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Preface

This standard was prepared by the Australian Railway Rolling Stock - Body Structural Requirements - Part 1: Locomotive Development Group, overseen by the RISSB Rolling Stock Standing Committee.

Objective

This document describes requirements for the structural strength of railway locomotive bodies.

The objective of this Standard is to:

(a) prescribe the minimum structural integrity level of the vehicle body to ensure safe performance under normal operating conditions and extreme operating conditions; and

(b) minimize risks to train crew and members of the general public in the event of collisions or derailments.

Compliance

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

(c) Requirements.

(d) Recommendations.

(e) Permissions.

(f) 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.

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’.

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.

RISSB Standards address known hazards within the railway industry. Hazards, and clauses within this Standard that address those hazards, are listed in Appendix A.

Appendices in RISSB 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 applies to new and modified locomotive rolling stock.

The requirements mandated in this Standard do not retrospectively apply to any existing vehicles other than vehicles which are being modified in areas covered by this Standard so far as reasonably practicable.

The document covers the design, construction and maintenance of rolling stock.

Operation of rolling stock is not covered.

This Standard is not specifically intended to cover rolling stock used on light rail and cane railways, but items from this Standard may be applied to such systems as deemed appropriate by the relevant RTO.

This Standard 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.

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 4991, *Lifting Devices*
- AS 7501, *Rolling stock compliance certification*
- AS 7507, *Rolling Stock Outlines*
- AS 7520.2, *Body Structural Requirements - Part 2: Freight Rolling Stock*
- AS 7522, *Access and Egress*
- AS/NZS 2080, *Safety Glass for Land Transport*
- EN 15152, *Railway applications - Front Windscreens for Train Cabs*
- EN 15227, *Railway applications - Crashworthiness Requirements for Railway Vehicles*
- AAR Standard S-5506, *Performance Requirements for Diesel Electric Locomotive Fuel Tanks, 2001*
- AAR Standard S-580, *Locomotive Crashworthiness Requirements, 2008*
- APTA SS-C&S-034-bogie, *Design and Construction of Passenger Railroad Rolling Stock*
- FRA Standard 49 CFR Part 223, *Safety Glazing Standards - Locomotives, Passenger Cars and Cabooses*
- UK RSSB Standard - GM/RT2130, *Vehicle Fire Safety and Evacuation*
- UK RSSB Standard - GM/RT2100, *Requirements for Rail Vehicle Structures*

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

cab
driving cabs or any enclosed occupiable workspace

1.3.2
CEMS
crash energy management system

1.3.3
critical design stress
either the yield stress (0.2% proof limit), 80% of the ultimate stress or 80% of the critical buckling stress whichever is less

1.3.4
external door
door on the side or end of a vehicle which provides access between the outside and the inside for either the train crew or the passengers

1.3.5
front windscreen
forward-facing window including partially side mounted quarter style windows which have a forward-facing aspect

1.3.6
heavy duty locomotive
heavy locomotive used for example in freight heavy haul or standard gauge (1,435 mm) interstate operations, typical axle load greater than 22 tonnes

1.3.7
light duty locomotive
lighter locomotive used for example in loco-hauled passenger operations or light duty freight operations with typical axle load less than 18 tonnes

1.3.8
medium duty locomotive
medium-sized locomotive used for example in intrastate main and branch line operations, typical axle load between 18 tonnes and 22 tonnes

1.3.9
modifications
changes to a railway vehicle body structure or components which could affect its original structural integrity or safety in areas covered by this standard

1.3.10
power car locomotive
locomotive used exclusively for hauling passenger rolling stock and typically forms an integral part of the train set

1.3.11
RIM
rail infrastructure manager

1.3.12
RTO

rail transport operator

1.3.13
underframe
framework carrying the main body structure of a vehicle usually located under the floor level

1.3.14
wheel guard
deflector mounted in front of the leading wheels of a vehicle to deflect small obstacles from the track. Also lifeguards or guard-irons

General rail industry terms and definitions are maintained in the RISSB Glossary. Refer to: https://www.rissb.com.au/glossary/

Section 2 Design verification

Verification of compliance with the requirements of this Standard shall be undertaken by calculation, inspection, comparison with other vehicles or tests.

Validation of compliance with the crashworthiness requirement of this Standard shall be based on:

(a) test of energy absorbing devices and crumple zones;

(b) calibration of the numerical model of the structure; and

(c) numerical simulation of the design collision scenarios.

Verification of compliance with the requirements of this Standard shall include the full range of variations in vehicle condition that are likely to be experienced.

Where experimental verification is undertaken, a correlation between the analysis and test results should be carried out.

Commentary *C2*

It is suggested to apply a load factor to the proof load cases defined within this Standard where demonstration of compliance is exclusively by calculation to account for the possible inaccuracies in the assessment.

GM/RT2100 and EN 12663 suggest that the proof load factor could be 1.15.

GM/RT2100 and EN 12663 suggest using a 1.5 ultimate load factor to prevent catastrophic failure.

The stress criteria used in this Standard is the Critical Design Stress. Using a no-permanent deformation criterion instead of the Critical Design Stress is also acceptable.

If demonstration of compliance with this Standard is undertaken using Finite Element Analysis, high localized stresses may acceptably exceed the stress criteria limits set in this Standard so long as one of the following conditions is fulfilled:

(a) They are associated with model singularities.

(b) They would not result in significant permanent deformation being experienced by the vehicle structure when the load is removed.

Methods used to demonstrate that no significant permanent deformation is experienced include:

(c) engineering judgement;

(d) the use of non-linear analysis to determine if there is any deformation after a load application/removal cycle; and

(e) relating the results of physical tests to analysis results.

Where this Standard adopts a prescribed load case from a specific nominated Standard (i.e. AAR, EN, etc.) then the stress criteria proposed in that particular Standard would also be used.

Further guidance on the Finite Element Analysis of rolling stock body structures and the acceptability of calculated stresses is available in the AAR Manual Section C-II and EN 12663.

Section 3 Construction

Construction of rolling stock shall meet the requirements of Standards and codes of practice appropriate to the material of construction.

The quality of the workmanship in construction shall be sufficient to ensure that the actual structure meets the structural requirements of this Standard.

Structural welding shall be in accordance with relevant Australian or International Standards applicable to the material.

The construction of the rolling stock shall be verified to be in accordance with the design documentation.

Commentary *C3*

Materials used in the construction of vehicles and their parts is not limited to steel and aluminium. They include other materials such as bronze, stainless steel, ductile iron, grp and composites. Relevant Standards include but are not limited to:

(a) AS/NZS 1554 for carbon and stainless steel;

(b) AS/NZS 1665 for aluminium; and

(c) EN 15085, *Railway Applications – Welding of Railway Vehicles and Components.*

Where rolling stock compliance certification is carried out as per the requirements of AS 7501, the construction conformance certificate issued by the manufacturer is one method of providing this verification.

Section 4 Maintenance

Rolling stock shall have their structural integrity maintained over their service life.

Any structural damage to a rolling stock body shall be repaired in such a way that the structural integrity is restored to the extent required by the RTO and maintainer.

Where a structural repair introduces design features that are different from the original design, the structural integrity of these features shall be demonstrated to meet the requirements of this Standard so far as is practicable either absolutely or by comparison with other local design features.

Fasteners, brackets and supports associated with equipment mounted to the exterior of the body including but not limited to:

(a) underframe mounted equipment;

(b) modular vehicle attachments including cabs; and

(c) roof mounted equipment,

shall be maintained to prevent the equipment from detaching from the vehicle, encroaching upon the kinematic envelope, or adversely affecting the crashworthiness performance.

Commentary *C4*

It is desirable that the vehicle designer feed the output from any fatigue assessment (see Section 8) into the vehicle maintenance manual to guide the RTO and maintainer on what areas of the vehicle structure are to be particularly inspected.

Repair considerations include:

(a) the remaining serviceable life of the vehicle; and

(b) planned maintenance or overhaul activities.

The intent of this clause is to ensure adequate controls are introduced to address hazards associated with the failure of mounting systems due to inadequate maintenance procedures. When determining appropriate maintenance procedures considerations include material type, component serviceable life, failure modes of mounting system components and the effects of corrosion on structural integrity.

Section 5 Vehicle masses

Unless otherwise stated, the rolling stock mass that shall be used in all structural assessment presented in this Standard relates to the maximum service mass of the vehicle. This includes the full operating reserves of water, waste products, sand, fuel, etc., and the overall weight of the crew, luggage, and catering for passenger stock.

Commentary *C5*

EN 15663 and AS 7501 provide definitions of vehicle reference masses and further guidance.

Section 6 Structural rating

Locomotive rolling stock designs shall comply with the appropriate structural rating given in this Standard based on the intended mode of operation and the likely loads the vehicle will experience in service.

For new locomotives, the structural rating used for the design and assessment of the structural performance in accordance with this Standard shall be either:

(a) marked on the underframe of the locomotives; or

(b) recorded in the vehicles data register as per the requirements of AS 7501.

Commentary *C6*

Issues such as the anticipated trailing load, track profile and train performance requirements are important when considering likely loading.

Section 1.3 of this Standard defines the following four main categories for structural rating:

(a) Heavy duty locomotives

(b) Medium duty freight locomotives

(c) Light duty locomotives

(d) Power car locomotives

For railway applications which do not fall under these categories, alternative load cases could be considered.

Section 7 Proof loads

7.1 Longitudinal proof loads

7.1.1 Compressive loads

Locomotive bodies should be designed to withstand a compressive longitudinal load, applied along the centre line of the draft gear at each end of the body without exceeding the critical design stress, of the following applicable magnitude:

(a) 4,450 kN for heavy duty locomotives.

(b) 3,500 kN for medium duty locomotives.

(c) 2,000 kN for light duty and power car locomotives.

7.1.2 Tensile loads

Locomotive bodies should be designed to withstand a tensile longitudinal load applied along the centre line of the draft gear at each end of the body without exceeding the critical design stress, of the following applicable magnitude:

(a) 3,375 kN for heavy duty locomotives.

(b) 2,700 kN for medium duty locomotives.

(c) 1,500 kN for light duty and power car locomotives.

7.1.3 Anti-climb devices

Anti-climb devices shall be fitted to both leading and trailing ends of locomotive vehicles.

Locomotive vehicle bodies should be designed to withstand a compressive longitudinal load of 1500 kN applied on the anti-climb devices without exceeding the critical design stress. Loads may be shared between anti-climb devices.

7.1.4 Collision posts

A minimum of two collision posts shall be provided at the cab end of the locomotive body.

Collision post should be located as per the requirements of AAR Standard S-580 for narrow nose locomotives.

Collision posts should be designed to withstand the following applicable above-floor loading:

(a) For heavy duty locomotives with an axle load of 25 tonnes or greater, as stated in AAR Standard S-580 for narrow nose locomotives.

(b) For medium duty locomotives and heavy-duty locomotives with an axle load less than 25 tonnes, each collision post should be designed to withstand a longitudinal load applied 760 mm above the top surface of the underframe of 890 kN without exceeding the ultimate strength of the material.

(c) For light duty and power car locomotives, each collision post should be designed to withstand a longitudinal load applied 760 mm above the top surface of the underframe of 445 kN without exceeding the ultimate strength of the material.

Collision posts should be designed to withstand the following, applicable at-floor loading:

(d) For heavy locomotives with an axle load of 25 tonnes or greater, as stated in AAR Standard S-580 for narrow nose locomotives.

(e) For medium duty locomotives and heavy-duty locomotives with an axle load of less than 25 tonnes, each collision post should be designed to withstand a longitudinal load applied in line with the top surface of the underframe of 2250 kN without exceeding the ultimate strength of the material.

(f) For light and power car locomotives, each collision post should be designed to withstand a longitudinal load applied in line with the top surface of the underframe of 1,000 kN without exceeding the ultimate strength of the material.

When there are more than two posts, the total load prescribed for two posts should be distributed evenly between all posts.

Commentary *C7.1.4*

It is acceptable to profile or even split the collision post so as to match the general shape of the vehicle end.

7.1.5 End cab structure

Locomotive cab end structure should be designed to AAR Standard S-580 for narrow-nose locomotives.

Commentary *C7.1.5*

Glazing requirements are covered in Section 13.

7.1.6 Corner posts

Corner posts should be provided at each corner of the cab structure.

Corner posts should be designed to withstand the following applicable loading:

(a) For heavy duty and medium duty locomotives, as stated in AAR Standard S-580 for narrow nose locomotives.

(b) For light duty and power car locomotives, each corner post should be designed to withstand a longitudinal load applied at cantrail level of 300 kN and a longitudinal load applied anywhere up the post of 150 kN

7.2 Vertical proof loads

7.2.1 Live loads

Locomotive bodies, when loaded to their maximum service mass, shall be capable of supporting the effects of a dynamic load factor representative of its operation for that load without exceeding the critical design stress.

Commentary *C7.2.1*

EN 12663 uses a dynamic factor of 1.3.

7.2.2 Vertical and longitudinal loads

Locomotive bodies, when loaded to their maximum service mass, shall be capable of supporting that load in the static condition combined with the longitudinal loads described in Section 7.1.1 to Section 7.1.2 without exceeding the critical design stress.

7.2.3 Lifting and Jacking

Locomotive rolling stock shall be designed to incorporate facilities for jacking and lifting operations during maintenance or after derailment.

Fully loaded vehicles (except crew) complete with bogies, shall withstand the loads arising from lifting and jacking in the following situation:

(a) Lifting or jacking from either end, on or near the draft gear carrier and coupler, with the vehicle supported by the other bogie without exceeding the critical design stress.

(b) Lifting or jacking on jacking pads, or lifting brackets where fitted, without exceeding 0.6 x critical design stress.

The supplementary requirements of AS 4991 may be used for the design of lifting devices used to lift railway vehicles.

Commentary *C 7.2.3*

Recovery via the lifting or jacking via jacking pads or lifting brackets is the preferable method where possible.

7.2.4 Coupler vertical loads

Locomotive bodies shall be designed to withstand a vertical load of 220 kN applied to the coupler, both upwards and downwards, without exceeding the critical design stress.

7.2.5 Anti-climb devices vertical loads

Locomotive bodies shall be designed to withstand a vertical load, applied upwards or downwards, applied on the anti-climb devices without exceeding the critical design stress, of the following applicable magnitude:

(a) 890 kN for medium and heavy-duty locomotives.

(b) 220 kN for light duty locomotives.

The vertical load should be applied individually to each shelf of an anti-climb device, centrally and uniformly between centre sill webs.

The shelves or bars on anti-climb devices should consist of the following physical characteristics:

(c) There should be not less than three.

(d) They should be spaced vertically 100 mm to 110 mm apart (Centre-distance spacing).

(e) They should be located horizontally to cover the fullest width of the body structure as practicable.

(f) Each should not be less than 15 mm thick (vertically).

(g) Each should protrude 25 mm or more (horizontally).

(h) They should be located vertically to span the range of at least 1,300 mm to 1,530 mm above rail.

Commentary *C7.2.5*

The configuration of anti-climb devices ideally matches that of anti-climb devices on other rolling stock with which the locomotive is most likely to encounter.

Section 8 Fatigue loads

A fatigue assessment shall be performed for all new locomotive designs.

Where available load spectra that reflect the anticipated operating condition should be used.

Commentary *C8*

A suitable example of the process for fatigue assessment is described in the AAR Manual of Standards, Section C, Part II and EN 12663.

Generic structural Standards such as AS 4100 or AS 3990 (for steel) and AS/NZS 1664 (for aluminium), or international equivalents such as BS 7608 and EN 1993-1-9, also contain suitable fatigue assessment processes.

An example of the fatigue assessment process is provided below:

(a) the fatigue loading spectrum is determined from direct measurement, simulation, from other Standards, or sinusoidal approximation (e.g. for locomotives (1 +/-0.2) g vertical for 10^7 cycles and + /-0.2 g lateral for 10^7 cycles extracted from EN 12663);

(b) the designer identifies all locations that are subject to fatigue loading;

(c) for non-welded details and fusion welded fabrications BS 7608 is used to determine relevant classification and associated allowable stress at 10^7 cycles;

(d) Miner's rule is used to add cumulative damages from each load case at each critical location; and

(e) mean - 2 Standard deviation data (i.e. 97.7% probability of survival) is the minimum level of confidence for fatigue life acceptance.

Section 9 Crashworthiness performance

9.1 Collision performance

Power car locomotive structures shall be designed with a CEMS (crash energy management system) to dissipate impact energy during a collision as per the requirements of EN 15227, GM/RT2100 or equivalent applicable Standards.

Locomotive structures should be designed with a CEMS (crash energy management system) to dissipate impact energy during a collision as per the requirements of EN 15227, GM/RT2100 or equivalent applicable Standards.

The CEMS shall provide a controlled deformation and collapse of designated sections (crumple zones) within the unoccupied areas of the vehicles in the consist to absorb collision energy and to limit the decelerations on passengers and crew members.

Commentary *C9.1*

The following international Standards may be considered when defining the CEMS for locomotives:

(a) EN 15227 C-I

(b) APTA SS-C&S-034-99

(c) 49 CFR, Part 238, Subpart C - Tier I vehicles

(d) 49 CFR, Part 238, Subpart D - Tier II vehicles

9.2 Collision scenarios

The supplier should demonstrate how the rolling stock design performs in collisions not explicitly covered by or beyond the scope of EN 15227 and its design collision scenarios. This demonstration may involve providing a combination of, but not limited to, the following:

(a) additional design collision scenario simulations and analyses, including static analysis;

(b) qualitative analysis of the inherent structural and crashworthiness design of the vehicle, incorporating design provisions from other industry-recognized standards and existing local practices; and

(c) analysis of the vehicle's design performance in previous real-world incidents.

Collisions not explicitly covered by or beyond the scope of EN 15227 can include:

(d) collision speeds that exceed the EN 15227 collision scenario collision speeds;

(e) collisions with other rolling stock with higher or lesser crashworthiness or structural integrity (for mixed traffic operations);

(f) side-on impact collisions by a road truck or heavy motor vehicle at level crossings (for operations with no grade separation with road traffic);

(g) frontal collision with a road truck or heavy vehicle at level crossings (for operations with no grade separation with road traffic);

(h) collisions with various infrastructure due to derailment resulting in frontal or partial frontal impacts or side swiping impacts;

(i) non-ideal collisions that occur on curved tracks, switches and crossings rather than direct head-on idealized collisions on straight tracks;

(j) collisions due to derailments causing a vehicle to enter the path of another vehicle resulting in partial frontal impacts or side swiping impacts; and

(k) vehicle rollovers due to derailment at various speeds.

The amount of energy required to be absorbed in each crumple zone shall be appropriate for the intended service and operating conditions. The amount of energy shall be defined based on the relevant collision scenarios.

The details of the collision scenarios (applicable collision scenarios, impact speeds, state of braking, mass of vehicles, angle of impact, etc) and acceptance criteria shall be defined by the purchaser prior to contract award. These details shall reflect all operating positions and all operating conditions for which the rolling stock was designed and include all directions of travel.

The acceptance criteria should include the following:

(l) a limit on deceleration of the vehicles or a maximum collapse force as identified by the CEMS; and

(m) a requirement that collapse of the vehicle structures is confined to the areas that have been identified in the CEMS as crumple zones.

Particular attention should be given to choosing crashworthiness requirements that are compatible with the proof strength requirements defined in Section 7.1.1 and Section 7.1.2.

The front exterior face of the driver's cab, except for glazing, but including framework, panels and external doors shall have sufficient impact strength to resist penetration into the vehicle in accordance with the impact resistance requirements of EN 15152.

Commentary *C9.2*

The previous version of this Standard defined a sharp-cornered hollow steel cube based on the withdrawn standard BS 566.

The new requirement utilizes a different projectile in accordance with EN 15152.

9.3 Rollover performance – All locomotive types

The cab roof structure, cab mounting systems and adjacent structures shall be capable of supporting half the mass of the locomotive (including the bogies) in the situation when the locomotive is inverted without exceeding the critical design stress in the main supporting members.

Commentary *C9.3-1*

Safety risks associated with vehicle rollover events include, but are not limited to, the following:

- Loss of vehicle body structural integrity;
- detachment of the drivers cab from the locomotive structure;
- ejection of vehicle occupants from the vehicle or direct contact with the ground due to the loss of structural integrity of the vehicle body, bodyside doors and windows;
- ingress of foreign matter such as dirt and ballast, due to dislodgement of doors and windows, and impacting vehicle occupants;
- secondary impacts of vehicle occupants with the vehicle interior; and
- delayed rescue or self-evacuation of passengers due to lack of egress points when the vehicle is resting on its side.

The supplier shall provide detailed information on the design provisions used to address rollover safety risks.

The cab roof structure, cab mounting systems and adjacent structures shall be capable of supporting the weight of the locomotive (including the bogies) in the situation when the locomotive is resting on its

side without exceeding the critical design stress in the main supporting members, assuming the locomotive is supported on the side of the underframe and at the cantrail of the cab and adjacent structures.

Driving cabs should be restrained and not detach during a collision or rollover event.

The locomotive structure, other than the cab structure, shall be capable of retaining the principal components (e.g., engine, alternator, bogies, compressor, cab mounted HVAC equipment, onboard energy storage system if fitted) in the event of derailments, collisions, and rollovers.

Commentary *C.9.3-2*

The intent is to provide a safety cage for crew within the cab in the case of rollover. Therefore, it is important to consider to what extent the adjacent structure such as vestibules or end wall cabinets are able to contribute.

Compliance with Clause 15.4 of this Standard is an acceptable method of demonstrating retention of principal components in the event of derailments, collisions, and rollovers.

APTA SS-C&S-034-99 provides guidance on applied loads that may be incorporated into the design.

9.4 Roof structure penetration

The cab roof structure shall be capable of resisting the external penetration of a concrete block (typical cube size 300 x 300 x 300 mm) weighing 100 kg dropped on all roof horizontal surfaces from 3 m above the roof without loss of interior ceiling height.

Commentary *C.9.4*

Clause 9.4 provides a requirement to assist with managing impacts which could arise from a number of scenarios including but not limited to vehicle rollover on uneven surface or falling objects impacting the cab roof.

Section 10 Cow catchers

A cowcatcher shall be fitted to any leading ends of the locomotive.

A cowcatcher should meet the requirements of EN 15227.

Section 11 Wheel guards

As an additional safety measure, the leading bogie or wheelset of a locomotive vehicle may be fitted with wheel guards to minimize the risk of derailment due to small objects on the rails.

Commentary *C11*

Refer to GM/RT2100 for a suitable set of requirements on wheel guards.

Section 12 Doors

Doors shall comply with the locomotive requirements of AS 7522.

The design of the doors and surrounding areas shall assess and incorporate into the design the effects of events such as collision and vehicle rollover. The vehicle designer shall identify potential failure modes of the external crew doors during collision and rollover and include design solutions that address these failure modes.

External crew doors shall be retained closed and latched under all normal operating conditions including shock/minor impact loads defined in Section 15.4 of this Standard and aerodynamic loads.

Locomotives should not be fitted with side doors directly mounted to the driver's cab area.

Commentary *C12-1*

The above requirement is to eliminate the potential for side door failure during a rollover event and ingress of debris into the cab space.

Modern locomotive cab designs typically include a rear cab door that proceeds into a vestibule area, with access doors on either side of the locomotive behind the cab. This is a preferred arrangement to minimize the risk of debris ingress into the cab if the door fails during a rollover event.

GM/RT2100 provides useful guidance and rationale when assessing the adequacy of external doors.

If cab mounted hinged or plug type doors side doors are fitted:

(a) the hinges shall be mounted towards the front of the locomotive (i.e., the door opening is towards the rear of the locomotive);

(b) the door hinges, door latching mechanism, door lock, door structure and surrounding structural frame shall be designed to ensure that door failure (and thus ingress of debris such as ballast and soft earth) cannot occur following a rollover derailment at the locomotive maximum operating mass and speed;

(c) the door assembly shall have an equivalent strength (i.e., perpendicular load over a given area) and penetration resistance to the neighbouring side walls of the cab structure; and

(d) if the cab mounted doors are powered, the emergency ingress operation shall be available from ground level;

(e) if the cab mounted doors are manually operated, then the door handles/locks shall be accessible from ground level, inset and still be usable from both inside the cab and external to the cab in the event of a collision and/or rollover;

(f) door handles, or door operating buttons, should be recessed to help eliminate snagging that could otherwise occur in a rollover derailment; and

(g) handrails should not block access to the doorways in the event of handrail detachment/distortion in the event of a collision and/or rollover.

The details of the load cases above (for cab mounted external doors) shall be defined by the purchaser prior to contract award. These details shall reflect all operating conditions for which the locomotive will operate on and include all directions of travel.

The rolling stock supplier/ designer shall propose quantitative load cases to address the specific qualitative requirements of this Section 12. These load cases shall be reviewed and agreed by the purchaser prior to Contract award.

An acceptance criterion shall be defined and agreed between the purchaser and the manufacturer.

Commentary *C12-2*

APTA SS-C&S-034-99 provides guidance on transverse strength requirements.

A closed and latched door panel, including any of its components such as:

(h) glazing;

(i) frame/mounting system(s); or

(j) associated door hardware such as latches, locks, hinges and tracks/runners,

shall be capable of retaining the cab occupants within the cab survival space. This can be deemed to be met where:

(k) a force of 1,000 N per metre over the width of the exposed internal surface is applied from inside the vehicle onto the door panel over a strip of 200 mm in height, positioned 1,300 mm above car floor level; and

(l) the applied force can be withstood by the closed and latched door panel without exceeding the critical design stress of the body, door or door components.

Commentary *C12-3*

The intent of Clause 12 is to ensure that the cab occupants are retained within the cab survival space. Refer to AS 7522 for other requirements on doors.

Section 13 Glazing

13.1 Windscreens

Front windscreens shall comply with the locomotive requirements of AS 7522.

Windscreens include front and rear facing glazing.

The windscreens of locomotives shall be manufactured to comply with the requirements of AS/NZS 2080 supplemented by the impact requirements defined in one of the following standards:

(a) FRA Standard 49 CFR Part 223 Type 1;

(b) EN 15152; or

(c) GM/RT2100.

Windscreens should include the ability for emergency access/egress in the event of an accident (which can include a derailment, collision or rollover event). If the windscreen is fitted with emergency access/egress capability (e.g., hinged panel, edge seal cutter, etc), these shall be in accordance with AS 7522.

Windscreen mounting attachments, fixings and surrounding structure shall withstand the aerodynamic loads defined in GM/RT2100 without failure.

To control the risks of a windscreen detaching under impact (e.g., from derailment, impact or vehicle rollover), the windscreen, attachments, fixings and surrounding structure shall comply with the requirements of GM/RT2100.

Each windscreen shall have an effective electrically operated demisting element, with thermal protection for the windscreen included. Each demisting element shall be individually controlled.

13.2 Side windows

Side windows shall comply with the locomotive requirements of AS 7522.

All side window units and their attachment to the vehicle body (including windows fitted to side access doors) shall be manufactured to comply with the requirements of AS/NZS 2080 supplemented by the impact requirements defined in one of the following standards:

(a) FRA Standard 49 CFR Part 223 Type 2; or

(b) GM/RT2100.

Side windows including mounting attachments, fixings and surrounding structure shall withstand the aerodynamic loads, pressure pulse test and passenger containment test requirements defined in GM/RT2100 without failure.

Cab side windows shall include the ability for emergency access/egress in the event of an accident (which can include a derailment, collision or rollover event) or medical episode requiring stretcher evacuation of a person in accordance with AS 7522.

Section 14 Towing fixtures

This Standard contains no requirements for towing fixtures. AS 7520.2 contains requirement that may be applied to locomotives.

Section 15 Body mounted equipment

15.1 General requirements

AS 7507 provides requirements for hatches and expendable items. Body mounted components other than hatches or expendable items that are hinged or moveable and can open and exceed the vehicles kinematic envelope shall incorporate as a minimum a secondary method of restraining the component within the kinematic envelop.

Commentary *C15.1*

Appropriate ways of meeting the requirements of Clause 15.1 include the over design of mountings and attachments, the use of fasteners incorporating high strain energy or the provision of emergency restraints in addition to ensuring mountings and attachments meet the shock/minor impact loading requirements of Clause 15.4.

15.2 Underframe components

The retention of underframe components within the limits of the rolling stock shall have at least one level of redundancy.

Commentary *C15.2*

Appropriate ways of meeting the requirements of Clause 15.2 include the over design of mountings and attachments, the use of fasteners incorporating high strain energy or the provision of emergency restraints in addition to ensuring mountings and attachments meet the shock/minor impact loading requirements of Clause 15.4.

Particular attention is warranted to the mounting and support of underframe equipment that is frequently removed.

15.3 Modular cabs

The retention of modular cabs within the limits of the rolling stock shall have at least one level of redundancy.

Commentary *C15.2*

A secondary restraint system could assist with meeting the requirements of Clause 15.3.

15.4 Shock/minor impact loading

The following accelerations applied individually to components and their mountings to the body shall not cause the critical design stress to be exceeded in any member:

(a) Longitudinally 4 g

(b) Laterally 2 g

(c) Vertically 2 g

Commentary *C15.4*

The accelerations quoted above are to be applied to the centre of inertia of the equipment.

Section 16 Fuel tanks

Fuel tanks mounted beneath the underframe should be designed to comply with one of the following Standards:

(a) AAR S-5506 excluding load cases 1, 2 and 3

(b) GM/RT2130 for light duty and power car locomotives only

Appendix A Hazard register (Informative)

Hazard Number	Hazard
5.1.1	Rolling Stock - Harm to the environment - Derailment or Collision, Human Error, Design Failure, Organisational SMS Failure, Security Breach, Loads not Secure and or Vandalism
5.2.1	Rolling Stock - Harm to infrastructure by rolling stock - Derailment or Collision, Human Error, Design Failure, Security Breach, Loads not Secure, and or Vandalism
5.3.1	Rolling Stock - Harm to persons - Derailment or Collision, Human Error, Track Failure, Design Failure, Health, Organisational SMS Failure, Security Breaches, Loads not Secure and or Vandalism
5.4.1	Rolling Stock - 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
5.7.1	Rolling Stock - Path Infringement - Derailment or Collision, Human Error, Track Failure, Track Obstructions, Design, Health Failures, Environmental Impact, Security Breach, Load not Secure, Vandalism and or Threat
5.8.1	Rolling Stock - Collision - Derailment, Human Error, Track Failure, Track Obstructions, Design Failure, Health Failure, Organisational SMS Failure, Security Breach, Load not Secure and or Vandalism
5.19.1	Rolling Stock - Derailment - Collision, Human Error, Track Failure, Track Obstructions, Design Failure, Health Failure, Security Breach and or Vandalism
5.28.1	Rolling Stock - Vehicles overturning - Derailment or Collision, Human Error, Track Failure, Track Obstructions, Design Failure, Health Failure, Organisational SMS Failure, Security Breach and or Vandalism

Bibliography (Informative)

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

- AS 3990, *Mechanical Equipment- steelwork*
- AS 4100, *Steel Structures*
- AS/NZS 1554, *Structural Steel Welding*
- AS/NZS 1665, *Welding of Aluminium Structures*
- EN 12663, *Railway applications – Structural Requirements for Railway Vehicles*
- EN 15085 Series, *Railway applications - Welding of railway vehicles and components*
- EN 1993-1-9, *Eurocode 3: Design of steel structures - Part 1-9: Fatigue*
- BS 7608, *Guide to fatigue design and assessment of steel products*
- AAR Manual of Standards, Section C, Part II
- FRA Standard 49 CFR Part 238, *Passenger Equipment Safety Standards*