SECTION 3

ROAD WORTHINESS ACCEPTANCE STANDARDS FOR RAIL FREIGHT VEHICLES

ROA MANUAL

SCHEDULE OF AMENDMENTS

SECTION 3

AMENDMENT NUMBER	PAGES AMENDED	AMENDMENT SUMMARY	DATE ISSUED

This Section of the ROA Manual, as highlighted by red text, is superseded by the following RISSB Australian Standards:

- AS 7508 Railway rolling stock - Track forces and stresses
- AS 7509 Railway rolling stock - Dynamic behaviour

The superseding Australian Standard is identified adjacent to the superseded portion.

CONTENTS

APPENDICES

Section 3 superseded by AS 7509

3.1 PURPOSE AND SCOPE

3.1.1 This section specifies the mimimum standards of testing and performance for new and substantially modified or rebuilt vehicles necessary to provide the level of operational safety required by Australian Rail Systems. Further testing by the owning System, e.g. testing with instrumented wheelsets, is encouraged.

3.1.2 All test vehicles shall be designed and constructed according to the requirements of this Manual, except for unconventional vehicles, to which the requirements shall be applied where applicable (refer to Section 16.)

This section DOES NOT consider structural fatigue life.

3.1.3 This section uses a combination of theoretical and field tests to establish the safety of the vehicle under test. This combination is required to show that there is an adequate margin of safety for the vehicle to show any tendency:

(a) to derail
(b) to uncouple
(c) for interference to occur between non contacting components (ie no fouling)
(d) to be unstable, or
(e) for the vehicle forces to:
cause the wheel to climb the rail
permanently displace the track or rail laterally or
induce excessive vertical forces into the track structure

3.1.4 When a vehicle has successfully passed all the field tests and has been designated with the appropriate speed classification, the vehicle shall be able to run at this speed on the Specified Track (Appendix 2), or on one of better quality. If the mainline track is of a significantly lower standard than the test section, the operating system shall impose appropriate speed restrictions on the track. If the mainline track is of a significantly higher standard than the test section, and has a higher permissible track speed than that designated to the vehicle when tested, speed restrictions shall be imposed on any train to which that vehicle is attached,i.e. the maximum speed of any train shall be the lowest authorised speed of the vehicles in the consist, or the maximum track speed over that section, whichever is the lowest.

3.1.5 As an aid to design, theoretical models e.g. Simcar, Nucars etc. may be used for preliminary evaluation but shall not be used as a basis for final approval of a vehicle/bogie combination.

Section 3 superseded by AS 7509

3.2 PERFORMANCE ASSESSMENT

3.2.1 CRITERIA

3.2.1.1 The results from all field tests shall comply with the TEST CRITERIA given for each test, and summarised in Table 3.1. The results are subject to the requirements of observability in field tests, using appropriate visual aids. Values worse than the test criteria are regarded as having a high risk of unsafe behaviour. Values better than the test criteria are regarded as indicating safe and practical vehicle performance.

3.2.1.2 Certification and approval of a vehicle by the testing System, whether it is the owning System or not, shall be accepted by the other Rail Systems without any requirement for further tests to be performed.

3.2.1.3 A visual inspection of the test vehicle shall be made after each static and impact test. Following the impact tests, the vehicle shall be unloaded and visually inspected.

Any damage, as defined, to any major structural part of the vehicle shall be sufficient cause for rejection of the design. For the purposes of these tests, damage shall be defined as any defect which is caused by contact or interference between vehicle and bogie components and/or which requires repair or correction before the vehicle can safely operate in service.

3.2.3 Acceptance

All new or modified vehicles tested and permitted to enter service on new/developmental bogies shall be given INTERIM approval, subject to the vehicle type successfully meeting the critical acceptance test criteria. In this situation the vehicle shall be given further ride tests (3.3.3, 3.3.4 and 3.3.6) after 100,000 km and 250,000 km of service. Failure of either test shall result in immediate withdrawal of the vehicle class from service, until the faults are rectified, either by reclassification to a lower permissible speed or by alteration of the design. Passing of both tests shall qualify the vehicle for a full Certificate of Compliance. (Refer Appendix 3.)

A vehicle, in the same class and of the same design as the original test vehicle, shall be tested when it has completed 750,000 km in service. The test shall be conducted with field worn wheels to ensure compliance with the test conditions at the design speed. Failure of this test shall result in reclassification of all vehicles of the same design, or their removal from service until overhauled.

At the completion of these tests, provided the criteria are satisfied, the vehicles shall be classified in accordance with Section 23.

A report including results and data from the following tests shall be submitted by the testing System to the nominated officer of the other rail Systems with the Certificate of Compliance.

Section 3 superseded by AS 7509

TABLE 3.1

SUMMARY OF CRITERIA FOR ASSESSING ROAD WORTHINESS

Regime	Section	Criterion	Limiting Value	Test Speed
Theoretical Tests				
P2 Force	3.3.6	See 3.3.6.1	200 kN	Design speed
Field Tests				
Hunting (empty)	3.3.3	Min critical speed Max body lat acc Av body lat acc Av body vert acc Max body vert acc	110% design ±0.5 g* ±0.35 g ±0.5 g ±0.8 g *	110% design
Twist Test	3.3.4	Bogie centres:≤6 m Twist limit 1 in 150 Bogie centres:6-7 m Twist limit 1 in 160 Bogie centres:7-8 m Twist limit 1 in 170 Bogie centres:8-9 m Twist limit 1 in 180 Bogie centres:>9 m Twist limit 1 in 190 Articulated vehicles ***	60% wheel unloading and a minimum of 14 mm centre plate engagement	Static
Pitch/Bounce (Loaded)	3.3.5	Min vert wheel-load Max body vert acc Ave body vert acc	10% 0.8 g ±0.5 g	110% design speed
P2 Force	3.3.6		200 kN as in 3.3.6.2	Design Speed

* excluding transients

*** Articulated vehicles shall have at least two platforms/units subjected to the twist test requirements at the same time to simulate an intermediate bogie in a rail dip.

Section 3 superseded by AS 7509

3.3 FIELD TESTS

3.3.1 GENERAL

The tests in this section shall be carried out in the field using the vehicle/bogie combination as intended for intersystem operation. The vehicle shall be tested in accordance with the requirements of each clause and in the condition specified.

3.3.2 FIELD TEST CONDITIONS

3.3.2.1 Conventional Vehicles

3.3.2.1.1 Test Vehicle

A vehicle having the same configuration as is proposed for regular service shall be utilised for all tests.

During impact tests, the test vehicle shall be the struck (stationary) vehicle and shall be loaded to its maximum designed capacity or to the maximum permitted gross load on rail as determined by the axle capacity, whichever is the lower.

Vehicles designed for bulk loading shall be loaded with the product for which they have been designed and shall be so loaded as to have a minimum of 85% of the total volume filled.

For loaded tests, vehicles designed for general service, other than those for bulk loading, shall be loaded so that the combined centre of gravity of the vehicle and loading is as close as is practicable to the maximum expected centre of gravity for the vehicle in service. The loads shall be rigidly braced where necessary, and various types of loads shall be used to test each component to its maximum load.

The test vehicle shall be equipped with the draft gear or cushioning devices for which the vehicle was designed, and which comply with Section 9.

Vehicles shall be tested using the R.O.A. FIELD WORN WHEEL PROFILE, as shown in Diagram 3-1, with snubbers/damping devices worn to within 10% of condemning limits, UNLESS OTHERWISE SPECIFIED. Wheelsets shall have been in service for approximately 5000 km, to remove any machining marks on the treads.

3.3.2.1.2 Other Vehicles in Consist

The vehicles, other than the test vehicle, shall be loaded to the allowable gross mass on rail. A high density granular material shall be used to load vehicles in order to provide a low centre of gravity, and the load shall be well braced to prevent shifting. Such vehicles shall be equipped with draft gears meeting the requirements of A.A.R. Specification M-901, except at the striking end of the moving vehicles in impact tests where M-901E rubber friction gear shall be used.

3.3.2.2 Unconventional Vehicles

THIS PART IS YET TO BE ADDED

'Unconventional Vehicles' such as High Productivity Integral Train Units are new/untried types of vehicles for special purposes that are not necessarily designed to comply with all the requirements of this Manual.

3.3.2.3 Instrumentation

The coupler force shall be measured by means of a transducer complying with A.A.R. Specification M-901F, or other recognised means.

Instrumentation used for recording of other data shall be of generally recognised type properly calibrated and certified as to accuracy. Recordings of body motions and accelerations shall be filtered at 10 Hz (low pass), except where otherwise specified.

3.3.3 LATERAL STABILITY ON TANGENT TRACK (HUNTING)

This requirement is designed to ensure the absence of hunting, which can result from the transfer of energy from forward motion into a sustained lateral oscillation between the wheel flanges and running rails, in certain vehicle and bogie suspension designs. The tests are required to show that the resulting forces between the wheel and the rail remain within the limits necessary to provide an adequate margin of safety from any tendency to derail.

3.3.3.1 Test Procedure and Conditions

The empty test vehicle(s) shall be marshalled behind the Instrumentation/Research Car and within the last five (5) vehicles at the rear of the test train consist. The test train shall be operated at speeds up to 110% of the design speed or the critical speed, whichever is the lesser.

The tests shall be conducted over a test section of track at least 3 km in length which permits the tests to be conducted with the train running slack. There shall be sufficient length of track at either end of the test section to allow for accelerating to speed and stopping after each test. The standard of the track shall be at least equivalent to that specified in Appendix 2.

3.3.3.2 Instrumentation and Criteria

Lateral and vertical accelerometers shall be placed as near as practicable to the centreplate along the longitudinal centreline of the vehicle at floor level, or over an axle in the case of two-axle vehicles.

Sustained hunting is defined as lateral sinusoidal acceleration greater than ±0.35 g average over a period of at least 5 consecutive seconds. During this period the maximum lateral accelerations, excluding transient peaks, shall not exceed ±0.5g. During the same time period the average and maximum vertical accelerations shall not exceed ±0.5 g and ±0.8g respectively, excluding transient peaks.

Components of the measured accelerations having frequencies above 10 Hz shall be filtered out.

The vehicle shall not experience sustained hunting during any test. A record of the maximum lateral and vertical accelerations, related to speed, at the worst location shall be submitted as required test data.

Section 3 superseded by AS 7509

3.3.4 TEST RESPONSE TO TRACK TWIST

3.3.4.1 Static Response to Track Twist

The empty vehicle shall be subjected to a static twist test, the severity of which is to be calculated over the outer wheelsets as shown in Table 3.1, with the required packing applied to one side of one bogie. Wheel unloading shall not exceed 60% at any location. Body-centre plate shall be engaged by at least 14 mm in the bolster centre plate lip.

In addition to the above twist test , the empty vehicle shall also be subjected to a static combined twist test incorporating a general twist of 1 in 250 over the vehicle bogie centres plus a local (bogie) twist of 1 in 100 over a 4 metre ramp.

The test for articulated vehicles shall include twisting the bogies either side of an intermediate bogie simulating the wheel on one side of the intermediate bogie being in a dip in one rail.

3.3.4.2 General Twist Conditions

The wheels of the test vehicle shall be packed to simulate the required test configuration determined from the limits given in Table 3.1. Diagram 3.2 shows the method to be used for determining the relatove packings required. Single vehicles shall be packed and the wheel loads measured as shown on Diagram 3-5.
Articulated vehicles shall be tested as shown on Diagrams 3-7 to 3-11 inclusive.

3.3.4.3 Combined Twist Conditions

The combined twist is the resultant of a track twist of 1 in 250 between the bogie centres combined with a local twist of 1 in 100 over one bogie. Diagram 3-3 shows the method to be used to calculate the relative packings required to achieve the effective vehicle body twist.
Single vehicles shall be packed and the wheel loads measured as shown on Diagram 3-6.
Articulated vehicles shall be tested as shown on Diagram 3-11.

3.3.5 RESPONSE TO SURFACE VARIATION (PITCH AND BOUNCE)

This requirement is designed to ensure the satisfactory negotiation of the vehicle over track which provides a continuous or transient excitation in pitch and bounce, and in particular the negotiation of level crossings and bridges, where changes in vertical track stiffness may lead to sudden changes in the loaded track profile beyond those measured during inspection. The tests are required to show that the resulting forces between the wheel and rail show an adequate margin of safety from any tendency of the vehicle to derail, uncouple or to show interference, either between subsystems of the vehicle or between vehicle components and track.

3.3.5.1 Test Procedure and Conditions

The fully loaded test vehicle shall be tested between two empty vehicles having bogie centres of at least 13 m.

Tests shall be carried out over a test section of tangent track with surface deviations providing a continuous, near sinusoidal, excitation with a vertical amplitude to the track surface of 20 mm peak to peak, refer diagram 3.12A, and a single symmetric vertical bump in both rails of the shape and amplitude shown in diagram 3.12B. These tests may be carried out separately or simulataneously with a separation of at least 30 m.

Testing shall start at a constant speed well below any calculated resonant speed, increasing in 10 km/h increments until the critical values of Table 3-1 are reached, the resonance level is passed, or 110% of design speed is reached. The speed at which resonance is expected may be approached from a higher speed, using steps to decrease the speed. It shall be regarded as unsafe if any wheel lifts.

3.3.5.2 Instrumentation and Criteria

Vertical accelerometers shall be fitted to the deck of the vehicle over the centreplate of both bogies. Vertical wheel forces shall be measured continuously through the test zone. Measured force components having frequencies above 10 Hz shall be filtered out.

Section 3.3.5 superseded by AS 7509

The vertical accelerations shall not exceed an average of ±0.5 g through the test zone; the maximum vertical acceleration excluding transients shall not exceed ±0.8 g. Vertical wheel force shall not be less than 10% of its static value on any wheel at any speed tested.

3.3.6 P2 FORCE DETERMINATION

Section 3.3.6 superseded by AS 7508

3.3.6.1 General

This test is designed to evaluate the effects on the track structure of unsprung vehicle mass and to ensure that such effects do not cause critical stress failures at known in-track defects.

All test results and track geometry shall be recorded and submitted.

The vertical P2 force shall be extracted by measurement, at design speed. The P2 force shall not exceed 200 kN for a 10 milli-radian ramp angle (total joint angle) on 47 kg/m rail, where stiffness is in the order of 90 MN/m, and damping 70 kNs/m.

For pre-field test evaluation the following P2 force formula shall be used:

$$P_2 = P_0 + 2\alpha.v\left[\frac{M_u}{M_u + M_t}\right]^{\text{‰}} x \left[1 - \frac{C_t \pi}{4[K_t(M_u + M_t)]^{\text{‰}}}\right] x \left[K_t M_u\right]^{\text{‰}}$$

where: P_2 *= Force (kN)*

P_o = Vehicle Static Wheel Load (kN)

M_u = Vehicle Unsprung Mass per Wheel (kg)

2α = Total Joint Angle, normally 0.01 radians.

v = Vehicle Velocity (m/s)

K_t = Equivalent Track Stiffness (MN/m)

C_t = Equivalent Track Damping (kNs/m)

M_t = Equivalent Track Mass (kg)

3.3.6.2 Test Conditions

In determining the weld site at which the P2 force is to be found the following points shall be taken into consideration:

(a) The welded joint shall be located between two adjacent sleepers and within the measuring length of the load bridge (Diagram 3-13).

(b) To ensure all results can be compared on the same basis the test site shall be on a solid foundation, tamped and subjected to normal service traffic for one month prior to testing. Alternatively a ballast compactor may be used.

To ensure capture of the peak P2 load the measuring length shall be long enough to pick up at least a quarter of a cycle at the predicted wavelength. Table 3.2 gives the expected wavelengths according to the vehicle speed and frequency. As can be seen from Table 3.2, at high speeds the measuring length of the bridge required may be greater than that available from standard sleeper spacings. Sleeper spacings at the measuring point may therefore need to be increased for testing purposes. This may affect results to some extent, however, tests conducted in a consistent way will give directly comparable results.

The general test set up is shown in Diagram 3-13 with the arrangement for the gauges in Diagram 3-14 and the circuit diagram in Diagram 3-15.

Data shall be low pass filtered before analysis at approximately 70 Hz to remove high frequency components of the waveform which are not relevant to P2 force measurement. It is also preferable to remove quasi-static signals (e.g. less than 20 Hz) so that peak forces can more easily be determined.

Calibration of the load bridge shall be carried out before testing as follows:

Section 3.3.6 superseded by AS 7508

Roll a loaded test vehicle of known axle loading over the site at a crawl speed such that the output signal can be calibrated against the axle-loadings. The test vehicle shall be weighed as accurately as possible for such a purpose.

The Wave Frequency (Hz) is given by:

$$f = \frac{1}{2\pi}\sqrt{\frac{k}{m}}$$

where k = Effective Spring Constant (N/m),
m = Unsprung Mass (kg)

The Wavelength (m) is given by : v/f

where v = Vehicle Velocity (m/s)
f = Wave Frequency (Hz)

Table 3.2
Wavelengths (m) for Wave Frequency vs. Speed

Wave Frequency (Hz)	Velocity (km/h)	
	50	140
20	0.695	1.945
30	0.463	1.297
40	0.384	0.973
50	0.278	0.778
60	0.232	0.648
70	0.198	0.556

3.3.7 COUPLER OR JACKING POINT VERTICAL LOADS

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

A load of ±220 kN shall be applied in the vertical plane at the coupler head as near as possible to the pulling face and held for 60 seconds in both directions.

Sections of articulated vehicles that do not form the end units, of the articulated vehicle, shall not be subjected to these tests, as they have no bogie overhang.

Section 3.3.8 superseded by AS 7509

3.3.8 CURVE STABILITY

The test consist shall be subjected to a squeeze and draft load of 750 kN without vehicle body-suspension separation or wheel lift. Load application, firstly static and then at a nominal speed of 5 km/h, shall be of minimum 20 seconds sustained duration. The static case evaluates the roll stability, the dynamic case evaluates the vehicle's tendency to derail. Articulated vehicles consisting of more than two units shall be tested with a minimum of three units in the test consist. The number of units used shall generate maximum load in the critical L/V location of the vehicle.

For the purpose of this test the test vehicle shall be fitted with new full flange wheel profiles.

The empty vehicle shall be subjected to squeeze and draft load on a curve of not greater than 175 m radius. The curve shall have 12 mm maximum superelevation. The test vehicle shall be coupled to a "base vehicle" as defined below and a "long vehicle" having a length over strikers of 25 m , long shank couplers and conventional

Section 3.3.8 superseded by AS 7509

draft gear.

The "base" vehicle shall be a vehicle nominally 13 m over headstocks, or shorter, with nominal bogie centres of 9.5 m , and fitted with short shank couplers.

3.3.9 STATIC END COMPRESSION

The single vehicle impact (3.3.11) may be performed as an alternative to this test.

A longitudinal compressive end load of 4500 kN shall be applied at the couplers and held for 60 seconds minimum. The load shall be applied over an area equal to the contact area between the draft lugs and the draft gear. The vehicle as tested shall simulate an axially loaded beam having ball end restraints. i.e. the loading fixture shall be constrained from lateral and vertical motion, see Fig. 3.16.

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

3.3.10 SINGLE VEHICLE IMPACT

This test may be performed in lieu of the static end compression test described at 3.3.9.

The loaded test vehicle shall be impacted by a string of vehicles, consisting of three nominal 50 tonne capacity vehicles. These vehicles shall be loaded to their allowable maximum gross mass on rail with sand or other granular material, equipped with A.A.R. M-901E rubber-friction draft gear at the striking end. A metal plate may be placed on top of the granular material to stop load shift.

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

A series of impacts shall be made on tangent track by the striking consist starting at 10 km/h, increasing the impact speed by small increments of approximately 3 km/h, until a coupler force of 5500 kN or a speed of 22 km/h has been reached, whichever occurs first.

A vehicle consisting of two or more permanently coupled units shall also undergo impact testing as outlined above with the struck unit of the test vehicle being empty for a two-unit vehicle, or with the first two units being empty for a three (or more) unit vehicle. No carbody-suspension disengagement or wheel lift, as defined, is permitted during the partially loaded impact tests.

3.3.11 RESPONSE TO VERTICAL CURVING

THIS PART IS YET TO BE DETERMINED

Sections 3.3.11 to 3.3.12 superseded by AS 7509

3.3.12 RESPONSE TO HORIZONTAL CURVING

THIS PART IS YET TO BE DETERMINED

Section 3 superseded by AS 7509

Appendix 1 GLOSSARY OF TERMS

Bounce:
is the simple vertical oscillation of the body on its suspension in which the vehicle body remains substantially horizontal.

Cant:
is the slope on a baseplate on which the rail sits.

Critical Speed:
is the vehicle speed at which hunting commences.

Damage:
is considered to be caused when the vehicle requires shopping for repairs.

Effective Conicity, E,:
of a wheel on a rail is its apparent cone angle used in the calculation of the path of the wheel on the rail. It is defined as:

$$E = A \frac{R_w}{(R_w - R_r)}$$

where A is the angle of the contact plane between the wheel and rail, to the plane of the track.
Rw is the transverse profile radius of the wheel.
Rr is the transverse profile radius of the rail.

The Effective Conicity:
of the R.O.A. PROFILE OF FIELD WORN WHEEL of Diagram 3-1 on 47 kg rail is between 0.1 and 0.3.

Hunting:
is defined as sinusoidal lateral oscillations of the wheelset greater than 0.5 Hz resulting in lateral accelerations of greater than ±0.35 g, sustained for longer than 20 seconds. If any of these parameters is less than that specified the vehicle is not considered to be hunting.

L/V Ratios (Lateral to Vertical forces):
are used as criteria in the assessment of vehicle performance. These are:

(a) The (individual) wheel L/V: the ratio of the lateral force on the rail to the vertical force between the wheel and rail on any individual wheel.
(b) The Sum L/V axle: the instantaneous sum of the absolute values of the individual wheel L/V's on the same axle.
(c) The L/V Bogie Side: the total sum of the lateral forces between the wheels and rails on one side of a bogie divided by the total sum of the vertical forces on the same wheels of the bogie.

Pitch:
of the body is the rotation about its transverse axis through the centre of mass.

Radial Misalignment:
of axles in a bogie or vehicle is the difference in yaw angle in their loaded but otherwise unforced condition. It causes a preference to curving in a given direction.

Roll:
is the rotation of the body about a longitudinal axis, with reference to the perpendicular to the actual track plane, through the vehicle's centre of mass.

Superelevation:
is the height added to the outer rail of a track curve to improve dynamics.

Superelevation Angle:
is the angle subtended by the plane, through the rail head centrelines, to the horizontal plane.

Sway:
is the coupled body mode in roll and yaw and often occurs where the loading is not symmetrical.

Test Vehicle:
is the vehicle undergoing the test, not the vehicle measuring the test.

Upper (Lower) Centre Roll:
are the coupled lateral motion and roll of the body centre of mass. They combine to give an instantaneous centre of rotation above or below the centre of mass. When above (below) the centre of mass, the motion is called upper (lower) centre roll.

Yaw:
is the rotation of the body about a vertical axis through it's centre of mass.

Wheel Lift:
is defined as a separation of wheel and rail exceeding 3 mm when measured at the lateral centreline of the wheel.

Section 3 superseded by AS 7509

Appendix 2 TRACK

The test track shall be of equivalent standard to FRA (Federal Railroad Administration) Class 4, with the following geometric parameters and a rail head profile width of not less than 95% of the original value when new.

Track Geometry Parameters

Track Speed - 130 km/hr

Gauge	-minimum	Tangent = 1435 mm Curved = 1435 mm
	-maximum	Tangent = 1448 mm Curved = 1454 mm
	-maximum rate of change = 2 mm/m	

Alignment (Maximum)

Mid-ordinate on 10 m Chord

Tangent = 6 mm
Curved = 5 mm

Track Surface (Maximum)

Midordinate on either rail (10 m chord) = 9 mm

Deviation from design cross level at any point:

Tangent = 25 mm
Curved = 25 mm
Transition = 20 mm

Difference in cross level over a 10 m length:

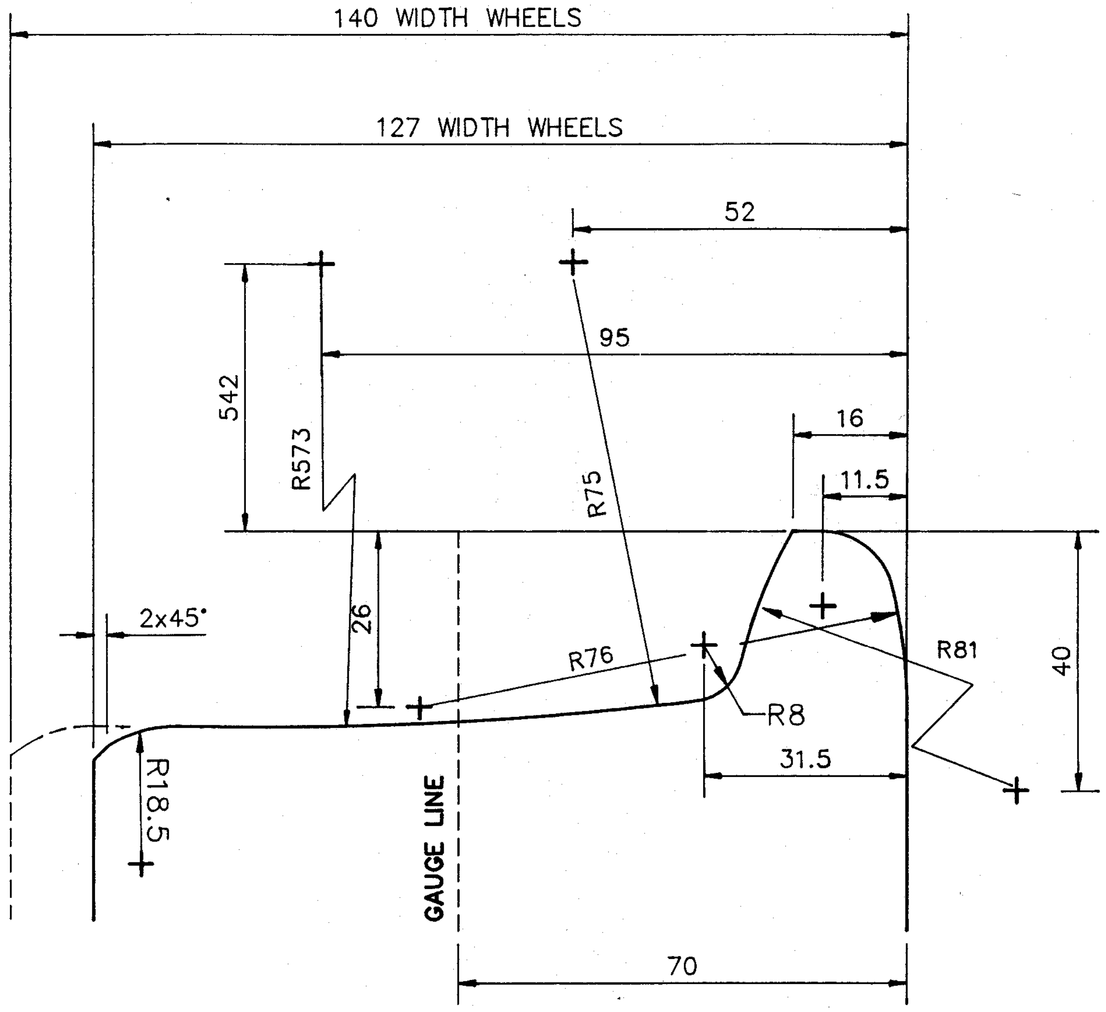
Tangent = 11 mm
Curved = 11 mm
Transition = 17 mm

Maximum runoff over 10 m at the end of a lift (either rail) = 18 mm

Adopted 5/12/91

DIAGRAM 3-1

ROA PROFILE OF FIELD WORN WHEEL

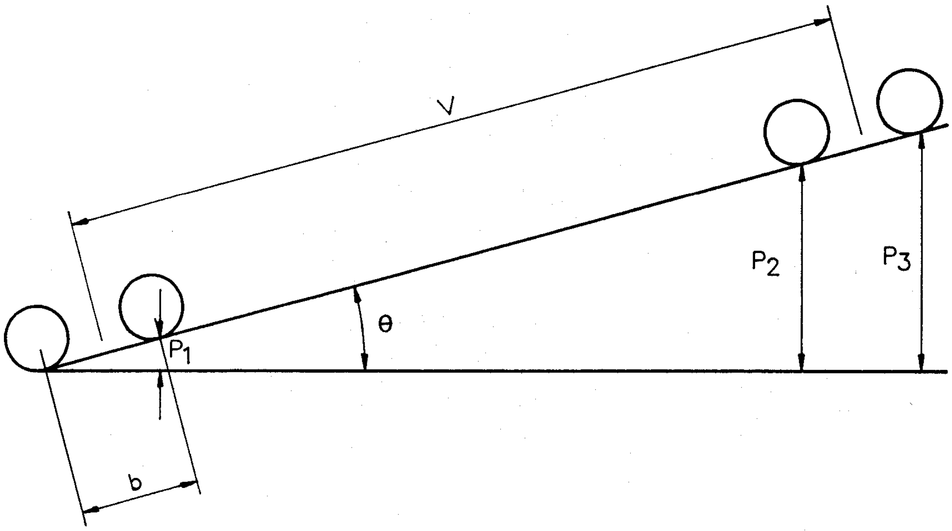


Adopted 5/12/91

DIAGRAM 3-2

GENERAL TWIST - CALCULATION OF PACKINGS

N	Slope of ramp on one side of vehicle e.g N = 150 for short vehicles	1 in N
b	Bogie wheelbase	mm
v	Vehicle bogie centres	mm
P_1 =	b/N	mm
P_2 =	v/N	mm
P_3 =	(b + v)/N	mm



Adopted 5/12/91

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DIAGRAM 3-3

COMBINED TWIST - CALCULATION OF PACKINGS

b	Bogie wheelbase	mm
v	Vehicle bogie centres	mm
α =	$\tan^{-1}(1/100) = 0.01$	radian
β =	$\tan^{-1}(1/250) = 0.004$	radian
γ =	$\alpha - \beta = 0.006$	radian
θ =	$\pi - \gamma$	
=	$\pi - 0.006$	radian
δ =	$\sin\delta = (4000 - b/2)\sin\theta/v$	
=	$0.006(4000 - b/2)/v$	radian

N_e= Effective twist ratio incorporating the 1 in 250 general twist and the local twist due to the bogie being at the bottom of a 4 metre 1 in 100 ramp.

= $1/\tan(\delta + \beta)$ or $\cot(\delta + \beta)$

P =	$(v + b/2)/N_e$	mm
P_1=	(b/100) mm	

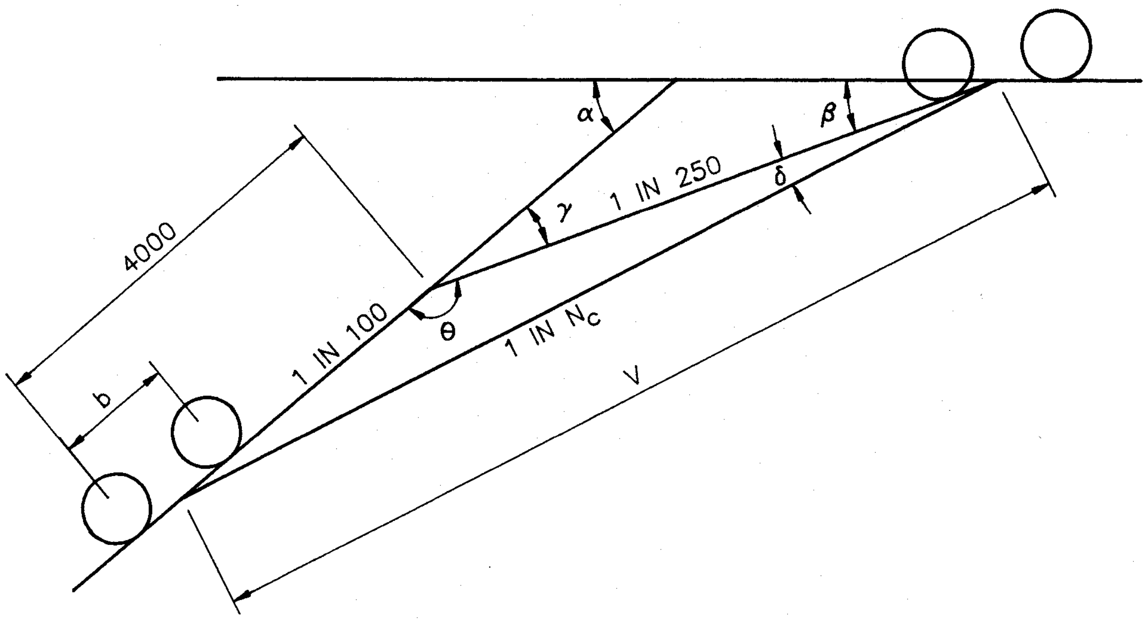

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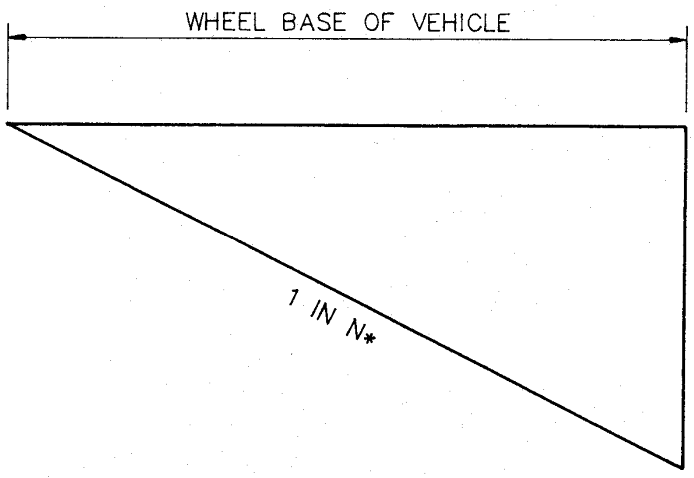
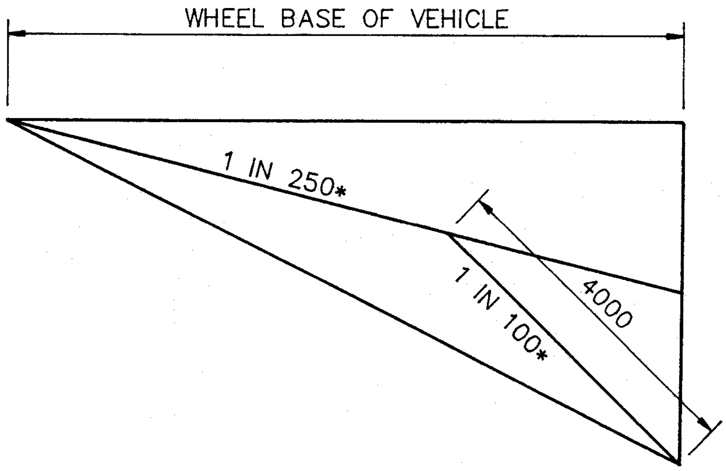
DIAGRAM 3-4

TWIST DIAGRAMS

GENERAL TRACK TWIST



COMBINED TRACK TWIST



NOTE: * ALL RAMPS ARE RELATIVE TO THE HORIZONTAL.
REFER TO TABLE 3.1

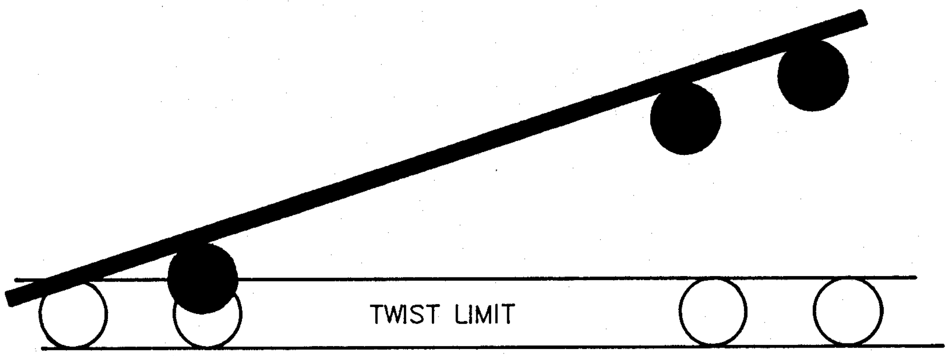
Adopted 5/12/91

Section 3 superseded by AS 7509

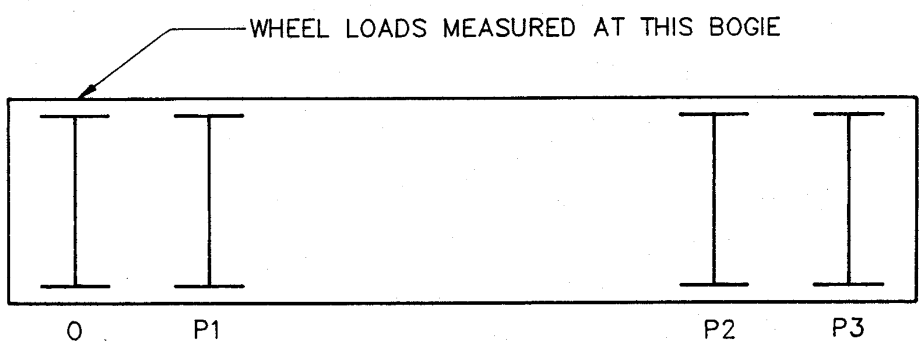
DIAGRAM 3-5

GENERAL TWIST

VEHICLE PACKING DIAGRAM



PACKING APPLIED TO ONE SIDE OF VEHICLE

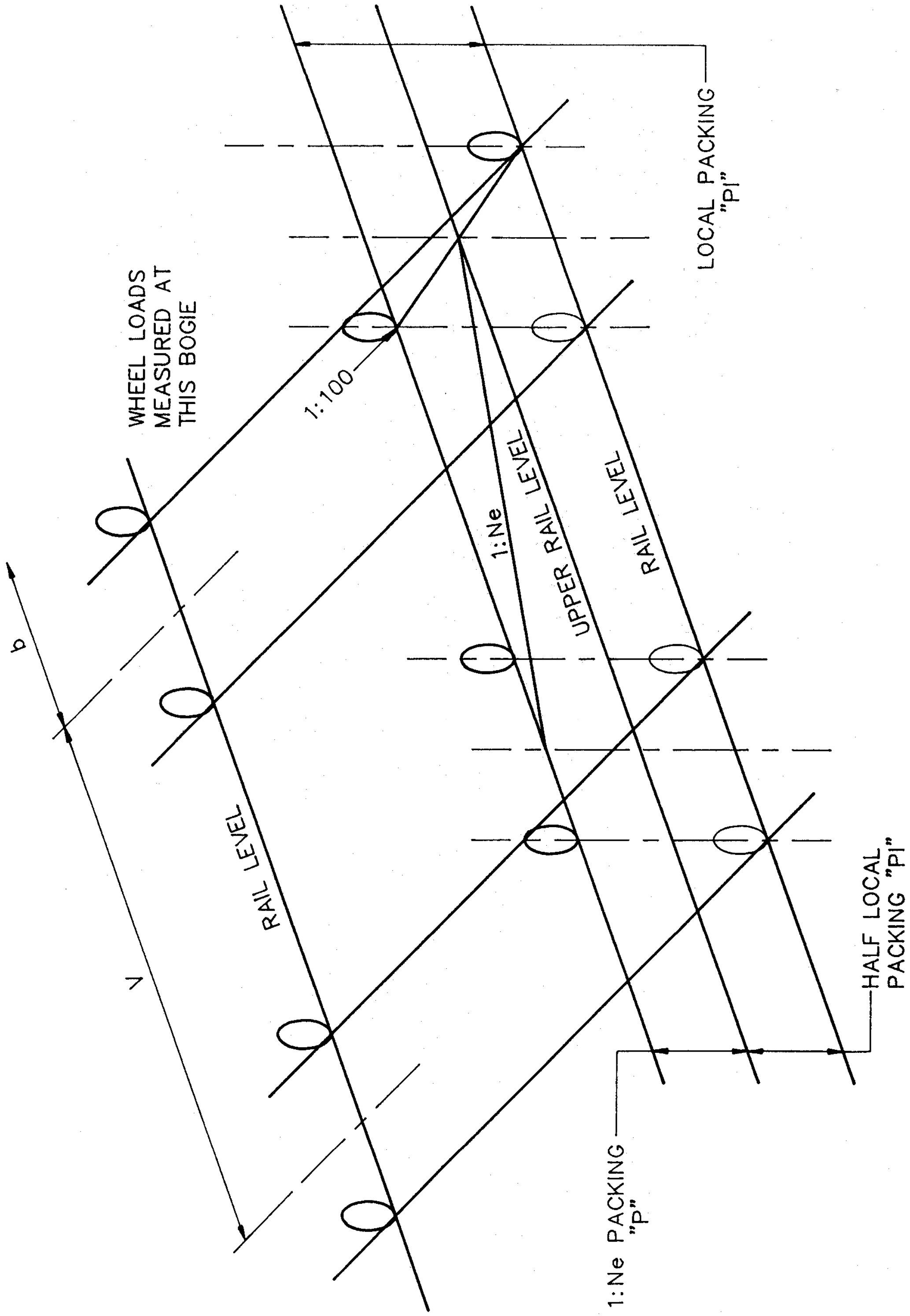


Adopted 5/12/91

Section 3 superseded by AS 7509

DIAGRAM 3-6

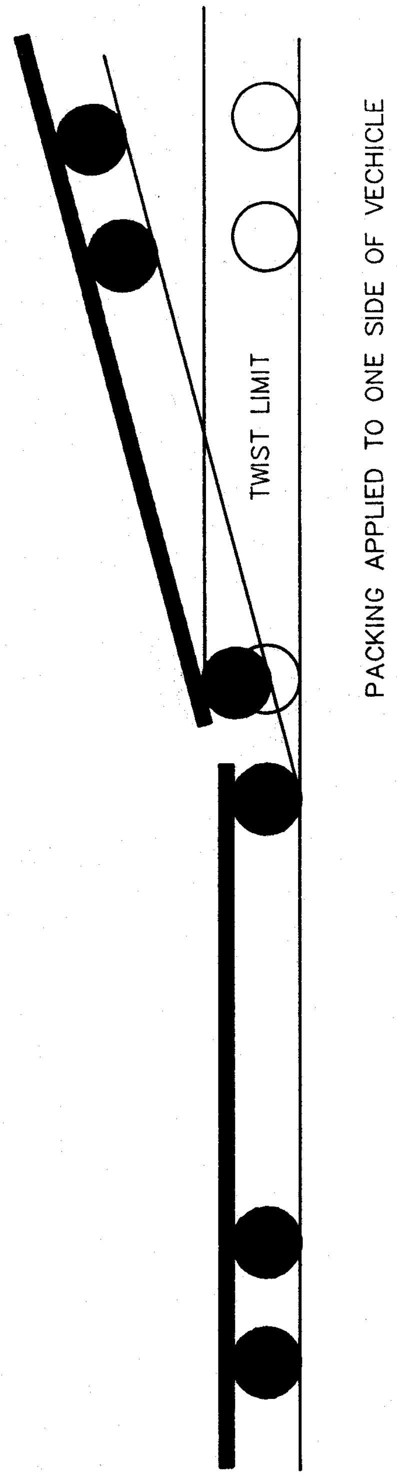
COMBINED TWIST -
VEHICLE PACKING DIAGRAM



Adopted 5/12/91

DIAGRAM 3-7

ARTICULATED VEHICLE - END PLATFORM TWIST

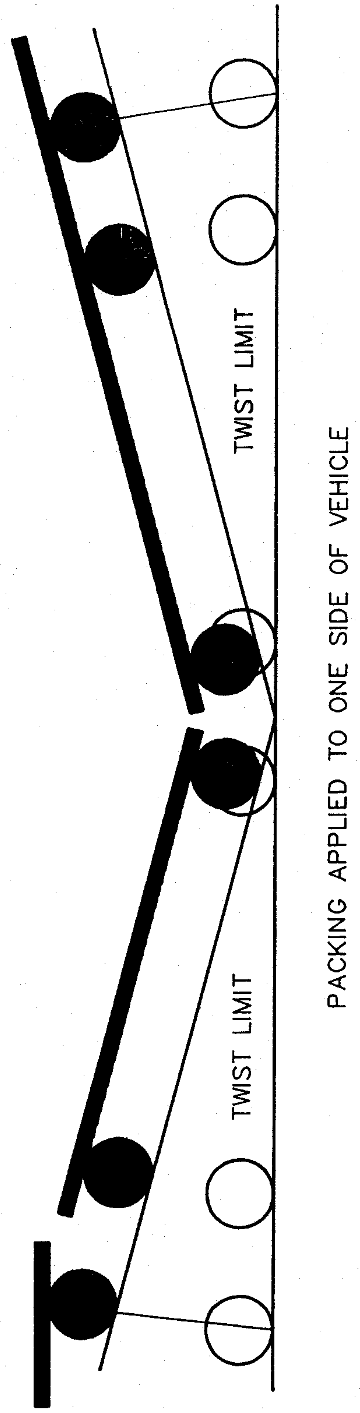


Adopted 5/12/91

Section 3 superseded by AS 7509

DIAGRAM 3-8

ARTICULATED VEHICLE - END AND INTERMEDIATE PLATFORM TWIST

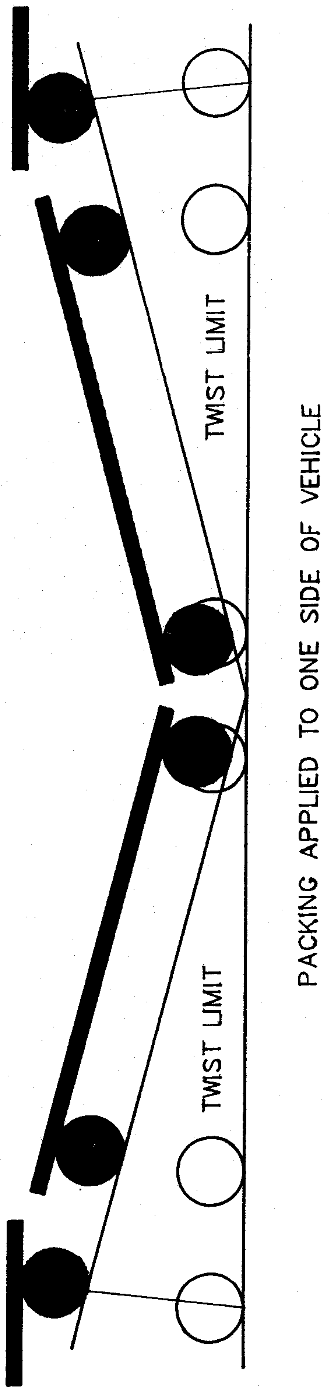


Adopted 5/12/91

Section 3 superseded by AS 7509

DIAGRAM 3-9

ARTICULATED VEHICLE - TWO INTERMEDIATE PLATFORMS TWIST

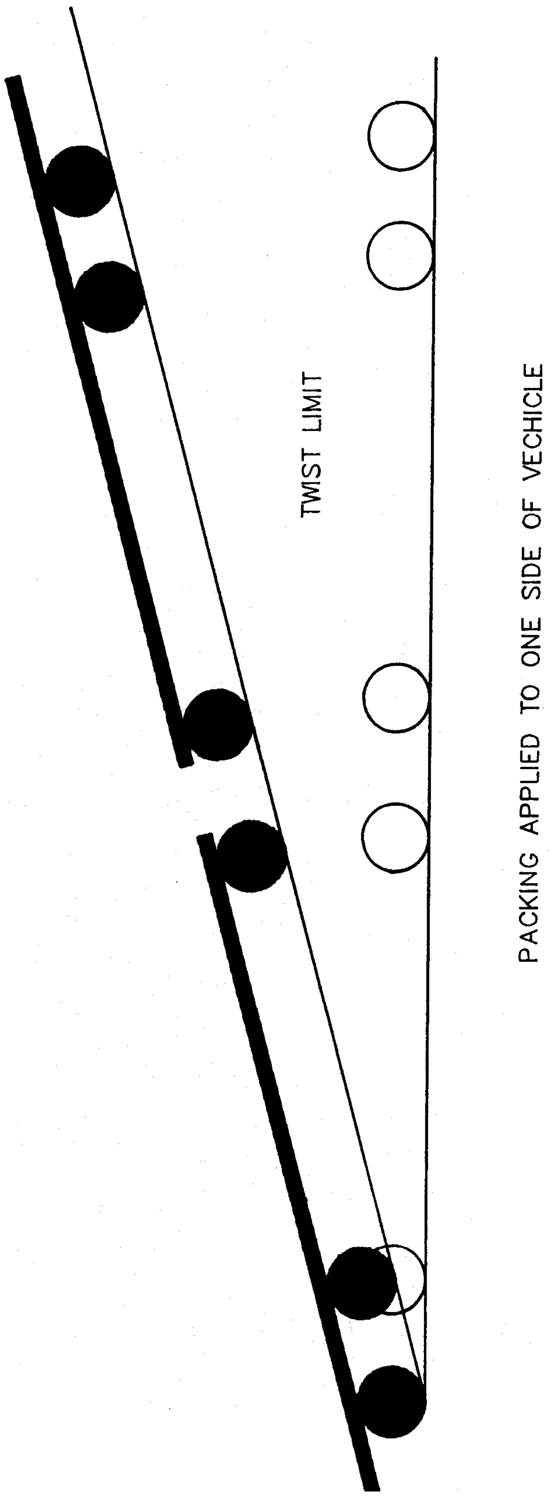


Adopted 5/12/91

Section 3 superseded by AS 7509

DIAGRAM 3-10

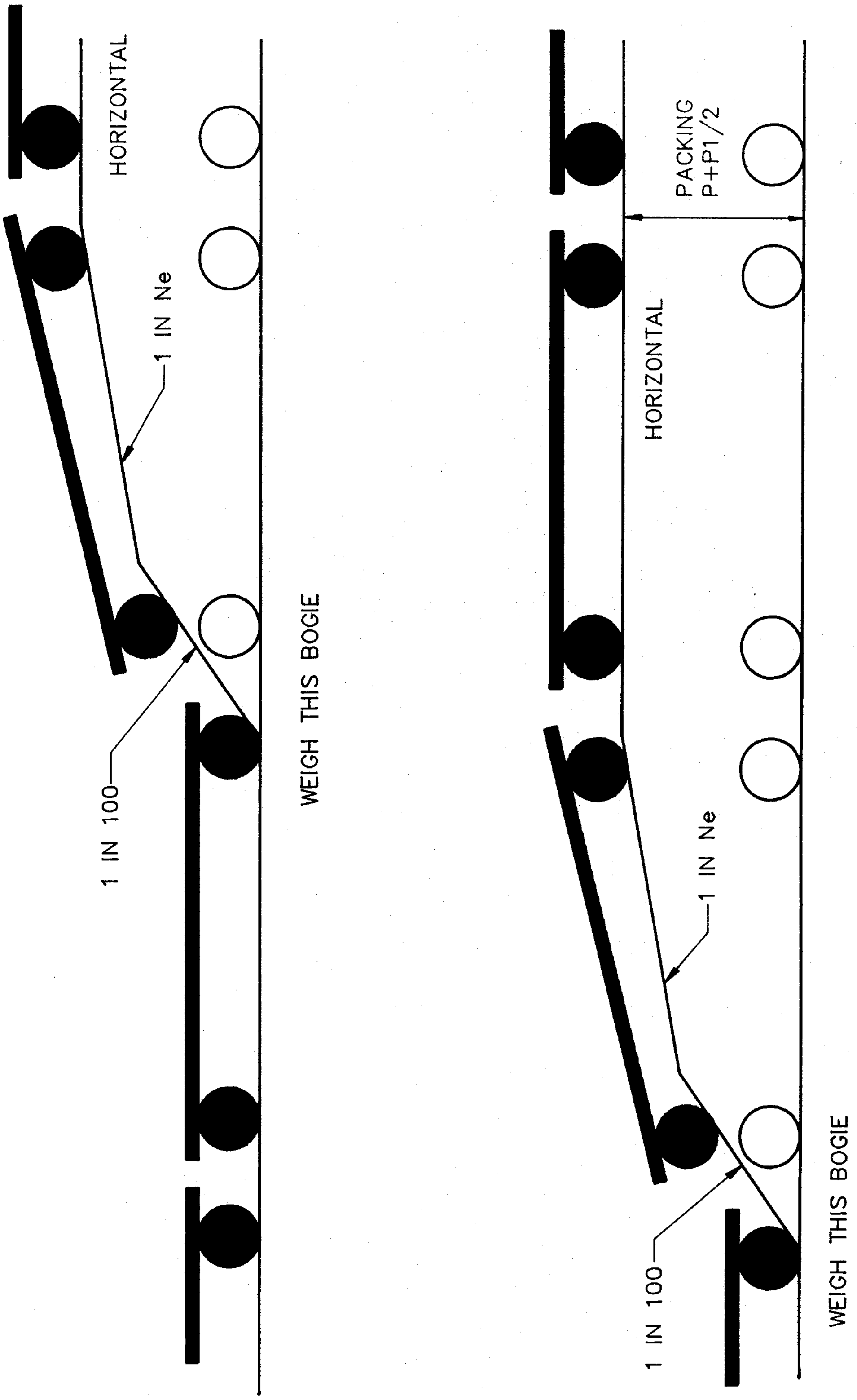
ARTICULATED VEHICLE - MAXIMUM LENGTH TWIST



Adopted 5/12/91

DIAGRAM 3-11

ARTICULATED VEHICLE - COMBINED TWIST



Adopted 5/12/91

Section 3 superseded by AS 7509

DIAGRAM 3-12A

SURFACE VARIATION TRACK GEOMETRY
CONTINUOUS DIPS AT SYMMETRIC POINTS

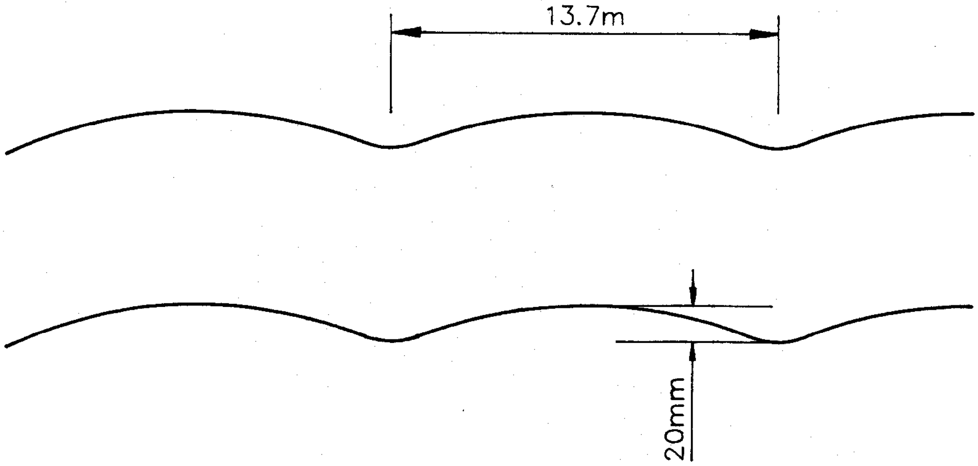
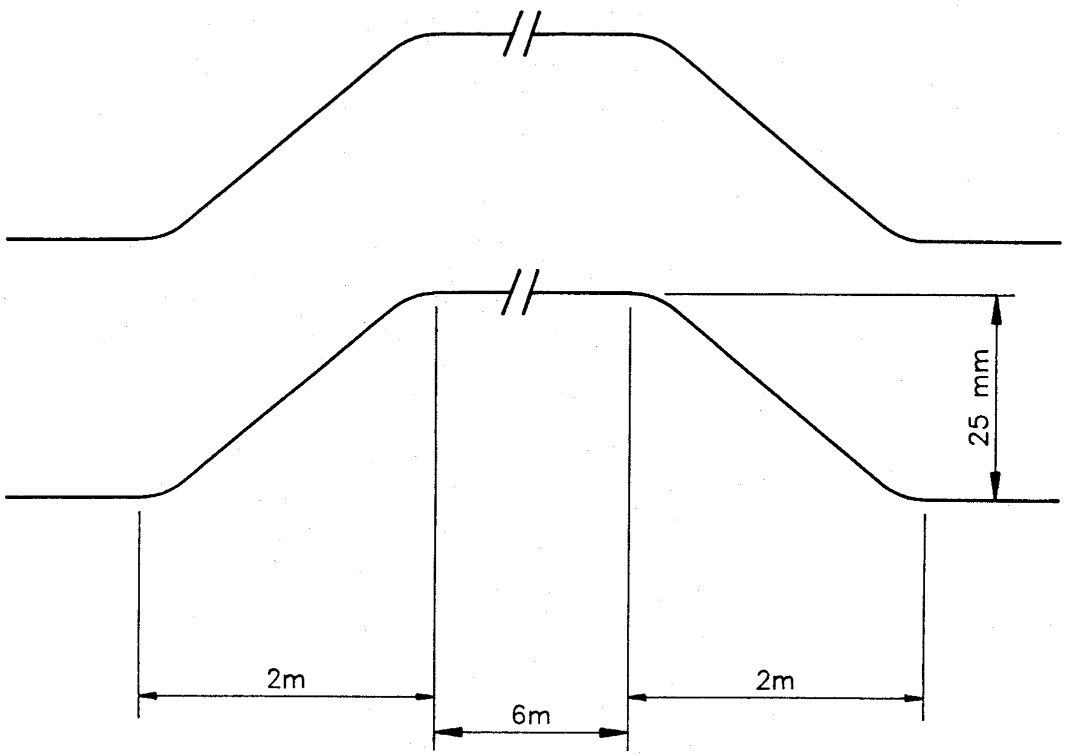


DIAGRAM 3-12B

SURFACE VARIATION TRACK GEOMETRY SINGLE VERTICAL BUMP



Adopted 5/12/91

Diagram 3-13 superseded by AS 7508

DIAGRAM 3-13

GENERAL P2 FORCE TEST SITE

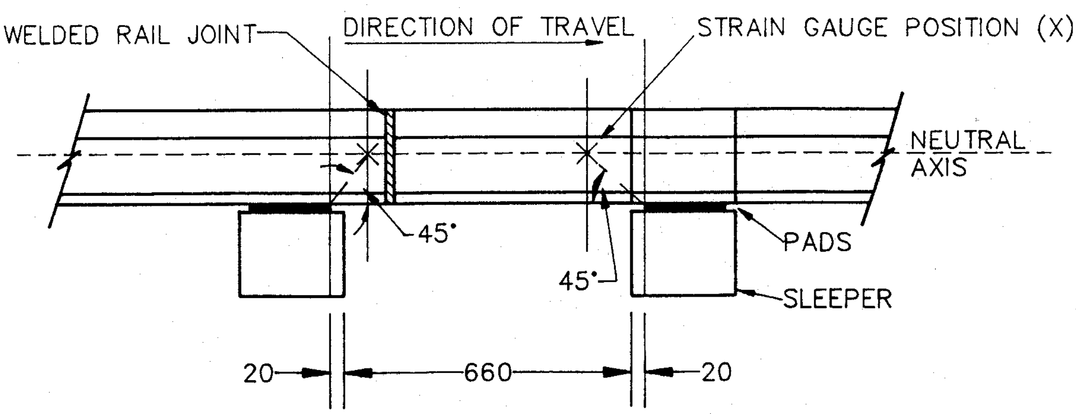


Diagram 3-14 superseded by AS 7508

DIAGRAM 3-14

STRAIN GAUGE ARRANGEMENT

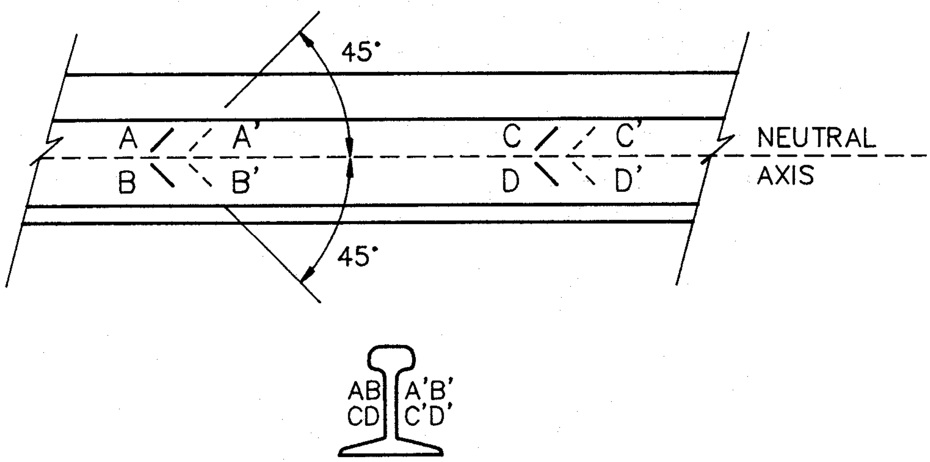
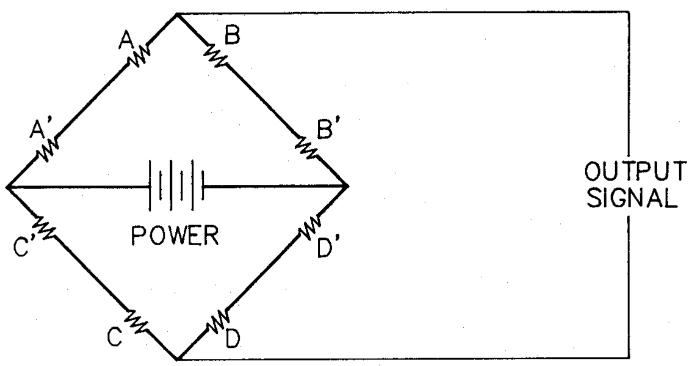


Diagram 3-15 superseded by AS 7508

DIAGRAM 3-15

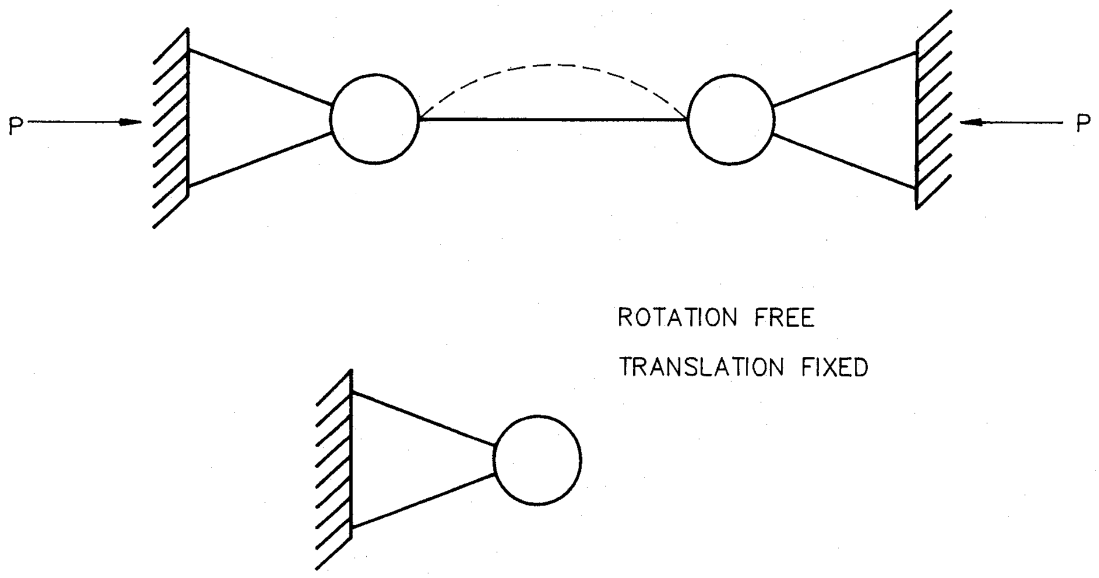
CIRCUIT DIAGRAM FOR STRAIN GAUGE



Adopted 5/12/91

DIAGRAM 3-16

LOADING FIXTURES FOR STATIC END COMPRESSION



Adopted 5/12/91

Section 3 superseded by AS 7509

RAILWAYS OF AUSTRALIA

FREIGHT VEHICLE

CERTIFICATE OF COMPLIANCE

Certificate Number..

This Certificate is issued to confirm that the vehicle specified has been tested in accordance with ROA Manual of Standards, Section 3, Roadworthiness Acceptance Standards for Freight Vehicles and found to comply.

This Certificate is issued as an . . . . (INTERIM or FULL) Certificate and may be withdrawn at any time if deemed necessary by the ROA Mechanical Engineering Steering Committee.

Testing System ....

Date Tested ....

Vehicle Specification

Vehicle Class ....

Designed by ....

Vehicle No.s..

Manufactured by ....

Vehicle Type ....

Owning System..

Bogie Specification

Bogie Type...

Sidebearer Type ....

Bogie No.s ....

Owning System..

Designed by...

Manufactured by ....

This Certificate is issued to . . . . (owning System) on this the . . . . day of . . . . 19. . . . . .

Signed

....
Chairman MESC

....
Witness

Adopted 5/12/91