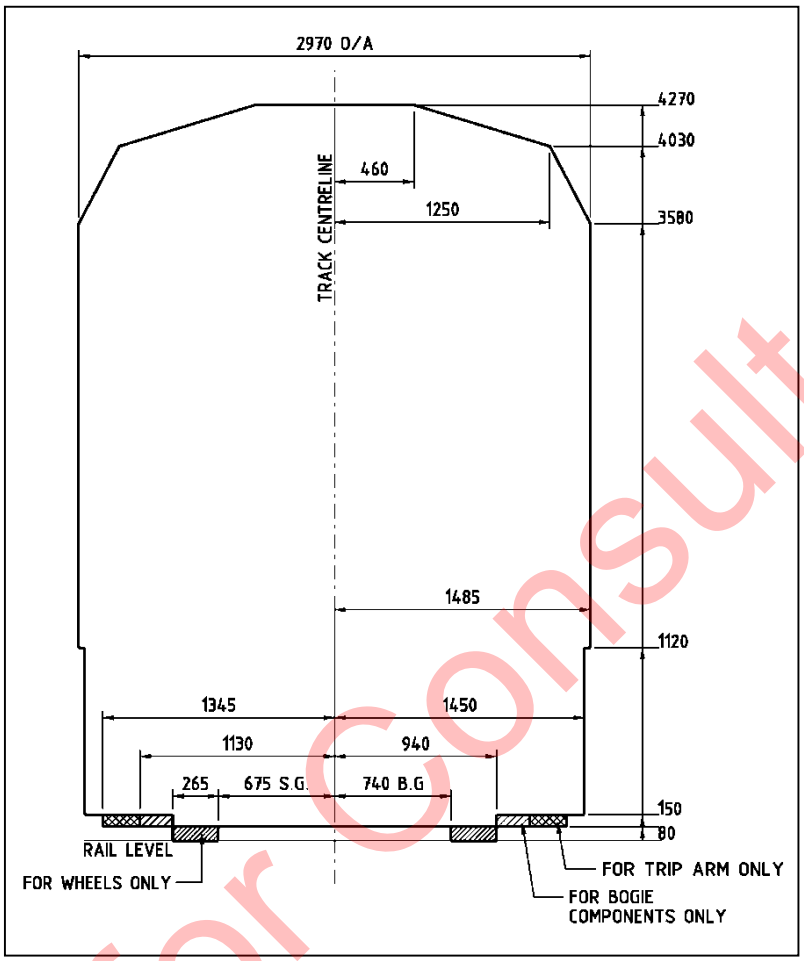


Figure A 5 - Static rolling stock outline dimensions for RISSB reference vehicle 3.

RISSB Reference Vehicle 3	Lateral Translation +/- (mm)	Body Roll		Bounce (Upwards Only) (mm)	Wheel Clearance +/- (mm)
		Angle +/- (degrees)	Point of Rotation ARL (mm)		
Interstate Plate C	40	2.0	610	50	20

Table A 3 - Kinematic outline translations for RISSB reference vehicle 3.

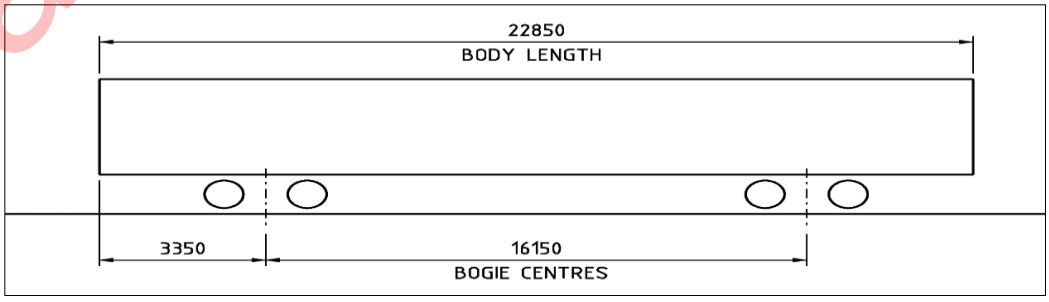


Figure A 6 - Swept outline vehicle dimensions for RISSB reference vehicle 3.

A.4 RISSB Reference Vehicle 4

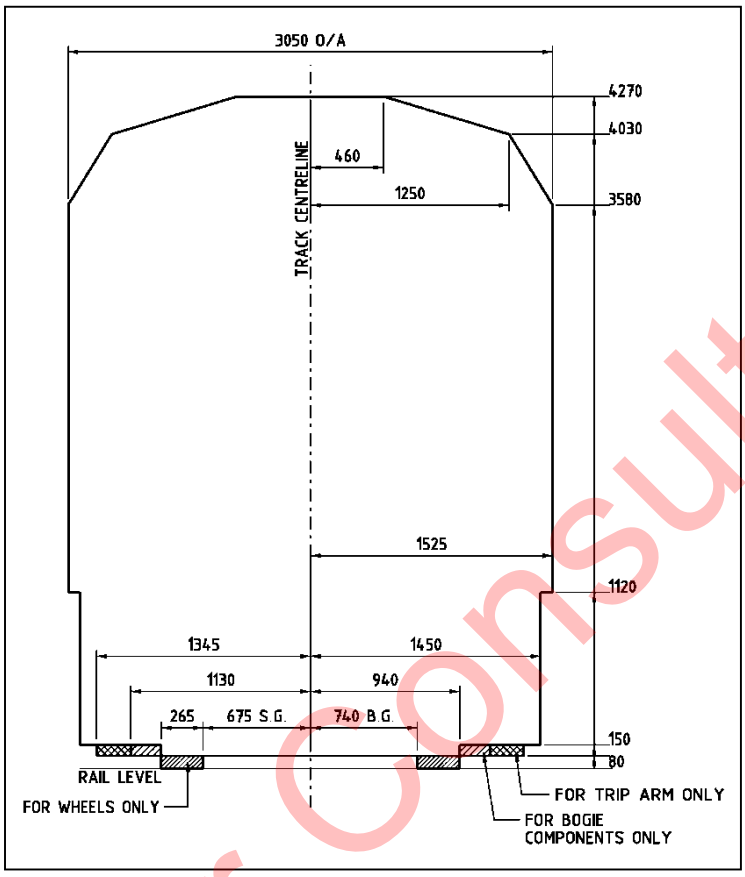


Figure A 7 - Static rolling stock outline dimensions for RISSB reference vehicle 4.

RISSB Reference Vehicle 4	Lateral Translation +/- (mm)	Body Roll		Bounce (Upwards Only) (mm)	Wheel Clearance +/- (mm)
		Angle +/- (degrees)	Point of Rotation ARL (mm)		
Interstate Plate D	40	2.0	610	50	20

Table A 4 - Kinematic outline translations for RISSB reference vehicle 4.

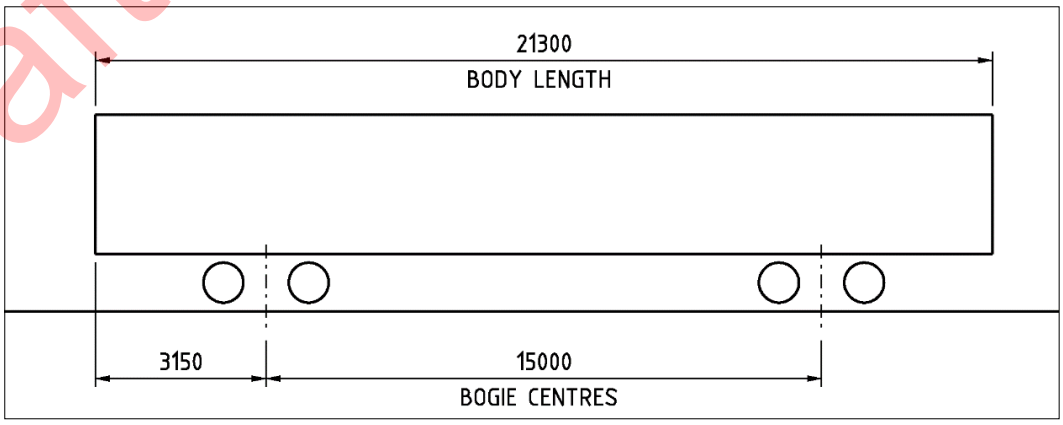


Figure A 8 - Swept outline vehicle dimensions for RISSB reference vehicle 4.

A.5 RISSB Reference Vehicle 5

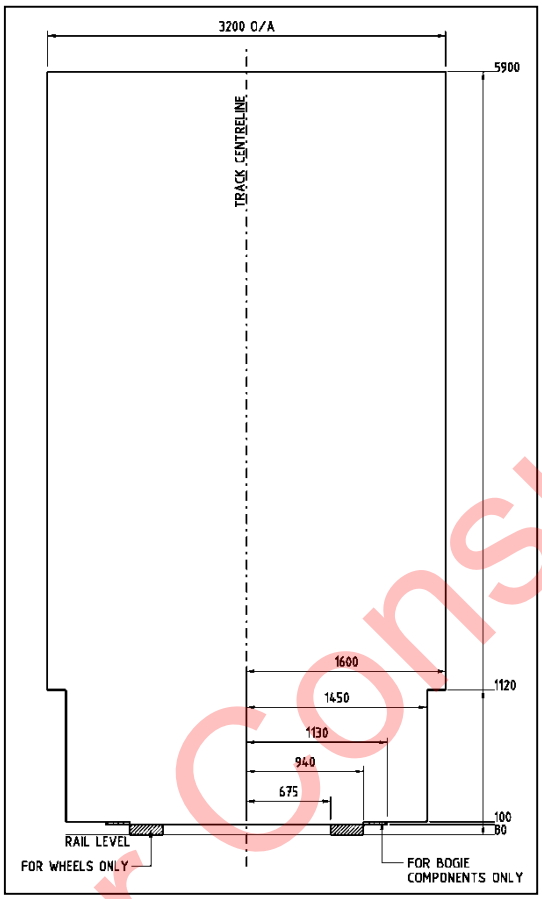


Figure A 9 - Static rolling stock outline dimensions for RISSB reference vehicle 5.

RISSB Reference Vehicle 5	Lateral Translation +/- (mm)	Body Roll		Bounce (Upwards Only) (mm)	Wheel Clearance +/- (mm)
		Angle +/- (degrees)	Point of Rotation ARL (mm)		
Interstate Plate E	40	2.5	440	50	20

Table A 5 - Kinematic outline translations for RISSB reference vehicle 5.

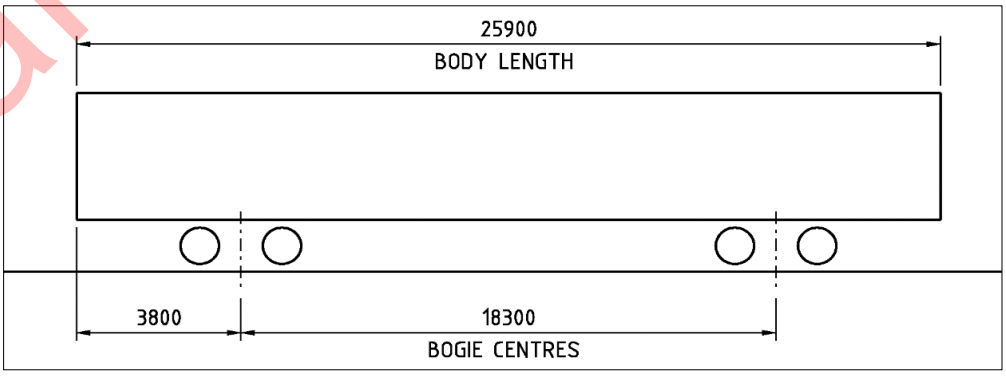


Figure A 10 - Swept outline vehicle dimensions for RISSB reference vehicle 5.

A.6 RISSB Reference Vehicle 6

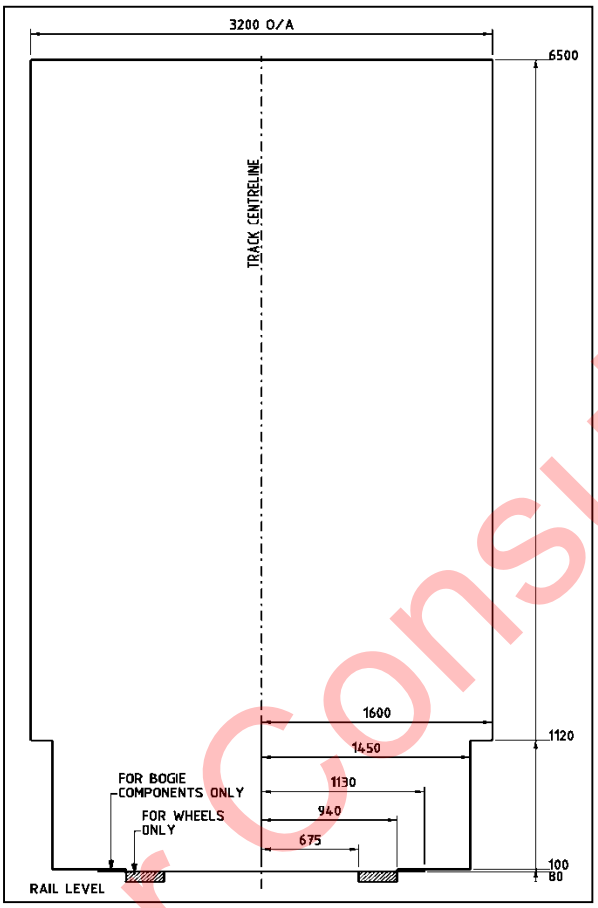


Figure A 11 - Static rolling stock outline dimensions for RISSB reference vehicle 6.

RISSB Reference Vehicle 6	Lateral Translation +/- (mm)	Body Roll		Bounce (Upwards Only) (mm)	Wheel Clearance +/- (mm)
		Angle +/- (degrees)	Point of Rotation ARL (mm)		
Interstate Plate F	40	2.5	440	50	20

Table A 6 - Kinematic outline translations for RISSB reference vehicle 6.

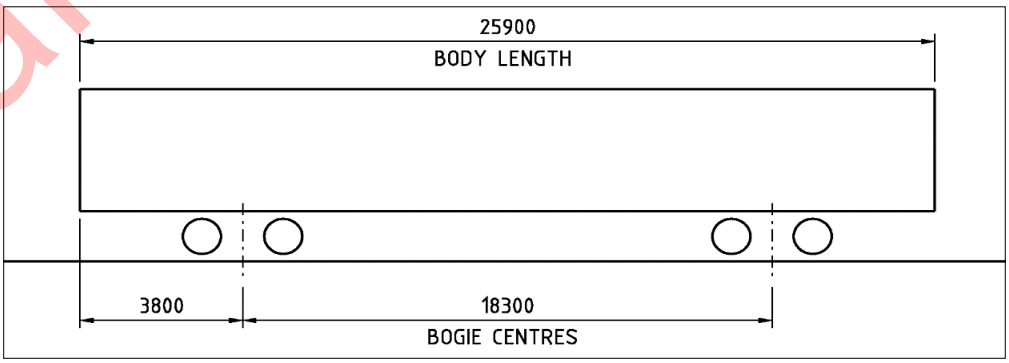


Figure A 12 - Swept outline vehicle dimensions for RISSB reference vehicle 6.

A.7 RISSB Reference Vehicle 7

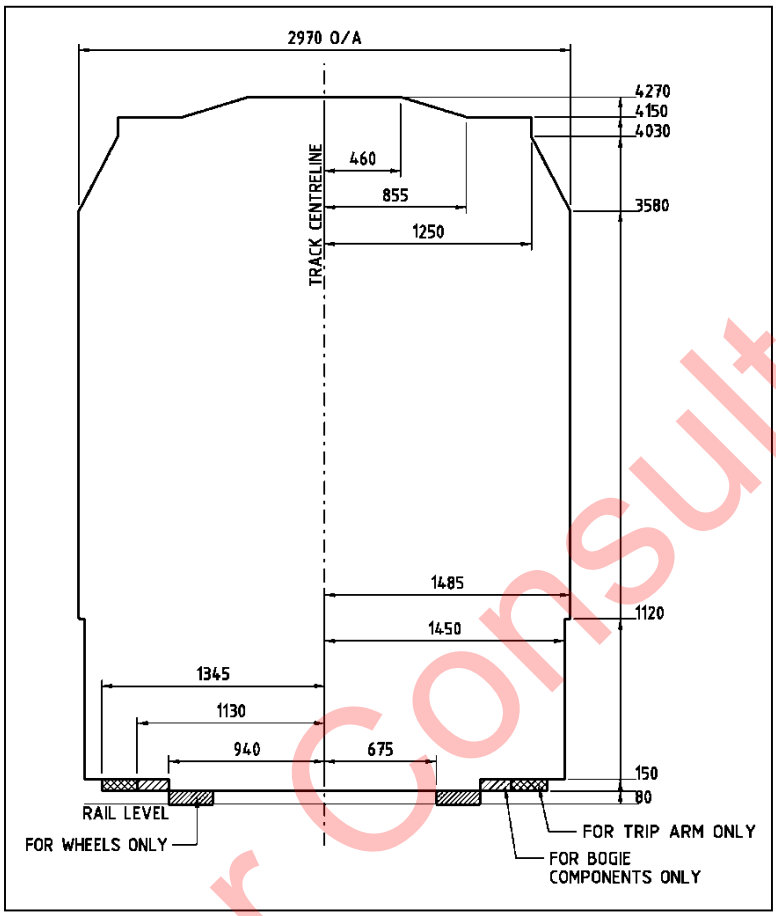


Figure A 13 - Static rolling stock outline dimensions for RISSB reference vehicle 7.

RISSB Reference Vehicle 7	Lateral Translation +/- (mm)	Body Roll		Bounce (Upwards Only) (mm)	Wheel Clearance +/- (mm)
		Angle +/- (degrees)	Point of Rotation ARL (mm)		
ARTC CY4150	40	2.0	610	50	20

Table A 7 - Kinematic outline translations for RISSB reference vehicle 7.

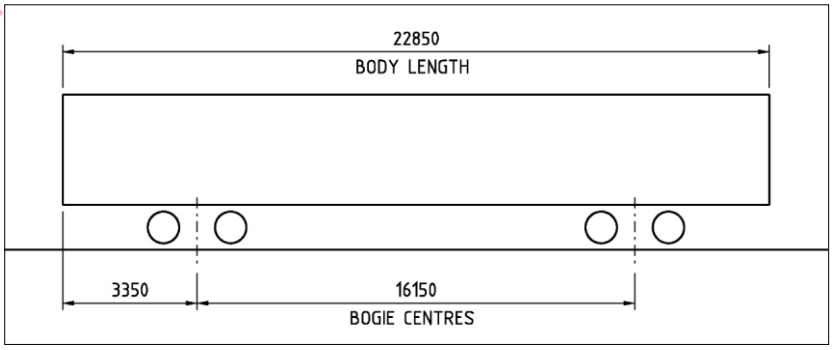


Figure A 14 - Swept outline vehicle dimensions for RISSB reference vehicle 7.

A.8 RISSB Reference Vehicle 8

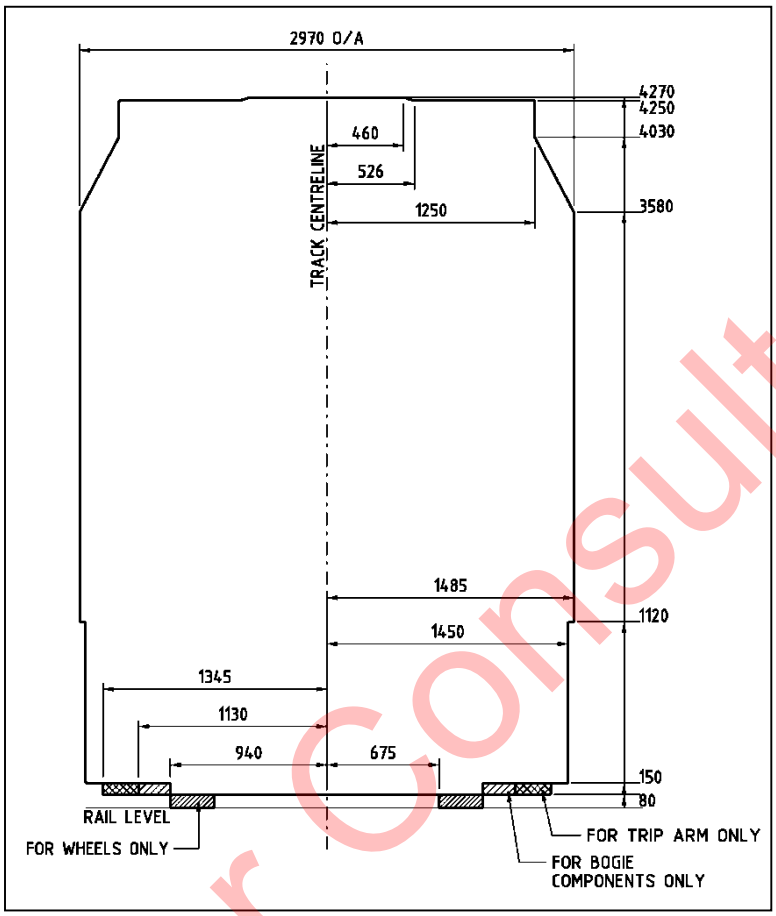


Figure A 15 - Static rolling stock outline dimensions for RISSB reference vehicle 8.

RISSB Reference Vehicle 8	Lateral Translation +/- (mm)	Body Roll		Bounce (Upwards Only) (mm)	Wheel Clearance +/- (mm)
		Angle +/- (degrees)	Point of Rotation ARL (mm)		
ARTC CZ	40	2.0	610	50	20

Table A 8 - Kinematic outline translations for RISSB reference vehicle 8.

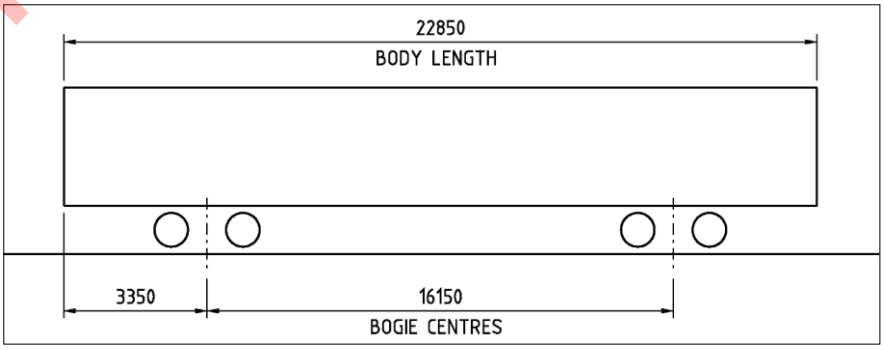


Figure A 16 - Swept outline vehicle dimensions for RISSB reference vehicle 8.

A.9 RISSB Reference Vehicle 9

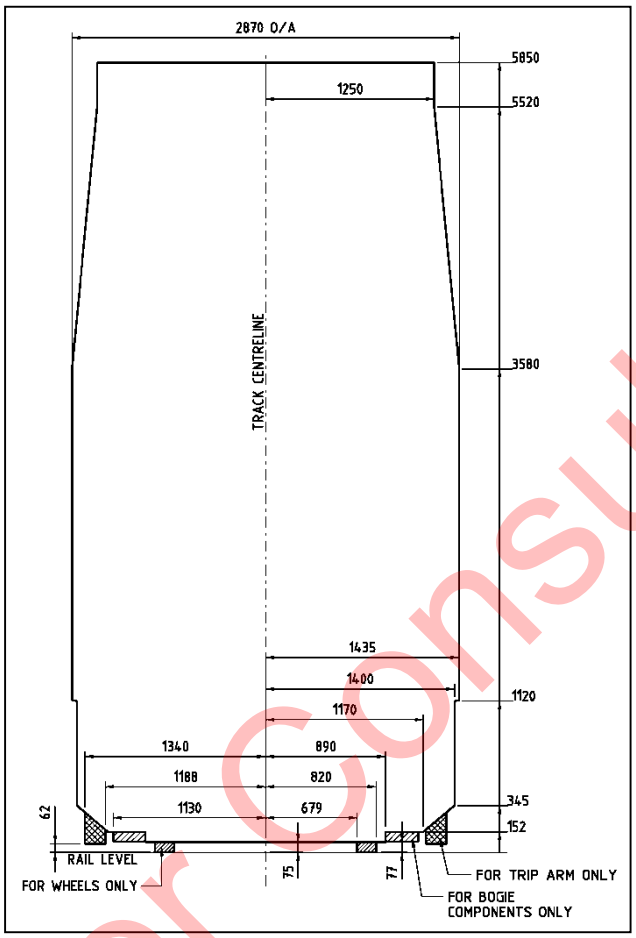


Figure A 17 - Static rolling stock outline dimensions for RISSB reference vehicle 9.

RISSB Reference Vehicle 9	Lateral Translation +/- (mm)	Body Roll		Bounce (Upwards Only) (mm)	Wheel Clearance +/- (mm)
		Angle +/- (degrees)	Point of Rotation ARL (mm)		
NSW Double Stack Container	60	2.5	440	50	20

Table A 9 - Kinematic outline translations for RISSB reference vehicle 9.

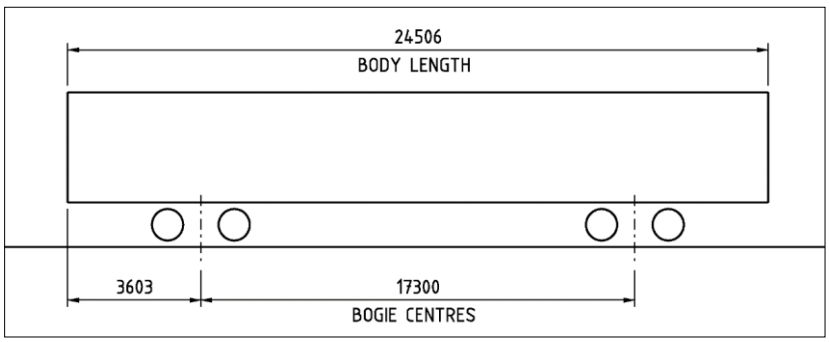


Figure A 18 - Swept outline vehicle dimensions for RISSB reference vehicle 9.

A.10 RISSB Reference Vehicle 10

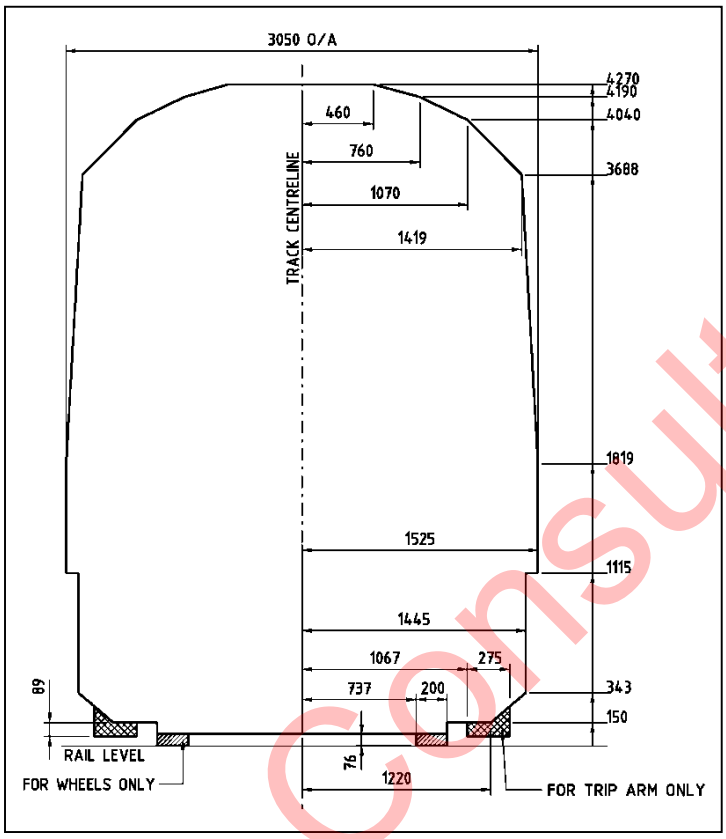


Figure A 19 - Static rolling stock outline dimensions for RISSB reference vehicle 10.

RISSB Reference Vehicle 10	Lateral Translation +/- (mm)	Body Roll		Bounce (Upwards Only) (mm)	Wheel Clearance +/- (mm)
		Angle +/- (degrees)	Point of Rotation ARL (mm)		
Melbourne Broad Gauge Suburban Car	45	2.0	600	50	18

Table A 10 - Kinematic outline translations for RISSB reference vehicle 10.

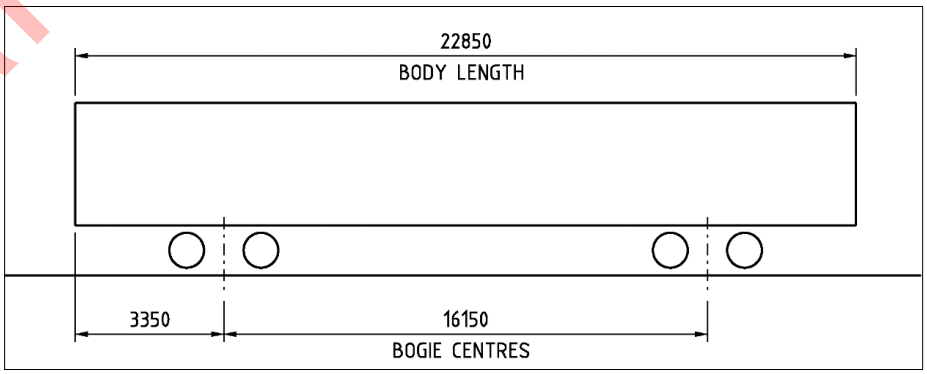


Figure A 20 - Swept outline vehicle dimensions for RISSB reference vehicle 10.

A.11 RISSB Reference Vehicle 11

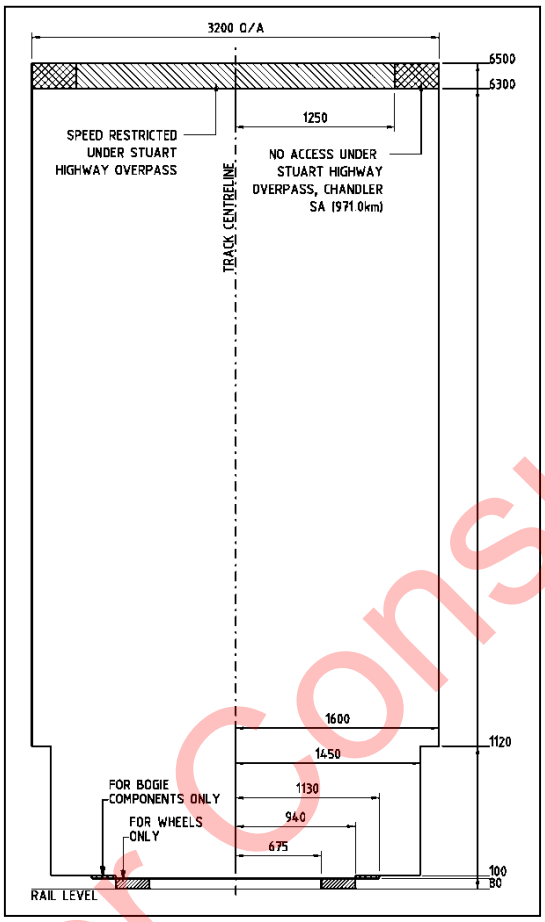


Figure A 21 - Static rolling stock outline dimensions for RISSB reference vehicle 11.

RISSB Reference Vehicle 11	Lateral Translation +/- (mm)	Body Roll		Bounce (Upwards Only) (mm)	Wheel Clearance +/- (mm)
		Angle +/- (degrees)	Point of Rotation ARL (mm)		
Tarcoola to Darwin	40	2.5	440	50	20

Table A 11 - Kinematic outline translations for RISSB reference vehicle 11.

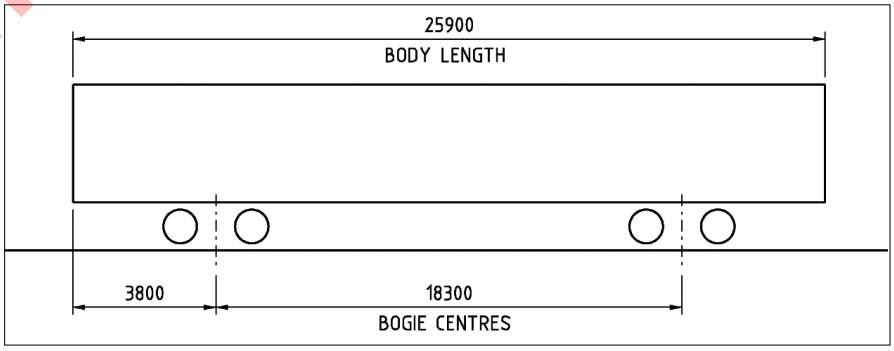


Figure A 22 - Swept outline vehicle dimensions for RISSB reference vehicle 11.

A.12 RISSB Reference Vehicle 12

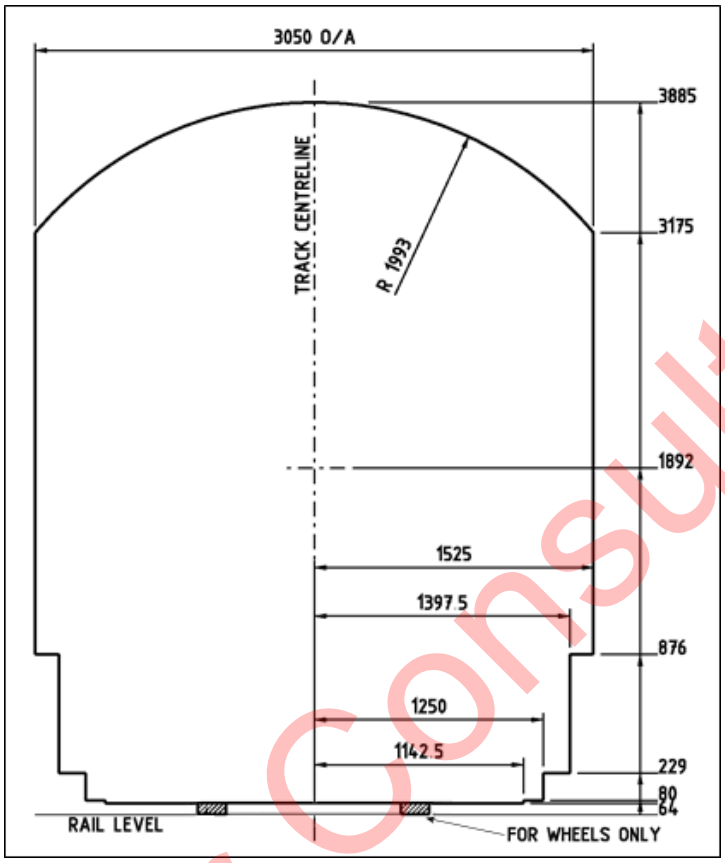


Figure A 23 - Static rolling stock outline dimensions for RISSB reference vehicle 12.

RISSB Reference Vehicle 12	Lateral Translation +/- (mm)	Body Roll		Bounce (Upwards Only) (mm)	Wheel Clearance +/- (mm)
		Angle +/- (degrees)	Point of Rotation ARL (mm)		
Tasmania	40	2.5	440	50	(?)

Table A 12 - Kinematic outline translations for RISSB reference vehicle 12.

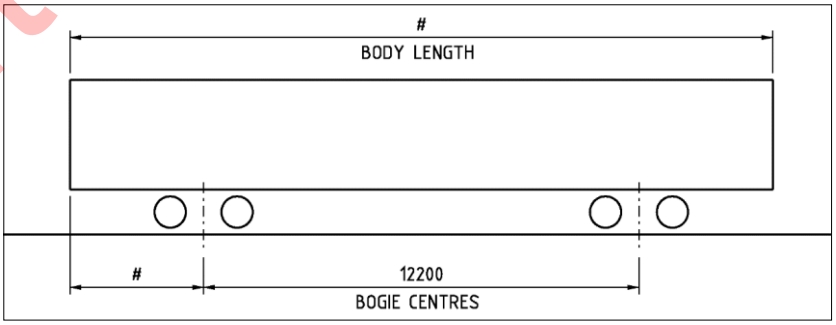


Figure A 24 - Swept outline vehicle dimensions for RISSB reference vehicle 12.[35]

[35] Note that dimensions for body overall length and body length beyond bogie pivots are not defined.

A.13 RISSB Reference Vehicle 13

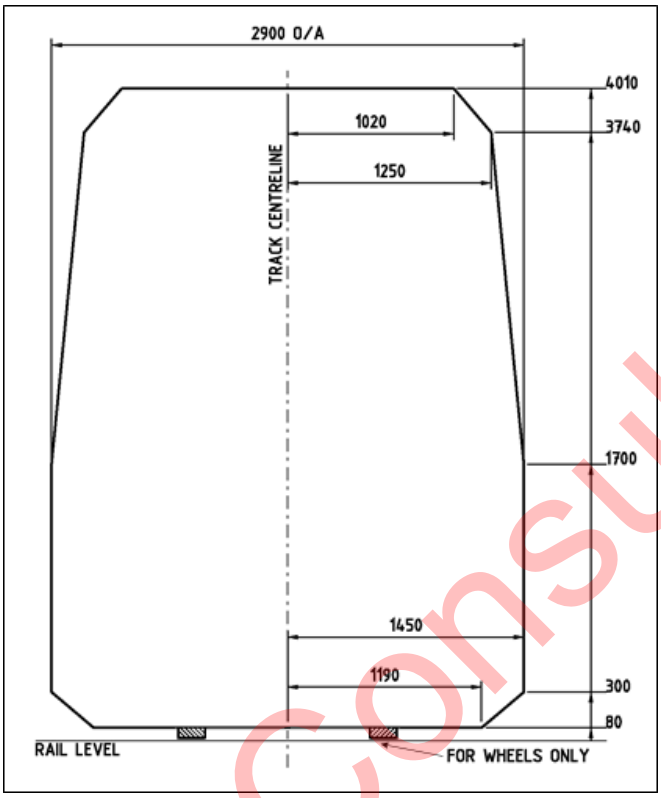


Figure A 25 - Static rolling stock outline dimensions for RISSB reference vehicle 13.

RISSB Reference Vehicle 13	Lateral Translation +/- (mm)	Body Roll		Bounce (Upwards Only) (mm)	Wheel Clearance +/- (mm)
		Angle +/- (degrees)	Point of Rotation ARL (mm)		
Perth Narrow Gauge Railcar	51[36]	3.5	1,000	50	15

Table A 13 - Kinematic outline translations for RISSB reference vehicle 13.

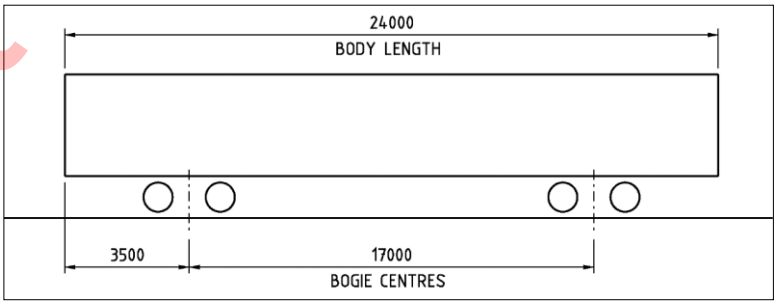


Figure A 26 - Swept outline vehicle dimensions for RISSB reference vehicle 13.

[36] 51mm Lateral Translation for Perth Narrow Gauge Railcar excludes 10mm allowance for yaw (no other outlines have stated allowances for yaw).

A.14 RISSB Reference Vehicle 14

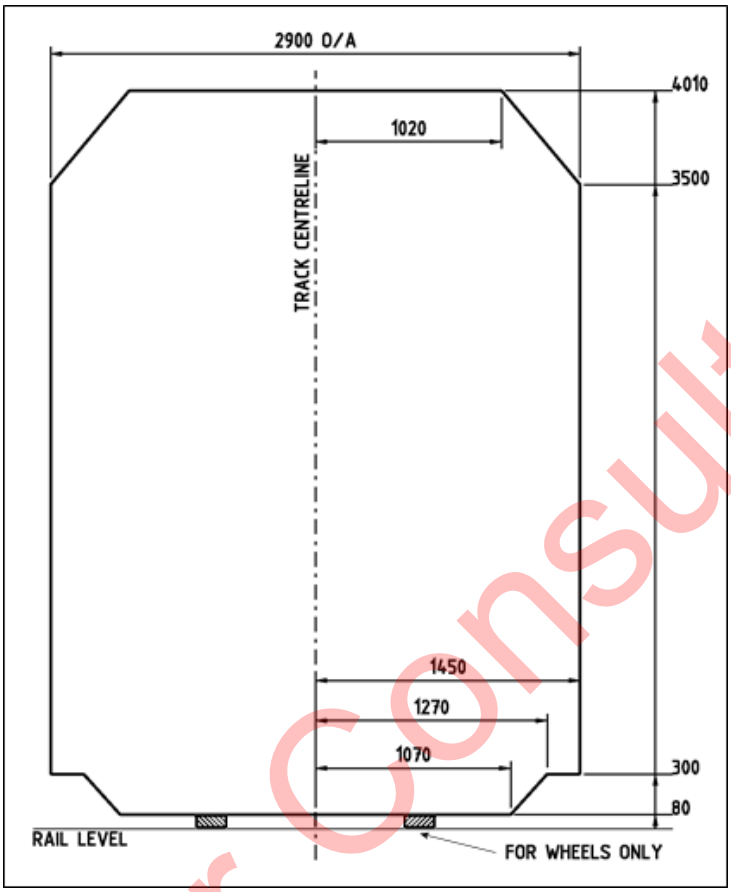


Figure A 27 - Static rolling stock outline dimensions for RISSB reference vehicle 14.

RISSB Reference Vehicle 14	Lateral Translation +/- (mm)	Body Roll		Bounce (Upwards Only) (mm)	Wheel Clearance +/- (mm)
		Angle +/- (degrees)	Point of Rotation ARL (mm)		
Perth Narrow Gauge General	20	1.0	610	25	20

Table A 14 - Kinematic outline translations for RISSB reference vehicle 14.

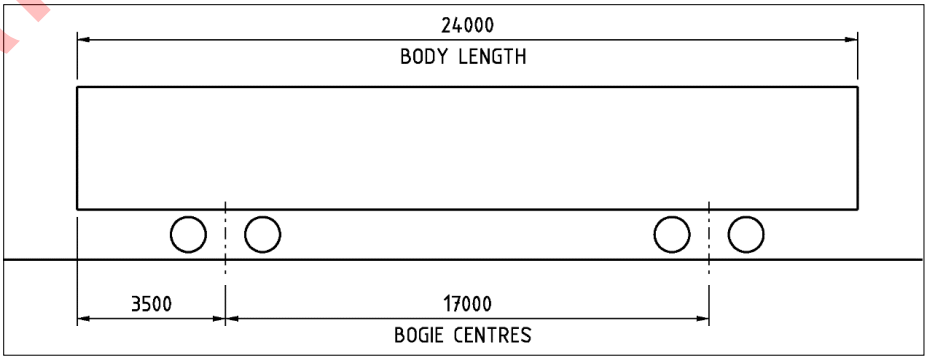


Figure A 28 - Swept outline vehicle dimensions for RISSB reference vehicle 14.

A.15 RISSB Reference Vehicle 15

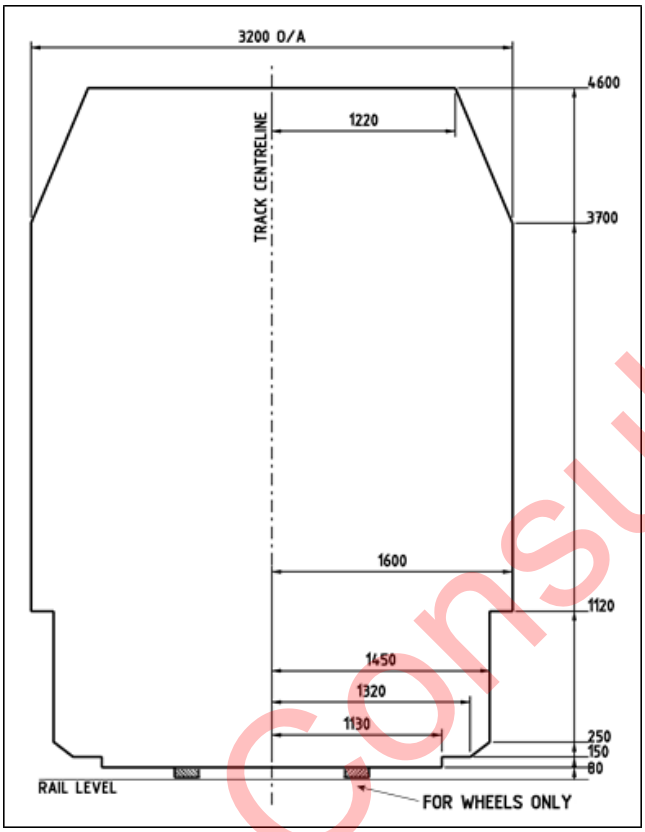


Figure A 29 - Static rolling stock outline dimensions for RISSB reference vehicle 15.

RISSB Reference Vehicle 15	Lateral Translation +/- (mm)	Body Roll		Bounce (Upwards Only) (mm)	Wheel Clearance +/- (mm)
		Angle +/- (degrees)	Point of Rotation ARL (mm)		
WA Dual & Standard Gauge East Perth - Midland	40	2.5	440	50	20

Table A 15 - Kinematic outline translations for RISSB reference vehicle 15.

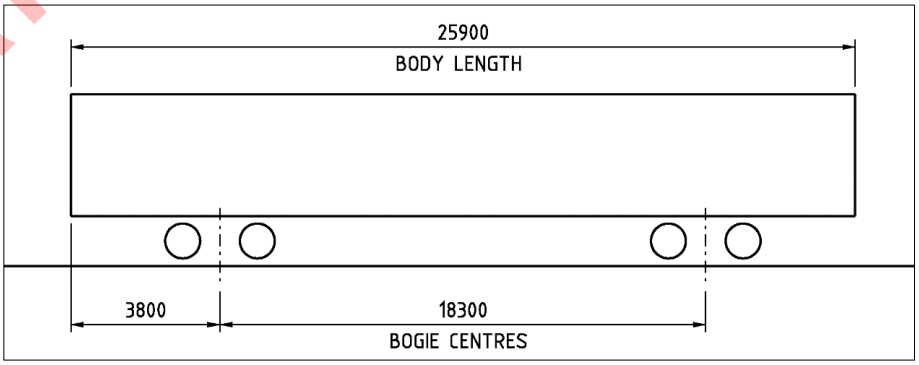


Figure A 30 - Swept outline vehicle dimensions for RISSB reference vehicle 15.

A.16 RISSB Reference Vehicle 16

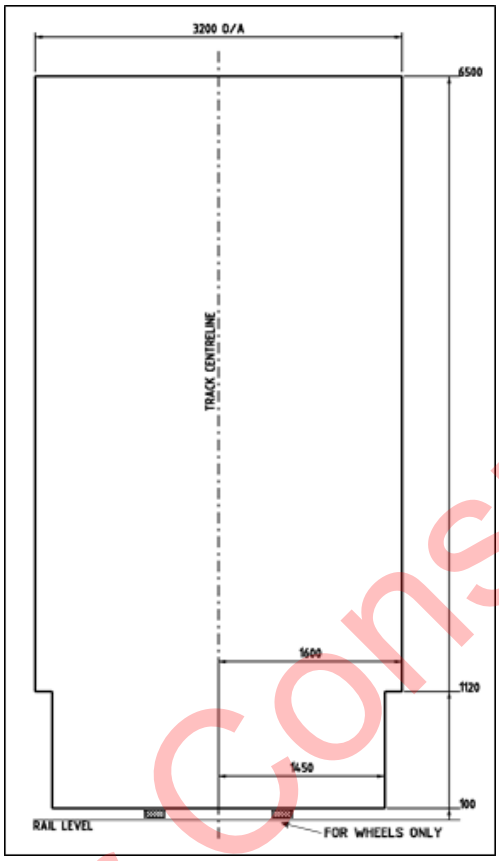


Figure A 31 - Static rolling stock outline dimensions for RISSB reference vehicle 16.

RISSB Reference Vehicle 16	Lateral Translation +/- (mm)	Body Roll		Bounce (Upwards Only) (mm)	Wheel Clearance +/- (mm)
		Angle +/- (degrees)	Point of Rotation ARL (mm)		
WA Dual & Standard Gauge North Fremantle - Robb Jetty	40	2.5	440	50	20

Table A 16 - Kinematic outline translations for RISSB reference vehicle 16.

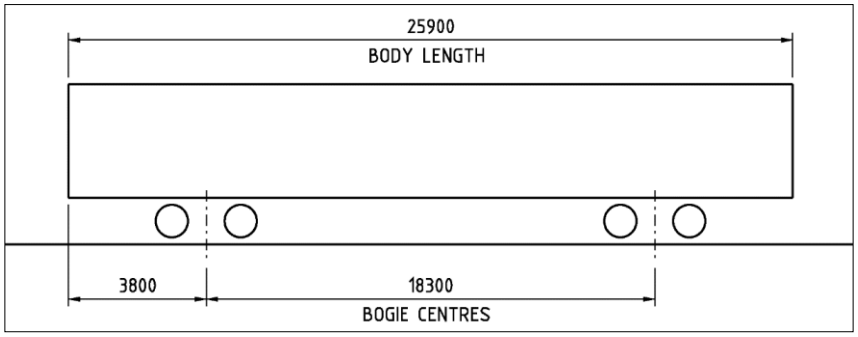


Figure A 32 - Swept outline vehicle dimensions for RISSB reference vehicle 16.

A.17 RISSB Reference Vehicle 17

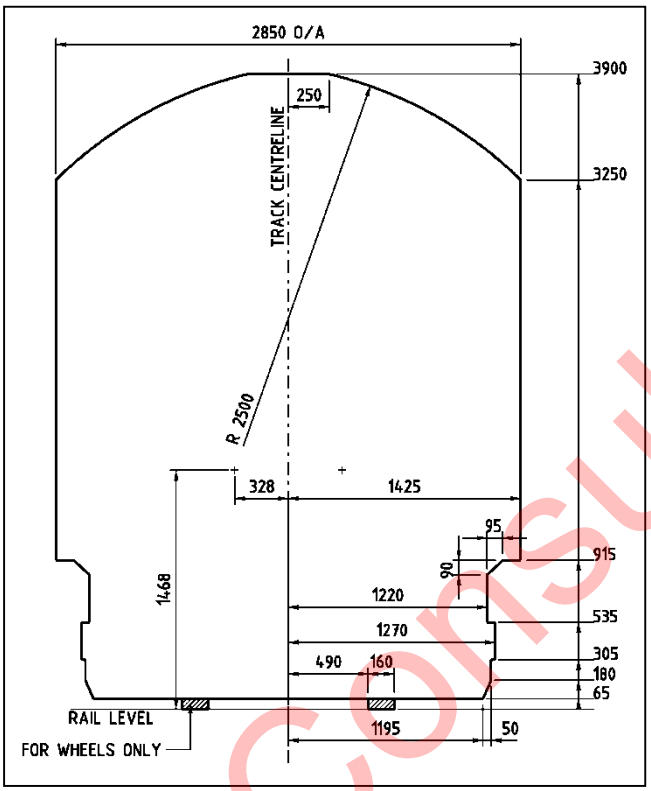


Figure A 33 - Static rolling stock outline dimensions for RISSB reference vehicle 17.

RISSB Reference Vehicle 17	Lateral Translation +/- (mm)	Body Roll		Bounce (Upwards Only) (mm)	Wheel Clearance +/- (mm)
		Angle +/- (degrees)	Point of Rotation ARL (mm)		
Qld Non-Electric Rolling stock	43	1.25[37]	1100	50 / 25[38]	11

Table A 17 - Kinematic outline translations for RISSB reference vehicle 17.

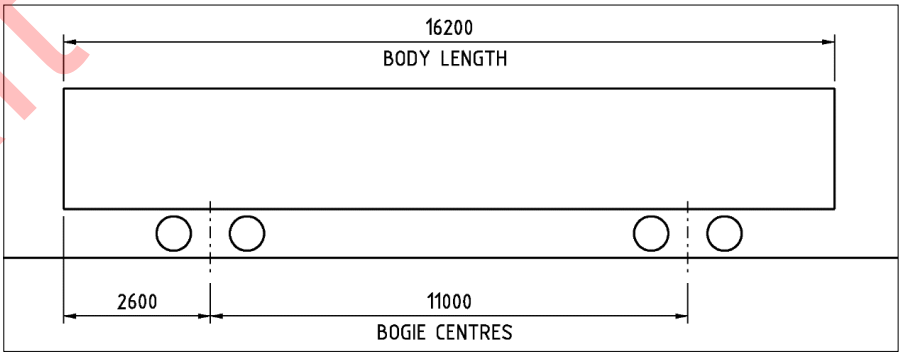


Figure A 34 - Swept outline vehicle dimensions for RISSB reference vehicle 17.

[37] +/-1.25o of body roll displacement is applied to all points above the point of rotation only.
[38] Bounce is 50mm for civil infrastructure clearance and 25mm for electrical infrastructure clearance.

A.18 RISSB Reference Vehicle 18

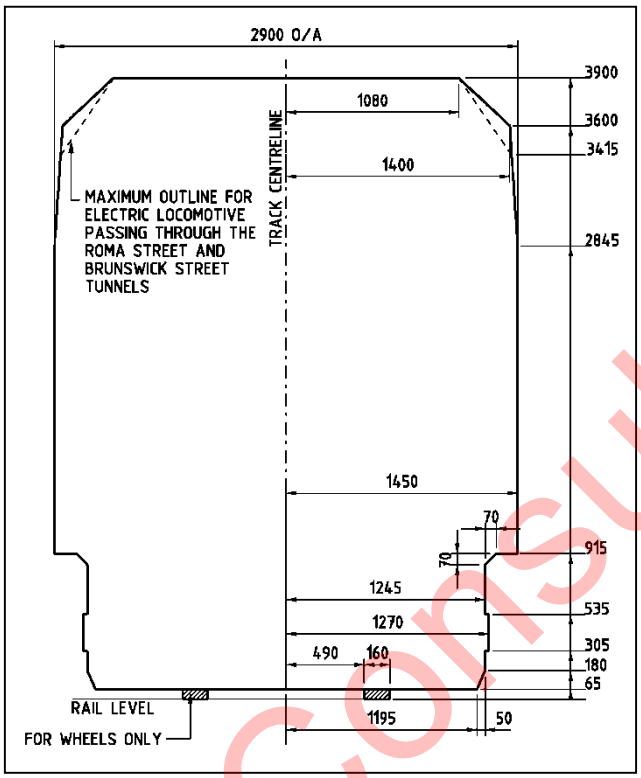


Figure A 35 - Static rolling stock outline dimensions for RISSB reference vehicle 18.

RISSB Reference Vehicle 18	Lateral Translation +/- (mm)	Body Roll		Bounce (Upwards Only) (mm)	Wheel Clearance +/- (mm)
		Angle +/- (degrees)	Point of Rotation ARL (mm)		
Qld Electric Locomotive	43	1.25[39]	1100	50 / 25[40]	11

Table A 18 - Kinematic outline translations for RISSB reference vehicle 18.

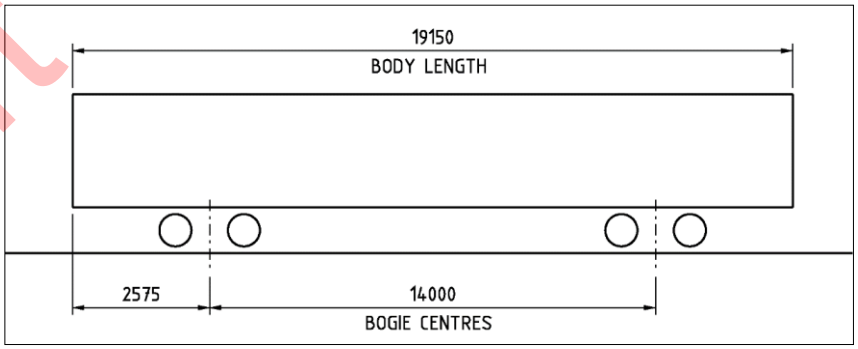


Figure A 36 - Swept outline vehicle dimensions for RISSB reference vehicle 18.

[39] +/-1.25o of body roll displacement is applied to all points above the point of rotation only.
[40] Bounce is 50mm for civil infrastructure clearance and 25mm for electrical infrastructure clearance.

A.19 RISSB Reference Vehicle 19

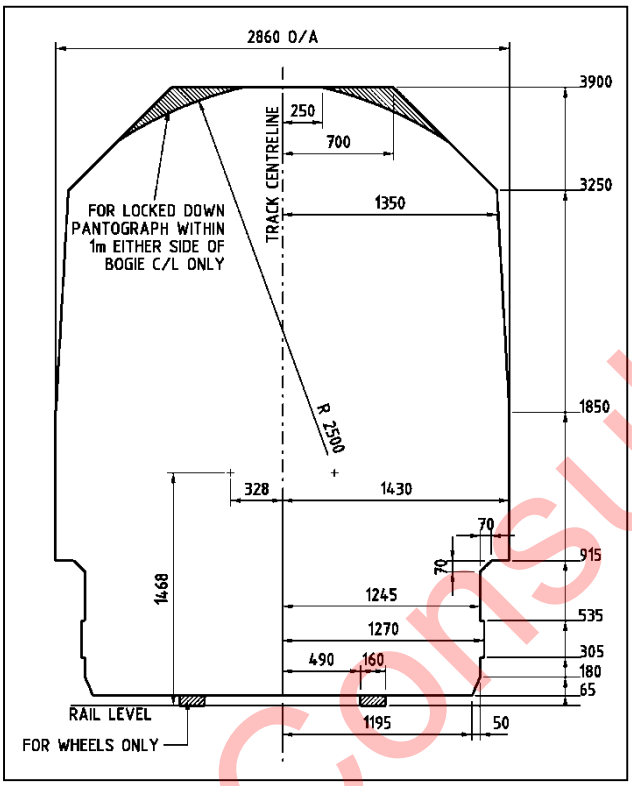


Figure A 37 - Static rolling stock outline dimensions for RISSB reference vehicle 19.

RISSB Reference Vehicle 19	Lateral Translation +/- (mm)	Body Roll		Bounce (Upwards Only) (mm)	Wheel Clearance +/- (mm)
		Angle +/- (degrees)	Point of Rotation ARL (mm)		
Qld Electric Multiple Unit	43	1.25[41]	1100	50 / 25[42]	11

Table A 19 - Kinematic outline translations for RISSB reference vehicle 19.

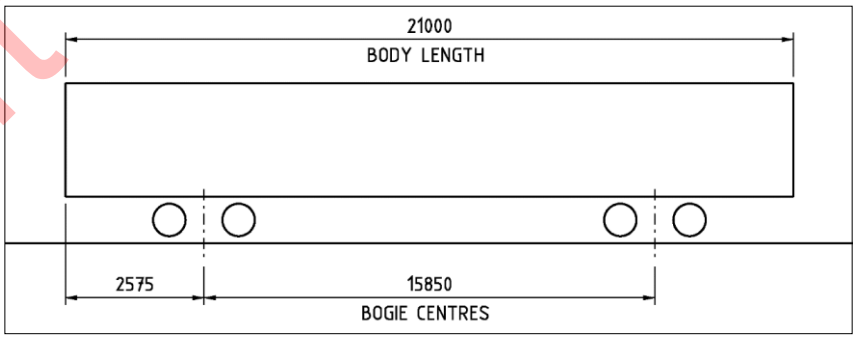


Figure A 38 - Swept outline vehicle dimensions for RISSB reference vehicle 19.

[41] +/-1.25o of body roll displacement is applied to all points above the point of rotation only.
[42] Bounce is 50mm for civil infrastructure clearance and 25mm for electrical infrastructure clearance.

A.20 RISSB Reference Vehicle 20

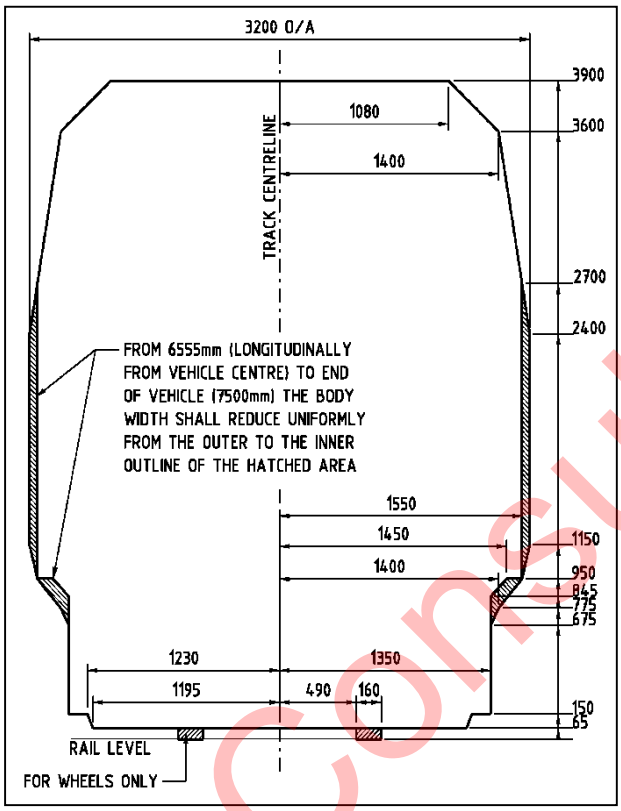


Figure A 39 - Static rolling stock outline dimensions for RISSB reference vehicle 20.

RISSB Reference Vehicle 20	Lateral Translation +/- (mm)	Body Roll		Bounce (Upwards Only) (mm)	Wheel Clearance +/- (mm)
		Angle +/- (degrees)	Point of Rotation ARL (mm)		
Qld Central Coal Network	40	2.0[43]	610	50 / 25[44]	11

Table A 20 - Kinematic outline translations for RISSB reference vehicle 20.

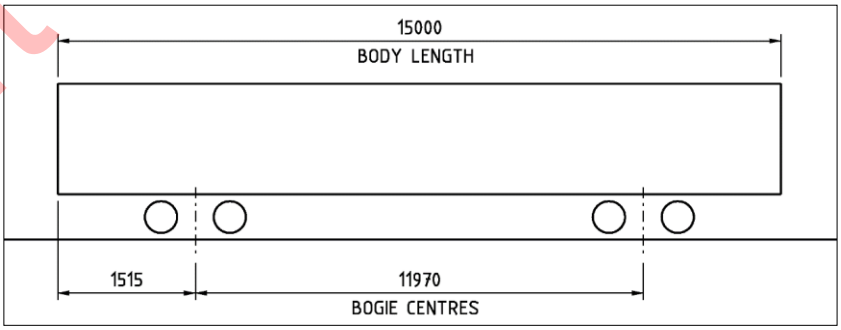


Figure A 40 - Swept outline vehicle dimensions for RISSB reference vehicle 20.

[43] +/-1.25o of body roll displacement is applied to all points above the point of rotation only.
[44] Bounce is 50mm for civil infrastructure clearance and 25mm for electrical infrastructure clearance.

A.21 RISSB Reference Vehicle 21

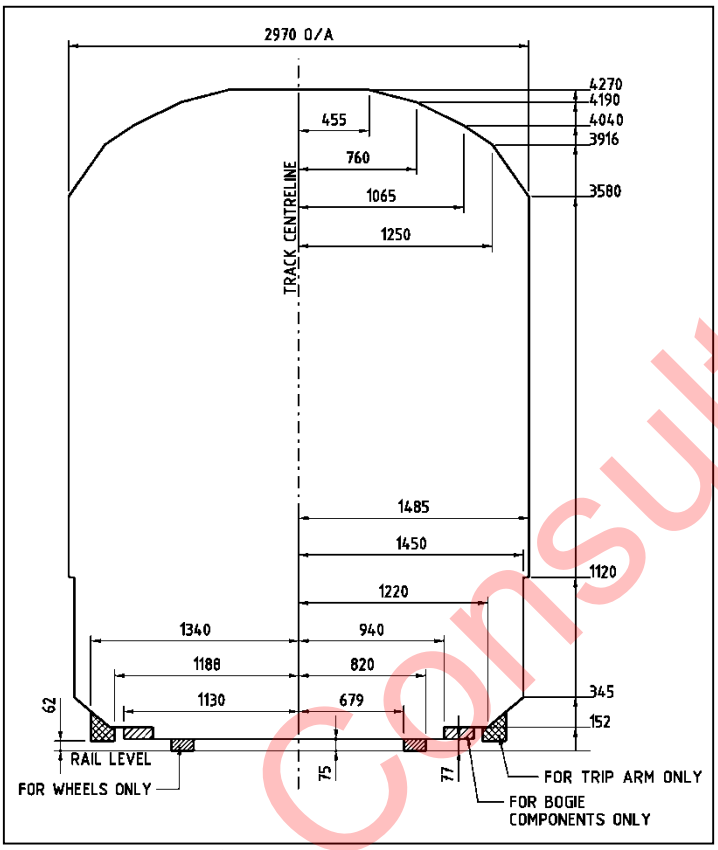


Figure A 41 - Static rolling stock outline dimensions for RISSB reference vehicle 21.

RISSB Reference Vehicle 21	Lateral Translation +/- (mm)	Body Roll		Bounce (Upwards Only) (mm)	Wheel Clearance +/- (mm)
		Angle +/- (degrees)	Point of Rotation ARL (mm)		
NSW Narrow Non-Electric	60	2.0	610	50	20.5

Table A 21 - Kinematic outline translations for RISSB reference vehicle 21.

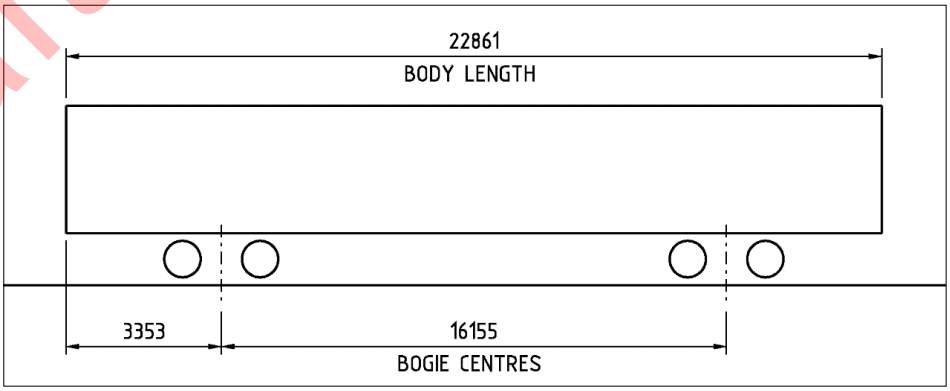


Figure A 42 - Swept outline vehicle dimensions for RISSB reference vehicle 21.

A.22 RISSB Reference Vehicle 22

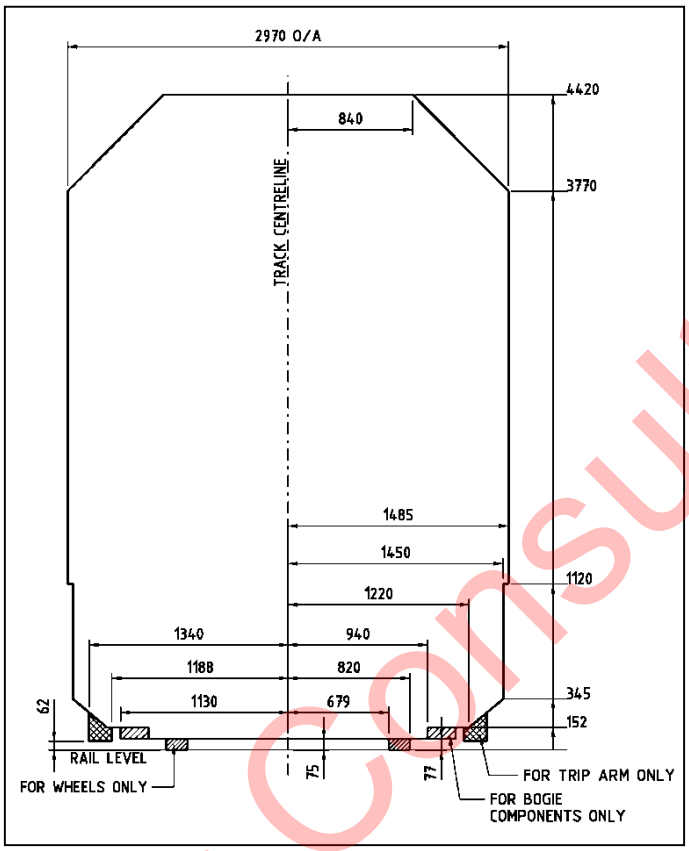


Figure A 43 - Static rolling stock outline dimensions for RISSB reference vehicle 22.

RISSB Reference Vehicle 22	Lateral Translation +/- (mm)	Body Roll		Bounce (Upwards Only) (mm)	Wheel Clearance +/- (mm)
		Angle +/- (degrees)	Point of Rotation ARL (mm)		
NSW Narrow Electric	60	2.0	610	50	20.5

Table A 22 - Kinematic outline translations for RISSB reference vehicle 22.

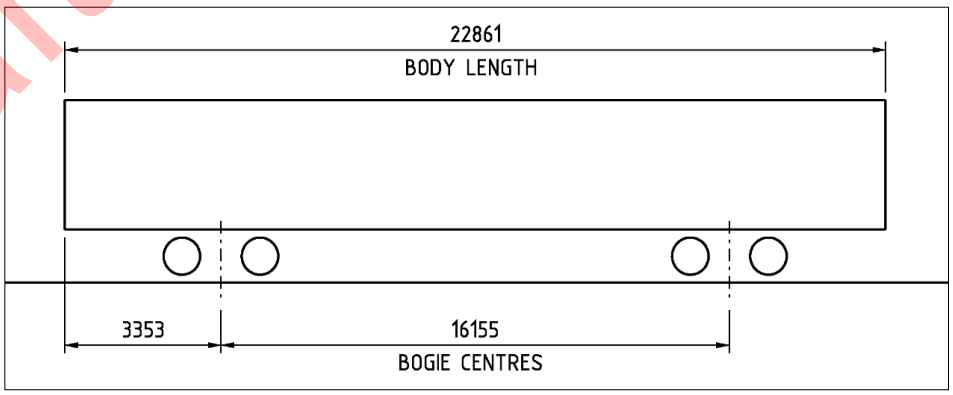


Figure A 44 - Swept outline vehicle dimensions for RISSB reference vehicle 22.

A.23 RISSB Reference Vehicle 23

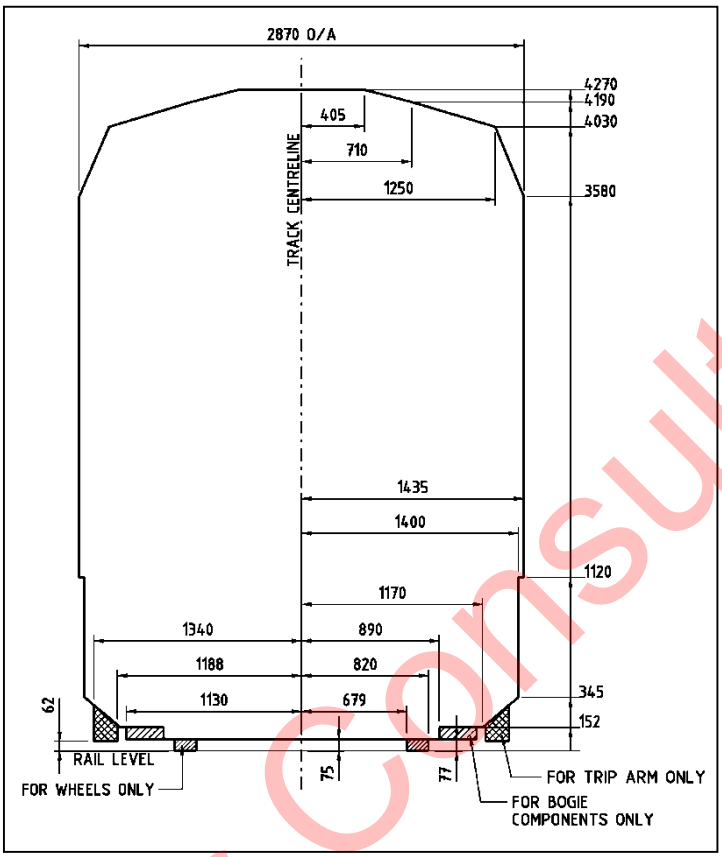


Figure A 45 - Static rolling stock outline dimensions for RISSB reference vehicle 23.

RISSB Reference Vehicle 23	Lateral Translation +/- (mm)	Body Roll		Bounce (Upwards Only) (mm)	Wheel Clearance +/- (mm)
		Angle +/- (degrees)	Point of Rotation ARL (mm)		
NSW Narrow Container	60	2.0	610	50	20.5

Table A 23 - Kinematic outline translations for RISSB reference vehicle 23.

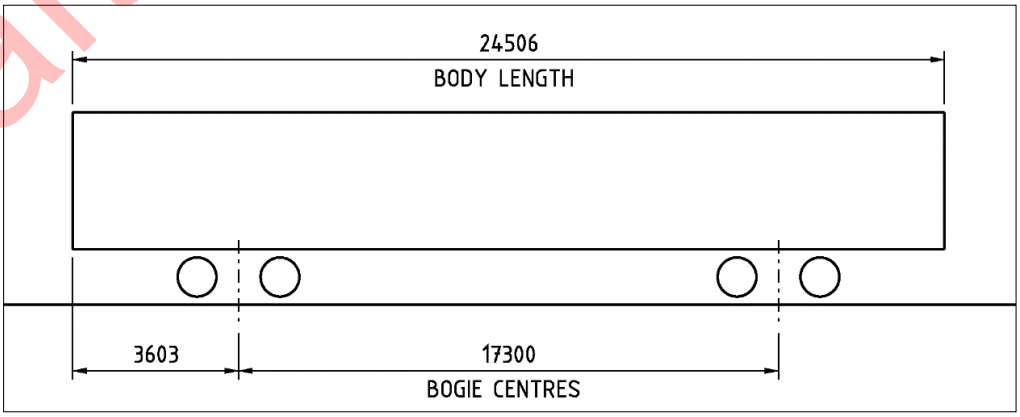


Figure A 46 - Swept outline vehicle dimensions for RISSB reference vehicle 23.

A.24 RISSB Reference Vehicle 24

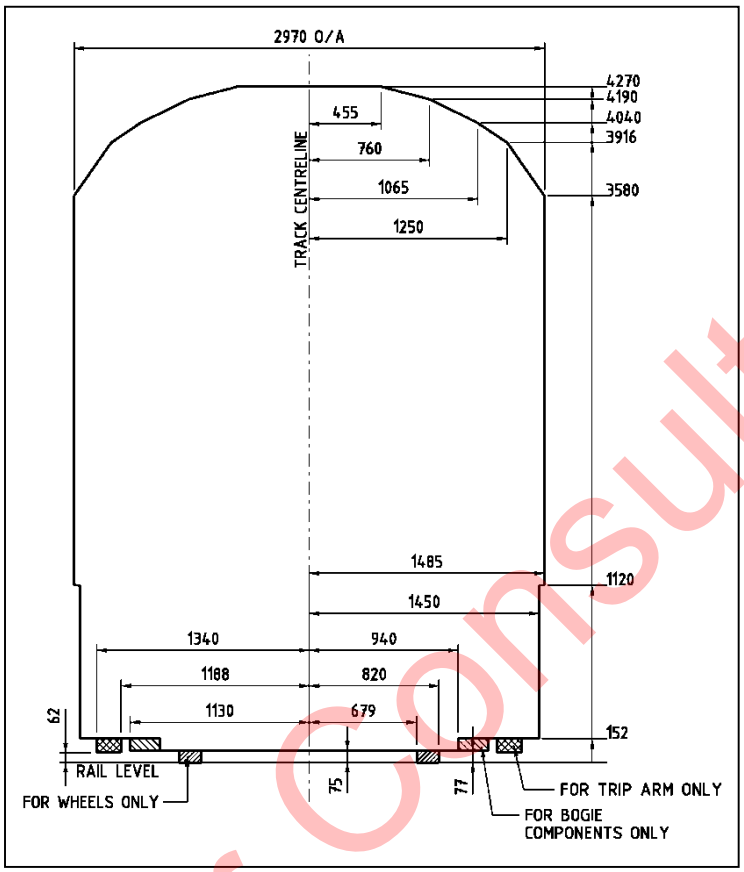


Figure A 47 - Static rolling stock outline dimensions for RISSB reference vehicle 24.

RISSB Reference Vehicle 24	Lateral Translation +/- (mm)	Body Roll		Bounce (Upwards Only) (mm)	Wheel Clearance +/- (mm)
		Angle +/- (degrees)	Point of Rotation ARL (mm)		
NSW Narrow Square	60	2.0	610	50	20.5

Table A 24 - Kinematic outline translations for RISSB reference vehicle 24.

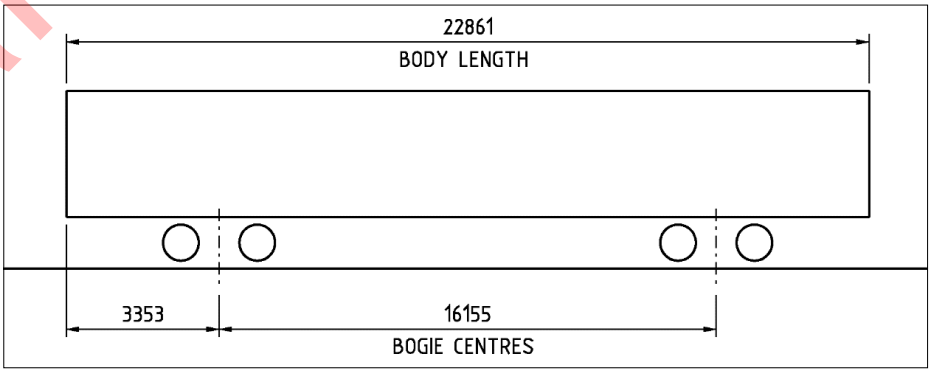


Figure A 48 - Swept outline vehicle dimensions for RISSB reference vehicle 24.

A.25 RISSB Reference Vehicle 25

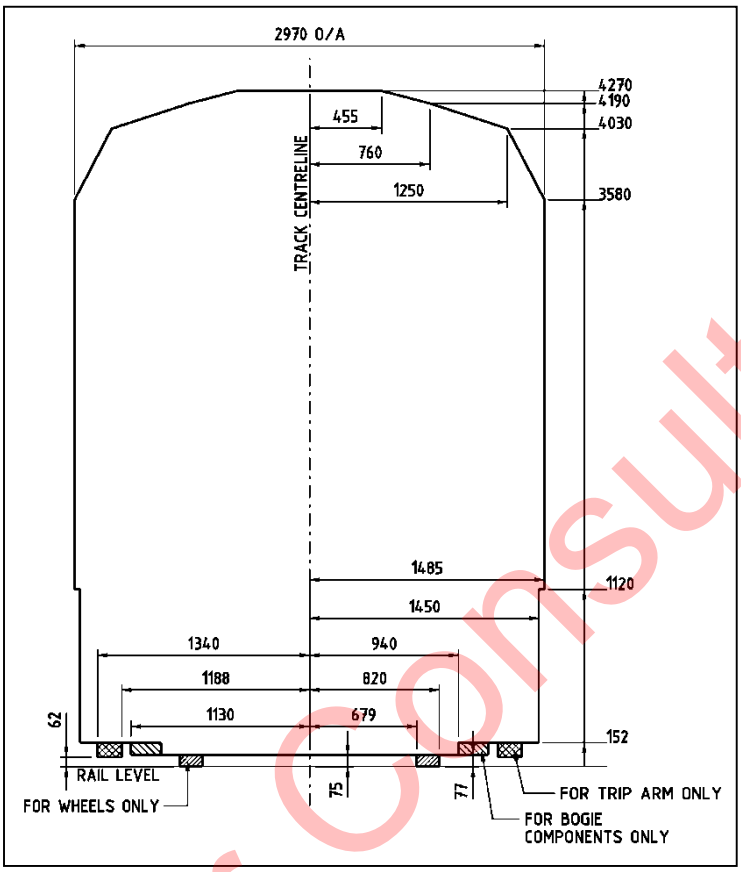


Figure A 49 - Static rolling stock outline dimensions for RISSB reference vehicle 25.

RISSB Reference Vehicle 25	Lateral Translation +/- (mm)	Body Roll		Bounce (Upwards Only) (mm)	Wheel Clearance +/- (mm)
		Angle +/- (degrees)	Point of Rotation ARL (mm)		
NSW Intersystem	60	2.0	610	50	20.5

Table A 25 - Kinematic outline translations for RISSB reference vehicle 25.

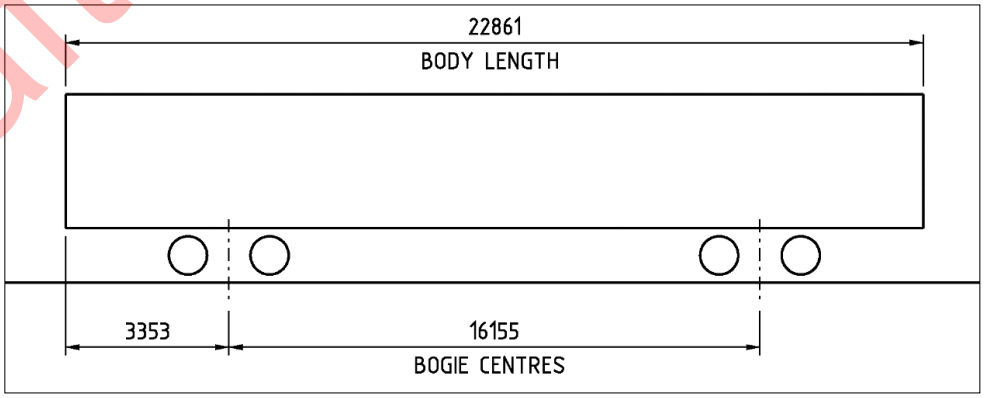


Figure A 50 - Swept outline vehicle dimensions for RISSB reference vehicle 25.

A.26 RISSB Reference Vehicle 26

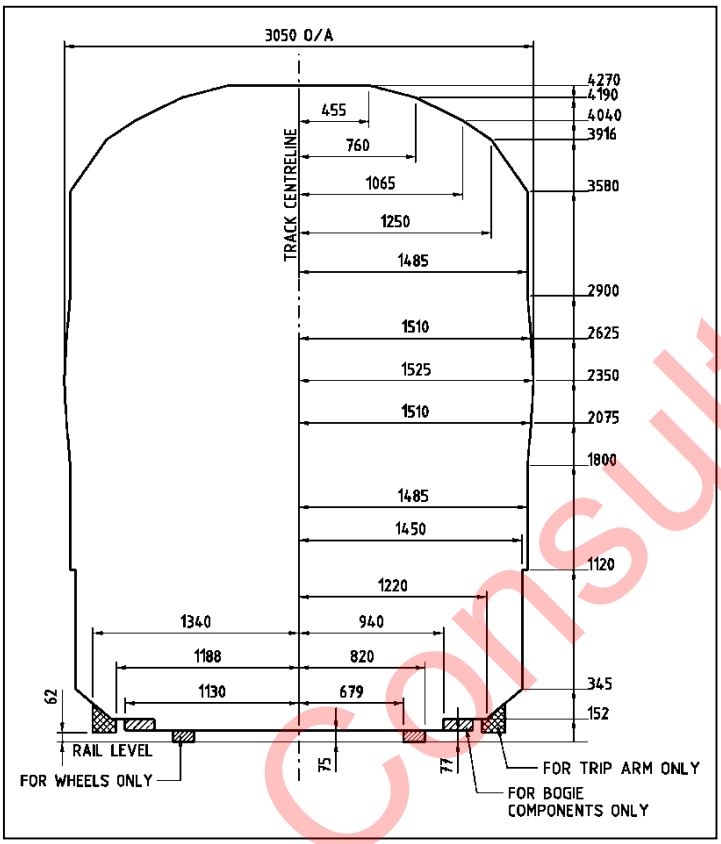


Figure A 51 - Static rolling stock outline dimensions for RISSB reference vehicle 26.

RISSB Reference Vehicle 26	Lateral Translation +/- (mm)	Body Roll		Bounce (Upwards Only) (mm)	Wheel Clearance +/- (mm)
		Angle +/- (degrees)	Point of Rotation ARL (mm)		
NSW Narrow Hopper	60	2.0	610	50	20.5

Table A 26 - Kinematic outline translations for RISSB reference vehicle 26.

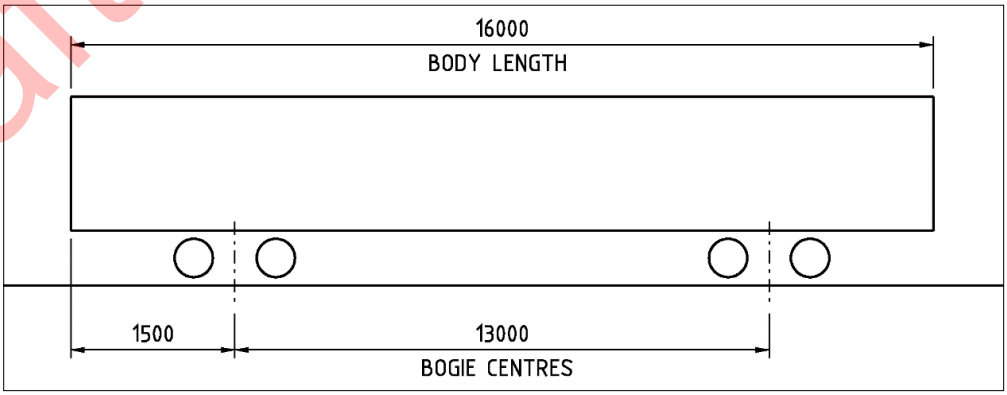


Figure A 52 - Swept outline vehicle dimensions for RISSB reference vehicle 26.

A.27 RISSB Reference Vehicle 27

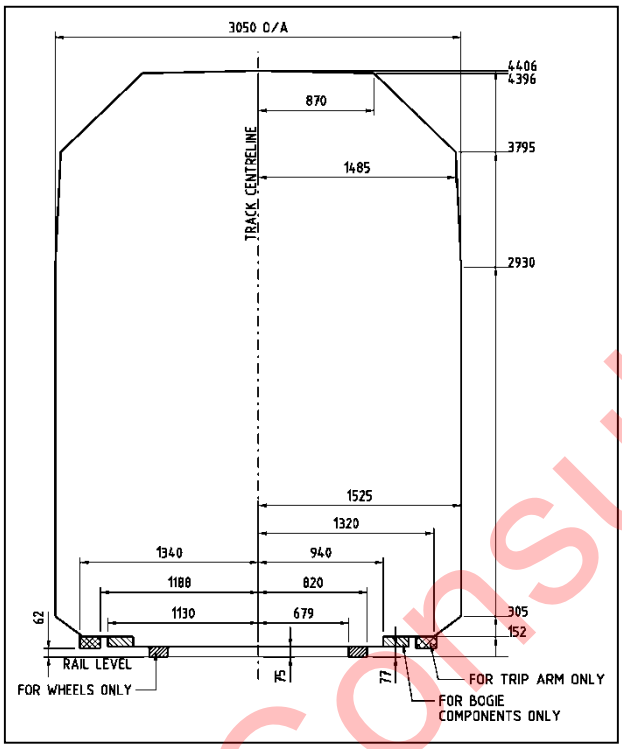


Figure A 53 - Static rolling stock outline dimensions for RISSB reference vehicle 27.[45]

RISSB Reference Vehicle 27	Lateral Translation +/- (mm)	Body Roll		Bounce (Upwards Only) (mm)	Wheel Clearance +/- (mm)
		Angle +/- (degrees)	Point of Rotation ARL (mm)		
NSW Medium Electric	60	2.0	610	50	20.5

Table A 27 - Kinematic outline translations for RISSB reference vehicle 27.

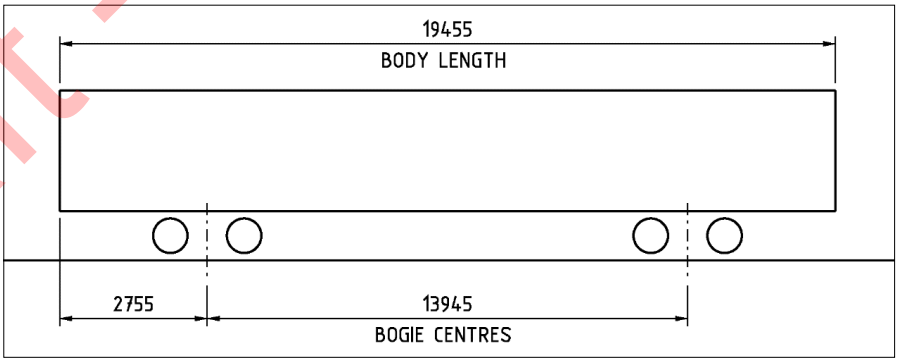


Figure A 54 - Swept outline vehicle dimensions for RISSB reference vehicle 27.

[45] Note that top of roof of this outline is not flat, it has a slight 'point' at the centre. Height of centre of roof is 4406mm above rail level, height at edge of roof section 870mm from centreline is 4396mm above rail level.

A.28 RISSB Reference Vehicle 28

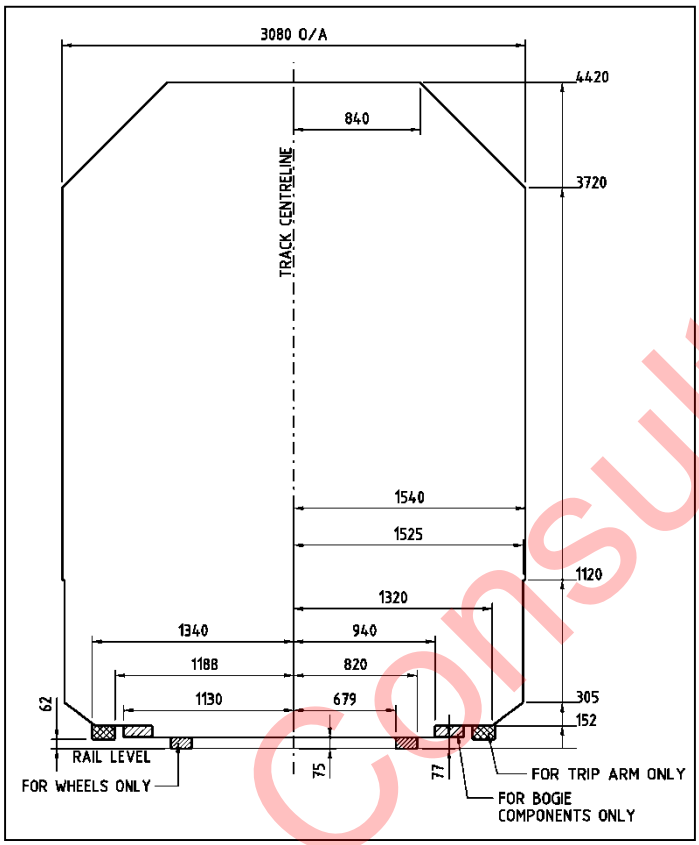


Figure A 55 - Static rolling stock outline dimensions for RISSB reference vehicle 28.

RISSB Reference Vehicle 28	Lateral Translation +/- (mm)	Body Roll		Bounce (Upwards Only) (mm)	Wheel Clearance +/- (mm)
		Angle +/- (degrees)	Point of Rotation ARL (mm)		
NSW Extended Medium	60	2.0	610	50	20.5

Table A 28 - Kinematic outline translations for RISSB reference vehicle 28.

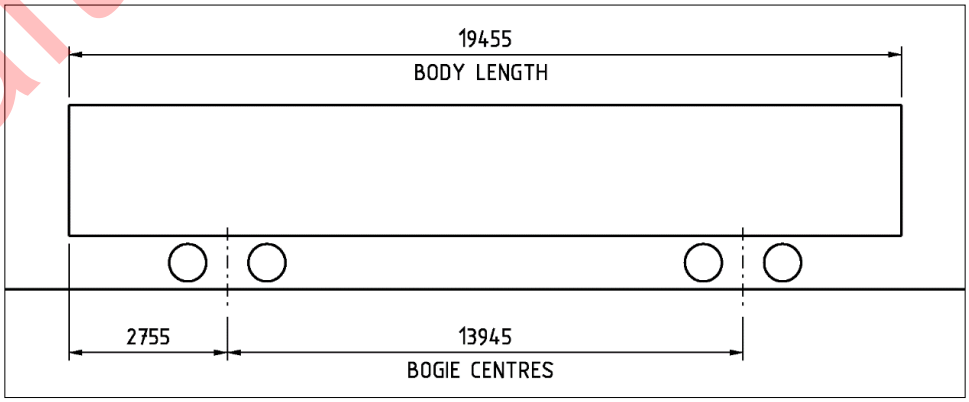


Figure A 56 - Swept outline vehicle dimensions for RISSB reference vehicle 28.

A.29 RISSB Reference Vehicle 29

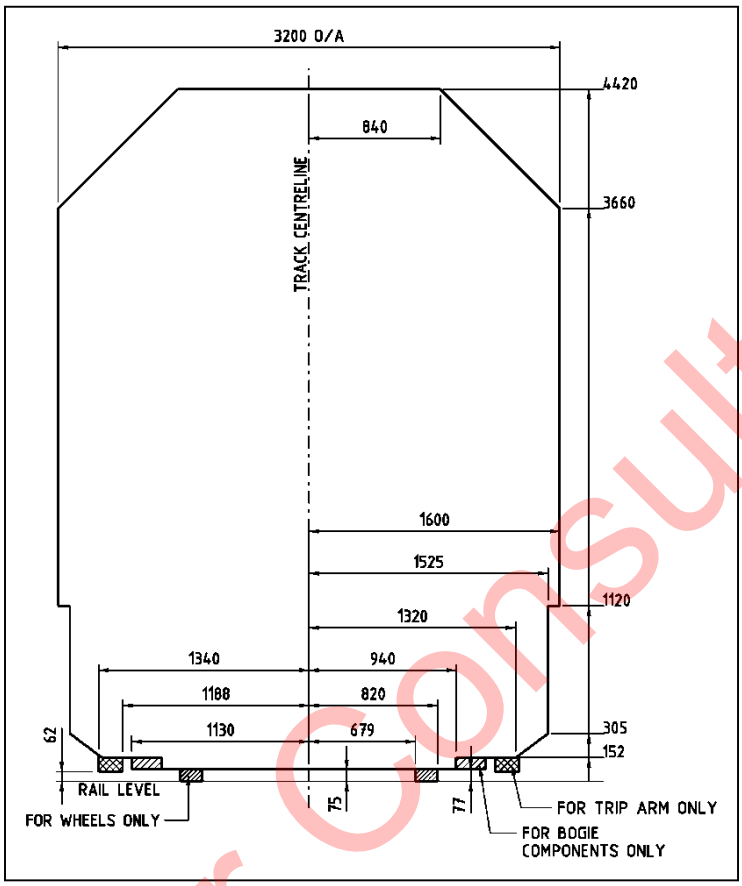


Figure A 57 - Static rolling stock outline dimensions for RISSB reference vehicle 29.

RISSB Reference Vehicle 29	Lateral Translation +/- (mm)	Body Roll		Bounce (Upwards Only) (mm)	Wheel Clearance +/- (mm)
		Angle +/- (degrees)	Point of Rotation ARL (mm)		
NSW Wide Electric	60	2.0	610	50	20.5

Table A 29 - Kinematic outline translations for RISSB reference vehicle 29.

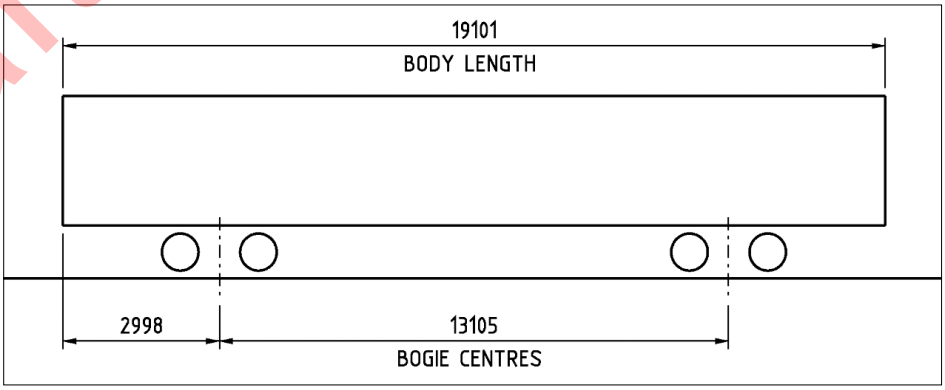


Figure A 58 - Swept outline vehicle dimensions for RISSB reference vehicle 29.

A.30 RISSB Reference Vehicle 30

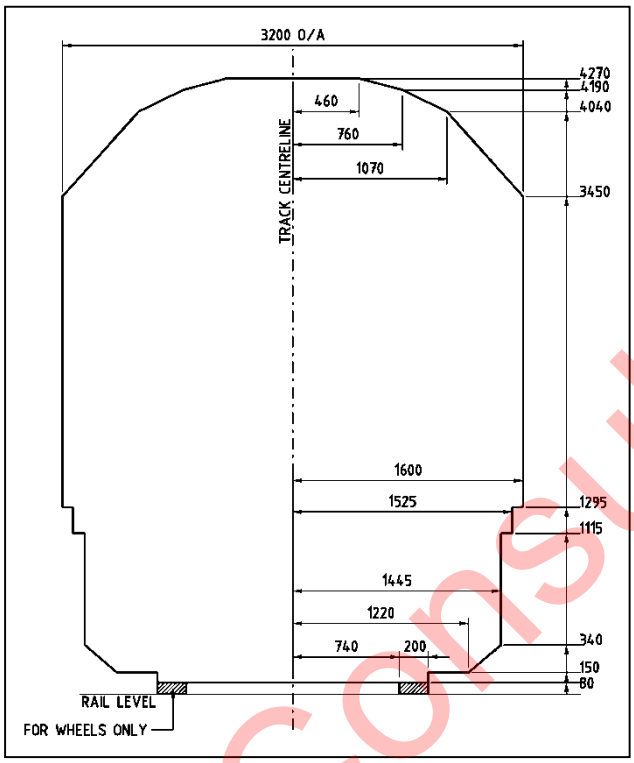


Figure A 59 - Static rolling stock outline dimensions for RISSB reference vehicle 30.

RISSB Reference Vehicle 30	Lateral Translation +/- (mm)	Body Roll		Bounce (Upwards Only) (mm)	Wheel Clearance +/- (mm)
		Angle +/- (degrees)	Point of Rotation ARL (mm)		
Adelaide Broad Gauge Passenger Car	40	2.0 or 2.5	610 or 440	50	20

Table A 30 - Kinematic outline translations for RISSB reference vehicle 30.[46]

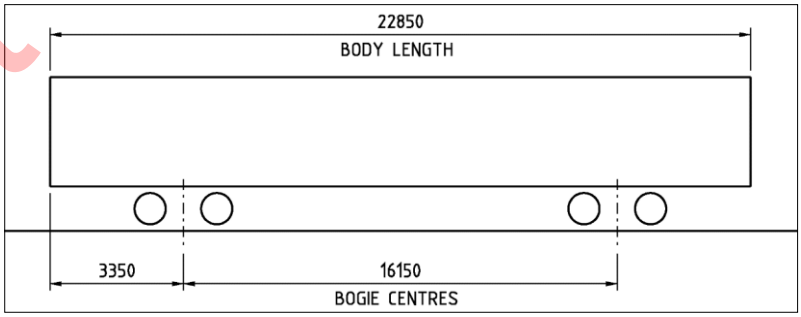


Figure A 60 - Swept outline vehicle dimensions for RISSB reference vehicle 30.

[46] Roll of 2.0° is applied to the body about a roll centre 610mm above rail level and roll of 2.5° is applied to the body about a roll centre 440mm above rail level. For each point around the resulting profile, the worst of each case is taken to produce the kinematic outline.

A.31 RISSB Reference Vehicle 31

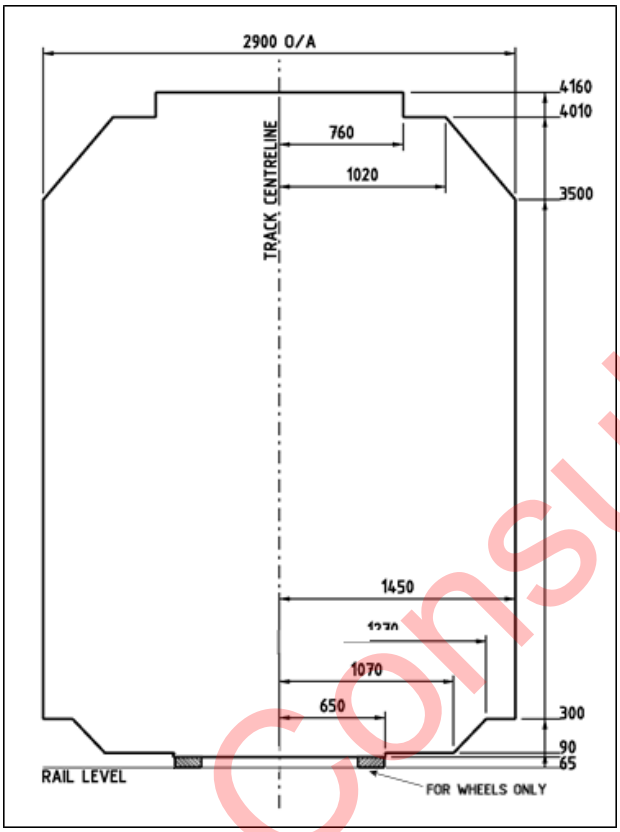


Figure A 61 - Static rolling stock outline dimensions for RISSB reference vehicle 31.

RISSB Reference Vehicle 31	Lateral Translation +/- (mm)	Body Roll		Bounce (Upwards Only) (mm)	Wheel Clearance +/- (mm)
		Angle +/- (degrees)	Point of Rotation ARL (mm)		
WA Narrow Gauge Passenger	75	3.5	1000	50	15

Table A 31 - Kinematic outline translations for RISSB reference vehicle 31.

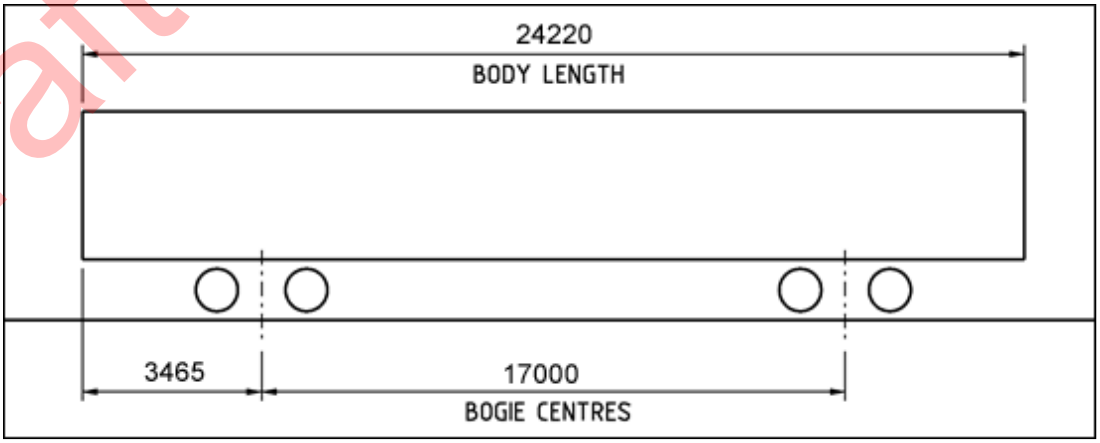


Figure A 62 - Swept outline vehicle dimensions for RISSB reference vehicle 31.

A.32 RISSB Reference Vehicle 32

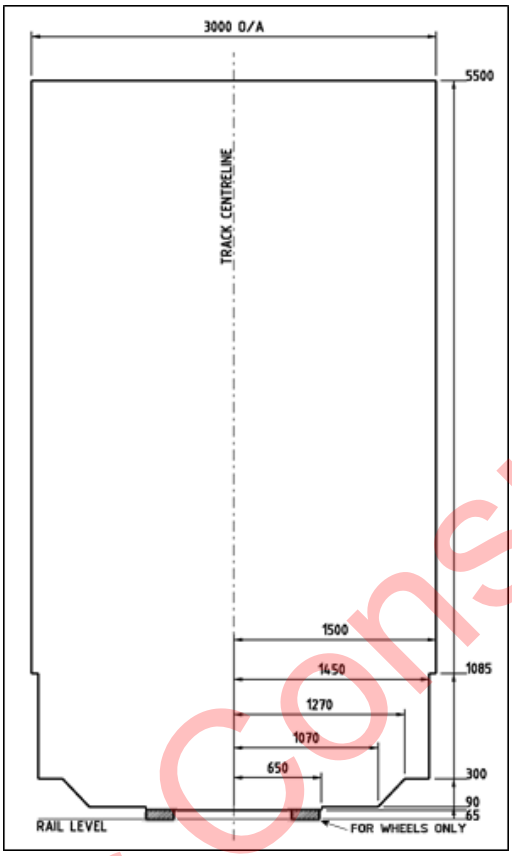


Figure A 63 - Static rolling stock outline dimensions for RISSB reference vehicle 32.

RISSB Reference Vehicle 32	Lateral Translation +/- (mm)	Body Roll		Bounce (Upwards Only) (mm)	Wheel Clearance +/- (mm)
		Angle +/- (degrees)	Point of Rotation ARL (mm)		
WA Narrow Gauge Trailer on Flat Car	40	2.5	440	50	20

Table A 32 - Kinematic outline translations for RISSB reference vehicle 32.

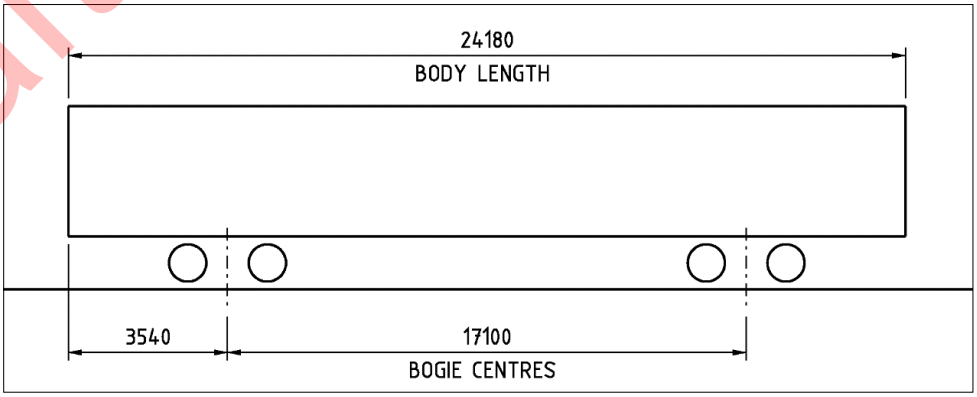


Figure A 64 - Swept outline vehicle dimensions for RISSB reference vehicle 32.

A.33 RISSB Reference Vehicle 33

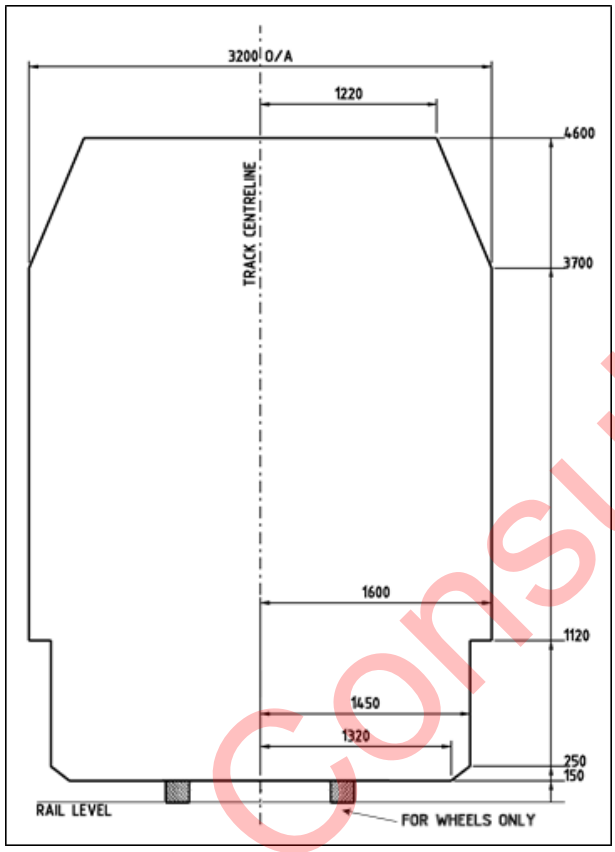


Figure A 65 - Static rolling stock outline dimensions for RISSB reference vehicle 33.

RISSB Reference Vehicle 33	Lateral Translation +/- (mm)	Body Roll		Bounce (Upwards Only) (mm)	Wheel Clearance +/- (mm)
		Angle +/- (degrees)	Point of Rotation ARL (mm)		
WA Standard Gauge General	40	2.5	440	50	20

Table A 33 - Kinematic outline translations for RISSB reference vehicle 33.

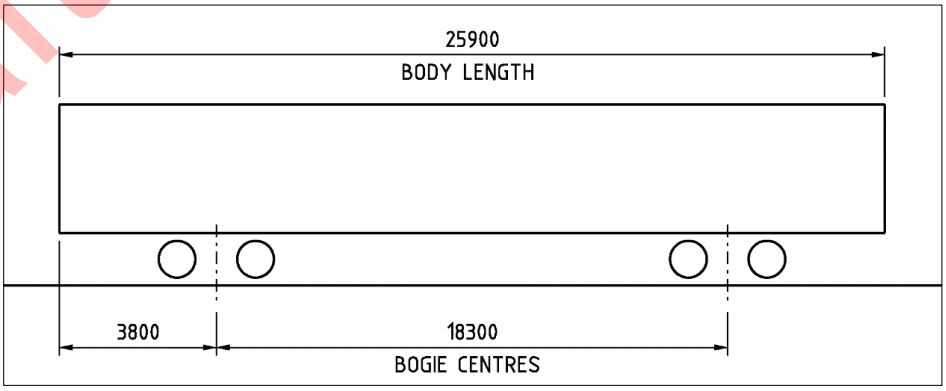


Figure A 66 - Swept outline vehicle dimensions for RISSB reference vehicle 33.

A.34 RISSB Reference Vehicle 34

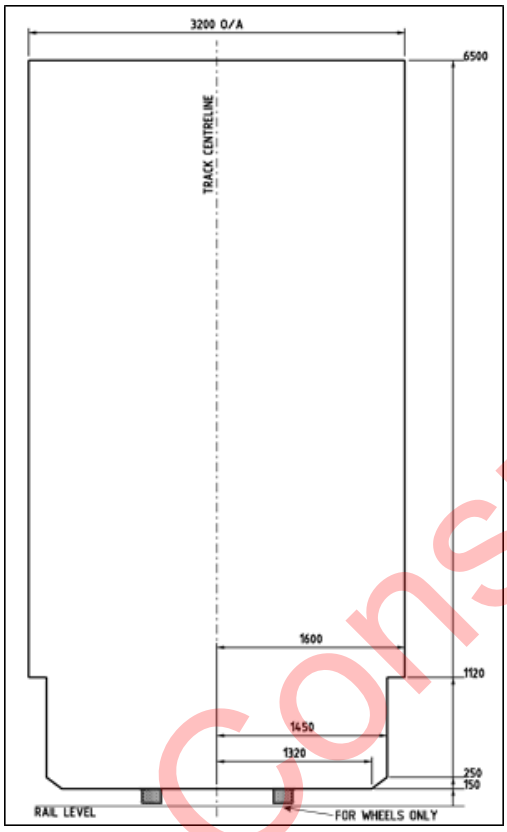


Figure A 67 - Static rolling stock outline dimensions for RISSB reference vehicle 34.

RISSB Reference Vehicle 34	Lateral Translation +/- (mm)	Body Roll		Bounce (Upwards Only) (mm)	Wheel Clearance +/- (mm)
		Angle +/- (degrees)	Point of Rotation ARL (mm)		
WA Standard Gauge Double Stack Container	40	2.5	440	50	20

Table A 34 - Kinematic outline translations for RISSB reference vehicle 34.

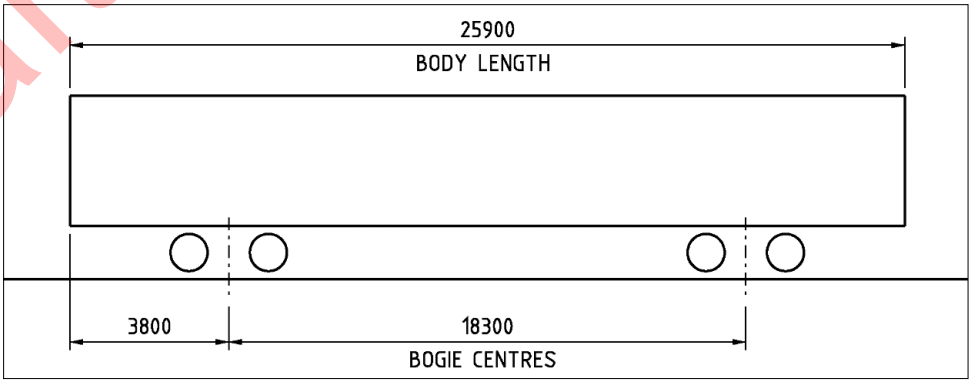


Figure A 68 - Swept outline vehicle dimensions for RISSB reference vehicle 34.

A.35 RISSB Reference Vehicle 35

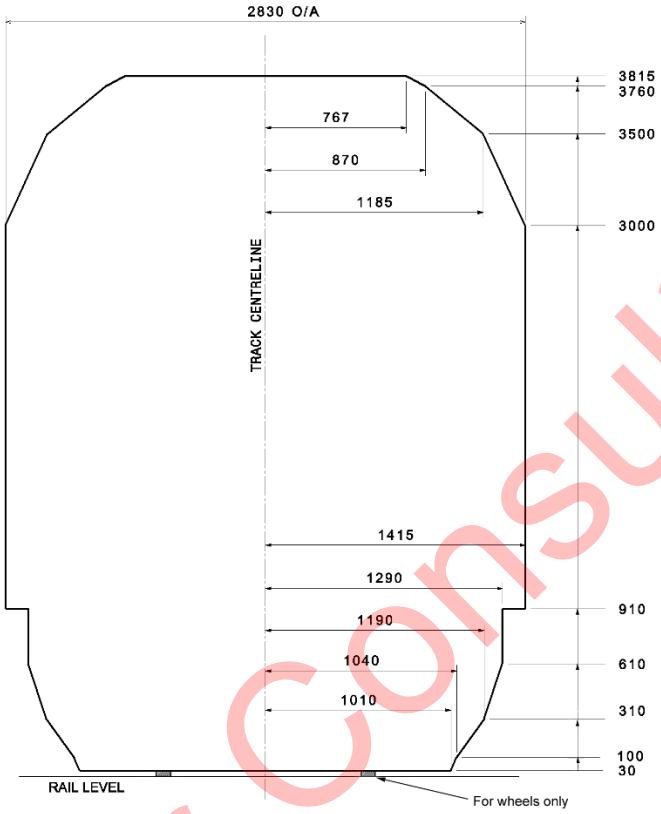


Figure A 69 - Static rolling stock outline dimensions for RISSB reference vehicle 35.

RISSB Reference Vehicle 35	Lateral Translation +/- (mm)	Body Roll		Bounce (Upwards Only) (mm)	Wheel Clearance +/- (mm)
		Angle +/- (degrees)	Point of Rotation ARL (mm)		
KiwiRail[47]	N/A	N/A	N/A	N/A	

Table A 35 - Kinematic outline translations for RISSB reference vehicle 35.

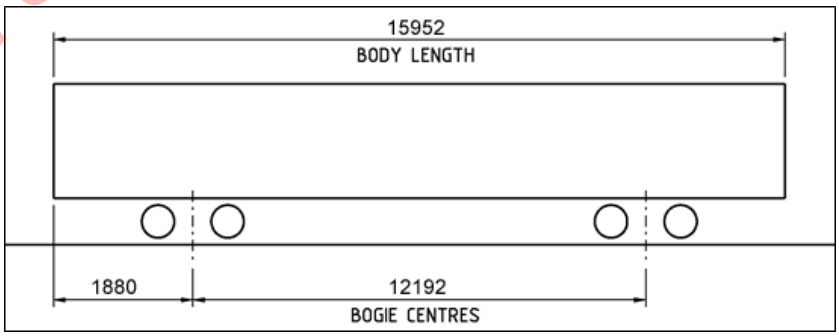


Figure A 70 - Swept outline vehicle dimensions for RISSB reference vehicle 35.

[47] KiwiRail do not currently use kinematic outlines on their network

A.36 RISSB Reference Vehicle 36

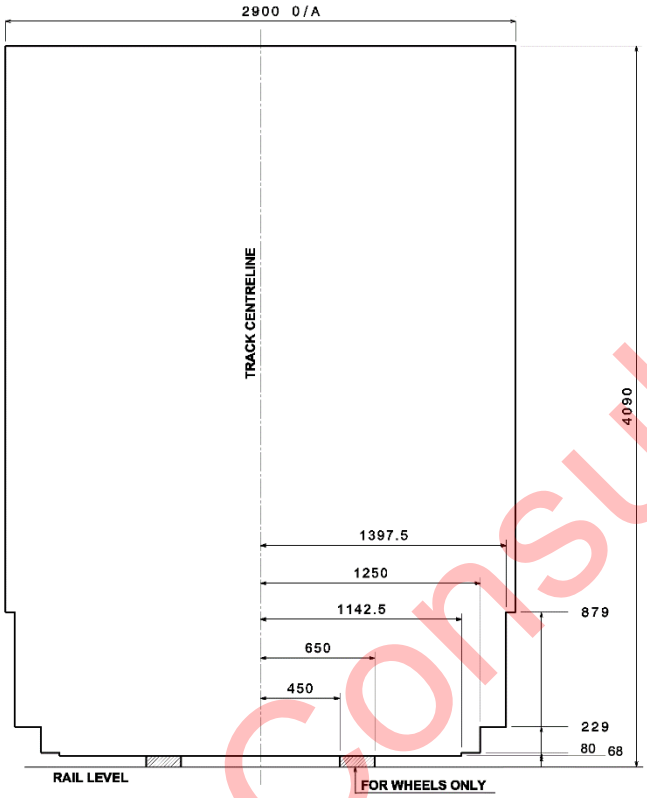


Figure A 71 - Static rolling stock outline dimensions for RISSB reference vehicle 36

RISSB Reference Vehicle 36	Lateral Translation +/- (mm)	Body Roll		Bounce (Upwards Only) (mm)	Wheel Clearance +/- (mm)
		Angle +/- (degrees)	Point of Rotation ARL (mm)		
TasRail – All lines except Melba	50	2	610	50	68

Table A 36 - Kinematic outline translations for RISSB reference vehicle 36

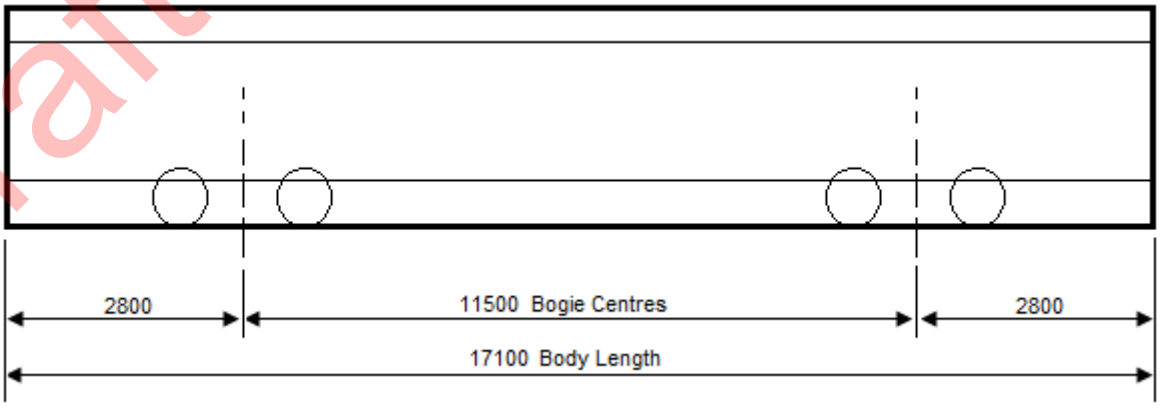


Figure A 72 - Swept outline vehicle dimensions for RISSB reference vehicle 36

A.37 RISSB Reference Vehicle 37

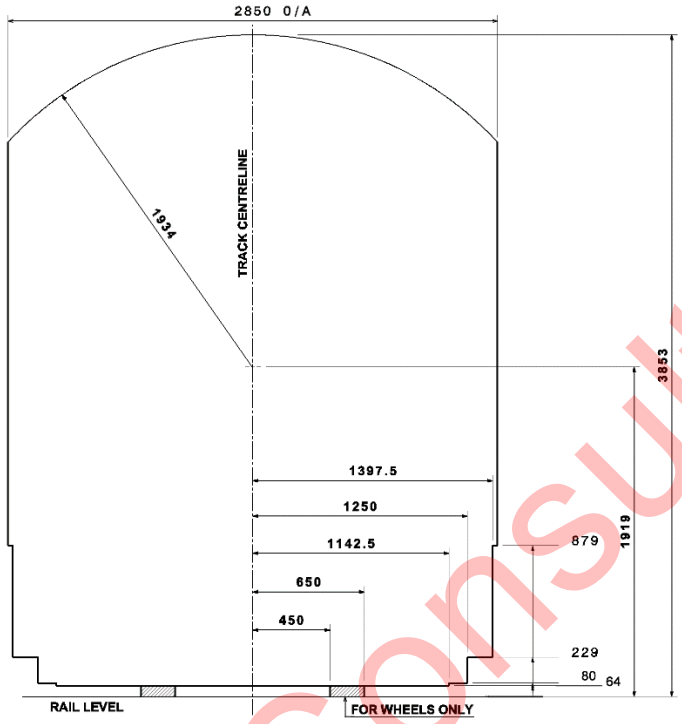


Figure A 73 - Static rolling stock outline dimensions for RISSB reference vehicle 37

RISSB Reference Vehicle 36	Lateral Translation +/- (mm)	Body Roll		Bounce (Upwards Only) (mm)	Wheel Clearance +/- (mm)
		Angle +/- (degrees)	Point of Rotation ARL (mm)		
TasRail – Melba Line	50	2	610	50	64

Table A 37 - Kinematic outline translations for RISSB reference vehicle 37

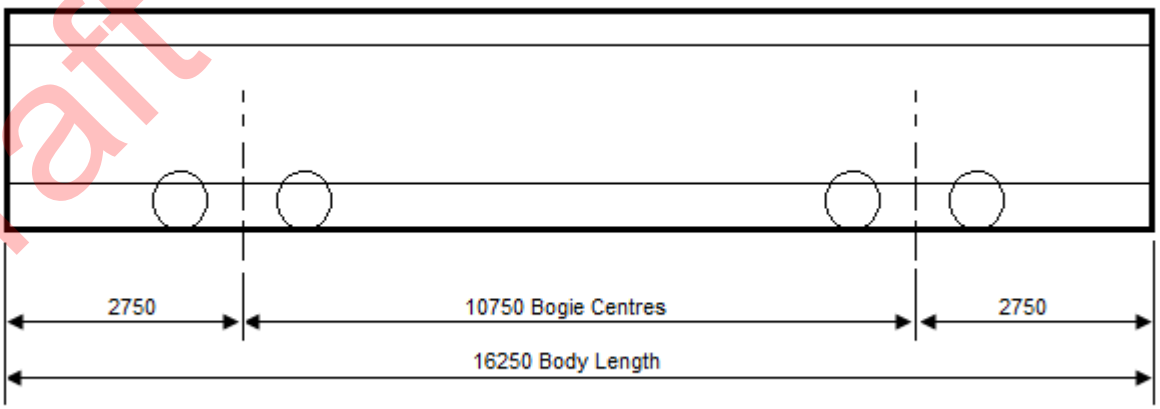


Figure A 74- Swept outline vehicle dimensions for RISSB reference vehicle 37

Appendix B Specific Items

B.1 Expendable Items

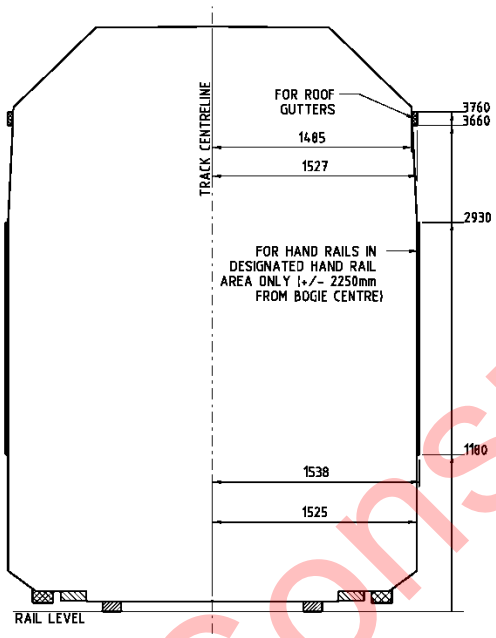


Figure B 1 - Expendable Items for RISSB Reference Vehicle 27[48]

B.2 Pantographs

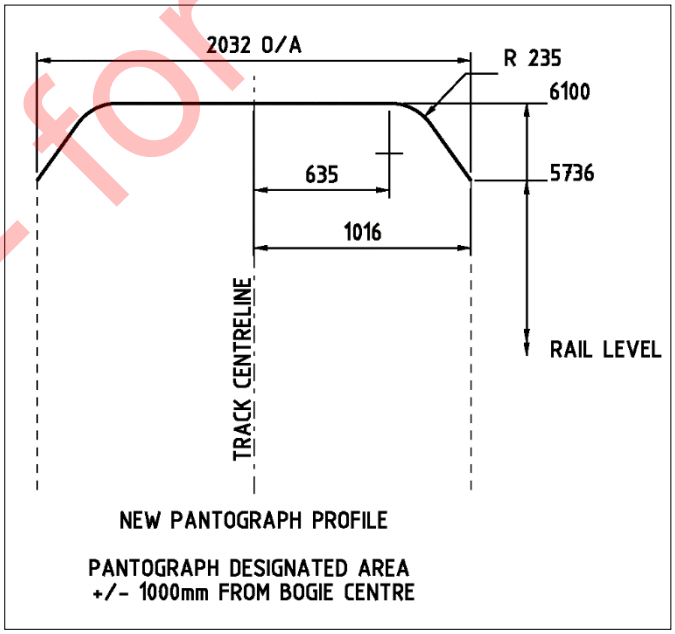


Figure B 2 - RISSB Pantograph Outline 1[49]

[48] Note that 1538mm dimension line refers to maximum width hand rail area from vehicle centreline.
[49] New pantograph profile.

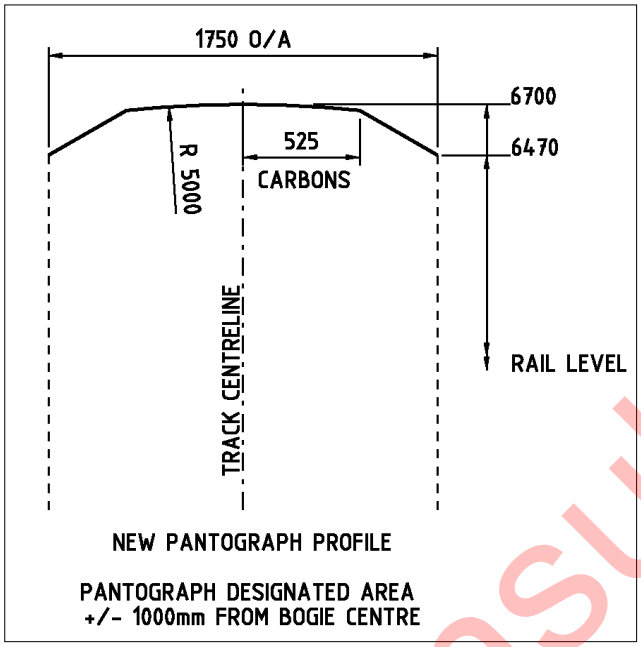


Figure B 3 - RISSB Pantograph Outline 2[50]

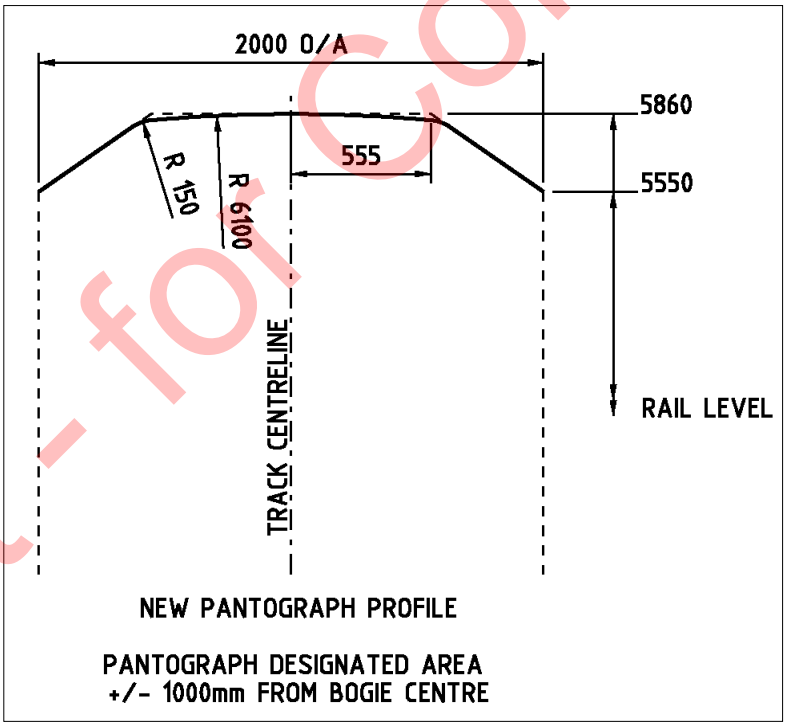


Figure B 4 - RISSB Pantograph Outline 3[51]

[50] New pantograph profile.
[51] New pantograph profile.

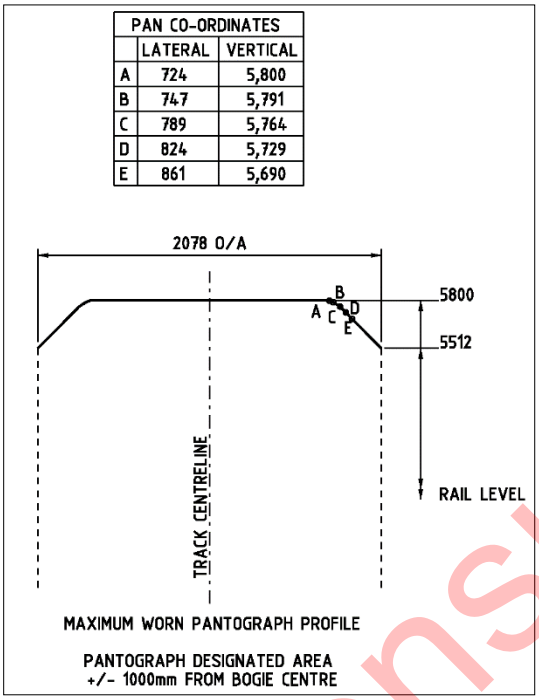


Figure B 5 - RISSB Pantograph Outline 4[52]

B.3 Doors

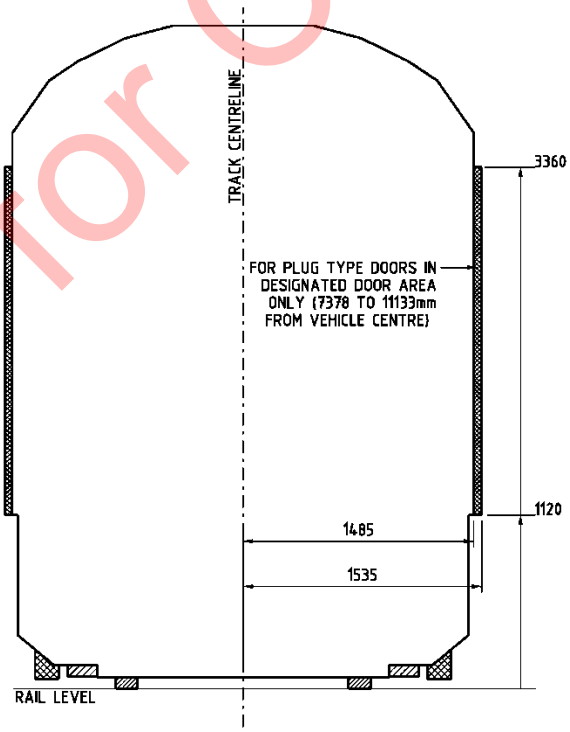


Figure B 6 - Out of Gauge Outline for Failed Plug Doors on RISSB Reference Vehicle 21.

[52] Maximum worn pantograph profile.

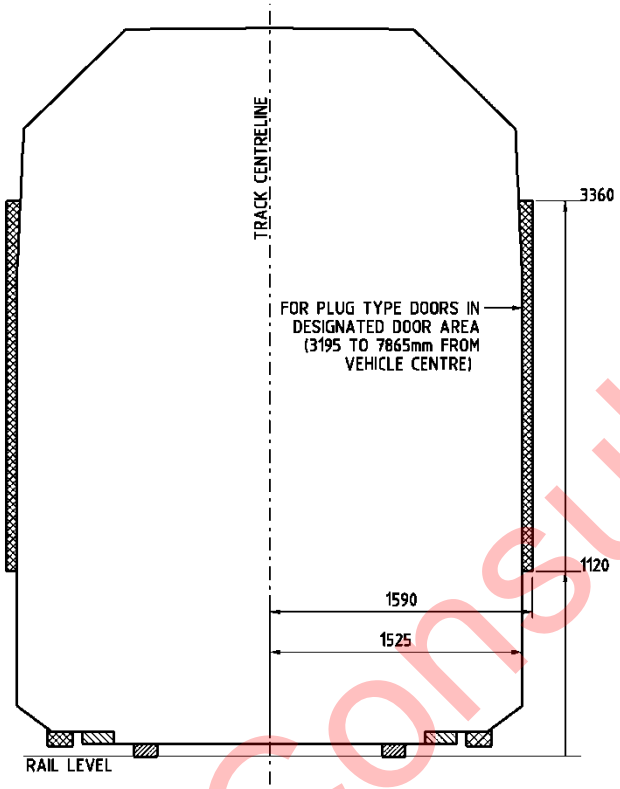


Figure B 7 - Out of Gauge Outline for Failed Plug Doors on RISSB Reference Vehicle 27.

Appendix C Static Kinematic Test

C.1 Static Kinematic Test

This section outlines the procedures for carrying out a static kinematic rolling stock outline test for a standard gauge track. This procedure is the same for all gauges, but superelevation will need to be adjusted accordingly. This includes setting up a 160 mm superelevated track and measuring the roll angle & lateral displacement.

A static kinematic outline test is required to determine the roll and lateral displacements of a vehicle standing on a simulated 160 mm superelevated track.

The intent of this test is to ensure that the vehicle is able to operate up to its design speed including cant deficiency, without becoming foul of the kinematic rolling stock outline.

C.2 Equipment and setup

The following equipment and test site requirements apply:

A straight level test site, preferably with rails embedded in concrete. The top of the rail should be level within ± 3 mm over the length of the vehicle.

Suitable jacking equipment to lift the wheels of the test vehicle.

Suitable steel and/or aluminium packers to be inserted beneath wheels of the test vehicle to simulate the specified track superelevation.

Stringline and plumb-bob.

Tape measure and steel rule.

C.3 Static kinematic outline test

C.3.1 Test vehicle configuration

The test vehicle should be setup in a condition to maximise the vehicle's centre of gravity (e.g. on locomotives fuel tanks should be near empty). Friction wedges and other damping devices should be engaged and operational.

All brakes should be fully released, to allow the suspension system to operate freely, and chocks applied to the vehicle to prevent it moving.

C.3.2 Test procedure

(a) Check that the test vehicle is in the condition that gives maximum centre of gravity from rail level.

(b) Place a red flag on the front and rear of the test vehicle and place a chock/ wedge at each side of one rail wheel on the opposite side of the vehicle to the side being jacked.

(c) Using a stringline and plumb-bob setup a vertical datum point on the vehicle. Measure and record the length of the stringline and the lateral offset (if any).[53]

(d) Lift and pack all wheels on one side of the vehicle incrementally to 160 mm, at increments not exceeding 50 mm.[54]

[53] Surveys or laser measurements might be considered as acceptable alternates, with prior approval of the Rail Infrastructure Manager.
[54] The vehicle may slide laterally against flange during lifting. Ensure all rams and packing are securely placed/aligned. STOP and realign packing where necessary.

(e) Before each increment in packing measure and record the stringline lateral displacement w.r.t the vertical datum point.

(f) Before each increment in packing measure the record the lateral bump stop clearance across the lateral bump stop brackets for each side.

(g) Lower the vehicle gently in increments back to the level condition.

(h) Repeat steps c) to g) on the other side of the vehicle.

Calculate and total body roll and effective lateral displacement for every packing increment, using the following equations:

$$Super\ angle = arctan\left(\frac{Applied\ packing\ (mm)}{1500}\right)$$

Equation C 1

$$Total\ roll\ angle\ including\ super = arcsin\left(\frac{lateral\ disp\ w.r.t.\ vertical\ datum}{length\ of\ stringline}\right)$$

Equation C 2

$$Total\ body\ roll = total\ roll\ angle\ including\ super - super\ angle$$

Equation C 3

$$Lateral\ displacement = \left(\frac{Avg\ bump\ stop\ clearance\ RHS - Avg\ bump\ stop\ clearance\ LHS}{2}\right)$$

Equation C 4

$$Axle\ box/side\ frame\ displacement = \left(\frac{Difference\ axle\ box/side\ frame\ clearance\ both\ sides}{2}\right)$$

Equation C 5

$$Effective\ lateral\ displacement = lateral\ displacement + axle\ box/side\ frame\ displacement$$

Equation C 6

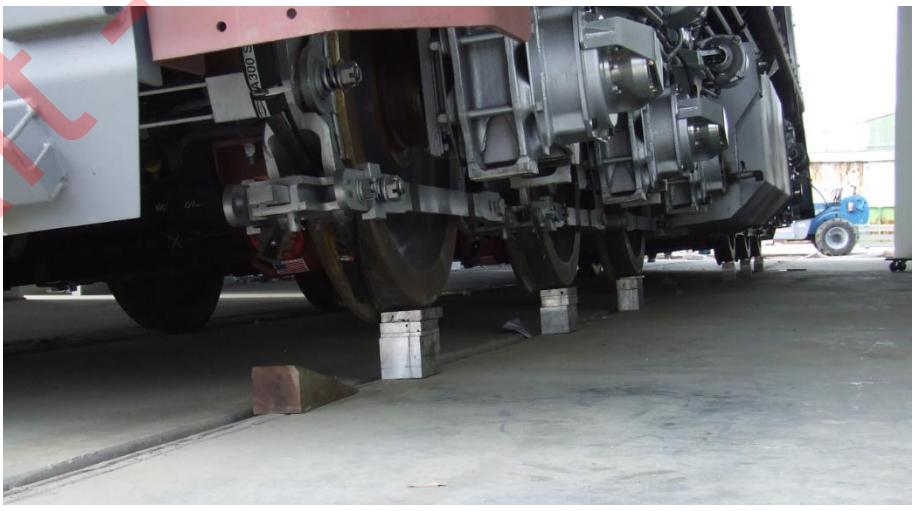


Figure C 1 - Static kinematic test setup (wheels packed to 160 mm)

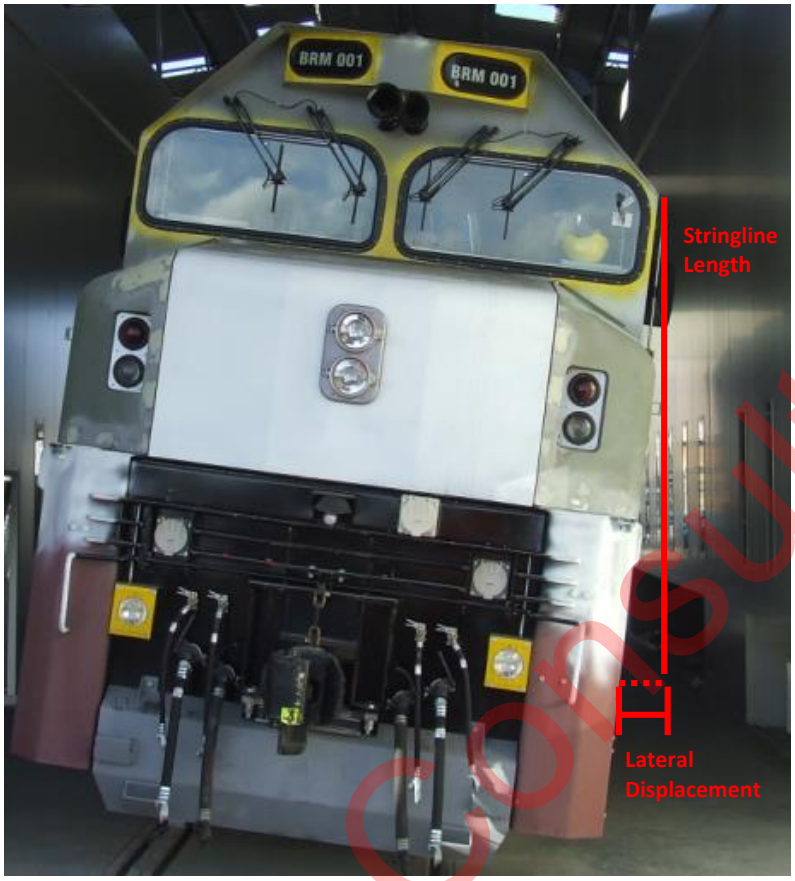


Figure C 2 - Interpretation of body roll

C.4 Test results (Example using plumb-bob)

C.4.1 Roll Assessment

Applied superelevation (mm)	Superelevation angle (deg)	Lateral displacement w.r.t. datum (mm)	Total measured roll angle including super (deg)	Total body roll (deg)
0	0	0	0	0
50	1.91	33	1.8	-0.11
100	3.82	72	3.93	0.11
160	6.12	119	6.51	0.38
100	3.82	81	4.42	0.6
50	1.91	40	2.18	0.27
0	0	6	0.33	0.33

Table C 1- Roll (right) measurements

Applied superelevation (mm)	Superelevation angle (deg)	Lateral displacement w.r.t. datum (mm)	Total measured roll angle including super (deg)	Total body roll (deg)
0	0	0	0	0
50	1.91	41	2.12	0.21
100	3.82	83	4.29	0.47
160	6.12	136	7.04	0.91
100	3.82	89	4.6	0.78
50	1.91	48	2.48	0.57
0	0	6	0.31	0.31

Table C 2- Roll (left) measurements

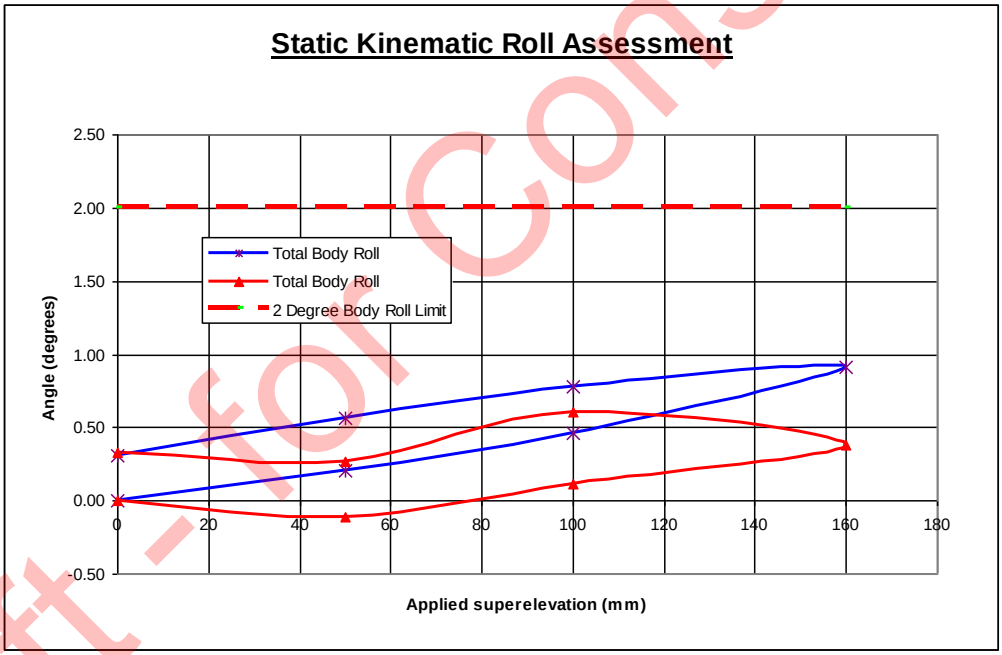


Figure C 3 - Plot of body roll vs applied superelevation

C.4.2 Lateral displacement assessment

Applied superelevation (mm)	Average bump stop clearance (mm)	Axle box/side frame clearance (mm)	Effective lateral displacement (mm)
0	Right = 35	6	0
	Left = 35	6	
50	Right = 33	6	3
	Left = 39	6	
100	Right = 13	10	22.5
	Left = 48	0	
160	Right = 1	12	50
	Left = 89	0	

Table C 3- Lateral displacement (right) measurements

Applied superelevation (mm)	Average bump stop clearance (mm)	Axle box/side frame clearance (mm)	Effective lateral displacement (mm)
0	Right = 33.5	6	-2
	Left = 37	6	
50	Right = 35.5	6	0.5
	Left = 35	6	
100	Right = 39	0	14
	Left = 21	10	
160	Right = 85	10	47.5
	Left = 0	0	

Table C 4- Lateral displacement (left) measurements

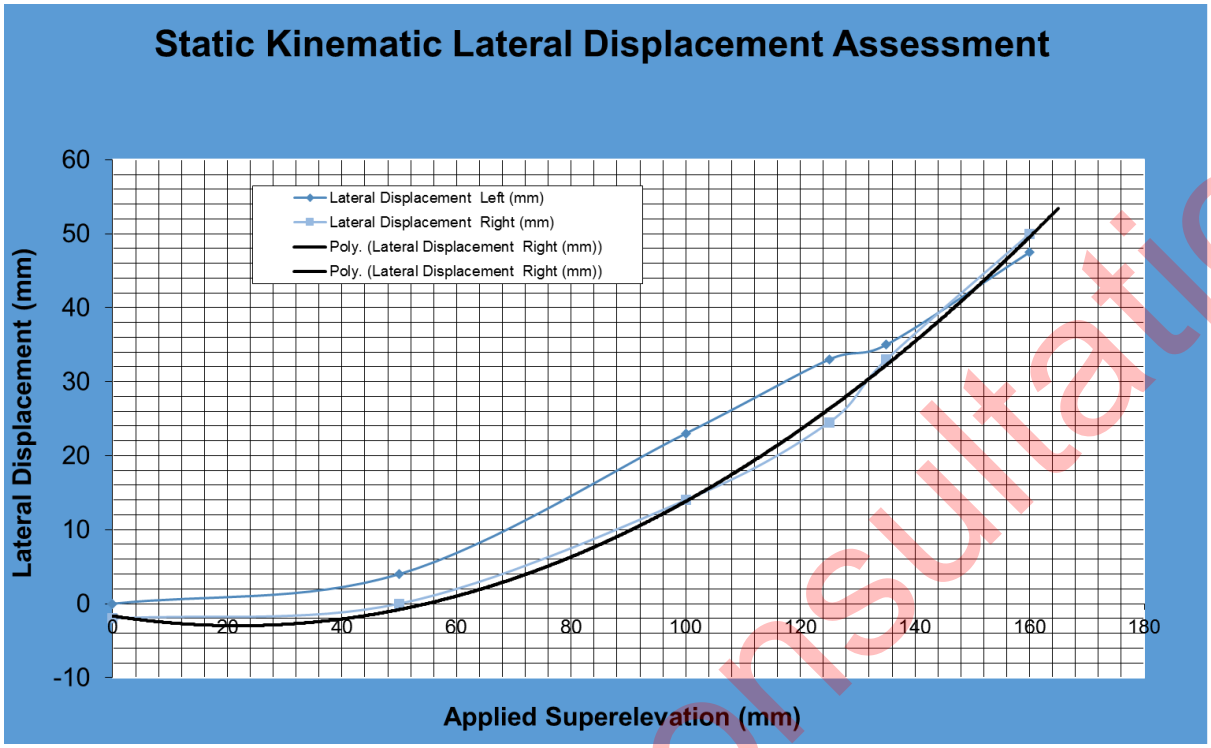


Figure C 4- Plot of body lateral displacement vs applied superelevation

Appendix D Hazard Register

Hazard Tree Reference	Hazard Description	Applicable Reference
3.12	Out of gauge train - Hit wayside structure - Harm to infrastructure by rolling stock	2, 3, 4, 5, 6
3.39	Out of gauge train - Dewirement - Harm to overhead power system - Harm to infrastructure by rolling stock	3, 4
3.45	Pan head too narrow - Contact wire runs off edge of pan head - Dewirement - Harm to overhead power system - Harm to infrastructure by rolling stock	4
3.53	Pantograph located too far from a bogie centre - Pan head translation or sway excessive - Contact wire runs off edge of pan head - Dewirement - Harm to overhead power system - Harm to infrastructure by rolling stock	4
9.17	Out of gauge train - Side swipe by other train - Collision	2, 3, 4, 5, 6
9.25	Train overhang from extremity axles too long – at turnouts - Train foul - Side swipe by other train - Collision	3, 5
32.4	Rolling stock not tested / verified for gauge compliance - Out of gauge train	2, 3, 4, 5, 6, 8
32.5	Rolling stock modification creates out of gauge - Out of gauge train	3
32.7	Rolling stock operating on incorrect / forbidden route - Out of gauge train	2
32.8	Excessive sway - Out of gauge train	3, 5
32.9	Critical component failure - Out of gauge train	3
32.10	Rolling stock too high - Out of gauge train	3, 5
32.11	Rolling stock too low - Out of gauge train	3, 4, 5
32.12	Rolling stock too wide - Out of gauge train	3, 5
32.14	Tilt system failure - Critical component failure - Out of gauge train	3
32.14	Tilt system failure - Excessive sway - Out of gauge train	3
32.19	Bogies too tall - Rolling stock too high - Out of gauge train	3, 5
32.21	Cyclic top irregularities resulting in sway of vehicles - Excessive Sway - Out of gauge train	3, 5
32.23	Rear-view mirrors extended too far - Rolling stock too wide - Out of gauge train	4
32.29	Outward hinging doors - Poorly restrained equipment - Out of gauge train	4
32.33	Cyclic top irregularities resulting in bogie or body pitching/bouncing - Rolling stock too high - Out of gauge train	3, 5
32.35	Conveyors, plows etc on track machines - Plant - Poorly restrained equipment - Out of gauge train	6
32.36	Crane jibs - Plant - Poorly restrained equipment - Out of gauge train	6
32.37	Inadequate suspension - Cyclic top irregularities resulting in sway of vehicles - Excessive sway - Out of gauge train	3, 5

Hazard Tree Reference	Hazard Description	Applicable Reference
32.37	Inadequate suspension - Cyclic top irregularities resulting in bogie or body pitching / bouncing - Rolling stock too high - Out of gauge train	3, 5
32.40	Cowcatcher not adjusted for adequate rail clearance - Rolling stock too low - Out of gauge train	3, 4, 5
32.43	Fully / over worn wheels - Rolling stock too low - Out of gauge train	3, 5
32.44	Overloaded - Rolling stock too low - Out of gauge train	3, 5
32.45	Spring failure - Rolling stock too low - Out of gauge train	3, 5

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