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ARISO Contact details:

Head office:

Phone:	Email:	Web:
(07) 3724 0000 +61 7 3724 0000	info@ariso.org.au	www.ariso.org.au

Standard Development Manager:

Name:	Phone:	Email:
Frank Szanto	0419 916 693	fszanto@ariso.org.au

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SDM name	Frank Szanto
SDM phone	0419 916 693
SDM email	fszanto@ariso.org.au

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Preface

This Standard was prepared by the Braking System – Part 3: Multiple Unit Passenger Development Group, overseen by the ARISO Rolling Stock Standing Committee.

Objective

The objective of this document is to provide safety benefits in that proper braking performance contributes to the prevention of collisions or derailments of railway rolling stock by providing controls for known hazards.

This document describes minimum standards for brake performance, features and compatibility for the braking systems of Multiple Unit Passenger Sets.

This document is intended to compliment the rolling stock compliance certification process outlined in AS 7501, including all vehicle types such as new, modified and heritage rolling stock.

Compliance

There are four types of provisions contained within Australian Standards developed by ARISO:

(a) Requirements.

(b) Recommendations.

(c) Permissions.

(d) Constraints.

Requirements – it is mandatory to follow all requirements to claim full compliance with the Standard. Requirements are identified within the text by the term ‘shall’.

Recommendations – do not mention or exclude other possibilities but do offer the one that is preferred. Recommendations are identified within the text by the term ‘should’.

Recommendations recognize that there could be limitations to the universal application of the control, i.e. the identified control is not able to be applied, or other controls are more appropriate or better.

For compliance purposes, where a recommended control is not applied as written in the standard it could be incumbent on the adopter of the standard to demonstrate their actual method of controlling the risk as part of their WHS or Rail Safety National Law obligations. Similarly, it could also be incumbent on an adopter of the standard to demonstrate their method of controlling the risk to contracting entities or interfacing organisations where the risk may be shared.

Permissions – conveys consent by providing an allowable option. Permissions are identified within the text by the term ‘may’.

Constraints – provided by an external source such as legislation. Constraints are identified within the text by the term ‘must’.

ARISO products identify known hazards relevant to the railway industry. Appendix A provides a non-exhaustive list of hazards relevant to the scope of this document.

Appendices in ARISO Standards may be designated either “normative” or “informative”. A "normative" appendix is an integral part of a Standard and compliance with it is a requirement, whereas an "informative" appendix is only for information and guidance.

Commentary

Commentary *C Preface*

This Standard includes a commentary on some of the clauses. The commentary directly follows the relevant clause, is designated by 'C' preceding the clause number and is printed in italics in a box. The commentary is for information and guidance and does not form part of the Standard.

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Section 1 Scope and general

1.1 Scope

This document describes the requirements for brake performance, features and compatibility for the braking systems of multiple unit passenger sets including fixed consists which can be coupled together, push-pull sets and single self-propelled passenger cars that are new, substantially modified or that are to operate in a network in which they have not previously operated.

This document covers the design and construction of brake systems including electro-pneumatic (EP) and automatic air brake systems.

This document covers the maintenance of the brake systems including EP and automatic air brake systems.

The operation of multiple unit passenger sets, considering network safeworking rules and route standards, is not covered.

1.2 Normative references

The following documents are referred to in the text in such a way that *some* or all of their content constitutes requirements of this document:

- AS 1210:2010, *Pressure vessels*
- AS 2435:1992, *Elastomeric hose for railway air brakes*
- AS 7503:2023, *Rail vehicle identification and markings*
- AS 7504:2018, *Brake Blocks*
- AS 7504.2:2023, *Brake components, Part 2: Brake discs and pads*
- AS 61508-1:2011, *Functional safety of electrical/electronic/programmable electronic safety-related systems, Part 1: General requirements*
- AS/NZ 3788:2024, *Pressure equipment - In-service inspection*
- BS EN 286-3:1994, *Simple unfired pressure vessels designed to contain air or nitrogen - Part 3: Steel pressure vessels designed for air braking equipment and auxiliary pneumatic equipment for railway rolling stock*
- BS EN 14531-1:2015, Railway applications - Methods for calculation of stopping distances, slowing distances and immobilisation braking - Part 1: General algorithms

NOTE:

Documents for informative purposes are listed in a Bibliography at the back of the Standard.

1.3 Defined terms and abbreviations

For the purposes of this document, the following terms and definitions apply:

1.3.1
abrasive brake block
trim block
brake block that can be used to remove minor wheel and tread irregularities

1.3.2
acceptance criteria
specified conditions or limits against which test results or inspection outcomes are assessed to determine compliance

1.3.3
automatic air brake
brake that automatically applies throughout a train when the brake pipe pressure is reduced and releases when the brake pipe pressure is restored

1.3.4
automatic brake
continuous brake system for trains or sets that will self-apply in the event of loss of continuity

Note 1 to entry: This includes train or set separation.

1.3.5
automatic park brake (APB)
park brake able to self-apply in predetermined circumstances without direct human intervention

1.3.6
auxiliary reservoir
automatic air brake reservoir on a vehicle in which is stored compressed air as the primary source specific to that vehicle for a non-relayed brake system or the compressed air that provides the pilot signal for a relayed brake system

1.3.7
blended braking
braking in which two or more braking systems (such as friction braking, regenerative braking, or rheostatic braking) are automatically coordinated by a control system to achieve the required braking effort or deceleration

1.3.8
brake disc pad
friction element that is forced directly onto a brake disc for the purpose of vehicle braking

1.3.9
brake pipe
automatic air brake system conduit that is installed throughout the length of a train for the delivery of brake system compressed air and in which pressure signals for brake system control can be delivered

1.3.10
braking energy
energy to be dissipated from the braking surface

1.3.11
braking surface
equipment surface at which vehicle braking can be developed by friction

1.3.12
coefficient of adhesion
ratio of the tangential force exerted on the rail by the wheel divided by the vertical force on the rail due to the axle load

1.3.13
composition brake block
brake block containing non-metallic friction material

1.3.14
continuity
continuous connection and the operability of the brake system of a train on all vehicles from the front of the train to its rear

1.3.15
direct release
brake system that is effective continuously along the length of the train

1.3.16
drag braking
continuous application of a controlled braking effort intended to maintain speed or limit acceleration

Note 1 to entry: Drag braking is typically applied during prolonged downhill operation and not intended to produce a full service or emergency stop.

1.3.17
control valve
triple valve
distributor valve
control element of the automatic air brake of a vehicle

1.3.18
direct release
only applicable to the automatic air brake system where it can only be released in a single step as distinct from many steps in a graduated release system

1.3.19
dummy volume
automatic air brake reservoir on a vehicle which provides the reference volume for the pilot signal for a relayed brake system

1.3.20
dynamic brake
generic term for regenerative, rheostatic or hydrodynamic braking

1.3.21
emergency application
application of an automatic air brake by venting the brake pipe or de-energising an electric trainline and magnet valves resulting in a rate of retardation that is greater to equal to the normal rate of a service application

1.3.22
electro-pneumatic (EP)
air brake equipment incorporating principal function control by electromagnetically operated valves but not electronically controlled in the manner of ECP brakes

1.3.23
equalising reservoir
automatic air brake reservoir on self-propelled rolling stock in which is stored compressed air at a reference pressure for replication in the brake pipe

1.3.24
friction element
sacrificial pad or block that is forced onto a braking surface to develop a braking force by friction

1.3.25
full service
application of the automatic air brake resulting from service braking to the extent that the maximum normal rate of retardation is achieved

1.3.26
function check
brake checking in the field performed for the purpose of confirming the serviceability of the brake system of a vehicle or vehicles

1.3.27
graduated application
brake system that allows the gradual application of the brakes

1.3.28
graduated release
brake system that allows the gradual release of the brakes as distinct from a direct release system

1.3.29
handbrake
park brake operated by manual effort via a wheel or lever

1.3.30
holding brake
in an EP brake system, the application of a predetermined braking effort for emergency purposes or for parking or securing a train

1.3.31
hydrodynamic brake
braking equipment that enables a train driver to apply variable retardation by the utilisation of the transmission system of a prime-mover fitted with a hydraulic power transmission system

1.3.32
intra-train
within a train

1.3.33
inter-vehicle
between vehicles

1.3.34
limp-home mode
degraded operational state automatically entered following detection of a fault, in which braking functionality is maintained at a reduced but safe level sufficient to permit controlled movement of the train to a designated place of safety under defined operating limits

1.3.35
longitudinal jerk
rate of change of longitudinal acceleration of a train over time

1.3.36
main reservoir
one or more interconnected compressed air reservoirs supplied directly by one or more air compressors as a primary source of compressed air for a vehicle air brake system and often for additional purposes

1.3.37
main reservoir pipe
vehicle through pipe having flexible end connections to permit the supply of compressed air to that vehicle and others attached to it from the main reservoirs of an attached locomotive

1.3.38
minimum reduction
pre-determined reduction of brake pipe pressure below the standard brake pipe pressure that will cause the minimum controllable application of the automatic air brake

1.3.39
multiple unit control
full functional operation of more than one coupled vehicle from a single driving station

1.3.40
multiple unit passenger set
diesel multiple unit (DMU) train or an electric multiple unit (EMU) train made up of more than one vehicle and not readily divisible or two such units coupled together

1.3.41
onboard train protection system (OTPS)
driving supervisory system
vehicle equipment designed to maintain safety in the event of driver incapacitation, including vigilance control systems, operator enable (deadman) systems and trip gear

1.3.42
passenger rolling stock
hauled or self-propelled rolling stock intended for the transportation of passengers or for use specifically on passenger trains

1.3.43
powered park brake
park brake that can be remote-controlled by a train driver

1.3.44
rail infrastructure manager (RIM)
As defined in Rail Safety National Law.

1.3.45
regenerative brake
braking equipment that enables a train driver to apply variable retardation by the utilisation of traction motors to generate electrical energy that is fed into the off-train supply system or stored on board

1.3.46
relayed brake
arrangement of the automatic air brake installation within a vehicle that incorporates a relay valve and a supplementary reservoir to increase the amount of brake system compressed air that can be controlled by a single control valve

1.3.47
relay valve
pneumatic device that permits a pilot signal to control brake system compressed air

1.3.48
rheostatic brake
braking equipment that enables a train driver to apply variable retardation by the utilisation of traction motors to generate electrical energy that is dissipated on board

1.3.49
rolling stock operator (RSO)
As defined in Rail Safety National Law.

1.3.50
service application
application of the stopping brake that is propagated within a train at a normal rate that is pre-determined and that results in a normal rate of retardation according to driver demand

1.3.51
service braking
normal manipulation of the stopping brake during train running

1.3.52
set
more than one vehicle coupled for operation

1.3.53
slack adjuster
device that automatically compensates for wear or clearance changes in brake rigging to maintain effective brake force transmission

1.3.54
spring park brake
park brake that is applied by spring force and released by compressed air or hydraulic force

1.3.55
standard brake pipe pressure
network specified maximum brake pipe pressure to which an automatic air brake is to be initially charged for normal train operation

Note 1 to entry: Standard brake pipe pressure is typically 500 kPa.

1.3.56
static brake test
brake test performed on a vehicle or train whilst it is stationary

1.3.57
stopping brake
braking equipment used for stopping a train in running

1.3.58
supplementary reservoir
supply reservoir
compressed air reservoir on a vehicle that is the source of air pressure for the brake cylinders on EP systems and relayed brake systems

1.3.59
through brake pipe
continuous brake pipe that passes through a vehicle to enable propagation of pneumatic control signals to adjacent vehicles in the train

1.3.60
wheel slide protection equipment (WSP)
wheel slide prevention equipment
automatic system designed to prevent wheel slide by making localized reductions and reinstatements of braking force to make the best use of available wheel and rail adhesion and to avoid wheel damage

General rail industry terms and definitions are maintained in the ARISO Glossary. Refer to:
https://www.ariso.org.au/glossary/

Section 2 Brake system

2.1 General

The brake system of a multiple unit passenger set shall incorporate an EP brake and an automatic brake. The EP system will generally incorporate a blended dynamic brake.

All brake system requirements shall be met when sets are coupled, except when for recovery purposes.

Isolation of one brake system shall not affect the ability of the other systems to brake the set.

Proven equipment should be selected to ensure reliability, which is of high importance. The RSO shall demonstrate that any novel equipment or systems meet the requirements of this document and comply with the certification process.

The quantity of compressed air stored on a multiple unit passenger set for use in the brake system shall be sufficient to enable at least two successive emergency applications of the automatic brake from maximum speed, which each meet the required stopping distance.

Compressed air for the brake system shall be protected from any connected auxiliary system so that the brake system always has priority.

Interlocks shall prevent traction power being applied until available compressed air is adequate for braking.

An emergency application by any method shall automatically interrupt traction power.

A service brake application shall interrupt traction except in case of holding brake or power against brake functions.

The train brake control system shall be designed such that no single point of failure in the brake system will prevent the system applying the emergency brakes.

The brake system should incorporate load compensation to enable braking performance to be maintained despite variations in vehicle mass.

Air pressures nominated in this document which do not include a tolerance or are described as nominal shall have a tolerance of ±15 kPa.

The brake system shall be able to operate effectively as intended under the full range of environmental conditions that can be expected in its area of operation.

Commentary *C2.1*

The ambient temperatures of the Australian environment for the operation of trains range from -5°C to +50°C.

2.2 Performance

The stopping brake shall provide the required braking forces to meet the stopping distance requirements for the RIM where operating.

The automatic brake should not require a coefficient of adhesion between the wheel and rail greater than 0.14.

An emergency application shall stop the train in a distance less than or equal to that by a normal full service application.

The friction brakes acting alone without dynamic braking shall have the capacity to absorb and dissipate the braking energy without damage and meet network stopping distance requirements.

2.3 Driving diagnostics

The brake system shall incorporate instruments that indicate to the driver the main reservoir pressure, brake pipe pressure and brake cylinder pressure in units of kPa.

The accuracy of air pressure displays to the driver that are required to control the air brakes shall be corrected if found to be in error by ±15 kPa.

The brake system should incorporate means for fault indication such as loss of continuity, location of isolated brakes or dragging brakes caused by brake cylinder pressure present or park brake applied.

When brake cylinder pressure above 40 kPa is present, or the park brake is applied, an indication shall be provided to the driver.

The driver shall receive indication that:

(a) there is a loss of continuity;

(b) the system has reverted to auto or emergency due to a fault;

(c) the nature of the fault causing the revert to auto/emergency;

(d) which safety system is applying the brakes; and

(e) number and location of brakes isolated.

2.4 Cocks and pipework

Where a through brake pipe is fitted, it should have a minimum internal diameter of 25 mm and generous curve radii with no reductions in cross-sectional area or restrictions due to fittings.

Bores of branch pipes should not be undersized.

The following shall be in accordance with AS 7503:2023:

(a) the colour of cut-out or isolating cock handles;

(b) the colour of all identifying embossed letters on air brake equipment; and

(c) the marking of the point of attachment of the manual air brake release.

All identifying embossed letters on air brake equipment should be painted in a contrasting colour to aid legibility.

All cut-out or isolating cocks shall:

(d) latch in both the open and closed positions;

(e) have each position clearly labelled;

(f) be orientated to be inline in the normal operating condition with the exception of reservoir drain cocks; and

(g) as far as possible, isolation cocks be protected from malicious interference.

To aid pre-trip inspection, cocks should be visible from the exterior side of the vehicle.

2.5 Bogie brake equipment

An isolation cock shall be provided to manually release the brake cylinder pressure and inhibit further application of the friction brakes on the isolated bogie in the event of a failure.

There shall be an individual isolation cock for each bogie.

The isolation of the bogie shall be detectable by the driver (see Clause 2.3).

The isolation cock shall be visible to authorized users.

The isolation cock shall be clearly labelled as per AS 7503:2023.

Brake cylinder travel should be regulated by an automatic slack adjuster to maintain the specified travel and clearance irrespective of friction element wear.

All brake gear shall be securely mounted and supported.

2.6 Emergency cocks

Each cab shall have an emergency cock which enables the brake pipe to be exhausted, or an emergency button which breaks the safety loop circuit, causing an emergency application of the train brakes.

Manual action shall be required to close the emergency cock or reset the emergency button.

The emergency button/operating handle of the emergency brake pipe cock shall be red.

An emergency cock/button shall be accessible from all seated positions.

The emergency cock and the pipework connecting it to the brake pipe should have nominal bore of at least 25 mm.

The air flow capacity of the emergency cock and pipe work shall be sufficient to give an emergency application even with the driver's brake valve feeding the brake pipe.

2.7 Compressed air reservoirs

Compressed air storage reservoirs shall comply with AS 1210:2010, BS EN 286-3:1994 or recognized equivalent international standard, for a minimum design pressure of 1,000 kPa.

AS 1200:2010 shall be used to provide guidance regarding recognized equivalent standards.

Applicable state and federal legislation for registration of compressed air storage reservoirs shall be complied with.

The main reservoir compressed air system shall be provided with suitable filtration equipment to ensure that the transfer of any foreign matter, water or oil into the system is kept to a practical minimum and that all pneumatic equipment will operate with reliability.

Air drying equipment shall be fitted for all brake system air.

The main reservoir safety valves shall be set according to the relevant requirements of AS 1210:2010.

Safety valves shall have sufficient discharge flow capacity to retain main reservoir pressure at a safe level with the compressor pumping continuously at full speed.

Each main reservoir shall be fitted with means for draining accumulated water.

Drain cocks shall not be fitted to auxiliary reservoirs, dummy volumes or brake cylinders.

Drain cocks should not be fitted to supplementary/supply reservoirs.

There shall be a safe system for discharging stored compressed air.

2.8 Air compressors

The capacity and number of compressors shall meet the requirements of single and coupled sets, and where relevant, a set attached for recovery, taking into account the need for redundancy, which will be higher for long distance services.

Compressor and reservoir capacity should be matched to the expected duty cycle, with control set to minimize cold starts and short cycles which can decrease service life.

Multiple unit passenger rolling stock shall safely operate when coupled to other trains with main reservoir pressure in the range 750 kPa to 850 kPa if required for recovery purposes.

2.9 Brake system couplings between vehicles

2.9.1 General

With the exception of vehicles coupled together with fixed drawbars or couplers incorporating pneumatic connections, pneumatic couplings between vehicles shall be designed to provide connections that are secure but easily parted without damage in the event of train separation.

Brake system couplings between vehicles shall be arranged to avoid damage to or kinking of flexible hoses.

All multiple unit passenger sets shall be fitted with brake system couplings that are compatible with those of all other rolling stock in use on that network or have adaptor couplings as in Clause 2.10.

End cocks shall be vented on the hose side so that pressure can be relieved before disconnection.

2.9.2 Brake pipe end cocks

Where fitted, brake pipe compressed air end cocks shall:

(a) be ball type cocks;

(b) be of minimum size 25 mm nominal bore;

(c) have a detent or other means of securing the cock when in the open position;

(d) have a ramp or other means of ensuring that the cock remains in the closed position when closed;

(e) vent the hose when the cock is closed; and

(f) be closed in the up/vertical position.

2.9.3 MR end cocks

Where fitted, compressed air end cocks for main reservoir pipe coupling hoses shall:

(a) be ball-type cocks;

(b) be of a minimum size of 20 mm nominal bore;

(c) have spring-loaded or latching handles to prevent accidental operation;

(d) latch in the open position;

(e) be readily accessible to ground staff during coupling and uncoupling for recovery purposes;

(f) be equipped with straight handles;

(g) be open when the handle is pointing in line with the pipe; and

(h) vent the hose when the cock is closed.

2.9.4 Coupling hose components

Brake system coupling compressed air hoses shall comply with the requirements of AS 2435:1992 or international equivalent.

The internal diameter of elastomeric hose for brake system coupling compressed air hoses:

(a) for the brake pipe shall be 25 mm (minimum) or 35 mm; and

(b) for the main reservoir should be 29 mm.

Where used, coupling heads for brake system coupling compressed air hoses shall incorporate orifices of minimum size as follows:

(c) Brake pipe: 32 mm

(d) Main reservoir: 25 mm

Provision shall be made to secure coupling heads by the use of dummy couplings or receptacles.

2.10 Vehicles fitted with couplers incorporating air brake connections

This section does not apply to multiple units which operate on isolated systems where there are no trains with conventional couplings and brake systems.

End vehicles fitted with multi-function couplers that incorporate air brake connections shall be equipped with adaptor couplings having standard air brake hose connections to enable coupling to vehicles fitted with standard automatic couplers and conventional air brake systems.

The brake system of each vehicle shall incorporate a brake that can be controlled from a hauling vehicle having a standard brake pipe pressure of 500 kPa, for the purpose of recovery.

The brake systems of vehicles shall allow for the operation of multiple sets coupled together for the recovery of disabled vehicles or trains.

Section 3 Brake System Control

3.1 General

At each driving position, there shall be a single controller for setting the brake demand for EP, automatic and dynamic brake. This may be a combined controller or separate from the tractive effort controller.

Combined power and brake controllers, if fitted, shall:

(a) have sufficient stop/detent positions to allow the driver to distinguish when tractive power is requested; and

(b) not inhibit the ability to easily apply brakes.

The brake controller shall be arranged so that in the normal direction of travel, the brake is applied when the handle is moved forwards/away from the driver, and released when the brake handle is moved backwards/towards the driver.

Separate to the emergency cock or button (see Clause 2.6), the brake controller shall have an emergency position beyond and clearly separated from the service range.

On any multiple unit train, it shall only be possible to make one controller active to control the EP and automatic brake, with inputs from other controllers ignored except for emergency application.

When a controller is shut down or no controller is activated, the emergency brake shall be applied.

The stopping brake of a vehicle should be designed for operational compatibility with the stopping brakes of all other vehicles to which it could be coupled.

3.2 Pressures and timings

Standard automatic air brake (and EP brakes) timings are:

(a) brake cylinder filling time to 95%: 3–5 s (EP: 2–3 s)

(b) brake cylinder release time: 6–11 s (EP: 2.5–4 s)

When charging from the brake pipe in a train which is being recovered by a locomotive:

(c) auxiliary reservoir initial filling time: 0–400 kPa in 115–125 s; and

(d) auxiliary reservoir recharge 240–450 kPa in 60–70 s.

Readings should be taken from pressure gauges and not from screen displays to avoid screen display time lag.

Timings should be taken from the movement of pressure gauge pointers and not from brake controller movement.

3.3 Automatic brake

The automatic brake shall be an automatic air brake, or an alternative system which relies on electrical continuity to provide fail-safe application of emergency braking.

A through brake pipe with conventional distributor valves should be fitted unless it is agreed with the RIM that this is not required for redundancy or recovery purposes.

A train separation shall result in an emergency application on both (all) portions of the train.

The automatic brake control system shall permit an emergency application at any time when running.

De-energisation of the OTPS signal shall result in an emergency application.

The automatic brake shall provide sufficient functionality to allow limp home or recovery in the event of a failure in the EP brake system.

Where fitted, the control valve should be of the diaphragm type, although simplified functionality may be demonstrated to be acceptable in some operations.

3.3.1 Automatic air brake

The following clauses apply where an automatic air brake system is fitted:

The control valve shall provide for graduated application and release of braking.

The operating performance of a control valve should be fully compatible with the cars to which it can be coupled.

The driver's brake controller shall have the following functions when the automatic air brake is used as the method of brake control:

(a) Release position: Charge the brake pipe to the standard brake pipe pressure (500 kPa).

(b) Minimum reduction (or Initial) position: Reduce the pressure in the brake pipe to 50 kPa below the standard brake pipe pressure.

(c) Full service position: Reduce the brake pipe to a value that is between 150–160 kpa below the standard brake pipe pressure.

When the controller is moved to the emergency position, the automatic air brake shall:

(d) inhibit air feeding the brake pipe; and

(e) rapidly reduce the pressure in the brake pipe to atmospheric pressure.

3.4 Electro-pneumatic brake

An electro-pneumatic (EP) brake control system shall provide for graduated application and release of EP braking.

An EP brake control system shall permit an emergency application of the stopping brake at any time when in running.

Where EP is blended with the dynamic brake, the braking rate demanded by the single control handle shall be achieved irrespective of the split in brake effort.

Under blended braking, transitions between dynamic and EP shall be smooth and without degradation in braking performance.

Fluctuations in the instantaneous deceleration rate during transition between EP friction braking and dynamic braking should not exceed ±0.15 m/s^2 during any 1-second period at any speed and level of braking demand.

For long-distance trains with braking rates below 1 m/s^2, the maximum longitudinal jerk during deceleration for service braking should not exceed 0.7 m/s^3.

In suburban and metro service with higher rates of deceleration, jerk may be proportionally higher and rates of up to 1.5 m/s^3 under service braking transitions may be acceptable.

Any longitudinal jerk with a duration of 0.5 s or less should not be subject to the jerk requirement.

In the event of dynamic braking failure during service braking, the EP brake shall take up at least 95% of the demanded braking effort within 2.5 s.

When dynamic braking has been abandoned during a stop it shall not reset unless the brake controller has been first returned to the release position.

Emergency brake shall have the effect of reducing existing dynamic braking smoothly to zero in 2 s.

In the event of failure of the EP brake, the automatic brake shall take up service braking at a level similar to that demanded, with minimal drop in brake cylinder pressure, or emergency braking shall apply.

Interlocks shall prevent the release of the brakes when the passenger doors are open to ensure vehicle remains stationary during passenger entry and egress.

Section 4 Wheel slide protection

The stopping brake shall incorporate wheel slide protection (WSP).

Where separate WSP systems are provided for the friction and traction system braking, the two shall be integrated so as not to cause conflicting actions.

The WSP system(s) should intervene for all braking systems of a vehicle other than the park brake.

The WSP system should permit the achievement of maximum deceleration given the available wheel and rail adhesion while minimizing wheel slide during braking.

The WSP system should, in general, conform to the requirements of EN15595:2018+A1:2023 or UIC 541-05.

As an adjunct to the WSP system, where mandated by the RIM, sanding systems should be utilized to improve braking performance in low adhesion conditions.

NOTE:

TfNSW requires that sand is removed from the rail after the wheels have passed.

Where fitted, sanding systems should conform to the requirements of GMRT2461 Iss 3.1.

Section 5 Park brake

5.1 General

Each vehicle in a multiple unit passenger set shall be fitted with a park brake that complies with the requirements in either Clause 5.2 or Clause 5.3.

The park brakes of each multiple unit passenger set shall hold the set stationary on a 1:30 gradient under all conditions of loading.

For its intended operation, a park brake should not be reliant upon the coefficient of adhesion exceeding 0.085 between the wheel and rail.

The park brake shall be applied mechanically such that the force does not decrease over time.

5.2 Powered park brakes

The force to apply a powered park brake is normally via a spring (with pneumatic release) but other methods of providing a braking force may be used, for example, electro/hydraulic or electro/mechanical.

Compounding of forces from the powered park brake and brake cylinder pressure shall be prevented.

A powered park brake shall be able to be released by manual means.

A powered park brake should be able to be applied even when air or electrical power are not available.

The command status of a powered park brake shall be indicated at each driving position near the park brake operating controls.

5.3 Automatic park brakes

An automatic park brake (APB) shall comply with all the requirements of a powered park brake.

Where an APB is applied or armed when the brake pipe is vented, it shall not be released without driver intervention when the brake pipe is charged.

Section 6 Calculation of braking system performance

6.1 Stopping brake

For design and prior to testing, a methodology such as in EN 14531-1:2015 shall be used to assess stopping brake performance.

Commentary *C6.1*

When assessing stopping performance, Australian experience has demonstrated that:

- the effects of wheelset and drivetrain rotational inertia is included;
- the effect of rolling resistance is not included; and
- residual tractive effort can be neglected.

Stopping performance assessments for braking systems incorporating disc brakes shall be based on new wheel diameters.

Where a stopping distance requirement does not specify whether the braking mode is service or emergency, then the assessment shall be for service applications of the stopping brake.

6.2 Park brake

For design and prior to testing, a methodology such as in EN 14531-1:2015 shall be used to assess park brake holding to testing.

Park brake holding performance shall be assessed for vehicles in the fully loaded condition.

Commentary *C6.2*

When assessing holding performance, Australian experience has demonstrated that the effects of wind force and rolling resistance can be neglected.

6.3 Coefficient of friction

The coefficient of friction used in performance assessments shall be based on testing in accordance with:

(a) AS 7504:2018 for brake blocks; and

(b) AS 7504.2:2023 for disc brake pads.

Section 7 Brake system software

Software used in association with a brake system shall be designed, validated and tested to an appropriate safety integrity level (SIL) rating, in accordance with the requirements of AS 61508-1:2011 or an alternative internationally recognized auditable standard that is specific to railway braking or to railway safety systems.

Section 8 Brake force application

8.1 General

Friction elements on a multiple unit passenger set shall transmit stopping brake forces to the tread of each wheel or to brake discs securely connected to each wheelset.

During any normal braking, temperatures reached by a friction element and the associated wheel or disc shall not affect the structural integrity of the braking surfaces of either.

The mechanism that applies the brake force shall be capable of sustaining all loadings that can arise during normal train operations whilst providing the freedom necessary to accommodate relative movement between brake gear and running gear without loss of performance.

Brake blocks shall be centred laterally and restrained from contacting the wheel flange or the outer edge of the wheel rim during braking.

Brake blocks shall not deposit material onto wheel treads to the extent that the detection of vehicles by the signalling system is inhibited.

Brake blocks when new should conform to the cross-sectional tread contours of new wheels.

Noise emissions from friction elements during braking should conform to accepted environment protection standards.

8.2 Composition brake blocks and brake disc pads

Composition brake blocks and brake disc pads shall comply with the requirements of AS 7504:2018 and AS 7504.2:2023 respectively.

When introducing new brake blocks or disc pads, RSOs shall follow an approval process and perform testing to demonstrate that:

(a) train stopping distances comply with the requirements of the rail infrastructure manager;

(b) acceptable brake block and brake disc pad life;

(c) acceptable performance under drag braking conditions;

(d) brake blocks and brake disc pads do not produce offensive odours;

(e) compliance with legislative noise requirements;

(f) brake blocks and brake disc pads do not contribute to wheel damage such as excessive wear, grooving, shelling, spalling, thermal cracking or any other detrimental effects on wheel tread surfaces and brake disc surfaces; and

(g) brake blocks and brake disc pads do not produce sparks, fire banding or hot spots on wheels and brake discs.

8.3 Brake discs

Brake discs shall be designed to resist fatigue failure.

The design of brake discs shall include an assessment of the braking forces, centrifugal forces, localized and bulk thermal inputs and inertial loads from track irregularities.

The integrity of brake discs shall be ensured by the provision of fasteners incorporating proven locking mechanisms.

If brake disc pads can overhang the disc friction face edges, they shall be designed to prevent the formation of lips or grooves.

Section 9 Maintenance

9.1 General

Operators shall carry out inspections, routine function checks and overhaul procedures with acceptance criteria to maintain specified brake system performance.

Air reservoirs shall be inspected in accordance with AS/NZS 3788:2024.

The content and periodicity of the inspection, testing and maintenance of brake equipment should be based on the recommendations of the brake equipment manufacturer and data derived from in-service experience and testing.

9.2 Function checks – Serviceability

A multiple unit passenger set brake system routine function check shall be undertaken to confirm serviceability when brake system components are repaired, replaced, disconnected and reconnected on a multiple unit in the field.

The results of brake system function checks shall be recorded and the documentation retained for reference.

9.3 Abrasive brake blocks and pads

Abrasive brake blocks (trim blocks) may be used to remove minor wheel and tread irregularities

Abrasive brake blocks should have a thin coating of abrasive material over a conventional brake block material or an insert of abrasive material.

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

As the coefficient of friction, an abrasive brake block is generally higher than that of the brake block that it will temporarily replace, the possible consequences of increased adhesion demand should be taken into account.

Abrasive brake disc pads may be used to remove scoring marks on brake discs.

Section 10 Validation of braking function and performance

10.1 General

Multiple unit passenger set brake system function and performance shall be validated by type and routine testing.

The results of brake system function and performance tests shall be recorded and the documentation retained for reference.

Operators shall specify and manage the implementation of in-service brake system function and performance testing of multiple unit passenger set brakes.

10.2 Static brake type & routine tests

10.2.1 Reasons for conducting a static brake type test

A static brake type test and static brake routine tests shall be conducted in any of the following circumstances:

(a) Introduction to service of a previously untested multiple unit passenger set.

(b) A new type or build of multiple unit passenger set is to be introduced to service.

(c) Modification of a multiple unit passenger set such as to affect braking performance.

(d) Modification of the brake system of a multiple unit passenger set.

(e) Change to the configuration of a multiple unit passenger set.

10.2.2 Requirements

Static brake type tests shall be carried out on one or more multiple unit passenger cars of a production run as specified by the RSO.

Static brake routine tests shall be carried out on all multiple unit passenger cars of a production run.

A static brake type test conducted on a multiple unit passenger set shall establish whether its brake system will function and perform as specified when placed in service.

A static brake test of a park brake shall confirm function and static performance.

Corrective action followed by retesting shall be carried out if the train brake system function or static performance specifications are not met.

10.2.3 Static brake type test content

Brake force tests should be carried out by the equipment manufacturer. A static brake type test should verify:

(a) actual braking forces with the service brake cylinder pressure; and

(b) actual braking forces for park brake.

10.2.4 Static brake routine test content

The brake system of all multiple unit passenger sets shall be tested as follows:

(a) All brake valve positions are checked for correct function.

(b) That the brakes apply and release (i.e. The brake blocks/brake disc pads are forced onto the wheels/discs and then released).

(c) All air pressures are to specification for each brake application and release.

(d) The brake application and release timings are to specification.

(e) All air leakage is within specification.

(f) All pressure switches and interlocks associated with the brake system operate to specification.

10.3 Braking performance type test

10.3.1 Reasons for conducting a braking performance type test

The brake system of a prototype of each type of multiple unit passenger set is typically subjected to a braking performance type test to ensure that:

(a) the brake system functions as specified;

(b) all brake system component parts meet their specifications; and

(c) braking performance specifications are met.

10.3.2 Requirements

A braking performance type test on a prototype, developmental or substantially modified vehicle shall be performed to establish whether its brake system achieves the required performance in service.

10.3.3 Braking performance type test content

A braking performance type test shall include stopping distance testing for all modes of braking.

A braking performance type test shall include WSP testing in low adhesion conditions.

A braking performance type test shall include a park brake holding test.

10.4 Scheduled static brake tests

10.4.1 Reason for conducting scheduled brake tests

A scheduled static brake test shall be conducted on a vehicle:

(a) when required by the maintenance schedule; and

(b) if a brake system fault is suspected.

10.4.2 Requirements

A scheduled static brake test shall be carried out in accordance with the OEM's maintenance manual and recommended intervals.

A static brake test shall:

(a) check that brake equipment functions correctly; and

(b) check of indicated and actual brake cylinder pressures.

Appendix A Hazard Register (Informative)

A.1 ARISO hazard register

The following hazards have been sourced from the ARISO hazard register.

Hazard number	Hazard
5.1.1.7	Harm to the environment - Derailment or Collision, Human Error, Design Failure, Organisational SMS Failure, Security Breach, Loads not Secure and or Vandalism - Sparks from brake equipment causing fire
5.1.1.44	Harm to the environment - Derailment or Collision, Human Error, Design Failure, Organisational SMS Failure, Security Breach, Loads not Secure and or Vandalism - Braking causing excessive noise
5.3.1.39	Harm to persons - Derailment or Collision, Human Error, Track Failure, Design Failure, Health, Organisational SMS Failure, Security Breaches, Loads not Secure and or Vandalism - Harmful exposure to noise
5.3.1.43	Harm to persons - Derailment or Collision, Human Error, Track Failure, Design Failure, Health, Organisational SMS Failure, Security Breaches, Loads not Secure and or Vandalism - Harmful exposure to released pressured gas or fluid
5.4.1.60	Harm to Rolling Stock - Derailment or Collision, Human Error, Track Failure, Track Obstruction, Design Failure, Health Failure, Organisational SMS Failure, Security Breach, Load not Secure and or Vandalism - Inadequate rolling stock pre-service testing and commissioning
5.4.1.61	Harm to Rolling Stock - Derailment or Collision, Human Error, Track Failure, Track Obstruction, Design Failure, Health Failure, Organisational SMS Failure, Security Breach, Load not Secure and or Vandalism - Inadequate rolling stock in-service testing
5.4.1.65	Harm to Rolling Stock - Derailment or Collision, Human Error, Track Failure, Track Obstruction, Design Failure, Health Failure, Organisational SMS Failure, Security Breach, Load not Secure and or Vandalism - Draft gear and coupler excessive wear due to high longitudinal in-train forces
5.4.1.66	Harm to Rolling Stock - Derailment or Collision, Human Error, Track Failure, Track Obstruction, Design Failure, Health Failure, Organisational SMS Failure, Security Breach, Load not Secure and or Vandalism - Wheel excessive wear due to high braking duty
5.5.1.8	Harm to Rolling Stock Related Processes - Derailment or Collision, Human Error, Track Failure, Track Obstruction, Design Failure, Health Failure, Organisational SMS Failure, Security Breach, Load not Secure and or Vandalism - Being unable to release brakes leading to the inability to haul dead trains off the sections
5.5.1.45	Harm to Rolling Stock Related Processes - Derailment or Collision, Human Error, Track Failure, Track Obstruction, Design Failure, Health Failure, Organisational SMS Failure, Security Breach, Load not Secure and or Vandalism - Design deficiency causing the inability to operate trains
5.5.1.46	Harm to Rolling Stock Related Processes - Derailment or Collision, Human Error, Track Failure, Track Obstruction, Design Failure, Health Failure, Organisational SMS Failure, Security Breach, Load not Secure and or Vandalism - Manufacturing deficiency causing the inability to operate trains

Hazard number	Hazard
5.5.1.47	Harm to Rolling Stock Related Processes - Derailment or Collision, Human Error, Track Failure, Track Obstruction, Design Failure, Health Failure, Organisational SMS Failure, Security Breach, Load not Secure and or Vandalism - Maintenance deficiencies causing the inability to operate trains
5.5.1.48	Harm to Rolling Stock Related Processes - Derailment or Collision, Human Error, Track Failure, Track Obstruction, Design Failure, Health Failure, Organisational SMS Failure, Security Breach, Load not Secure and or Vandalism - Operational deficiencies causing the inability to operate trains
5.5.1.49	Harm to Rolling Stock Related Processes - Derailment or Collision, Human Error, Track Failure, Track Obstruction, Design Failure, Health Failure, Organisational SMS Failure, Security Breach, Load not Secure and or Vandalism - The absence of (unique) components identification causing the inability to trace or identify (suspected) faulty components
5.6.1.6	Out of Control Trains - Human Error, Design Failure, Health Failure, Organisational SMS Failure, Security Breach and or Vandalism - Brakes being applied somewhere on train and traction not cutting out resulting in uncommanded traction
5.9.1.36	Signal Passed at Danger - Human Error, Track Failure, Design Failure, Health Failure, Lack of Training and or Vandalism - Brake block material /residue is electrically insulating causing contaminated rail head surfaces leading to high wheel to rail electrical resistance resulting in the loss of signal detection so that trains are not detected (Signal failure)
5.10.1.4	Brakes being Inadequate when Moving - Derailment and Collision, Human Error, Design Failure, Organizational SMS Failure, Security Breach and or Vandalism - Inadequate braking on down grades
5.10.1.5	Brakes being Inadequate when Moving - Derailment and Collision, Human Error, Design Failure, Organizational SMS Failure, Security Breach and or Vandalism - Brake fade
5.10.1.8	Brakes being Inadequate when Moving - Derailment and Collision, Human Error, Design Failure, Organizational SMS Failure, Security Breach and or Vandalism - Reservoirs being full of water leading to insufficient brake cylinder pressure
5.10.1.9	Brakes being Inadequate when Moving - Derailment and Collision, Human Error, Design Failure, Organizational SMS Failure, Security Breach and or Vandalism - Leaking brake cylinders leading to insufficient brake cylinder pressure
5.10.1.10	Brakes being Inadequate when Moving - Derailment and Collision, Human Error, Design Failure, Organizational SMS Failure, Security Breach and or Vandalism - Isolation cocks handles in the wrong or inconsistent orientation causing too many brakes to cut out (mistakenly)
5.10.1.11	Brakes being Inadequate when Moving - Derailment and Collision, Human Error, Design Failure, Organizational SMS Failure, Security Breach and or Vandalism - Friction elements are excessively worn or missing causing insufficient braking stroke
5.10.1.13	Brakes being Inadequate when Moving - Derailment and Collision, Human Error, Design Failure, Organizational SMS Failure, Security Breach and or Vandalism - Faulty slack adjusters causing insufficient braking stroke

Hazard number	Hazard
5.10.1.15	Brakes being Inadequate when Moving - Derailment and Collision, Human Error, Design Failure, Organizational SMS Failure, Security Breach and or Vandalism - Friction elements misaligned to tread / disc
5.10.1.18	Brakes being Inadequate when Moving - Derailment and Collision, Human Error, Design Failure, Organizational SMS Failure, Security Breach and or Vandalism - Brake energy source failure e.g., main compressor, (Braking system failure)
5.10.1.19	Brakes being Inadequate when Moving - Derailment and Collision, Human Error, Design Failure, Organizational SMS Failure, Security Breach and or Vandalism - Local brake control system mechanical failure e.g., control valve, (Braking system failure)
5.10.1.21	Brakes being Inadequate when Moving - Derailment and Collision, Human Error, Design Failure, Organizational SMS Failure, Security Breach and or Vandalism - Brake control system software ‘failure’ - (Braking system failure)
5.10.1.22	Brakes being Inadequate when Moving - Derailment and Collision, Human Error, Design Failure, Organizational SMS Failure, Security Breach and or Vandalism - Second controller incorrectly cut out causing a brake controller failure (Braking system failure)
5.10.1.23	Brakes being Inadequate when Moving - Derailment and Collision, Human Error, Design Failure, Organizational SMS Failure, Security Breach and or Vandalism - Component failure causing a brake controller failure (Braking system failure)
5.10.1.24	Brakes being Inadequate when Moving - Derailment and Collision, Human Error, Design Failure, Organizational SMS Failure, Security Breach and or Vandalism - Exhaust being partially blocked increasing delay causing a brake controller failure
5.10.1.25	Brakes being Inadequate when Moving - Derailment and Collision, Human Error, Design Failure, Organizational SMS Failure, Security Breach and or Vandalism - One-way partial blockage of brake pipes causing a braking signal transmission system failure resulting in a brake controller failure (Braking system failure)
5.10.1.26	Brakes being Inadequate when Moving - Derailment and Collision, Human Error, Design Failure, Organizational SMS Failure, Security Breach and or Vandalism - Kinked brake pipe hoses causing a braking signal transmission system failure (Braking system failure)
5.10.1.27	Brakes being Inadequate when Moving - Derailment and Collision, Human Error, Design Failure, Organizational SMS Failure, Security Breach and or Vandalism - Damaged or flow-restricted brake piping or hoses causing a braking signal transmission system failure (Braking system failure)
5.10.1.36	Brakes being Inadequate when Moving - Derailment and Collision, Human Error, Design Failure, Organizational SMS Failure, Security Breach and or Vandalism - Reservoir capacity being inadequate causing a brake energy reservoir failure (Braking system failure)
5.10.1.37	Brakes being Inadequate when Moving - Derailment and Collision, Human Error, Design Failure, Organizational SMS Failure, Security Breach and or Vandalism - Reservoir being insufficiently recharged before next application causing a brake energy reservoir failure (Braking system failure)

Hazard number	Hazard
5.10.1.38	Brakes being Inadequate when Moving - Derailment and Collision, Human Error, Design Failure, Organizational SMS Failure, Security Breach and or Vandalism - Traction power still applied
5.10.1.41	Brakes being Inadequate when Moving - Derailment and Collision, Human Error, Design Failure, Organizational SMS Failure, Security Breach and or Vandalism - Incompatible braking systems on coupled vehicles (Braking system failure)
5.10.1.43	Brakes being Inadequate when Moving - Derailment and Collision, Human Error, Design Failure, Organizational SMS Failure, Security Breach and or Vandalism - Low air supply pressure leading to insufficient brake cylinder pressure
5.10.1.44	Brakes being Inadequate when Moving - Derailment and Collision, Human Error, Design Failure, Organizational SMS Failure, Security Breach and or Vandalism - Brake rigging ratio too low
5.10.1.46	Brakes being Inadequate when Moving - Derailment and Collision, Human Error, Design Failure, Organizational SMS Failure, Security Breach and or Vandalism - Brake rigging failure (Braking system failure)
5.10.1.47	Brakes being Inadequate when Moving - Derailment and Collision, Human Error, Design Failure, Organizational SMS Failure, Security Breach and or Vandalism - Incorrect friction elements
5.10.1.48	Brakes being Inadequate when Moving - Derailment and Collision, Human Error, Design Failure, Organizational SMS Failure, Security Breach and or Vandalism - Auxiliary air system affects brake operation (Braking system failure)
5.10.1.49	Brakes being Inadequate when Moving - Derailment and Collision, Human Error, Design Failure, Organizational SMS Failure, Security Breach and or Vandalism - Unable to apply emergency brake due to brake controller failure (Braking system failure)
5.11.1.1	Brakes being Inadequate when Stationary - Human Error, Design Failure, Health Failure, Organizational SMS Failure, Security Breach and or Vandalism - Brake systems automatically releasing the brakes after a preset time
5.11.1.4	Brakes being Inadequate when Stationary - Human Error, Design Failure, Health Failure, Organizational SMS Failure, Security Breach and or Vandalism - Hand / park brakes not being applied causing air in brake cylinders to leak off
5.11.1.6	Brakes being Inadequate when Stationary - Human Error, Design Failure, Health Failure, Organizational SMS Failure, Security Breach and or Vandalism - Hand / park brakes being defective so that brakes cannot hold trains on steep grades
5.11.1.13	Brakes being Inadequate when Stationary - Human Error, Design Failure, Health Failure, Organizational SMS Failure, Security Breach and or Vandalism - Insufficient brake cylinder pressure
5.12.1.1	Wheel Skidding - Derailment or Collision, Human Error, Track Obstruction, Design Failure, Security Breach and or Vandalism - Defective or ineffective WSP
5.12.1.3	Wheel Skidding - Derailment or Collision, Human Error, Track Obstruction, Design Failure, Security Breach and or Vandalism - Incompatible brake systems on vehicles in the train (Brake not released)
5.12.1.4	Wheel Skidding - Derailment or Collision, Human Error, Track Obstruction, Design Failure, Security Breach and or Vandalism - Overcharged brake pipes (Brake not released)
5.12.1.5	Wheel Skidding - Derailment or Collision, Human Error, Track Obstruction, Design Failure, Security Breach and or Vandalism - Crews not releasing (all) hand / park brakes (hand/park brake not released)
5.12.1.6	Wheel Skidding - Derailment or Collision, Human Error, Track Obstruction, Design Failure, Security Breach and or Vandalism - Air and spring force compound on park brakes causing excessive brake cylinder force
5.12.1.9	Wheel Skidding - Derailment or Collision, Human Error, Track Obstruction, Design Failure, Security Breach and or Vandalism - Vehicles in tare condition with brakes set for gross condition causing excessive brake cylinder force

Hazard number	Hazard
5.12.1.14	Wheel Skidding - Derailment or Collision, Human Error, Track Obstruction, Design Failure, Security Breach and or Vandalism - Brake release propagation too weak
5.12.1.15	Wheel Skidding - Derailment or Collision, Human Error, Track Obstruction, Design Failure, Security Breach and or Vandalism - Faulty brake control equipment
5.12.1.16	Wheel Skidding - Derailment or Collision, Human Error, Track Obstruction, Design Failure, Security Breach and or Vandalism - Driver mismanagement of brake system
5.12.1.17	Wheel Skidding - Derailment or Collision, Human Error, Track Obstruction, Design Failure, Security Breach and or Vandalism - Excessive brake material friction
5.12.1.18	Wheel Skidding - Derailment or Collision, Human Error, Track Obstruction, Design Failure, Security Breach and or Vandalism - Brake rigging ratio too high
5.13.1.12	Inadequate adhesion - Design Failure, Security Breach and or Vandalism - Vehicle or wheelset over-braked
5.13.1.13	Inadequate adhesion - Design Failure, Security Breach and or Vandalism - Insufficient wheelsets braked on vehicle
5.26.1.7	Wheelset failure - Derailment or Collision, Human Error, Track Failure, Design Failure, Health Failure, Security Breach, Load not Secure and or Vandalism - Excessive thermal loading from tread braking causing cracked wheels - (Wheel failure)
5.26.1.8	Wheelset failure - Derailment or Collision, Human Error, Track Failure, Design Failure, Health Failure, Security Breach, Load not Secure and or Vandalism - Rolling contact fatigue causing cracked wheels - (Wheel failure)
5.29.1.14	Object on track - Derailment or Collision, Human Error, Track Failure, Design Failure, Security Breach, Load not Secure and or Vandalism - Mounts or components failing due to fatigue (Rolling stock equipment - Object drops down / falls off a train)
5.30.1.3	Excessive dynamic longitudinal train forces - Derailment or Collision, Human Error, Track Failure, Design Failure, Health Failure, Load not Secure and or Vandalism - Brake propagation down train too slow
5.30.1.5	Excessive dynamic longitudinal train forces - Derailment or Collision, Human Error, Track Failure, Design Failure, Health Failure, Load not Secure and or Vandalism - Brake jerk rate being too high
5.30.1.8	Excessive dynamic longitudinal train forces - Derailment or Collision, Human Error, Track Failure, Design Failure, Health Failure, Load not Secure and or Vandalism - High peak traction or braking forces
5.38.1.4	Hazardous substances contact - Derailment or Collision, Human Error, Track Failure, Track Obstructions, Design Failure, Organizational SMS Failure, Security Breach, Load not Secure and or Vandalism - Fibrous materials e.g., asbestos, silica (Breathing in hazardous substance)
5.47.1.6	Brakes being applied too little or too late - Organization's SMS Failures, Human Error and Health Failure - Power / brake controls being inconsistent with other rolling stock resulting in a lack of competence driving this type of train (Driver applies insufficient brake)
5.47.1.9	Brakes being applied too little or too late - Organization's SMS Failures, Human Error and Health Failure - Brake controls not being within reach (Driver applies brakes too late)

Bibliography (Informative)

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

- AS 7501, *Rolling Stock Compliance Certification*
- AS 7511:2020, *Onboard train protection systems*
- BS EN 13452-1, *Railway applications. Braking. Mass transit brake systems. Performance requirements*
- BS EN 14531-6:2019, Railway applications - Methods for calculation of stopping and slowing distances and immobilisation braking - Part 6: Step by step calculations for train sets or single vehicles
- EN 15595:2018+A1:2023, *Railway applications. Braking. Wheel slide protection*
- EN 16185-1:2014+A1:2020, *Railway applications. Braking systems of multiple unit trains Requirements and definitions*
- EN 16185-2:2014+A1:2019, *Railway applications. Braking systems of multiple unit trains Test methods*
- GMRT 2040, *Calculation of Brake Force Data for Rolling Stock Library* (withdrawn)
- GMRT 2045, *Compatibility Requirements for Braking Systems of Rail Vehicles*
- GMRT 2046, *Braking System Requirements and Performance for Trains which Operate above 125 mile/h* (withdrawn)
- GMRT 2461 Iss 3.1, *Sanding Equipment*
- UIC 541-05:2016, *Brakes — Manufacturing specifications for various brake parts —* Wheel Slide Protection device (WSP)