



Interior Crashworthiness



Rolling Stock Standard

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This Australian Standard® AS 7521 Interior Crashworthiness was prepared by a Rail Industry Safety and Standards Board (RISSB) Development Group consisting of representatives from the following organisations:

Queensland Rail
Downer Group

Transport for NSW
United Group Limited

Metro Trains Melbourne
ONRSR

The Standard was approved by the Development Group and the Rolling Stock Standing Committee in Select SC approval date. On Select Board approval date 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 sets the minimum requirements for the interiors of rolling stock to minimise the risk of injury during derailments, collisions and accidents.

This Standard contributes to the management of the following risks:

- individual striking / being struck by surfaces / structures / objects
- contact with hot / electrical / chemical / hazardous substances.

1.2 Scope

This Standard applies to all rolling stock (including rail bound track maintenance machines) intended to carry passengers as well as individuals carrying out their duties or resting.

This Standard applies to rolling stock -

- entering service after the published date of this Standard, or
- interior component undergoing major modifications or replacement with new designs after the published date of this Standard.

To determine application of this Standard to consider any interior component modifications or replacement with new designs after the published date of this Standard, a So Far As Is Reasonably Practicable (SFAIRP) justification assessment should be undertaken.

This Standard does not apply to heritage rolling stock and rolling stock operating on cane railways, monorail networks and road rail vehicles.

The requirements for car body structural crashworthiness are detailed in AS 7520.

1.3 Compliance

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

- (a) Requirements.
- (b) Recommendations.

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 recognise that there may be limitations to the universal application of the control, i.e. the identified control may not be able to be applied or other controls may be appropriate / better.

For compliance purposes, where a recommended control is not applied as written in the Standard it may 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 may 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.

Controls in RISSB Standards address known railway hazards as included in an appendix.

1.4 Referenced documents

1.4.1 Normative references

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

- (a) AS 2080 Safety glazing for land vehicles
- (b) AS 2208 Safety glazing materials in buildings
- (c) AS 7520 Australian Railway Rolling Stock - Body Structural Requirements
- (d) EN 15227 Railway applications - Crashworthiness requirements for railway vehicle bodies
- (e) EN 15152 Railway Applications - Front Windscreens
- (f) BRB 566 British Rail Specification for High Impact Resistance
- (g) RSSB GM/RT 2100 - Requirements for Rail Vehicle Structures
- (h) Federal Railroad Administration (FRA) Standard 49 CFR

1.4.2 Informative references

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

- (a) Queensland Rail Standard (MD-10-130) - Passenger Vehicle Interior Crashworthiness
- (b) Transport for NSW Technical Note (TN 085: 2015)
- (c) RSSB GM/GN2687 - Guidance on Rail Vehicle Interior Structure and Secondary Structural Elements.

1.5 Definitions

Bodyside windows: windows other than windscreens and interior glazing.

Crashworthiness: the ability of the vehicle structure and interior to minimise harm to the occupants during a collision or derailment.

Double glazed windows: two panes of glass, fitted to reduce the transmission of heat, sound, etc.

Existing rolling stock: Rolling stock that operates on a railway track in Australia, has Certificate of Engineering Compliance (certification, previously called registration) and first operated between 1/03/1999 and the effective date of this Standard.

Free flight distance: The distance a person is thrown from moment of collision up to point of impact on surfaces in direction of flight.

Interior glazing: all glazing not facing exterior vehicle, examples include: screens, partitions, luggage racks, glazing in internal doors, intercar doors and internal passenger information displays.

Laminated glass: laminated glass is a type of safety glass that holds together when shattered. In the event of breaking, it is held in place by an interlayer, typically of polyvinyl butyral or ethylene-vinyl acetate, between its two or more layers of glass.

Legacy rolling stock: Rolling stock that operates in Australia, registered without a Certificate of Engineering Compliance and first operated before 1/03/1999.

Occupant: any person occupying the train at any time, including passengers, maintainers, and train crew.

Operator: for the purposes of this document, operator means the party that has responsibility for defining the technical requirements for the railway vehicle so that it will perform the intended operation and meet the acceptance criteria.

Passive safety: for the purposes of this document, passive safety refers to systems which reduce the consequences of an accident should it occur.

Secondary impact: Impacts which are provoked as a consequence of the primary impact, such as passengers impacting other passengers or impacting interior features of the vehicle.

Secondary structural elements: those elements of a rail vehicle interfacing directly with occupants.

Supplier: for the purposes of this document, supplier means the organisation that has responsibility for supplying the railway vehicle to satisfy the regulations and functional requirements of the operator.

Windscreens: windows in the front and the rear of the rail vehicle facing outside.

2 General and common requirements

2.1 Collision energy management

The rolling stock collision energy management strategy shall be supplied by the rolling stock designer. This strategy shall include the design of the interior elements and how they integrate with the exterior crashworthiness.

Body structural requirements for rolling stock (including crashworthiness performance) are defined in AS 7520.

Dynamic testing can be replaced or augmented with computer simulations and calculations when done in accordance with GM/RT2100. Explanation of the original test data can be found in GM/GN2687 (Rail Industry Guidance Note for GM/RT2100) and shall be applied when using computer simulations and calculations.

2.2 Other rolling stock considerations

Consideration of other rolling stock requirements shall include maintaining the performance of override prevention and collision energy management, and ensuring alignment and engagement of anti-climb devices and coupler systems in the event of a collision.

In the event of a collision or derailment, electrical equipment should not cause harm to passengers.

3 Secondary structural elements

3.1 Glazing

Safety glazing for new or replacement windows shall be fitted and labelled in accordance with AS 2080. All interior glazing shall comply with AS 2208.

Windows shall be designed so that they do not become a hazard when damaged. This includes the selection of materials for the windows and surrounding structure.

Emergency window material identification and labelling shall comply with FRA Title 49 CFR.

Emergency windows shall be designed to be easily and safely removed in an emergency allowing passengers an escape path.

All window replacements shall meet the requirements of this Standard for new vehicles.

3.2 Windscreens

Windscreens shall be designed to meet the requirements of EN 15152, AS 2080, FRA Title 49 CFR, or BRB 566 for train cabs.

All vehicle windscreens shall comply with the AS 7520 for impact resistance and slivering.

Fittings attached to the glass of windscreens shall not have a mass greater than 15kg. The windscreen with those fittings shall meet the testing procedures applicable to windscreens.

3.3 Forward facing glazing

Forward facing glazing and associated housings, other than windscreens, shall be designed in such a way that, if the glazing is damaged, broken glass cannot enter to the driver's compartment. Alternatively, the glazing shall meet the requirements for windscreens.

3.4 Exterior windows

All exterior windows in passenger accessible areas shall have at least one pane of laminated safety glass. An alternative material with equivalent properties may be used if the alternative is proven to provide equivalent protection for passengers against spalls and shards.

Where windows are double glazed, toughened safety glass shall be installed on the exterior pane of the window and laminated safety glass shall be installed on the interior pane of the window.

The design of exterior windows (including those with fittings) shall meet the requirements of GM/RT 2100 for strength and impact resistance.

Exterior windows shall be tested in accordance with FRA Title 49 CFR.

All exterior window replacements shall meet the requirements of this Standard for new vehicles.

3.5 External vehicle doors

The design of external vehicle doors shall be in accordance with GM/RT 2100.

External vehicle door test loads shall be selected in accordance with AS 7520.

3.6 Inter-vehicle gangways

Inter-vehicle gangway elements shall not interfere with coupler collapse, anti-climber engagement or structural crush zones.

4 Rail vehicle interface with passengers and train crew

4.1 Vehicle interior crashworthiness

Internal materials should not have, nor present when damaged, sharp edges or fragments during the normal vehicle operation and following impact.

Loose items that are part of the train operation and can be found in the train cabin (e.g. instruments, indicators) shall be secured during train operation.

The use of toughened safety glass for internal glazing (other than windscreens and bodyside windows) shall be assessed as part of the rolling stock collision energy management strategy.

Items mounted inside rolling stock (seats, tables, etc.) shall be designed to not break away or detach during a collision or derailment.

The design of seats and tables shall give precedence to dynamic test loads over proof loading conditions.

Hot surfaces ($> 60^{\circ}\text{C}$) shall be separated from passengers and crew by a physical barrier or insulated.

For all interior elements that are possible to be impacted by passengers, personnel and crew during a collision or derailment, an assessment shall be produced of the secondary impact of people with these elements. Particular attention shall be given to the design solution, geometry and choice of material of the elements, and how they contribute to reduce injury to people impacting.

Surfaces, objects, etc. which are likely to be impacted by persons during a collision, derailment or accident shall be free of sharp corners, edges or projections.

Wherever practicable, surfaces, objects, etc., that are likely to be impacted by persons during a collision, derailment or accident shall be non-rigid and capable of absorbing energy due to bodily impact.

Surfaces, objects, etc. which may suffer failure during bodily impact or collisions shall, wherever practicable, be made from materials that avoid production of sharp edges, projections or other features that could cause injury. In particular, attention shall be paid to the above for flooring, transverse walls or bulkheads, and transverse seat backs.

4.2 Passengers, personnel or train crew seats

4.2.1 Passenger seats

Reversible seats shall include a method to minimise the risk of passengers being propelled out of the seat due to the inertia of the movable back rest.

Unidirectional transverse seating should be used as the primary choice. Bay seating, longitudinal, multifunctional seating or seats of extended pitch increase the risk of injury and should be designed with some large area of constraint.

The height of transverse seat backs should be maximised.

Tip-up seats shall be designed in accordance with GM/RT 2100.

Seating shall be dynamically tested to the requirements of GM/RT 2100. The acceleration pulse(s) from the design collision scenarios specified in EN 15227 shall be applied in the dynamic testing.

4.2.2 Personnel seats and train crew seats

Seats (including armrests, headrests, seat cushions and back squabs) shall comply with the requirements of GM/RT 2100.

The height of transverse seat backs should be maximised.

The headrests fitted to cab seats shall not be considered part of the seatback.

Tip-up seats shall be designed in accordance with GM/RT 2100.

4.3 Fixed tables

Fixed tables shall meet the requirements of GM/RT 2100.

4.4 Folding seat back tables

Arrangement of folding tables should reduce the risk of injury in a contact with occupant.

Dynamic testing for folding seat back tables shall comply with GM/RT 2100.

4.5 Passenger constraint

Potential passengers' free flight distance in collisions shall be constrained with armrests, seat backs from the front seats, bulkheads or partitions.

Passenger constraints shall be designed so that the number of constraints is minimised and the size of the constraints is maximised.

Beds for passenger or crew use should have a means of restraint to minimise injury in the event of a collision or derailment.

Impact loading used for testing passenger constraints shall be based on a passenger weighing 80kg.

The design of handrails, handholds, etc., shall be integrated to minimise hazard or injury impact of those elements.

4.6 Interior doors and glazing

All interior doors shall be manually openable after collision or derailment, or an alternative means of access or egress shall be provided.

Proof load for interior doors and partitions shall comply with the loading in GM/RT 2100.

Safety glass shall be utilised on all interior glass mirrors.

4.7 Loose items

Interior loose items being part of the train equipment shall be securely fastened to the rolling stock structure.

Loose items when not in use shall be stowed or secured such that they are unlikely to be a hazard under collision conditions.

Stowage areas shall be designed, to prevent loose items becoming projectiles, and attached so as not to break away during normal train operations and collisions.

Materials which are corrosive, poisonous or flammable, or materials which are hotter than 45°C shall be stored so that they do not cause harm to persons in the event of a collision or derailment.

4.8 Grab handles, poles and rails

Design for grab handles, poles and rails shall comply with GM/RT 2100.

Grab handles and handrails shall be designed as an integral part of the seats, luggage stowage and partitions within their original dimensions wherever possible. Results of the secondary impact assessment shall demonstrate they are not a hazard to occupants during collision or derailment.

Handrails, handholds, etc., shall be suitably attached to the primary structure to withstand impact loading.

4.9 Interior fixtures and fittings

Any internal equipment cubicle doors and access panels shall remain closed during normal train operation, collision or derailment. Additional securing fastenings (e.g. safety catches or straps) shall be provided when the doors are located in passenger areas or can block or restrict an exit during an emergency.

The design of additional securing fastenings on doors shall be in accordance with GM/RT 2100.

Provision for wheel chairs shall be made applicable to people with disabilities as defined by the Disability Discrimination Act 1992 and standards listed in this Act.

Toilets shall be designed in accordance with GM/RT 2100.

All internal fittings including areas reserved or enclosed for a specific purpose, passenger information displays, interior lighting and CCTV systems shall be designed to remain integrated into the interior to minimise the risk of causing harm to passengers and train crew during a collision or derailment.

Interior lighting shall be designed to ensure adequate lighting for emergency egress.

Provision shall be made for the secure storage of catering equipment including trolleys when not in use.

Catering equipment proof loadings shall comply with GM/RT 2100.

Security and location of fire-fighting equipment design shall be in accordance with GM/RT 2100.

4.10 Luggage stowage

Where on board luggage stowage is provided, it shall be suitably designed to contain luggage to minimise the hazard of injury during operation, collision or derailment.

Open transverse luggage stowage arrangements should be avoided or minimised if practicable.

The design of luggage stowage shall provide access in accordance with GM/RT 2100.

Luggage racks shall be designed to withstand loading of 100kg per m².

Overhead luggage racks shall be designed to comply with GM/RT 2100.

4.11 Cabs

Secondary impact assessment in areas occupied by individuals carrying out their duties or resting shall be undertaken to consider the potential for injury.

Dynamic testing shall be conducted for the driver seat zone as set out in GM/RT 2100.

Appendix A Hazard Register

Hazard Tree Reference	Hazard Description	Applicable Section
5.3.1.1	Electric shock	2.2
5.3.1.2	Hazardous substances	4.7
5.3.1.3	Bodily impact	2.1, 4.1
5.3.1.7	Persons being crushed	3.6, 4.5
5.3.1.12	Drowning due to derailment into water	4.6
5.3.1.15	Sharp edges, burrs or cuts	4.1
5.3.1.43	Harmful exposure to released pressured gas or fluid	4.7
5.36.1.21	Falls from bunk bed as a result of inadequate side restraints (Vertical drop)	4.6
5.36.1.35	Door/lock strength being inadequate causing persons to fall out the doors onto tracks (Vertical drop)	3.5
5.36.1.37	Guard rail, hand rail or hand hold strength being inadequate	4.8
5.40.1.16	Standing persons on overcrowded trains being crushed by other persons in a collision or derailment	4.8
5.40.1.17	Seated persons in facing seats being crushed by other persons in collision or derailment	4.2
5.40.1.18	Seated persons in longitudinal seats being crushed by other persons in collision or derailment	4.2
5.44.1.1	Impact with interior surfaces (Impact caused by excessive accelerations)	4.1
5.44.1.8	Compartment breaches or openings large enough for persons to pass through resulting in persons being thrown out of the vehicle during collision or derailment (Impact with wayside structure or other rolling stock)	2.2
5.44.1.9	Compartment breaches or openings large enough for persons to pass through resulting in persons being thrown out of the vehicle during collision or derailment (Impact with ground / floor)	2.1
5.44.1.10	Inadequate means of restraining persons inside vehicles resulting in persons being thrown out of the vehicle during collision or derailment (Impact with wayside structure or other rolling stock)	4.5
5.44.1.11	Inadequate means of restraining persons inside vehicles resulting in persons being thrown out of the vehicle during collision or derailment (Impact with ground / floor)	4.5
5.44.1.13	Parts of the body being outside vehicles' doors (Impact with wayside structure or other rolling stock)	3.5, 4.6

Hazard Tree Reference	Hazard Description	Applicable Section
5.44.1.14	Parts of the body being outside vehicles' windows (Impact with wayside structure or other rolling stock)	3.4
5.44.1.15	Being trapped or held by exterior doors resulting in parts of bodies being outside vehicles (Impact with wayside structure or other rolling stock)	3.5, 4.6
5.44.1.21	Impact with unrestrained sliding or hinging door as a result of accelerations during train operations (Person inside train - Impact with part of train)	4.5
5.44.1.26	Objects coming loose during collision or derailment (Impact with loose objects)	4.1
5.44.1.27	Heads being hit on low interior features (Person inside train - Impact with part of train)	4.1
5.44.1.28	Body parts being hit on protruding interior features (Person inside train - Impact with part of train)	4.1

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Authors work with RISSB's Project Managers and Development Groups to ensure that products are acceptable to industry. Standing Committees oversee this work and ensure that proper governance and process is followed. The products are exposed to the public and industry for comment, and validated by an independent validator.

Once agreed by the Development Groups, Standing Committees and Validator, the drafts are passed to the RISSB Board for approval.

The same process is used in developing other RISSB products, although Guidelines are not exposed to the public for comment or validated, given their non-binding nature.

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