



Rolling Stock - Dynamic Behaviour



Rolling Stock Standard



This Australian Standard® AS 7509 Rolling Stock - Dynamic Behaviour was prepared by a Rail Industry Safety and Standards Board (RISSB) Development Group consisting of representatives from the following organisations:

ARTC	Aurizon	Central Queensland University
Institute of Rail Technology (IRT)	PTA	Queensland Rail
UGL		

The Standard was approved by the Development Group and the Rolling Stock Standing Committee in June, 2017. On June 22, 2017 the RISSB Board approved the Standard for release.

This Standard was issued for public consultation and was independently validated before being approved.

Development of the Standard was undertaken in accordance with RISSB's accredited process. As part of the approval process, the Standing Committee verified that proper process was followed in developing the Standard.

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 Standard describes the dynamic behaviour requirements for locomotive, freight, passenger and infrastructure maintenance rolling stock to reduce the risk of derailment as well as to reduce the likelihood of accelerated degradation of the infrastructure.

1.2 Scope

This Standard sets the minimum requirements for the dynamic performance of locomotive, freight, passenger and infrastructure maintenance rolling stock, both new rolling stock and modified rolling stock, intended for operation on a railway network.

Road-rail vehicles are covered by AS 7502.

Track machines that are pushed by workers are not required to be assessed against the requirements of this Standard.

Operation of rolling stock is not covered.

AS 7509 covers design of rolling stock, including how the rolling stock performs in operation, but AS 7509 does not specify how the rolling stock should be operated.

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

1.3 Compliance

There are two types of control contained within Australian Standards developed by RISSB:

- (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 rail infrastructure manager (RIM), Rolling Stock Operator (RSO), 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 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.

Refer to AS 7501 for details on the Rolling Stock Compliance Assessment process.

1.4 Referenced documents

1.4.1 Normative references

The following referenced documents are indispensable for the application of this Standard.

The following documents are indispensable for the application of this Standard:

- (a) AS 7508 Railway Rolling Stock - Track Forces and Stresses.
- (b) AS 7514 Railway Rolling Stock - Wheels.
- (c) AS 7635 Railway Infrastructure - Track Geometry.
- (d) RISSB Guideline - Static Twist Test.

1.4.2 Informative references

The following referenced documents are cited in this Standard for information only:

- (a) AS 1418.1 Cranes, hoists and winches, Part 1: General requirements.
- (b) AS 1418.10 Cranes, hoists and winches, Part 10: Mobile elevating work platforms.
- (c) AS 4292 Railway safety management.
- (d) AS 7501 Railway Rolling Stock - Rolling Stock Compliance Certification.
- (e) AS 7506 Railway Rolling Stock - Electric Traction Infrastructure Interface.
- (f) AS 7507 Railway Rolling Stock - Rolling Stock Outlines.
- (g) AS 7513 Railway Rolling Stock - Interior Environment.
- (h) AS 7524 Railway Rolling Stock - Drawgear.
- (i) AAR Manual of Standards and Recommended Practices - Section C-II.
- (j) AAR Manual of Standards and Recommended Practices - Section D.
- (k) EN 280 Mobile elevating work platforms - Design calculations - Stability criteria - Construction - Safety - Examinations and tests.
- (l) EN 14033-2 Railway applications - Track - Railbound construction and maintenance machines.
- (m) EN 14067 Railway applications - Aerodynamics: Part 6: Requirements and test procedures for cross wind assessment.
- (n) EN 14363 Railway applications: Testing for the acceptance of running characteristics of railway vehicles - Testing of running behaviour and static tests.
- (o) European Technical Specification for Interoperability, Rolling stock sub-system, Working proposal of June 2000.
- (p) ISO 4305 Mobile cranes - Determination of stability.
- (q) ISO 4310 Cranes - Test code and procedures.
- (r) RISSB Guideline - Glossary of Railway Terminology.

- (s) RISSB Technical Note Number 1 - Changes to AS 7509 Rolling Stock Dynamic Behaviour, September 2013.
- (t) Transport for NSW standard t HR RS 00200 ST RSU 200 Series - Minimum Operating Standards for Rolling Stock - Common Interface Requirements.
- (u) UIC Code 518 Testing and approval of railway vehicles from the point of view of their running behaviour - Safety - Track fatigue - Running behaviour.
- (v) UK RSSB standard GM/RT2141 Resistance of railway vehicles to derailment and roll-over.
- (w) UK RSSB standard GM/RT2142 Resistance of railway vehicles to roll-over in gales.
- (x) UK RSSB guideline GM/RC2641 Recommendations for vehicle static testing.

1.5 Definitions

Air spring: A powered pneumatic device using compressed air as a spring. By controlling air volume, air springs also permit active levelling for constant suspension height with load.

Applied cant: The cant adopted for a particular curve radius for a particular track speed.

Approved rolling stock: Rolling stock that is currently operating on a railway network and has demonstrated satisfactory dynamic behaviour in service.

Base ride acceleration: An underframe based performance measure used to quantitatively assess the ride offered by the vehicle under specific test conditions.

Bounce: The vertical oscillation of the vehicle body on its suspensions, in-phase at each end such that the body remains horizontal.

Cane railway network: A railway system dedicated to hauling harvested sugar cane from farms to a raw sugar factory, typically 610 mm gauge.

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

Cant deficiency: The difference calculated as equilibrium cant minus applied cant (See definition for 'cant' in RISSB Glossary of Railway Terminology for a more detailed explanation).

Cant excess: A negative value of cant deficiency.

Cant imbalance: The difference between equilibrium cant, based on the rolling stock travel speed and curve radius, and the applied cant.

Cant ramp: A transition in cant, which by design varies from a maximum value to zero, or vice versa, over a prescribed length of track.

Complying rolling stock: Rolling stock that has been demonstrated to comply with the requirements of this Standard.

Conicity: A measure of the effective cone angle of the wheelset on the rails. For example, a wheel with a coned profile that has a slope of 1:20 that is sitting on the rails with a convex head would be expected to have a conicity of 0.05 (i.e. 1/20). Mathematically, the conicity is calculated as one-half of the slope of the graph of rolling radius difference versus lateral wheel shift.

Critical speed: The lowest speed at which hunting is demonstrated. Also used to describe the speed at which a resonant response occurs with isolated or cyclic track irregularities.

Damper: A mechanical device designed to smooth out (or damp) shock impulses and dissipate kinetic energy. Dampers can be hydraulic, pneumatic or friction type, such as friction snubbers/wedges. (Damping effects can also arise from sources such as friction generated at the mechanical interfaces between axle boxes and pedestal guides, between the leaves of leaf springs, etc., where such items are fitted. Certain suspension components, particularly those containing rubber elements, exhibit inherent damping known as hysteretic damping).

Dynamic behaviour: The performance of the vehicle when moving along the track, specifically with regard to the forces and torques affecting the motion of the vehicle's principal mass elements, e.g. body, bogie structural elements (where applicable) and wheelsets.

Equilibrium cant: The cant required, for a given curve radius and travel speed, that sees the vector addition of the developed centrifugal force and the vehicle weight result in a force with a line of action that is perpendicular to the plane of the track and acting through the track centreline (See definition for 'cant' in RISSB Glossary of Railway Terminology for a more detailed explanation).

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

Gross: Nominal total mass of rolling stock including (where applicable) maximum payload, provisioning, maximum service capacity of crew and passengers, and wheels at nominal new diameter.

Hunting: Cyclic lateral and yaw displacements of the wheelsets at a frequency greater than 0.5 Hz, causing lateral accelerations measured on the underframe at the bogie centre, with an RMS value in excess of 0.25 g over any window of 100 m in length. (Hunting causes accelerated wear and damage to both rolling stock and track, as well as discomfort to the crew and passengers (where applicable). Flange climb derailment can also occur if a wheel is sufficiently unloaded on a hunting vehicle.).

Individual wheel L/V: The ratio of the lateral force to the vertical force between the wheel and rail on any individual wheel (Sometimes used to assess the potential for the wheel to climb the rail. Refer also to sum L/V axle.).

Infrastructure maintenance rolling stock: Track machines, but excluding road-rail vehicles for the purposes of this Standard. Also known as on track vehicles. (Note that road-rail vehicles are covered by AS 7502.)

Instrumented wheelset: An item of test equipment which includes a wheelset equipped with strain gauges and processing electronics such that the lateral and vertical forces between each wheel and rail can be measured directly while the rolling stock is in motion.

Interstate corridor: Standard gauge track connecting the mainland Australian state capital cities.

Lateral: The direction across the track, perpendicular to the track centreline and parallel to the line joining the top of the rail heads.

Lateral acceleration: The signal from an accelerometer orientated such that its sensitive axis is aligned in the lateral direction when the vehicle is standing stationary on level track.

Lateral parameter limit: The maximum permitted value of lateral alignment of the track before a maintenance or inspection intervention is required.

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 rolling stock (typically freight or passenger rolling stock).

Longitudinal: The direction aligned with the track centreline, perpendicular to the lateral and vertical directions.

Modified rolling stock: Rolling stock that has been altered in such a way as to affect its compliance with the requirements in the Standard. (Rolling stock that includes changes to suspension characteristics, bogie rotational resistance, design wheel profile, bogie type, rolling stock operating conditions, tare mass, gross mass and/or centre of gravity position would be deemed to be modified rolling stock.)

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).

New rolling stock: Rolling stock manufactured to a new design that has not been assessed against the requirements of this Standard.

Novel suspension: A suspension design which has features such that combinations of wheel unloading and bogie rotational resistance may not be relied upon to demonstrate adequate resistance to derailment, for example, an active suspension system, or an active or passive tilting system.

Operator: The person or body responsible by reason of ownership, control or management, for the provision, maintenance or operation of trains, or a combination of these, or a person or body acting on its behalf.

Passenger rolling stock: Rolling stock carrying people and facilities for these people. This excludes locomotive and infrastructure maintenance rolling stock.

Peak acceleration: The local maximum magnitude, or minimum magnitude in the case of a negative-valued signal, of a measured acceleration waveform between zero crossings of the waveform.

Pitch: The vertical oscillation of the vehicle body on its suspension, but out-of-phase at each end such that the body rotates about a transverse axis through its pitch centre. (The pitch centre of a vehicle is typically located near to the mid-span point along the vehicle. End to end differences in vehicle suspension setup, and/or a longitudinally offset centre of gravity position, are likely to offset the pitch centre relative to the mid-span of the vehicle.)

Rail infrastructure manager (RIM): The person or body responsible by reason of ownership, control or management, for the construction and maintenance of track, civil and electric traction infrastructure, or the construction, operation or maintenance of train control and communication systems, or a combination of these; or a person or body acting on its behalf.

Railway network: A railway system owned or managed by a rail infrastructure manager.

Regulator: The National Rail Safety Regulator or an Acting National Rail Safety Regulator

RMS: Abbreviation for root mean square, a statistical measure defined as the square root of the arithmetic mean of the squares of a set of results.

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.

Rollover: A derailment mechanism whereby the rolling stock rolls over onto its side, pivoting about the wheels on that side.

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

Should: The word "should" indicates that a statement is a recommendation for the applicable vehicles.

Side bearers: Brackets or assemblies on both sides of the longitudinal centre of a bogie that limit the roll of the underframe on the bogie bolster.

Simulated service worn condition: Rolling stock featuring bogies with worn dampers and a worn wheel test profile on all wheelsets.

Steering mechanism: An active or passive system that acts to alter the angle of attack of the wheels or wheelsets in a curve, for example, cross-bracing, steering arms, yaw relaxation and other systems with the same purpose.

Sum L/V axle: Sum of the absolute values of the individual wheel L/V of both wheels on the same axle at a given instant in time. (Used to assess the potential for the wheel to climb the rail and is more appropriate than the individual wheel L/V when the angle of attack of the flanging wheel to the rail is low.)

Swing test: A physical test whereby the underframe or bogie is yawed to a particular position that replicates the rolling stock negotiating a nominated track geometry.

Tangent track: Track considered to be of infinite radius without applied cant (straight track).

Tare: The mass of the rolling stock in the lightest condition under which it will be operated. This includes provisioning with sand and water but fuelled to no more than one-third of capacity. (Note the lightest operating condition may be materially influenced by effects of wheel wear.)

Test section: A particular section of track nominated by the rail infrastructure manager over which physical testing of rolling stock can occur.

Top: Vertical alignment of the rails. Top is generally measured using the offset at a defined point along a chord of defined length.

Top parameter limit: The maximum permitted value of top before a maintenance or inspection intervention is required.

Track irregularity: An unintended deviation of the track's horizontal alignment, vertical alignment, cross-level, Cant and/or gauge from the design line of the track.

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

Track quality: A description of the degree of track irregularities present on a section of track.

Type test: A test conducted on one vehicle or train that is typical of all vehicles or trains constructed to the same specifications.

Vertical: The direction perpendicular to the plane of the rails, i.e. perpendicular to a line drawn across the top of the rail heads.

Vertical acceleration: The signal from an accelerometer orientated such that its sensitive axis is aligned in the vertical direction when the vehicle is standing stationary on level track.

Yaw: Rotation about the vertical axis.

Work closure: A section of railway track closed off to normal traffic and undergoing maintenance, construction or inspection.

Worn wheel test profile: A wheel profile that is a valid representation of the geometry that is expected to develop in service and intended to be used when assessing rolling stock dynamic behaviour.

2 Evaluation and testing

2.1 Scope

The dynamic behaviour of new rolling stock or modified rolling stock that travels outside work closures shall be evaluated for –

- (a) hunting as per section 3;
- (b) base ride accelerations as per section 4;
- (c) horizontal and vertical curve negotiation as per section 5;
- (d) transition curve negotiation as per section 6;
- (e) rollover as per section 7;
- (f) negotiation of isolated track irregularities as per section 8;
- (g) negotiation of cyclic track irregularities as per section 9; and
- (h) longitudinal forces in curves as per section 10.
- (i) wind loading as per section 11.

Refer to AS 7506 and AS 7507 for dynamic behaviour requirements of pantographs.

Refer to AS 7507 for requirements on a vehicle's dynamic swept outline.

Refer to AS 7508 for requirements on dynamic track forces from rolling stock.

The assessment of the dynamic behaviour of new or modified infrastructure maintenance rolling stock when in work mode or travelling inside work closures may require totally different criteria to that when travelling outside work closures.

The assessment of the dynamic behaviour of new or modified infrastructure maintenance rolling stock when in work mode or travelling inside work closures should identify the expected track conditions that the vehicle would be likely to operate over and the tolerability of wheel unloading and derailment.

Should new rolling stock or modified rolling stock be similar to complying rolling stock or approved rolling stock that is currently operating on a railway network, then the extent of evaluation against the requirements of this Standard may be reduced. (Guidance on 'similar' rolling stock is provided in the relevant sections of this Standard).

Guidance on the magnitude of the variation from existing rolling stock necessary to exclude assessment of particular aspects of dynamic behaviour is included in the following sections.

All evaluations required for dynamic behaviour are type tests only.

2.2 Rolling stock conditions

A key requirement of dynamic behaviour assessment is to determine the most adverse loading conditions that could be expected in service and then evaluate the rolling stock under these conditions.

Depending on the requirement being assessed, the most adverse loading condition could be the tare condition, the gross condition, an intermediate loading condition or a permitted asymmetric loading condition.

For rolling stock with multiple stage nested springs, the worst case can be when the vehicle is partially laden such that the bogie bolster rests at the change-over point of the suspension characteristic.

The critical loading condition for each aspect of dynamic behaviour is identified in the following sections.

Dynamic behaviour assessment may need to include consideration of the new condition as well as any degradation in performance due to wear of suspension components prior to maintenance.

Whilst wear of components can degrade performance in certain areas, the new condition can be worse in others.

For example, friction dampers will cause more wheel unloading in a twist test when in the new condition but will provide better damping in response to cyclic track irregularities.

Specific requirements for component condition for each assessment are given in the following sections.

Rolling stock being tested in a simulated service worn condition should have dampers replicated to be worn to within 10% of condemning limits.

Testing of hydraulic dampers at a range of strokes and speeds can give the required force versus velocity characteristics for modelling.

Methods of achieving a simulated service worn condition for physical testing include substituting softer springs in friction dampers, machining friction damper surfaces to simulate effects of wear, or substituting used dampers with appropriate dimensions.

For the purposes of this Standard it is assumed that potentially catastrophic failures of conventional mechanical parts are managed by the design and maintenance regime of the vehicle.

If an analysis of the requirements from the maintenance regime and operation condition show that the vehicle needs to be operated in a failure condition, assessment of running safety shall be performed according to this Standard.

2.3 Track conditions

Information on the relevant track geometry design data, and track geometry maintenance data shall be obtained from the rail infrastructure manager(s) for the railway network(s) where the rolling stock is to operate.

The track conditions required for dynamic behaviour assessment will generally be at the lower end of track quality likely to be encountered, however, the hunting test in tare condition requires good alignment to allow hunting to build up before being disturbed by track irregularities.

Lower track quality conditions may be required to check for hunting in gross condition.

Track data for dynamic behaviour modelling should have a similar frequency spectrum and amplitude of track irregularities to the actual track that the vehicle will operate on.

Where computer simulations are used to assess the dynamic behaviour of rolling stock running over real measured track, track data from inertial type track recording cars is preferred.

2.4 Modelling

Computer simulation programs that use numerical integration techniques and that cater for wheel to rail interaction non-linearities and rolling stock body and suspension non-linearities may be used in lieu of physical testing.

It is expected that, due to the difficulty in obtaining track with suitable defects, assessment of vehicle dynamic behaviour over track irregularities (i.e. specifically against the requirements of sections 8 and 9) is most likely to be done by modelling.

Dynamic behaviour simulation software shall be an industry-recognised kinematic tool, shall include the validated modelling of the behaviour of the wheel-rail interface (as evidenced by peer review in technical publications) and shall have been validated as being suitable for simulation of railway vehicle dynamic behaviour. (The supplier of the dynamic behaviour simulation software should be able to provide evidence of its validation and suitability for its application to rail vehicle dynamic behaviour and wheel-rail interaction.

A useful reference may be Vehicle System Dynamics 31, 'The Manchester Benchmarks for Rail Vehicle Simulation', S. Iwnicki, 1999, Taylor & Francis, London, UK. ISBN 978-90-2651-551-4)

Physical testing should be used to validate key elements of the vehicle simulation model and confirm the parameters used.

EN 14363 Annex T.3 and UIC 518 Appendix K provide useful advice on a validation process for simulation models.

2.5 Physical testing

Test equipment used to physically measure rolling stock dynamic behaviour shall have current calibration certificates covering the measurement range applicable to the test.

The type, calibration details and location of all measuring instruments used during rolling stock dynamic behaviour physical testing shall be recorded in the test reports. This is so tests can be repeated or reassessed.

It is good practice to measure all data in track testing at a minimum sampling rate of 200 samples/second, then a low pass filter applied of 40Hz or more at the point of acquisition. Typically, a sampling rate of 500 samples per second and a 100Hz low-pass filter are applied.

An anti-aliasing filter shall be applied at the point of digitisation of the measured data. A very high sampling rate is not considered sufficient to prevent the risk of aliasing.

Track testing should be done under dry rail conditions. This is mandatory for hunting tests.

It is good practice to record the rail conditions and atmospheric conditions during track testing in the test report.

The acceptance criteria limit values already include a margin for measuring uncertainty and no additional adjustment of the result or the limit value should be made.

If suspension deflection measurements are used in evaluating the rolling stock performance, then more stringent performance limits may be applicable due to the measurement uncertainty.

The test results should be examined for any anomalies. Sections with large deviations from the expected results should be investigated and reported if they cannot be explained by physical effects

Use of an instrumented wheelset enables direct measurements of wheel-rail forces to be made. (An instrumented wheelset may not provide reliable outputs when traction or braking inputs are applied. For testing Locomotive rolling stock equipped with creep control, the creep control outputs of the locomotive could be used to measure longitudinal creep.)

Where testing is being undertaken at a constant speed, a speed tolerance of $\pm 5\%$ of the target speed is acceptable.

If some of the required test input conditions are not achieved, this shall be documented in the test report.

The adequacy of the test results obtained shall be examined to see whether they can be reliably adjusted for the missing input conditions or whether a re-test is required.

3 Hunting

3.1 Introduction

Section 3 describes how to evaluate whether a vehicle will suffer from hunting.

3.2 Evaluation conditions

3.2.1 Exclusions

If all the following conditions are met, then assessment for hunting may not be required:

- (a) The maximum service operating speed is not greater than that of similar complying rolling stock or approved rolling stock.
- (b) The wheel profile is the same as that used on similar complying rolling stock or approved rolling stock.
- (c) The tare axle load is more than 95% of the tare axle load of similar complying rolling stock. (Generally, a higher axle load aids resistance to hunting and a lower axle load increases the risk of hunting, hence the restriction on reducing axle load.)
- (d) The yaw restraint of wheelsets and bogie frames can be shown to be similar to that of complying rolling stock or approved rolling stock.
- (e) The bogie wheelbase is more than 95% of that of similar complying rolling stock. (Generally, a longer bogie wheelbase aids resistance to hunting and a shorter bogie wheelbase increases the risk of hunting, hence the restriction on reducing bogie wheelbase.)

- (f) The bogie centre distance is more than 95% of that of similar complying rolling stock. (Generally, a longer bogie centre distance aids resistance to hunting and a shorter bogie centre distance increases the risk of hunting, hence the restriction on reducing bogie centre distance.)

In the above clauses, and for evaluation of the rolling stock for hunting, 'similar' means that the rolling stock being compared is of the same type (e.g. hopper wagon, container flat wagon, passenger car, locomotive, etc.) with the same type of bogie design and the same suspension component types.

Assessment for hunting is not required for infrastructure maintenance rolling stock that travels at speeds of less than or equal to 20km/h.

3.2.2 Hunting simulations

For simulations to assess rolling stock resistance to hunting, a recognised procedure is as follows:

- (a) The rolling stock speed is swept from high speed to low speed, where the high speed is in excess of the expected critical speed. (A series of speeds may be required in order to capture rolling stock that may hunt due to frequency coincidence at intermediate speeds.)
- (b) Hunting is initiated at high speed by a lateral track defect or track irregularity.
- (c) The rolling stock speed then reduces over perfectly smooth track.
- (d) The critical speed is the speed at which the lateral hunting oscillations of the wheelset are observed to stop.

Note that hunting simulations do not replace the need for a hunting test. The simulations provide design stage proof of stability. The test verifies stability is achieved, including under other wheel-rail conditions not included in the simulations.

3.2.3 Rolling stock conditions

A vehicle being evaluated for hunting should be in tare condition.

Vehicles with a short distance between bogie centres, a high centre of gravity, or with 3-piece bogies fitted with resilient shear pads, should also be evaluated for hunting in the gross load condition.

A vehicle being evaluated for hunting should be in the simulated service worn condition.

Features most critical to hunting will be wheel treads, yaw dampers, and any components providing yaw restraint of a wheelset or bogie frame e.g. pedestal liners, trailing arm bushes, bolster wear plates.

The wheelsets of the vehicle being evaluated should feature a worn wheel test profile on both wheels.

For a hunting assessment, a worn wheel test profile shall be used where the effective conicity is at or approaching the highest levels that will be seen in service.

Rolling stock with air springs should be evaluated with air springs inflated and air springs deflated.

3.2.4 Track conditions

Any track irregularities in the test section which are more severe than those requiring inspection within 7 days based on the vehicle's rated maximum speed or the track speed limit, whichever is lesser, should be spaced no closer than the distance travelled in 10 seconds at the testing speed. (Track irregularities can trigger the onset of hunting which will then continue on perfect track. Such irregularities can also interfere with hunting and prevent it building up to its potential acceleration amplitude. A track irregularity that requires inspection within 7 days is known as a 'priority class 2' response in AS 7635, but the relevant rail infrastructure manager's standard may use an alternative term.)

The gauge corner of the rails within the test section should have minimal grinding so that contact with the wheel tread occurs over the full distance between the tread line and the throat of the flange as the wheel moves towards flange contact. (Low effective conicity, discouraging hunting, occurs when the rail gauge corner is relieved sufficiently so that the contact point on the wheel stays close to the tread line rather than moving towards the flange as the wheelset moves laterally towards flange contact.)

The track gauge within the test section should not be more than 3mm wider or 3mm tighter than nominal gauge on average. (Tight gauge shifts the contact points on the wheels closer to the flange where the tread gradient is steeper, thus increasing the effective conicity and susceptibility to hunting. A test section with overly wide or tight gauge may place undue bias on the outcome of the test.)

3.2.5 Operating conditions

A vehicle being evaluated for hunting should be travelling as a single vehicle or hauled in a trailing position.

Hunting shall be evaluated under dry weather conditions. (Wet wheels and rail heads, during or shortly after rain, will result in a reduced coefficient of friction between wheels and rails, discouraging hunting.)

A vehicle being evaluated for hunting should travel at speeds in increments up to 110% of its intended maximum service operating speed. Increments in speed can be applied on the journey to the designated test section for 110% speed testing.

A vehicle being evaluated for hunting should travel over tangent track for a continuous distance of at least 2km. The presence of curves can suppress hunting behaviour.

3.3 Measurements

The underframe lateral acceleration at the leading and trailing bogie centres of rotation should be determined during hunting evaluation, or, for rolling stock without bogies, the lateral acceleration is to be measured at floor level as near as practicable to the leading and trailing axles.

For vehicles with a soft lateral suspension, a lateral acceleration measurement at the axle box or bogie frame longitudinal extremity for the leading and trailing bogies should also be taken during hunting evaluation. (For vehicles with a soft lateral suspension, bogie or wheelset hunting motions may not generate unacceptable body accelerations despite producing wheel/rail forces which are significant in derailment terms.)

Accelerations obtained for hunting evaluation should be evaluated as follows:

- (a) First, the accelerations should be filtered using a low pass filter with cut-off frequency of 10Hz and a filter roll-off of 24 dB/octave (Figure 1 illustrates the filter roll-off.).
- (b) Next, the accelerations should be filtered using a band pass filter set to ± 2 Hz each side of the dominant frequency with a filter roll-off of 24 dB/octave. (For any vehicles that show more than one dominant frequency, the user must ensure that the hunting frequency and vehicle performance is adequately assessed. Figure 2 illustrates the band pass filter and the filter roll-off.)
- (c) Then, a sliding RMS value of acceleration is calculated for a window length of 100m and a step length of 10m.

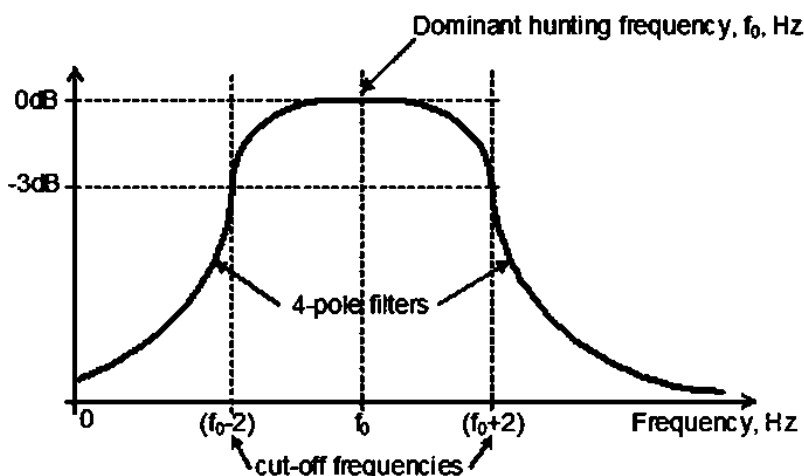


Figure 1 – Band-pass filter, cut-off frequency and roll-off (diagram only)

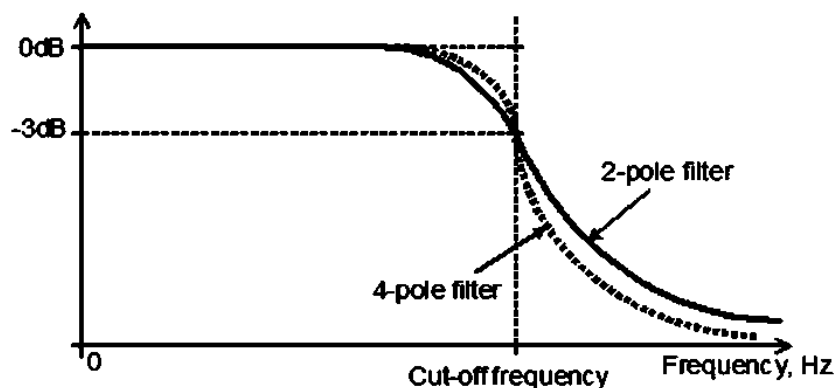


Figure 2 – Low-pass filter, cut-off frequency and roll-off (diagram only)

3.4 Acceptance criteria

A vehicle during hunting evaluation shall not experience an RMS value of underframe lateral acceleration that exceeds 0.25g over any 100m window.

For vehicles with a soft lateral suspension, where lateral acceleration is also measured at the axle box or bogie frame longitudinal extremity, the RMS value of these lateral accelerations shall not exceed 0.5g over any 100m window.

For vehicles with a soft lateral suspension, where the axle box or bogie frame lateral acceleration measurements indicate wheel/rail forces arising from instability are likely to be significant in terms of derailment risk, then a further assessment should be performed and the maximum individual wheel L/V ratio should not exceed 1.0 using a sliding mean over 2 m. (Note that this clause requires evaluation by a sliding mean, in line with European standards.)

4 Base ride accelerations

4.1 Introduction

Section 4 describes how to evaluate whether a vehicle will ride satisfactorily over track at the lower end of track quality expected to be encountered in service at the vehicle's rated maximum service speed.

Note that this section considers ride safety only and does not consider ride comfort for passengers and crew.

Ride comfort requirements for crew and passengers are covered in AS 7513 for locomotive rolling stock, passenger rolling stock and infrastructure maintenance rolling stock.

4.2 Evaluation conditions

4.2.1 Exclusions

If all the following conditions are met, then base ride acceleration assessment may not be required:

- (a) The wheel profile is the same as that used on similar complying rolling stock or approved rolling stock.
- (b) The tare axle load is more than 90% of the tare axle load of similar complying rolling stock or approved rolling stock. (Generally, for the same suspension, a lighter vehicle is expected to lead to higher accelerations and a heavier vehicle is expected to have lower accelerations, hence the restriction on reducing axle load.)
- (c) The suspension stiffnesses and damping rates are within 10% of those of similar complying rolling stock or approved rolling stock.
- (d) The yaw restraint of wheelsets and bogie frames can be shown to be similar to complying rolling stock or approved rolling stock.
- (e) The bogie centre distance is more than 95% of that of similar complying rolling stock or approved rolling stock. (Generally, for the same suspension, a shorter bogie centre separation is expected to lead to higher accelerations and a