Requirements for Rail Vehicle Structures

Synopsis
This document mandates requirements for the design and integrity of rail vehicle structures for both primary and secondary structures, including interior crashworthiness.
### Issue record

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<td>Two</td>
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<td>Supersedes issue two as a result of review. Incorporates and supersedes the requirements of GM/TT0179 and GM/TT0303</td>
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Revisions have not been marked by a vertical black line in this issue because the document has been revised throughout.

### Superseded documents

The following Railway Group documents are superseded, either in whole or in part as indicated:

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Other parts of GM/RT2160, issue three, are superseded by GM/RT2160, issue four, Environment Inside Railway Vehicles (Audibility of detonators).

Other parts of GM/RT2162, issue one, are superseded by GM/RT2162, issue two, Traincrew Access to and Egress from Railway Vehicles.

Other parts of GM/RT2190, issue two, are superseded by GM/RT2190, issue three, Compatibility Requirements for Rail Vehicle Couplings and Interconnectors.

Supply

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Part 1 Purpose and Introduction

1.1 Purpose

1.1.1 This document mandates requirements for the design and integrity of rail vehicles structures for both primary and secondary structures, including interior crashworthiness.

1.2 Introduction

1.2.1 Background

1.2.1.1 The implementation of the Technical Specifications for Interoperability (TSIs) mandated through a series of European Union Directives has resulted in a review of all requirements set out in Railway Group Standards.

1.2.1.2 Under the Strategy for Standards Management, RSSB has given a commitment to review all of its standards with a view to mandating only those requirements that define the interface and the need for co-operation between different categories of duty holder to manage risk safely.

1.2.1.3 A review of the requirements set out in a suite of standards associated with rail vehicle structures has resulted in a revised Railway Group Standard on this topic.

1.2.1.4 This document only mandates those requirements that satisfy one or more of the following:

   a) Requirements that define the interface and the need for co-operation between different categories of duty holder to manage risk safely.

   b) Requirements that are necessary to support an open point in a TSI and meet an essential requirement of the relevant EU Directive.

   c) Requirements that are necessary for interworking on non-TSI conforming GB infrastructure.

1.2.2 Principles

1.2.2.1 This document is based on the principles set out in the Railway Safety Principles and Guidance Part 1, which states that railway vehicles shall be designed, manufactured and maintained to ensure that as far as reasonably practicable:

   a) The safety of occupants is maintained under both normal operating conditions and abnormal conditions such as heavy shunts, derailments and collisions.

   b) The vehicle interior design controls the risk of injury to occupants in the event of a collision or derailment.

   c) The containment of passengers and traincrew inside a vehicle in the event of a collision is maximised.

   d) Structural integrity is maintained over the life of the vehicle and risks due to fatigue failure are controlled.

   e) Equipment and components remain attached in the event of heavy shunts, derailments and collisions.

   f) The vehicle can be safely coupled and for maintenance and recovery safely jacked or lifted.
Requirements for Rail Vehicle Structures

1.2.3 Support to essential requirements

1.2.3.1 The EU Directives applicable to Interoperability mandate that each TSI is required to address a number of essential requirements. In supporting specific open points in Rolling Stock TSIs, in particular the as yet unpublished Conventional Rail Locomotives and Passenger Rolling Stock TSI, the following essential requirements are addressed.

1.2.3.2 Directive 2008/57/EC of the European Parliament and of the Council of 17 June 2008 on the interoperability of the rail system within the community contains within Annex 3, Essential Requirements, the following relevant essential requirement:

2.4.1 paragraph 1

The rolling stock structures and those of the links between vehicles must be designed in such a way as to protect the passenger and driving compartments in the event of collision or derailment.

1.2.4 Supporting documents

1.2.4.1 The following Railway Group documents support this Railway Group Standard:

GM/GN2685 Guidance on Lifting, Jacking, Recovery and Emergency Movement of Rail Vehicles

GM/GN2686 Guidance on Rail Vehicle Bodyshell, Bogie and Suspension Elements

GM/GN2687 Guidance on Rail Vehicle Interior Structure and Secondary Structural Elements

GM/GN2688 Guidance on the Structural Design of Rail Freight Wagons including Rail Tank Wagons

GM/GN2689 Guidance on Mechanical Coupling of Rail Vehicles
Part 2  Structural Requirements for Rail Vehicles

2.1  Common structural requirements

2.1.1  Vehicle condition and loading

2.1.1.1  Vehicles shall meet the requirements of this document over the full range of variations in vehicle condition that are likely to be experienced.

2.1.1.2  Account shall be taken of variations due to vehicle dimensional and mass tolerances, variations and asymmetries in payload, variations in vehicle maintenance condition, potential for corrosion, effects due to material ageing and any other relevant variables.

2.1.1.3  It is permissible for load cases derived from test, service or simulation data in accordance with Appendix A to be used to support or to replace the loads specified in this document where technically justified.

2.1.1.4  Railway vehicle structures shall be designed, manufactured and maintained using materials suitable for an external temperature range of -20°C to +40°C.

2.1.1.5  The general criteria set out in this section shall apply unless specific criteria are set out elsewhere in this document.

2.1.2  Structural material properties

2.1.2.1  The suitability of structural materials (for example, the suitability of properties such as yield stress, tensile strength and elongation) shall be demonstrated by conformity with the requirements for structural material properties set out in the Euronorms mandated by this document. Where no requirements are set out in the Euronorms mandated by this document, the suitability of structural material properties shall be demonstrated by, in order of preference:

a)  Conformity with an applicable Euronorm (EN).

b)  Conformity with a British Standard (BS).

c)  Conformity with another applicable national or international standard available in English (for example a Deutsches Institut für Normung (DIN) standard or an International Organization for Standardization (ISO) standard).

d)  Evidence of established and successful use in other comparable railway vehicle structures.

e)  Test data, evidence from other applications or a combination to demonstrate that the structural properties are sufficiently well understood to allow reliable predictions to be made of performance under fatigue, proof and ultimate load conditions.

2.1.3  Structural failure

2.1.3.1  Structures shall be designed to ensure that, as far as is reasonably practicable, catastrophic failure does not occur, for example by rupture or gross instability, until the proof load conditions are exceeded by a significant margin. This shall be demonstrated by achieving the proof and ultimate load reserve factors set out 2.1.5 and 2.1.6.

2.1.3.2  Structures shall be designed to achieve their required fatigue life with a survival probability of at least 97.5%, when subjected to the cyclical loads associated with normal operation.
2.1.4 Demonstration of structural integrity

2.1.4.1 The satisfactory performance of railway vehicle structures and structural elements shall be demonstrated by calculation, testing, comparison with documented established practice on other vehicles or a combination of these methods.

2.1.4.2 In order to allow for uncertainties associated with methods of calculation and also for the consequences of failure, all proof or service load calculations or test results shall achieve the proof and ultimate load reserve factors as set out in 2.1.5 and 2.1.6.

2.1.4.3 Where an ultimate load is directly specified, an additional ultimate load reserve factor as set out in 2.1.6 shall not be applied.

2.1.5 Proof load reserve factor

2.1.5.1 The proof load reserve factor is defined as the allowable material proof stress divided by the calculated or measured stress for a given proof load case. The following requirements shall be satisfied:

a) Where there is to be no experimental verification, the proof load reserve factor shall not be less than 1.15.

b) Where there is to be experimental verification, it is permissible to reduce the proof load reserve factor to 1.0.

c) For glass or materials with similar characteristics the proof load reserve factor shall be equal to the ultimate load reserve factor and shall not be less than 1.5.

2.1.5.2 When determining the proof load reserve factor, where calculations predict relatively high localised stresses or ‘hot spots’, it is permissible for these stresses to be partially or fully discounted where it can be demonstrated that there will be no significant permanent deformation when the load is removed.

2.1.5.3 A localised proof load reserve factor less than 1.15 but greater than 1.0 shall be acceptable if it can be demonstrated that the required ultimate load reserve factor is achieved by means of detailed non-linear calculations or localised testing to validate the predicted structural performance.

2.1.5.4 Where structural elements, such as bodyside windows of glass or similar material, can be considered to form part of a primary structure, these elements shall not be included in the determination of the proof load capacity.

2.1.6 Ultimate load reserve factor

2.1.6.1 The ultimate load reserve factor is defined as the material ultimate tensile stress divided by the calculated or measured elastic stress for a given proof load case. Either of the following requirements shall be satisfied:

a) The ultimate load reserve factor shall not be less than 1.5 for calculated or measured elastic stresses.

Or

b) It is demonstrated by means of detailed non-linear calculations, testing or a combination of these that material rupture or failure shall not occur under the application of the applicable proof load case factored by 1.5.
2.1.6.2 Where controlled structural deformation or post-yield energy absorption is required to satisfy particular structural (see Part 3) or interior crashworthiness requirements (see Part 6), an ultimate load reserve factor is not required for a collapse zone or collapsible component provided that:

a) It can be demonstrated that the proof load criteria are satisfied taking account of material and manufacturing tolerances.

b) Post-yield performance against the requirements for the collapse zone or collapsible component is demonstrated by detailed non-linear calculations, testing or a combination of these.

2.1.6.3 Where structural elements such as bodyside windows of glass or similar material, can be considered to form part of a primary structure, these elements shall not be included in the determination of the ultimate load capacity.

2.1.6.4 Where an ultimate loadcase is specified, an ultimate load reserve factor is not required.

2.1.7 Vehicle repair

2.1.7.1 Any structural damage shall be repaired in such a way that the overall structural integrity is restored to:

a) The same level as for an otherwise identical undamaged vehicle. (It is permissible for this reference vehicle to be the same vehicle before the damage occurred.)

Or

b) A level which complies fully with this document.

2.1.7.2 In the event that the original design condition cannot be fully replicated, the repair shall result in an equivalent level of structural integrity consistent with the requirements of 2.1.7.1.
3.1 Structural requirements for all vehicle types

3.1.1 Rail vehicle body structures shall comply with the requirements of BS EN 12663-1:2010 or BS EN 12663-2:2010, BS EN 15227:2008 and the specific requirements set out in Part 3 of this document.

3.1.2 Vehicle payload shall be calculated in accordance with BS EN 15663:2009. As permitted by BS EN 15663:2009, it is permissible for the vehicle load to be defined as functions of the reference cases in the standard to accurately represent actual service conditions appropriate for design purposes.

3.1.3 In accordance with 2.1.1.3 above, it is permissible for alternative load cases to be used to support or to replace specified loads where this is permitted by BS EN 12663-1:2010 or BS EN 12663-2:2010.

3.1.4 The fatigue design life for rail vehicle structures or substructures shall be determined and shall be at least equal to either the design life of the vehicle or a predetermined maintenance interval at which point the structure shall be considered to be life expired.

3.2 Requirements for equipment attached to vehicle bodies

3.2.1 Equipment attached to vehicle bodies shall be designed according to the inertia load values set out in BS EN 12663-1:2010 or BS EN 12663-2:2010 for the relevant vehicle category unless otherwise set out in this document.

3.2.2 The ultimate strength of the equipment attachments shall be consistent with the inertia load values set out in BS EN 12663-1:2010 or BS EN 12663-2:2010 or the maximum mean deceleration levels for the collision scenarios set out in BS EN 15227:2008, whichever is the greater.

3.2.3 The equipment attachment strength shall be formally assessed unless, for minor items of equipment, it can be demonstrated that:

a) For a given type or method of attachment, items at or below a given mass will be securely retained for the acceleration loads specified.

Or

b) A minor item is sufficiently contained or enclosed to prevent it becoming a potential hazard if detached in the event of a collision or derailment or for any other reason.

Or

c) Service experience in an equivalent or more demanding environment has shown the installation to be satisfactory.

3.2.4 Where the failure of an individual mounting could lead to the overload and the potential sequential failure of adjacent mountings, or where a single mounting is used and a resulting failure will create a hazardous situation, secondary fasteners, retention devices or some other equivalent means shall be provided, taking into account the likelihood of detection of an initial failure when in service or during maintenance inspections.

3.2.5 Locally generated accelerations, forces and resonances acting within and on equipment shall be accounted for as well as the specified proof and fatigue inertia loads.
3.2.6 Sources of locally generated accelerations, forces and resonances to be considered for proof and fatigue loads shall include, but not be limited to:

a) Engines, gearboxes, cooler groups and hydrostatic drives.
b) Body mounted traction motors.
c) Transmission units.
d) Suspension elements (for example dampers, anti-rollbars, traction linkages).
e) Air compressors.
f) Door operating equipment.
g) Gangways.
h) Air conditioning systems.

3.2.7 The fatigue design life for equipment attachments shall be determined. If the fatigue design life is less than the design life of the vehicle, this shall be accounted for in inspection, maintenance and overhaul procedures, whereby life expired items are replaced.

3.3 Requirements for vehicles carrying passengers, personnel or traincrew

3.3.1 Structural collapse and prevention of overriding
3.3.1.1 The structural crashworthiness requirements of BS EN 15227:2008 shall apply. The collision scenarios set out in section 5 of BS EN 15227:2008 shall be applied in accordance with the crashworthiness design categories set out in section 4 of BS EN 15227:2008.

3.3.2 Obstacle deflectors
3.3.2.1 The requirements of BS EN 15227:2008 for obstacle deflectors shall apply in accordance with the crashworthiness design categories set out in section 4 of BS EN 15227:2008.

3.3.3 Missile protection
3.3.3.1 To resist penetration into the vehicle of missiles or other objects:

a) Forward facing surfaces of vehicles occupied by people shall have an equivalent impact resistance to that required for the vehicle cab windscreen (see 5.2).

b) Roofs over areas which are freely accessible to passengers, personnel or traincrew during normal service shall withstand, without penetration, the impact of a 100 kg concrete cube with an edge length of 0.36 m dropped from a height of 3.0 m above the roof. The cube shall be dropped so that a flat surface hits the roof.

3.4 Requirements for freight vehicles

3.4.1 Applicable standards for freight vehicles
3.4.1.1 The Conventional Rail Freight Wagons TSI (CR WAG TSI) sets out requirements for freight vehicles intended for operation over the conventional rail Trans-European Network (TEN).
3.4.1.2 In the case of freight vehicles for operation exclusively on other routes, these shall also be designed to comply with the requirements of the CR WAG TSI.

3.4.2 Tank wagons
3.4.2.1 Where a clearance of at least 920 mm from the uncompressed buffer face to the end of the tank does not exist, tank wagons designed to carry dangerous goods shall be provided with additional end protection against overriding in the event of a collision or derailment. Such protection shall:

a) Extend upwards from the buffer centreline for at least 500 mm

b) Minimise the risk of puncturing or damaging the tank end by the provision of smooth surfaces without sharp edges or corners in areas likely to contact the tank if the end protection is deflected or deformed in the event of a collision or derailment.

3.4.3 Barrier and translator vehicles
3.4.3.1 It is permissible for barrier vehicles or translator vehicles, intended solely for the purpose of permitting trains or units to be hauled by otherwise incompatible vehicles or locomotives, to be designed to the same structural design criteria as the hauled vehicles with which they interface.

3.4.3.2 It is permissible for structural criteria permitted by 3.4.3.1 to apply to either the complete vehicle or locally where required for non-standard or incompatible drawgear attachment points and associated interfaces on translator vehicles.

3.4.3.3 Compliance with the crashworthiness requirements set out in 3.3 shall not be required for barrier or translator vehicles, intended solely for the purpose of permitting trains or units to be hauled by otherwise incompatible vehicles or locomotives.
Part 4 Structural Elements for Bogies and Suspension

4.1 Bogies and running gear

4.1.1 Bogie structures

4.1.1.1 The bogie design load cases shall be consistent with both the extreme and normal service conditions under which the vehicle is required to operate.

4.1.1.2 Bogie design load cases for items of equipment and their attachments that are of sufficient mass to affect the dynamic behaviour of the bogie shall be determined from previous experience, testing, simulation, or by a combination of these techniques.

4.1.1.3 It is permissible to use bogie design load cases used for previous vehicles where it can be demonstrated that:

   a) The new application is directly comparable.

   b) Performance in service has been satisfactory in terms of no failures or unscheduled maintenance.

4.1.1.4 The bogie design load cases set out in 4.3 and 4.4 represent established values of inertia load for items of equipment outside the scope of 4.1.1.2 and which have resulted in satisfactory performance for typical conditions. However it shall be demonstrated that the general requirements have been met for any particular application.

4.1.2 Proof load cases

4.1.2.1 Bogie structures shall withstand as proof loads all peak forces imposed on them in service taking full account of the full range of operational conditions likely to be encountered. Proof load cases to be considered, taking into account the layout and suspension characteristics of the bogie, shall include, but not be limited to:

   a) Maximum dynamic vertical load due to track input.

   b) Maximum dynamic vertical load due to low speed derailment.

   c) Maximum dynamic vertical load due to abrupt application of payload for relevant freight vehicles.

   d) Maximum lateral load at point of wheel lifting due to overspeeding on a curve.

   e) Loads due to lifting a vehicle / bogie on its side in recovery situations.

   f) Maximum dynamic longitudinal load due to shunt / buffing operations

   g) Maximum twist load input.

   h) Maximum steering load (shear across the frame)

4.1.2.2 Bogie structures shall withstand as proof loads all reaction forces imposed on them by the proof load cases for bogie mounted and axle mounted equipment.

4.1.2.3 Bogie structures shall withstand as proof loads all reaction forces imposed on them by the vehicle body and bogie retention proof load cases.
4.1.3 Fatigue load cases

4.1.3.1 Bogie structures shall achieve their required fatigue life with a survival probability of at least 97.5%, when subjected to loads representative of operating conditions when in service. Fatigue load cases to be considered, taking into account the layout and suspension characteristics of the bogie, shall include, but not be limited to:

a) Vertical dynamic loads.

b) Lateral dynamic loads.

c) Repeated twist load inputs.

d) Dynamic steering loads (shear across the frame)

4.1.3.2 Each fatigue load case shall be considered as acting separately and the damage from the individual cases shall be summed.

4.1.3.3 The fatigue design life for bogie structures or substructures shall be determined and shall be at least equal to either the design life of the vehicle or a predetermined maintenance interval at which point the structure shall be considered to be life expired.

4.1.4 Derivation of bogie proof and fatigue load cases from test data

4.1.4.1 It is permissible for load cases derived from test or service data in accordance with Appendix A to be used to support or to replace the bogie equipment loads set out in 4.3 and 4.4.

4.2 Body to bogie attachments

4.2.1 Proof load cases

4.2.1.1 As far as is reasonably practicable, bogies shall remain attached to vehicle bodies during a collision or derailment. To achieve this objective, in addition to loads resulting from the requirements of 4.1.2, the body to bogie attachments shall withstand as proof loads the following conditions:

a) The bogie mass subject to a longitudinal acceleration of ±5 g. The relevant proportion of the maximum vertical body proof load at the secondary suspension shall be applied simultaneously.

b) The relevant proportion of the fully laden body mass, together with the associated bogie mass, subject to a lateral acceleration sufficient to lift the wheels from the rail at one side or the bogie mass subject to a lateral acceleration of 1 g, whichever is the greater.

c) A compressive vertical load of the fully laden body mass subject to an acceleration of 2 g.

d) A tensile vertical load of the bogie mass subject to an acceleration of 2 g.

4.2.1.2 For locomotives and vehicles in rigidly coupled rakes the longitudinal load shall be the bogie mass subject to an acceleration of ±3 g.

4.2.2 Ultimate load case

4.2.2.1 The body to bogie attachment shall withstand as ultimate loads the longitudinal decelerations and forces imposed by the collision scenarios set out in 3.3.1.1.
4.2.2.2 Body to bogie connection arrangements shall ensure that failure due to overload occurs in a predictable manner and that the structural integrity of the vehicle body structure is not reduced.

4.2.3 Fatigue load cases

4.2.3.1 Fatigue loads for body to bogie connections shall be determined in accordance with Appendix A.

4.2.3.2 The fatigue design life for body to bogie connections shall be determined and be at least equal to either the design life of the vehicle or a predetermined maintenance interval at which point the items affected shall be considered to be life expired.

4.3 Equipment attached to bogie frames

4.3.1 Proof load cases

4.3.1.1 Except for items of equipment in the scope of 4.1.1.1, items of equipment and their mountings shall withstand as proof loads, the inertia forces associated with the following accelerations:

a) Vertical ±20.0 g at the wheelset centreline, ±10.0 g at the bogie centreline. Values at other positions shall be obtained by linear interpolation or extrapolation.

b) Transverse ±10.0 g at the wheelset centreline, ±5.0 g at the bogie centreline. Values at other positions shall be obtained by linear interpolation or extrapolation.

c) Longitudinal ±5.0 g or ±3.0 g according to the criteria set out in 4.2.1.

4.3.2 Fatigue load cases

4.3.2.1 Except for items of equipment in the scope of 4.1.1.1, items of equipment and their mountings shall be assessed assuming a fatigue life of not less than 10^7 cycles with a survival probability of at least 97.5%, under the inertia forces associated with the following accelerations:

a) Vertical ±6.0 g at the wheelset centreline, ±3.0 g at the bogie centreline. Values at other positions shall be obtained by linear interpolation or extrapolation.

b) Transverse ±5.0 g at the wheelset centreline, ±2.5 g at the bogie centreline. Values at other positions shall be obtained by linear interpolation or extrapolation.

c) Longitudinal ±2.5 g.

4.3.2.2 The fatigue design life for items of equipment and their mountings shall be determined and be at least equal to either the design life of the vehicle or a predetermined maintenance interval at which point the items affected shall be considered to be life expired.

4.3.3 Locally generated accelerations, forces and resonances

4.3.3.1 The accelerations set out in 4.3.1 and 4.3.2 do not include the effects of locally generated accelerations, forces and resonances acting within and on equipment. Special provision shall be made to withstand such additional forces or means provided to avoid their occurrence.
4.3.3.2 Locally generated accelerations, forces and resonances to be considered shall include, but not be limited to, the effects of:

a) Traction motors.
b) Traction gearboxes, final drive units or drive couplings.
c) Brake equipment.
d) Suspension components or actuators.
e) Shoegear (if applicable).

4.4 Equipment attached to axleboxes

4.4.1 Proof load cases

4.4.1.1 Items of equipment attached to axleboxes, together with their mountings, shall withstand, as proof loads, the inertia forces associated with the following accelerations acting at the axle centreline. Values at other positions shall be derived using the characteristics of the suspension system:

a) Vertical ±70.0 g.
b) Transverse ±10.0 g.
c) Longitudinal ±10.0 g.

4.4.2 Fatigue load cases

4.4.2.1 Items of equipment attached to axleboxes, together with their mountings, shall be assessed assuming a fatigue life of not less than $10^7$ cycles with a survival probability of at least 97.5%, under the inertia forces associated with the following accelerations acting at the axle centreline. Values at other positions shall be derived using the characteristics of the suspension system:

a) Vertical ±25.0 g.
b) Transverse ±5.0 g.

4.4.2.2 The fatigue design life for items of equipment attached to axleboxes, together with their mountings shall be determined and be at least equal to either the design life of the vehicle or a predetermined maintenance interval at which point the items affected shall be considered to be life expired.

4.4.3 Locally generated accelerations, forces and resonances

4.4.3.1 The accelerations set out in 4.4.1 and 4.4.2 do not include the effects of locally generated accelerations, forces and resonances acting within and on equipment. Special provision shall be made to withstand such additional forces or means provided to avoid their occurrence.

4.4.3.2 The accelerations specified shall be factored if necessary to take into account any force variation effects due to the particular primary suspension arrangement.

4.5 Lifeguards

4.5.1 All leading bogies shall be fitted with lifeguards, as stipulated below, with the aim of reducing as far as is reasonably practicable the risk of derailment due to impact by small obstacles on the rails.
4.5.2 A lifeguard shall be:

a) Made of a ductile material.

b) Able to resist a sustained concentrated proof load of at least 20 kN applied at its bottom edge horizontally and in a longitudinal direction towards the adjacent wheel, and during deformation beyond the proof load, able to resist an ultimate load of at least 35 kN.

c) Able to resist the proof load set out in b) combined with a transverse load, in either direction, of at least 10 kN.

d) Designed so that, as the load in b) or c) is increased up to the ultimate or maximum dynamic load that it can sustain during impact with the obstacle, it deforms plastically to absorb as much additional energy as reasonably practicable.

e) Designed so that, during and after deformation due to the loads specified, it does not foul the track or running gear and that contact with the wheel tread, if it occurs, does not pose the risk of derailment.

f) Designed so that, under the conditions described above, it remains securely attached to the bogie.

4.5.3 The bogie and the attachment of the lifeguard to the bogie shall not be damaged or suffer significant permanent deformation under the loads set out above.

4.5.4 If mounted on a bogie frame or mounted on an axlebox, the lifeguard and its attachments shall be:

a) Capable of withstanding the applicable proof loads.

b) Capable of withstanding without failure the inertia forces associated with all applicable fatigue accelerations.

4.5.5 The accelerations specified shall be factored if necessary to take into account any force magnification due to the particular primary suspension arrangement.

4.5.6 Lifeguards shall be positioned as close as reasonably practicable to the rail head taking into account wheel wear, suspension movements, suspension wear and assembly tolerances.
Part 5 Secondary Structural Elements

5.1 Common design requirements

5.1.1 All secondary structural elements, together with all mounting attachments, fixings and surrounding vehicle structure shall, in addition to the particular loads set out below, comply with the proof, ultimate and fatigue load requirements specified for vehicle body mounted equipment (see 3.2).

5.2 Windscreens

5.2.1 Windscreen structural requirements

5.2.1.1 Any predominantly forward facing window which in normal service operation may be positioned at the leading end of a train behind which traincrew, personnel or passengers may be located shall satisfy the structural requirements for windscreens.

5.2.1.2 At intermediate ends of fixed formation units, any predominantly forward or rear facing window, behind which passengers, personnel or traincrew may be located in normal service, shall be considered to be a bodyside window.

5.2.1.3 The strength of windscreen fixings and the complete windscreen installation shall be consistent with the strength and impact requirements for the windscreen.

5.2.2 Impact resistance for vehicle windscreens

5.2.2.1 The requirements for impact resistance and spalling set out in BS EN 15152:2007 shall apply for all vehicle windscreens.

5.2.3 Windscreen aerodynamic loads

5.2.3.1 A windscreen together with all mounting attachments, fixings and surrounding vehicle structure shall withstand without failure the aerodynamic loads set out in Part 7.

5.3 Bodyside windows

5.3.1 Bodyside window requirements

5.3.1.1 All bodyside windows for vehicles carrying passengers, personnel or traincrew, in areas which are freely accessible during normal service, shall have at least one pane of laminated safety glass, or other material with equivalent or superior structural properties. The requirements for sleeper vehicles are set out in 5.3.1.3.

5.3.1.2 For refurbishment of existing vehicles where due to limitations imposed by the window frame design or the underlying vehicle structure it is not possible to achieve full compliance, the requirements of 5.3 shall be applied as far as it is reasonably practicable.

5.3.1.3 For dedicated sleeper vehicles the following requirements shall apply:

a) Means shall be provided to allow compartment and corridor windows to be safely removed or opened in an emergency to allow passenger escape from the vehicle.

b) For existing vehicles it is permissible, even if otherwise subject to the requirements of 10.2.1.3, for the windows to be breakable using a suitable hammer or other device to allow passenger escape in an emergency.
5.3.1.4 Where double glazed units are fitted, it is permissible for one pane to be of toughened safety glass. When installed in the vehicle the laminated safety glass pane shall always be fitted on the side of the unit forming part of the vehicle interior.

5.3.1.5 Where double glazed units incorporate toughened glass either:

a) A means of easily recognisable identification in English shall be provided on both the interior and exterior of the window to distinguish between laminated or toughened safety glass in order to show that windows are correctly fitted along the bodyside of the vehicle

Or

b) The double glazed unit and its mounting to the vehicle shall be designed to prevent incorrect installation.

5.3.2 Window design requirements

5.3.2.1 Glass shall be manufactured in accordance with BS 857:1967 or an equivalent specification.

5.3.2.2 Bodyside window fixings and the complete bodyside window installation shall be consistent with the strength and impact requirements for the bodyside window set out in 5.3.3 to 5.3.5.

5.3.2.3 Bodyside window systems representative of production quality and construction shall be tested as required below (see 5.3.4 to 5.3.6). Where a vehicle or unit is fitted with a number of different sized windows to an otherwise common design, it is permissible for impact, containment and pressure pulse testing required in accordance with Appendices B, C and D to be undertaken on only the largest window unit.

5.3.2.4 Impact, containment and pressure pulse testing required in accordance with Appendices B, C and D of this document is not required where either the height or width is less than 300 mm for window units or window unit subassemblies if the Bodyside window is subdivided.

5.3.2.5 Where a window unit or window unit type has already been tested in accordance with Appendices B, C and D of this document, additional testing for a new installation shall not be required if it can be demonstrated that the following conditions are satisfied:

a) The window unit design and mounting arrangements are mechanically equivalent to those for which test data has been obtained.

b) The window unit installation and corresponding vehicle structure can satisfactorily resist all structural loads from the series of tests for which data has been obtained.

5.3.3 Bodyside window structural requirements

5.3.3.1 Bodyside windows, when installed in a vehicle, shall remain fully serviceable after the application over the full surface area of the following loads:

a) The aerodynamic loads set out in Part 7.

b) For all windows in areas accessible to passengers, personnel or traincrew, with the exception of cabs, a sustained pressure of 6 kPa from inside the vehicle.
c) For external door windows, the sustained pressure loads specified for the door assembly (see 5.4.2).

d) For cab side windows, a sustained pressure of 3 kPa from inside the vehicle.

5.3.3.2 If a bodyside window pane is damaged by impact, the risk of injury to vehicle occupants from any spalling of the inner surface shall be controlled. This objective shall be deemed to be satisfied by demonstrating that, when windows are tested in accordance with Appendices B and C:

a) For the small missile tests (see Appendix B), the total amount of spall does not exceed 40 g.

b) For the sequence of containment tests (see Appendix C), the total amount of spall for the steel ball impact test (see Appendix C.5) does not exceed 10 g.

5.3.3.3 If a bodyside window pane is damaged by impact, the risk of detachment from the outer surface of pieces, with the consequent risk of injury for people outside the vehicle, shall be controlled. For double glazed bodyside window units, this shall be demonstrated by satisfactory testing in accordance with the requirements of Appendix D.

5.3.4 Laminated safety glass bodyside window and window unit loads and impact resistance

5.3.4.1 To demonstrate resistance to small missiles, a laminated safety glass bodyside window pane or a double glazed window unit incorporating laminated safety glass shall resist without penetration into the vehicle, the impact of a solid steel ball weighing 0.25 kg travelling at a speed of 100 km/h when tested in accordance with the requirements of Appendix B.

5.3.4.2 When tested in accordance with Appendix C, a bodyside window or window unit, with the exception of cab bodyside and cab door windows, using laminated safety glass shall demonstrate acceptable containment performance by withstanding the following sequence of loads:

a) The external impact of a solid steel ball weighing 5 kg travelling at a speed of 34 km/h.

This shall be followed by:

b) A 50 kg pendulum internal impact from a height of 1200 mm.

And then it shall be followed by:

c) A concentrated perpendicular internal load of 0.8 kN applied over an area of 0.1 m x 0.1 m on the surface at the window centre.

5.3.4.3 For cab bodyside and cab door windows acceptable performance shall be demonstrated only against the requirements of 5.3.4.2 a) when tested in accordance with the applicable parts of Appendix C.

5.3.5 Toughened safety glass bodyside window impact resistance

5.3.5.1 Where these are permitted, toughened safety glass bodyside window units shall withstand without penetration the impact of a solid steel ball weighing 0.25 kg travelling at a speed of 50 km/h when tested in accordance with the requirements of Appendix B.
5.3.6 **Bodyside window emergency access**

5.3.6.1 Testing shall be undertaken to demonstrate that the time to create an opening suitable for access shall not exceed 2 minutes, using tools typically available to rescue services.

5.3.6.2 Test samples shall be mounted at a height corresponding to the nominal relative height of the installed bodyside window from a standard station platform.

5.4 **External vehicle doors**

5.4.1 **External vehicle door design requirements**

5.4.1.1 The strength of door frames, door locks and associated equipment shall be compatible with the strength of the doors.

5.4.2 **External vehicle door loads**

5.4.2.1 External vehicle doors and their mountings shall withstand the following separate proof load cases without significant permanent deformation or loss of normal function:

a) A concentrated perpendicular load of 2.5 kN applied over an area of 0.1 m x 0.1 m, acting from within the vehicle. The structure shall be capable of withstanding this load at any position on the surface of the door.

b) An external surface pressure load of 2.5 kPa.

c) The inner surface pressure load of 2.5 kPa, applied over the internal surface of the door plus a concentrated perpendicular load, acting from within the vehicle, of 0.8 kN applied over an area of 0.1 m x 0.1 m. The structure shall be capable of withstanding the concentrated load at any position on the surface of the door.

5.4.2.2 In the case of vehicles with a maximum speed in excess of 125 mile/h or pressure sealing, an appropriate quasi-static aerodynamic pressure load shall be determined according to the requirements set out in Part 7.

5.4.2.3 External doors shall withstand as an ultimate load case a sustained pressure of 6 kPa over its internal surface. It shall not be necessary for the door and associated components to remain operational after the application of this load.

5.4.2.4 Direct access external doors exclusively for use by traincrew or personnel for access and egress and only accessible by them in normal operation shall withstand as an ultimate load case a sustained pressure of 3 kPa over its internal surface. It shall not be necessary for the door and associated components to remain operational after the application of this load.

5.4.2.5 External doors shall withstand without significant permanent deformation or loss of normal function the transient aerodynamic load requirements set out in Part 7.

5.5 **External steps, external grab rails and external handles**

5.5.1 **Structural requirements**

5.5.1.1 A step shall withstand a concentrated downward vertical proof load of 2 kN, applied over an area of 100 mm x 200 mm. The structure shall be capable of withstanding the concentrated load at any position on the step surface.

5.5.1.2 A step shall withstand a uniformly distributed downward vertical proof load of 4 kN per metre over its length, without significant permanent deformation.
5.5.1.3 External grab rails or handles shall withstand a perpendicular proof load of 1.7 kN applied at any point along its length without significant permanent deformation.

5.5.1.4 External handles on external doors shall withstand a downward vertical proof load of 1.7 kN without significant permanent deformation. For external handles which rotate, the proof load shall be applied with the handle in the worst case position(s).

5.5.1.5 Step materials and surfaces shall be slip resistant.

5.6 Inter-vehicle gangways

5.6.1 Structural requirements

5.6.1.1 A gangway, including all its flexible elements, shall remain stable and provide a safe passageway between vehicles. Compliance with the following requirements of 5.6.1 shall be deemed to satisfy these objectives for conventional gangways. Requirements for open wide gangways are an ‘open point’.

5.6.1.2 In service, gangway movement shall not expose any gaps, crevices or openings where passengers or traincrew could be caught, trapped or become injured by crushing or pinching.

5.6.1.3 Gangway loads, and where appropriate combinations of loads, shall be identified taking full account of the following conditions:

   a) Kinematic and dynamic movements due to operation in passenger service taking account of:

      i) Vehicle speed.

      ii) Vehicle loads.

      iii) Relative displacement between vehicles, including where applicable variations due to inflated and deflated suspensions on adjacent vehicles.

      iv) Combinations of horizontal and vertical curvature.

      v) Cant deficiency and cant excess conditions, including where applicable effects due to tilt systems.

      vi) Differences between vehicles due to wheel wear or vehicle set up or vehicle and suspension tolerances.

   b) Kinematic and dynamic movements due to low speed operation in sidings and depots.

   c) Aerodynamic forces due to pressure transients created by other trains, by lineside structures and by passage through tunnels.

5.6.1.4 A gangway shall withstand without significant permanent deformation the following proof loads:

   a) A pressure load of 6 kPa on the standing floor area.

   b) A concentrated perpendicular load, acting from within the gangway, of 0.8 kN applied over an area of 0.1 m x 0.1 m acting on the surface of the side walls. The gangway structure shall be capable of withstanding the concentrated load at any position.
5.6.1.5 A gangway shall withstand without significant permanent deformation as a proof load a differential pressure between the inside and outside of the gangway of ±2.5 kPa. In the case of vehicles with a maximum speed in excess of 125 mile/h, or pressure sealing, an appropriate quasi-static aerodynamic pressure load shall be determined according to the requirements set out in Part 7.
6.1 Vehicle interior design requirements

6.1.1 General requirements

6.1.1.1 The requirements of Part 6 apply to all vehicle interior elements and aspects of passenger vehicles that interface with personnel or traincrew, subject to the following considerations set out in 6.1.1.2 to 6.1.1.5.

6.1.1.2 For new designs of vehicle the requirements shall apply in full. Where additional vehicles of an existing design are added to an existing fleet, or vehicles are built to replace damaged vehicles, it is permissible to comply with the original specifications and standards.

6.1.1.3 It is permissible to make changes or enhancements to a vehicle interior or to a distinct area of the interior using items to the same design standard as the existing vehicle interior where it can be demonstrated that the level of safety is at least maintained.

6.1.1.4 Where panelling, partitions, doors, grab rails, grab poles or other items are substituted or added, the substitute or additional items shall, as far as reasonably practicable, comply with the relevant requirements in Part 6.

6.1.1.5 For refurbishment of existing vehicles, and where a reasonable opportunity exists, the requirements shall apply in full to all areas where the vehicle interior is essentially removed and replaced with a new design. Where due to limitations imposed by the underlying primary vehicle structure, it is not possible to achieve full compliance, the requirements of Part 6 shall be applied as far as it is reasonably practicable.

6.1.2 Dynamic testing, computer simulations and calculations

6.1.2.1 It is permissible to undertake computer simulations and calculations in place of dynamic testing where it can be demonstrated that the models used are validated against directly comparable test data for a rail vehicle interior. As a minimum, it shall be demonstrated that:

a) Validated computer models of the anthropomorphic test devices (ATDs) are used.

b) The models used for seats, tables or other fixtures are validated by testing or calculation.

c) The results obtained exhibit good correlation with existing test data for equivalent conditions.

6.1.2.2 Reference to dynamic testing within Part 6 therefore includes the use of simulation or calculation methods set out in 6.1.2.1.

6.1.3 Existing component test results

6.1.3.1 Where an item has already been dynamically tested in accordance with this document or in accordance with AV/ST9001 which is superseded by this document, additional testing for a new installation shall not be required if it can be demonstrated that all of the following conditions are satisfied:

a) The proposed layout in terms of occupant safety is equivalent or better than the arrangements previously tested.
b) Dynamic load data has been obtained from the original test series to define the dynamic load requirements for the item’s installation, attachment points and fixings.

c) The item’s fixings and corresponding vehicle structure can resist all loads resulting from static proof and dynamic collapse loads.

d) The item’s design and mounting arrangements are mechanically equivalent to those for which test data has been obtained.

6.1.4 Security of furniture, equipment and features

6.1.4.1 Except for trolleys being used for the provision of an at-seat service (see 6.7.5), there shall be no loose items of furniture or equipment.

6.1.4.2 All interior panelling, furniture, equipment, access panels or other features shall comply with the requirements of 3.2 and Part 2.

6.1.4.3 Proof acceleration loads for seats, tables, body mounted interior panelling, fittings or equipment shall exclude loads due to passengers or luggage. Specific load requirements relating to passengers and luggage are set out in 6.2 and 6.8.

6.1.5 Structural energy absorption and collapse

6.1.5.1 Seat assemblies, tables, and interior fixtures shall satisfy the following requirements under the proof, ultimate and, where applicable, dynamic load conditions specified in this document:

a) Elements that form part of a primary load path shall include ductile materials to ensure that the complete structure exhibits post-yield plasticity and energy absorption, when loaded beyond the specified proof loads.

b) All attachments to the primary structure shall remain intact for all load conditions specified in this document.

c) A continuous load path shall be maintained under all load conditions specified in this document without abrupt changes in force levels due to for example buckling, snap-through or fracture.

d) No sharp objects or fracture surfaces are produced which are likely to cause injury.

6.1.5.2 For seats and tables, after application of a specified proof load, it is permissible for any permanent deformation to be of greater magnitude than would normally be considered to be acceptable, subject to the following conditions being satisfied:

a) The item is dynamically tested in accordance with 6.2.4 (seats) and 6.3.2 (tables) and satisfies all dynamic test requirements for structural strength and passenger injury.

b) The permanent deformation is the result of post-yield plastic deformation.

c) All structural attachments to primary structure and any joints or connections within the seat or table assembly, do not show any local deformation or strain that could affect the integrity of the attachments, connections or joints.
6.1.6 Areas subject to secondary impact

6.1.6.1 Areas of a vehicle interior which are accessible to passengers, personnel or traincrew in normal service shall be assessed for potential injury due to secondary impact in the event of a collision or derailment. The secondary impact assessment shall include but not be limited to:

a) Parts of seats, tables and drivers desks outside the scope of dynamic testing requirements (see 6.2, 6.3 and 6.9).

b) Panels and panel edges.

c) Controls, instruments, switches and indicators (for example driver’s desks and guards panels).

d) Equipment cubicles or housings

e) Passenger information displays, screens, loudspeakers.

f) Luggage racks and luggage stacks.

g) Minor items (for example coat hooks, poster frames, magazine racks, light-stick boxes, small equipment housings).

6.1.6.2 The secondary impact assessment shall demonstrate that the risk of injury due to secondary impact is controlled, for impacts in the longitudinal, vertical and lateral directions or combinations of these, by ensuring that as far as reasonably practicable interior surfaces control or eliminate injury risk due to:

a) Sharp points.

b) Sharp corners.

c) Protrusions or recesses.

d) Abrupt changes of contour.

e) Abrupt changes of stiffness (for example locally rigid areas on panelling).

6.1.6.3 It is permissible for the secondary impact assessment to take into account the following considerations:

a) The probability of secondary impact occurring due to the location of a given item.

b) Functional requirements (for example statutory requirements for handrails).

c) Likely use and occupancy of any given part of the interior (for example second man’s position in cabs).

6.1.6.4 Where items of toughened safety glass are incorporated in a fixture or fitting, secondary impact shall also be assessed assuming that the glass had been broken before impact.
6.2 Seats for passengers, personnel or traincrew

6.2.1 General requirements for seats (see 6.2.5 for tip-up seats)

6.2.1.1 Seats, seat mountings and their fixings through to primary structure shall be designed to withstand without significant permanent deformation the following proof loads:

a) A vertical load of 2000 N applied downwards over an area of 380 mm wide by 200 mm deep located centrally on the seat cushion.

b) Longitudinal loads of ±1500 N (relative to the seat) applied over an area of 250 mm wide by 50 mm deep located centrally at the uppermost part of the seat back. For cab seats it is permissible for only the rear acting load to be considered.

6.2.1.2 For transverse seats which are wholly or partially attached to the vehicle floor, the seats, seat mountings and their fixings through to primary structure shall be designed to withstand as an ultimate load case an inward lateral displacement of the complete seat assembly of 100 mm. For the purposes of testing or calculation, for seats with bodyside attachments, it is permissible to apply the lateral load through the bodyside attachment points to achieve the required deflection. In the case of wholly floor mounted seats it is permissible to displace the complete seat assembly laterally 100 mm at seat cushion level.

6.2.1.3 In the case of multiple seats, the specified load cases shall be applied simultaneously on each seat.

6.2.1.4 Where seats are attached directly to partitions or the seat backs are placed sufficiently close to partitions, luggage stacks or other seat backs to allow them to be contacted when the seats are loaded, the partition, luggage stacks or adjacent seats shall withstand without significant permanent deformation all loads that are transferred from the affected seats.

6.2.1.5 Where luggage stacks or luggage stowage between or behind seats will place additional loads on seats these potentially additional loads shall be taken into account, assuming that the luggage areas are filled.

6.2.1.6 Seat cushions, back squabs, headrests or trim shall not become detached or sufficiently displaced when subjected to the static or dynamic loads set out in this document to expose sharp edges, sharp points or underlying structures which have the potential to cause injury if subsequently impacted. Any items that become exposed as a result of static or dynamic load shall be assessed according to the requirements of 6.1.6.

6.2.2 Seat armrests

6.2.2.1 Where seat armrests are fitted, they shall withstand:

a) Static proof loads of ±750 N applied in the transverse direction (relative to the seat) at the free end of the armrest.

b) Static proof loads of 1000 N applied vertically downwards at the free end of the armrest.

6.2.2.2 It shall be demonstrated that the specified armrest loads can be reacted through the seat frame including the primary seat fixing points.

6.2.2.3 In the case of multiple seats, for each seat the specified transverse proof loads shall be applied simultaneously to the armrest corresponding to the direction of load.
6.2.3 Transverse passenger seats

6.2.3.1 The seat back shall be continuous and provide support for a normally seated person. The seat back support shall be sufficient to control the risk of injury due to rotation of the head when subjected to a rearward acting (relative to the seat) deceleration. It is permissible to achieve this by either:

a) A rearward test in accordance with Appendix E with a 95th percentile male ATD. The head injury, neck injury and neck rotation criteria set out in Appendix H shall be satisfied. It is permissible to demonstrate that these objectives are satisfied in the course of dynamic testing as set out in 6.2.4.

Or

b) Using high backed seats with the top of the seat structure at least 20 mm above the level of the centre of gravity of the head of a 95th percentile male when seated on a compressed seat cushion.

6.2.3.2 Loads induced under dynamic test conditions shall not cause excessive deflections which will prejudice the survival space (as set out in Appendix H.8) of people occupying the seats in front of, and behind, the seat in question.

6.2.4 Dynamic testing requirements for transverse passenger seats

6.2.4.1 For each type or design of seat to be used in a vehicle (for example first class, standard class), critical seating positions shall be determined for:

a) Injury potential for unidirectional seating; projection forward of a 50th percentile male passenger or passengers into the back of the seat or seats in front.

b) Injury potential; rearward projection of a 50th percentile male passenger or passengers back into their own seats.

c) Dynamic structural integrity; for unidirectional seating, projection forward of a 95th percentile male passenger or passengers into the back of the seat or seats in front.

d) Dynamic structural integrity; rearward projection of a 95th percentile male passenger or passengers back into their own seats.

6.2.4.2 The determination of critical seating positions shall take into account at least the following factors, assuming a longitudinal deceleration pulse as set out in Appendix E:

a) Effects due to variations in nominal seat pitch.

b) For multiple seats, any differences in relative performance between seats, for example aisle or window positions.

c) Any differences in structural performance between otherwise similar seating arrangements due to, for example, the presence of adjacent partitions, luggage stacks, door pockets, adjacent seating arrangements.

d) Any differences in relative passenger position due to local variations in seating layout (for example due to a door pocket) which alter the passenger’s trajectory or impact when projected forward into the back of the seat or seats in front.
6.2.4.3 For the critical positions identified, unless the requirements of 6.1.3 are satisfied, dynamic testing shall be undertaken in accordance with Appendix E to give:

a) For seats identified as critical for injury potential, a satisfactory injury criteria assessment as set out in Appendix H.1.

b) For seats identified as critical for structural integrity, compliance with the structural strength and integrity criteria set out in 6.1.4.

6.2.5 Tip-up seats

6.2.5.1 When not in use tip-up seats shall fold away automatically.

6.2.5.2 Tip-up seats shall withstand without significant permanent deformation a vertical load of 2000 N applied downwards over an area of 380 mm wide by 200 mm deep located centrally on the seat cushion.

6.2.5.3 Where tip-up seats are attached to partitions which do not form part of the primary vehicle structure, the partition shall withstand without significant permanent deformation a rearward acting load of 1500 N (relative to the seat) applied over an area of 250 mm wide by 50 mm deep located centrally at the uppermost part of the seat back. If a seat back is not provided, the dimension from the seat base to the load point applicable for adjacent fixed seats shall be used.

6.2.5.4 In the case of multiple or grouped tip-up seats, the specified load cases shall be applied simultaneously on each seat.

6.2.5.5 Tip-up seat cushions, and where applicable back squabs, headrests or trim shall not become detached or sufficiently displaced when subjected to the loads set out in this document to expose sharp edges, sharp points or underlying structures with the potential to cause injury if subsequently impacted. Any items that become exposed shall be assessed according to the requirements of 6.1.6.

6.3 Fixed tables

6.3.1 General requirements

6.3.1.1 The tables and their fixings shall be designed to withstand without significant permanent deformation the following static proof loads:

a) 1000 N applied vertically downwards or upwards at any position

b) 1500 N applied horizontally to the edge of the table, in any direction and at any position on the edge.

6.3.1.2 Fixed tables shall be dynamically tested in conjunction with applicable seating arrangements, in accordance with the requirements of 6.3.2.

6.3.1.3 In bay seating areas longitudinal passenger impact against a table, under the dynamic load conditions set out in this document, shall not lead to the loss of survival space (as set out in Appendix H.8) on the opposite side of the seating bay. In unidirectional seating where single sided tables are used, there shall be no loss of survival space for the seat or seats in front.

6.3.2 Dynamic testing requirements for fixed tables

6.3.2.1 For each type or design of table to be used in a vehicle, the critical table and seat combinations shall be identified for potential passenger injury and dynamic structural strength taking into consideration the projection forward of a passenger or passengers into the table edge during a collision or derailment.
6.3.2.2 Where tables are fitted with hinged flaps or moveable elements to permit access to seating, both open and closed cases shall be considered and tested, unless it can be demonstrated that there is a single critical table configuration that can be identified for both injury criteria and dynamic strength.

6.3.2.3 For the critical positions identified, unless the requirements of 6.1.3 are satisfied, dynamic testing shall be undertaken in accordance with Appendix E to give:

a) For table and seat combinations identified as critical for injury potential, a satisfactory injury criteria assessment as set out in Appendix H.1.

b) For table and seat combinations identified as critical for structural integrity, compliance with the structural strength and integrity criteria set out in 6.1.4.

6.4 Folding seat back tables

6.4.1 Dynamic testing requirements for folding seat back tables

6.4.1.1 Each type or design of folding seat back table shall be dynamically tested in accordance with Appendix E to demonstrate a satisfactory injury criteria assessment as set out in Appendix H.1 when the seat back is impacted by the projection forward of a passenger into the table during a collision or derailment.

6.4.1.2 Folding tables shall be dynamically tested in both the fully deployed and fully stowed positions.

6.4.1.3 If under dynamic load conditions the seat back table closes, there shall be no contact between the neck or head of the impacting ATD and the edge of the table unless, where this occurs, it is shown to be acceptable as part of the injury criteria assessment set out in Appendix H.1.

6.5 Interior doors, glazing and partitions

6.5.1 Proof loads for interior doors and partitions

6.5.1.1 Interior doors or partitions, in any areas of such items which are not glazed, shall withstand the following proof loads without permanent deformation:

a) A concentrated perpendicular load of 2.5 kN applied over an area of 0.1 m x 0.1 m at any position on the surface.

b) A pressure of 2.5 kPa applied over the entire surface plus an additional concentrated perpendicular load of 0.8 kN applied over an area of 0.1 m x 0.1 m at any position on the surface.

6.5.1.2 The proof loads shall be applied to both sides of interior doors independently.

6.5.1.3 The proof loads shall be applied to partition faces which are fully or partly exposed to the vehicle interior and which could be subject to secondary impact. Where both faces of a partition are exposed to the vehicle interior the proof loads shall be applied to each face independently.

6.5.1.4 Where partitions are fitted with trim panels, it is permissible for the specified proof loads acting on the trim panels to be considered as ultimate loads for these items.

6.5.2 Interior glazing

6.5.2.1 Where glass is used in the construction of glazed saloon partitions, doors and draughtscreens and where glass panels are used in the construction of luggage racks or luggage stacks, the glass shall be laminated safety glass conforming to BS 857:1967 or an equivalent internationally recognised standard.
6.5.2.2 Interior glazing shall withstand without failure, the following ultimate load cases. Where both sides of the glazing are accessible by passengers or traincrew, the load cases shall be applied to both sides independently. The glazing shall remain intact and in position throughout the application and removal of the loads. The ultimate load cases are:

a) A concentrated perpendicular load of 2.5 kN applied over an area of 0.1 m x 0.1 m at any position on the surface.

b) A pressure of 2.5 kPa applied over its entire surface plus a concentrated perpendicular load of 0.8 kN applied over an area of 0.1 m x 0.1 m at any position on the surface.

6.5.2.3 Items shall not be secured to toughened safety glass panels.

6.5.2.4 Labels, transfers or stickers shall not be applied to toughened safety glass where both faces are exposed to the vehicle interior unless:

a) The entire glass surface is covered with anti-vandal film.

Or

b) It can be demonstrated that if the glazing is shattered the risks to the vehicle occupants from glass missiles being formed are not significantly increased by their application.

6.5.2.5 Interior glass mirrors shall utilise safety glass that complies with the requirements of BS 857:1967. It is permissible for alternative materials to be used if it can be demonstrated that at least the same level of performance for impact and injury potential can be achieved.

6.5.3 Interior doors

6.5.3.1 Requirements applicable to the design of interior doors as a means of escape are set out in Part 7 of GM/RT2130.

6.6 Grab handles, poles, rails and hand holds

6.6.1 Design requirements for grab handles, poles, rails and hand holds

6.6.1.1 The Persons with Reduced Mobility TSI (PRM TSI) (or alternatively in circumstances where the PRM TSI does not apply, the Rail Vehicle Accessibility Regulations (RVAR)) contains requirements that are applicable to grab handles, poles or rails and hand holds.

6.6.1.2 Panel, partition or draughtscreen mounted grab handles or handrails (for example in doorways, vestibules or passageways) shall not project from surrounding features in excess of any limiting dimensions set out in the PRM TSI (or RVAR) unless it can be demonstrated, as part of the secondary impact assessment (see 6.1.6), that the risk of personal injury in the event of an accident has been controlled. This requirement does not apply to moveable handrails required in universal toilets.

6.6.1.3 Overhead grab rails, mounted from either a luggage rack or from the ceiling shall withstand without significant permanent deformation of the rail, attachments or supporting structure a concentrated vertical proof load of 1.7 kN applied anywhere along the grab rail.

6.6.1.4 Grab poles and grab handles shall withstand a concentrated perpendicular proof load of 1.7 kN applied anywhere along the grab pole or grab handle.
6.6.1.5 Seat back hand holds shall withstand without significant permanent deformation longitudinal proof loads of ±1500 N (relative to the seat) applied uniformly over the handgrip area.

6.6.1.6 Where hand holds are fitted to the top of seats, the hand holds and their fixings shall be designed and integrated within the seat to ensure that the head injury criteria set out in Appendix H.2 are achieved when the seat is tested in accordance with 6.2.4.

6.7 Interior fixtures and fittings

6.7.1 Access panels and cubicle doors

6.7.1.1 Access panels or equipment cubicle doors shall, as far as reasonably practicable, be designed to resist accidental opening in service or in the event of a collision or derailment that could result in injury or hinder egress. A secondary means of retention (for example, safety catches or straps) shall be provided where the correct closure and locking of the panels or doors cannot be determined visually and the following conditions apply:

a) Where access panels or cubicle doors are located above or alongside areas normally occupied by seated or standing passengers, personnel or traincrew and when accidentally opened have the potential to cause injury due to their position, size, shape or weight when assessed in accordance with 6.1.6.

Or

b) Where access panels or cubicle doors could, if accidentally opened, block or restrict an escape route through an internal or external door.

6.7.1.2 Where secondary retention devices are fitted they shall limit accidental opening in service or in the event of a collision or derailment such that the risks identified in 6.1.5.1 are controlled. It is permissible for only the proof loads applicable to their primary line of action to be considered (for example secondary catches to prevent a ceiling access panel dropping fully open need only be designed for vertical proof loads).

6.7.2 Wheelchairs

6.7.2.1 Where provision is made for wheelchairs, the PRM TSI (or alternatively in circumstances where the PRM TSI does not apply, the RVAR) is applicable.

6.7.3 Toilets

6.7.3.1 In accordance with 6.1.6, toilet compartments shall be assessed for the potential for injury due to secondary impacts in the event of a collision or derailment.

6.7.4 Ceiling and wall lighting

6.7.4.1 All frangible lighting sources (for example, tubes, bulbs) shall be shielded by diffusers or similar devices.

6.7.4.2 Wall mounted interior lighting that could be contacted by passengers in normal service or in the event of a collision or derailment shall present a continuous surface without gaps and the lighting shall not constitute an unnecessary protrusion or recess relative to the surrounding vehicle interior. This shall be assessed as part of the secondary impact assessment (see 6.1.6).

6.7.5 Catering equipment

6.7.5.1 Where catering trolleys are intended to be unattended for all or part of a journey provision shall be made for the catering trolleys to be securely stowed.
6.7.5.2 Secure stowage shall be achieved using a fastening device or devices capable of restraining fully laden catering trolleys against the proof load accelerations specified for equipment attached to the vehicle body set out in Part 3.

6.7.6 Security and location of fire fighting equipment

6.7.6.1 Fire extinguishers and other fire extinguishing devices shall be securely located in position using quick-release restraints capable of withstanding the proof load accelerations specified for equipment attached to the vehicle body.

6.7.6.2 The open or openable face of a fire extinguisher enclosure or fire extinguisher mounting face shall not be oriented longitudinally unless located in a doorway, a vestibule or an alternative location which restricts longitudinal movement in the event of the extinguisher braking free during a collision or derailment.

6.7.6.3 The fire extinguisher enclosure shall be located at low height between floor and window level.

6.8 Luggage stowage

6.8.1 Floor mounted luggage stacks, luggage stowage or bicycle stowage

6.8.1.1 Luggage stacks or luggage stowage areas in passenger areas shall be oriented to give access to stowed items only from the side (in the transverse direction relative to the vehicle).

6.8.1.2 When fully laden with representative items, luggage stacks, luggage stowage areas or bicycle stowage, shall withstand as proof loads the accelerations specified for equipment attached to vehicle bodies (see Part 3).

6.8.2 Overhead luggage racks

6.8.2.1 Overhead luggage racks shall be orientated longitudinally relative to the vehicle.

6.8.2.2 Intermediate dividers shall be installed along the length of longitudinal racks, in order to control longitudinal movement of luggage during a collision or derailment. The pitch at which the dividers are spaced shall be no greater than 3 m. An end barrier shall be fitted where a luggage rack does not terminate against a fixed partition.

6.8.2.3 The dividers or end barriers shall withstand an applied ultimate load equal to the estimated maximum luggage load for the adjacent section of the luggage rack, when subjected to the accelerations specified for equipment attached to vehicle bodies (see Part 3).

6.8.2.4 Overhead luggage racks shall withstand the following loads applied simultaneously:

   a) A distributed proof load representing its maximum load capacity.

   b) Two concentrated vertical proof loads, each of 850 N and 750 mm apart, positioned anywhere along the front edge of the luggage rack.

6.9 Cabs

6.9.1 General requirements

6.9.1.1 In accordance with 6.1.6, cabs and areas occupied by traincrew shall be assessed for the potential for injury due to secondary impact in the event of a collision or derailment.
6.9.1.2 The cab seat zone (the area of the cab in which the driver is seated) shall be dynamically tested in accordance with Appendix F to simulate a frontal collision and shall give a satisfactory injury criteria assessment as set out in Appendix H.1 for a 50th percentile male ATD located in the driving position.

6.9.2 Evacuation requirements for driving cabs

6.9.2.1 To facilitate escape in an emergency, there shall be no upward steps or obstacles on the floor in the passageway from the cab through any door to a place of safety.
Part 7  Aerodynamic Rail Vehicle Loads

7.1  Vehicle resistance to aerodynamic loads

7.1.1  Design requirements

7.1.1.1 Items that shall be assessed for satisfactory performance when subjected to aerodynamic loads in operation shall include, but not be limited to:

a) Windscreens.
b) Bodyside windows.
c) Doors.
d) Gangways.
e) Canopies, fairings or other mouldings attached to the bodyshell.
f) Equipment cases.
g) Access hatches (bodyside or in equipment cases).
h) Access panels.
i) Underframe skirts.
j) Coupler hatches.

7.1.2  Quasi-static aerodynamic loads

7.1.2.1 For vehicles with a maximum speed of 125 mile/h or below, all structural elements or items of equipment attached to the vehicle shall resist as a proof load case a uniform pressure load of 2.5 kPa without damage or significant permanent deformation. This load shall be considered to act independently on either external or internal surfaces.

7.1.2.2 For vehicles intended for operation at speeds in excess of 125 mile/h, or where the vehicles are pressure sealed, an assessment of applicable quasi-static pressure loads shall be undertaken and an equivalent quasi-static pressure load shall be derived.

7.1.2.3 The capability to withstand the quasi-static aerodynamic loads shall be demonstrated by testing, calculation, comparison with other vehicles, or by a combination of these.

7.1.3  Transient pressure loads

7.1.3.1 For vehicles with a maximum speed in excess of 125 mile/h the capability to withstand the maximum pressure loads, including the transient pressure loads caused by a train entering, passing through and exiting tunnels, shall be demonstrated by testing, calculation, comparison with other vehicles, or by a combination of these.

7.1.3.2 In determining transient pressure loads for vehicles with a maximum speed in excess of 125 mile/h, any assessment shall include, but is not limited to, the aerodynamic effects due to:

a) Train and formation length.
b) Train cross-section.
c) Leading and trailing end shape.

d) Tunnel cross section, including effects due to portal geometry on entry and exit.

e) Tunnel length.

f) Ventilation shafts or cross-passages.

g) Single and double track tunnels.

h) Other train types likely to be encountered.

i) Relative entry times of trains entering a tunnel.

j) Operational speeds.

7.1.3.3 In determining the magnitude of transient load, the degree of pressure sealing of the vehicle shall be assessed and taken into account.

7.1.3.4 For vehicles with a maximum speed in excess of 125 mile/h the effect of aerodynamic transient pressure loads shall be included in the fatigue life assessment of the vehicle and its components.

7.1.3.5 Any operational limitations or restrictions to limit aerodynamic transient pressure loads caused by vehicles with a maximum speed in excess of 125 mile/h when in operation alongside existing lower speed rolling stock shall be identified.

7.2 Generation of pressure pulses by vehicles

7.2.1 Trains, with a maximum speed of greater than 80 mile/h, shall not generate a peak to peak pressure pulse from any part of the train greater than 1.44 kPa.

7.2.2 This requirement shall include pressure pulses generated by the nose to nose connections of multiple train formations.

7.2.3 Pressure pulse magnitudes shall be determined for open air conditions on a calm day, measured at a height corresponding to maximum body width on the side of a stationary passenger train on a straight stretch of adjacent track at nominal 3.4 m track centres.

7.2.4 Pressure pulse magnitudes shall be determined by testing, calculation, comparison with other vehicles, or by a combination of these.

7.3 Aerodynamic loads acting on traincrew and passengers

7.3.1 Transient variations in air pressure caused by the passage of trains through tunnels, and by aerodynamic interaction with other trains and track features, shall not result in traincrew inside railway vehicles being subjected to pressure pulses which exceed a maximum change in pressure of 10 kPa within any part of the time taken by the train to pass through any tunnel.

7.3.2 In the event of a sudden failure of the sealing of a pressure-sealed train the 10 kPa limit shall not be exceeded.

7.3.3 Transient air pressure variations shall be determined by testing, calculation, comparison with other vehicles, or by a combination of these.
Part 8  Mechanical Coupling of Rail Vehicles

8.1  Design requirements for coupling systems

8.1.1  General design requirements

8.1.1.1  The coupling system shall be designed to transmit, safely and without suffering significant permanent deformation, all sustained and shock loads that arise between rail vehicles associated with:

a)  Coupling and uncoupling.

b)  Traction and braking.

c)  Traversing curved track.

d)  Vertical changes in alignment.

e)  Shock loads caused by play and flexibility in the train coupling, drawgear and buffers, if fitted.

8.1.1.2  The coupling system, with the exception of buffers, shall engage positively with the coupling system of any rail vehicle to which it is intended to couple in a train.

8.1.1.3  The design of the system shall ensure that it is possible to determine that the coupling systems are positively engaged, either directly or by a suitable system of indication.

8.1.1.4  The limiting values for track features shall be identified. These shall include, for both mainline and non-passenger lines and sidings:

a)  Minimum horizontal track radius.

b)  Minimum horizontal track reverse radius with a 3 m intermediate straight.

c)  Minimum vertical track radius, concave and convex.

d)  Maximum installed cant.

e)  Maximum cant gradient.

f)  Maximum track twist.

8.1.1.5  The coupling systems, with the exception of buffers, shall remain positively engaged during all normal operations of the rail vehicles over the track features that they are required to negotiate.

8.1.1.6  Coupling and uncoupling shall be possible over the applicable range of track features for the particular vehicles.

8.1.1.7  Any system that controls the operation of the coupling or uncoupling system shall be protected from reasonably foreseeable interference that could result in the system’s inadvertent or malicious operation.

8.1.1.8  The coupling system design shall ensure that it is possible to arrange manual uncoupling if the systems normally required for uncoupling are unavailable, whilst protecting against inadvertent or malicious operation.

8.1.1.9  Passenger vehicle coupling systems, including the attachment to the vehicle structure, shall, during a collision or derailment, provide restraint that will resist the adjacent coupled vehicle uncoupling, overturning or overriding.
8.1.1.10 Passenger vehicle centre coupling systems shall be fitted with a positive locking arrangement that prevents inadvertent uncoupling when the locking components are subject to a sustained acceleration of at least 5 g in any direction.

8.2 Design requirements for drawgear
8.2.1 Drawgear and its attachments to a vehicle body shall be designed to fail at a lower tensile load than that for the primary vehicle structure.
8.2.2 Drawgear, and its attachment to a vehicle body, shall be designed to contribute to, or not conflict with, the requirements for body structural collapse and energy absorption.
8.2.3 Drawgear designed to be capable of transferring shear forces between adjacent vehicles shall withstand without significant permanent deformation the transfer of 100 kN in both the vertical and transverse directions simultaneously.

8.3 Design requirements for buffers
8.3.1 General requirements
8.3.1.1 The strength of buffers and their attachments to the vehicle body shall, under axial load, be the same as the longitudinal compressive strength specified at the buffer positions on vehicle bodies.
8.3.1.2 The strength of buffers and their attachments to the vehicle body shall take into account all expected eccentric loads due to relative misalignment between adjacent vehicles in normal use.
8.3.1.3 Buffers shall be designed to enable safe operation of the rail vehicles over the range of track features that they are required to negotiate, without buffer interlocking.

8.3.2 Buffer location and performance requirements
8.3.2.1 In the tare condition buffer height shall not exceed 1065 mm above rail level to centre of buffer.
8.3.2.2 Minimum buffer height for a vehicle in fully laden condition shall be 940 mm above rail level to centre of buffer.
8.3.2.3 Buffers shall be designed to withstand contact with fixed buffer stops to arrest the train speed without damage to vehicle or buffer stops. The impact force shall be calculated subject to the following conditions:
   a) The impact speed to be used in design calculations shall not be less than 7 km/h.
   b) For passenger vehicles the design mass under exceptional payload as set out in BS EN 15663:2009 shall be assumed. For freight vehicles the design mass under normal payload as set out in BS EN 15663:2009 shall be assumed. It is permissible to make the assumption that 25% of the kinetic energy will be absorbed by the vehicle and its load.

8.4 Design requirements for rescue and recovery coupling systems
8.4.1 Couplings for rescue and recovery
8.4.1.1 When a train is immobilised for any reason, but capable of being safely moved, there shall be provision for another train or locomotive to be attached to it to move the immobilised train safely.
8.4.1.2 Rescue and recovery of rail vehicles shall be achieved by using coupling systems fitted to the vehicles where the rescuing vehicle is compatible or by an adaptor coupling system that enables two rail vehicles with dissimilar coupling systems to be coupled together, together with any brake pipe hoses or interconnectors that may be required.

8.4.2 Adaptor couplings

8.4.2.1 Where used for rescue and recovery, adaptor couplings and rail vehicle coupling systems shall accept the forces and movements involved in the recovery of the failed vehicle or train, without significant permanent deformation or damage.

8.4.2.2 Where an adaptor coupling is designed for a particular vehicle or coupler type, any limitations on vehicle movement and operation arising from the use of the adaptor coupling system shall be identified.

8.4.2.3 Adaptor couplings or coupling components shall be designed to ensure safe handling, assembly or disassembly by traincrew.
Part 9  
Lifting, Jacking, Recovery and Emergency Movement of Rail Vehicles

9.1 Design requirements for the safe lifting of rail vehicles

9.1.1 General requirements

9.1.1.1 All rail vehicle body structures shall be designed with clearly identifiable jacking and lifting points or combined jacking and lifting points to enable maintenance and recovery to take place.

9.1.1.2 On bogie vehicles, it is permissible for lifting and jacking points to be provided additionally on the bogies, for recovery purposes.

9.1.1.3 The vehicle design shall allow for safe and efficient recovery in the event of a derailment, where the vehicle remains essentially upright, taking into account the effect of displacements from rail level to track bed of one or more wheelsets or bogies.

9.1.1.4 All jacking and lifting points or combined jacking and lifting points shall be clearly identified with symbols, as set out in Appendix J.

9.2 Lifting and jacking points

9.2.1 Design of lifting points

9.2.1.1 The locations of the lifting points shall enable the rail vehicle, or constituent part in the case of articulated vehicles, to remain level when fully suspended from one crane.

9.2.1.2 Lifting points shall be provided using either permanent built-in pockets for removable brackets or permanent built-in lifting points.

9.2.1.3 In the case of wagons only, it is permissible to manufacture specific areas on the vehicle to enable the use of endless polyester fibre round slings for lifting purposes.

9.2.2 Design of jacking points and pads

9.2.2.1 The locations of the jacking points shall enable the attitude (level) and twist of the rail vehicle to be controlled safely when lifting on jacks. It is permissible to provide additional jacking points for lifting vehicles at one end.

9.2.2.2 Jacking points shall be provided using either permanent built-in pockets for removable brackets equipped with jacking pads or permanent jacking pads. It is permissible for removable brackets to allow either lifting or jacking as required.

9.2.2.3 Jacking pad surfaces shall have a minimum area of 22,400 mm² and a minimum width of 80 mm and be flat and level.

9.2.2.4 Jacking pad surfaces as far as reasonably practicable shall be located within the following height range:

   a) Not less than 500 mm above rail level assuming fully worn wheels, a collapsed primary suspension and, where applicable, deflated air suspension.

   b) Not greater than 1,270 mm above rail level assuming new wheels, the vehicle in its lightest operational condition and where applicable inflated air suspension.
9.2.3  Structural requirements for lifting and jacking points

9.2.3.1 Lifting and jacking points, the adjacent structure and, where applicable, any removable brackets shall be designed and maintained to withstand without significant permanent deformation the loads expected under all likely jacking and lifting conditions.

9.2.3.2 The masses to be taken into account in the design of jacking and lifting points shall be:

a) For passenger vehicles and locomotives, the design mass in working order of the vehicle body as set out in BS EN 15663:2009 less the mass of any traincrew.

Or

b) For freight vehicles, the design mass under normal payload of the vehicle body as set out in BS EN 15663:2009, complete with all equipment.

Bogie masses shall be included as set out in 9.2.3.3 below.

9.2.3.3 The jacking and lifting points, adjacent structures and, where applicable, any removable brackets shall withstand as proof loads either:

a) Where there is no significant slack or flexibility in the bogie to body connections, a vertical load equal to the mass of the vehicle body plus the mass of the bogies, all subject to an acceleration of 2 g.

Or

b) Where there is significant slack or flexibility in the bogie to body connections:

i) A vertical load equal to the mass of the vehicle body subject to an acceleration of 2 g.

And

ii) A vertical load equal to the mass of the vehicle body subject to an acceleration of 1 g plus the mass of the bogies subject to an acceleration of 2 g.

9.2.3.4 The ultimate load reserve factor for lifting points, adjacent structures and, where applicable, any removable brackets shall not be less than 2.

9.2.3.5 Jacking pads shall withstand all expected jack head loads without significant indentation or other permanent deformation. It is permissible to assume that these loads are distributed over the jacking pad face by the use of packing material.

9.2.4  Restraint of wheels, suspensions and bogies when lifting

9.2.4.1 To ensure that bogies or wheelsets are prevented from uncontrolled movement when vehicles are lifted or jacked, provision shall be made for them to be retained and securely attached to the vehicle body by the use of either:

a) The design and installed configuration of the bogie and wheelsets

Or

b) The addition of temporary items such as chains or straps.
9.2.4.2 Bogie and wheelset retention arrangements for lifting shall be consistent with the requirements for structural bogie and wheelset retention set out in Part 4.

9.3 Wheelskates

9.3.1 Vehicle compatibility

9.3.1.1 A rail vehicle shall be designed to allow the use of either an existing design of wheelskate or a wheelskate designed specifically for that type of vehicle to enable the recovery of a rail vehicle with a seized or damaged wheelset or transmission.

9.3.1.2 The vehicle design shall ensure the area around the wheelset is free from obstruction, or that all such equipment is easily removable, to enable fitment of either an existing design of wheelskate and appropriate packing pieces or for the fitment of a wheelskate designed specifically for that type of vehicle.

9.3.2 Compatibility with infrastructure

9.3.2.1 A wheelskate shall support a seized or damaged wheelset on its own independent set of wheels. The use of skids is not permitted.

9.3.2.2 A wheelskate shall be designed to be compatible with the lower structure gauge over the range of vehicle conditions (load, suspension settlement, wear) for the vehicle or the range of vehicles for which the wheelskate is designed. Factors to be considered shall include axle load, new and worn wheel diameters, space envelope limitations around the wheelset and compatibility with track features such as raised checkrails.

9.3.2.3 Wheelskates shall be designed so that the flange of the wheel being carried is clear of the head of the rail, without creating an unnecessarily heavy load from the vehicle suspension.

9.3.2.4 Wheelskates shall be designed such that recovered vehicles remain within their designed swept envelope, subject to the operational speed restrictions required.

9.3.2.5 The swept envelopes of wheelskates (excluding the area occupied by the wheels and any frame member adjacent to the wheels of the wheelskate) shall provide the following clearances:

   a) 75 mm vertically above the plane of the rails for a distance of 630 mm either side of the centre line of the track, under all conditions, taking account of all suspension movements and vertical curves.

   b) 7.5 mm, under worst case conditions, to the area reserved for items intended to come in close proximity to trains (for example raised check rails, conductor rails and AWS magnets) forming part of the lower structure gauge.

9.3.3 Structural requirements for wheelskates

9.3.3.1 A wheelskate shall be designed to meet the following load cases:

   a) A vertical proof load of the maximum vertical static load multiplied by a factor of 1.3 to take account of forces generated by canted track, switches and crossings and track discontinuities.

   b) A lateral proof load which shall be assumed to be a maximum of 0.3 of the vertical proof load.
9.3.3.2 A wheelskate shall have a survival probability under fatigue loading of at least 97.5%, when subjected to the following loads:

a) A vertical fatigue load range from zero to the vertical proof load for $3.2 \times 10^4$ cycles.

b) A lateral fatigue load range from zero to the lateral proof load for $3.2 \times 10^4$ cycles.

9.3.3.3 As an alternative, it is permissible to develop fatigue load cases from experimental, simulation and calculation data.

9.3.3.4 Wheel and axle stresses shall be determined using a recognised and proven method.

9.3.3.5 Wheel materials shall be compatible with the requirements of GM/RT2466. Where wheel steels are not available, it is permissible to use more generally available engineering steels with equivalent mechanical properties.

9.3.3.6 Wheelskates shall use independently rotating wheels to avoid the generation of longitudinal wheel forces.

9.3.3.7 The design life of the bearings used in wheelskates shall be defined using a recognised and proven method, taking into account the following factors:

a) Radial and lateral load

b) Additional load inputs due to the effects of predictable wheel-tread defects

c) The full range of operating duties, rotating speeds and loads

d) Requirements for bearing lubrication.

9.3.3.8 Sealing shall be provided for the axle bearings to restrict ingress of foreign substances and loss of lubricants.

9.3.4 Wheelskate wheel geometry requirements

9.3.4.1 Terms and definitions used below shall be as set out in GM/RT2466.

9.3.4.2 Wheels of wheelskates shall be manufactured and maintained to the P6 wheel profile.

9.3.4.3 The design minimum wheel-tread diameter shall be not less than 200 mm. The scrapping limit of any wheel shall not be less than 187 mm. Tread diameter shall be measured at the tread datum.

9.3.4.4 The wheelskate design shall achieve a distance between the flange-backs across the wheels within the range 1360 - 1362 mm.

9.3.4.5 The width of the wheel rim measured between the flange-back and the outside face of the rim shall be within the range 127 - 140 mm.

9.3.5 Operational speed limits for wheelskates

9.3.5.1 In addition, on running lines, the maximum speed of any vehicle fitted with a wheelskate shall be limited by the axle load as set out in Table 1.
## Requirements for Rail Vehicle Structures

### Table 1  Maximum speeds for vehicles fitted with wheelskates

<table>
<thead>
<tr>
<th>Vehicle category</th>
<th>Vehicle design axle load</th>
<th>Maximum speed of wheelskate</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vehicles with bogies of three or more axles</td>
<td>Greater than 20 tonnes and less than or equal to 25.5 tonnes</td>
<td>20 mile/h</td>
</tr>
<tr>
<td>Vehicles with bogies of three or more axles</td>
<td>Up to 20 tonnes</td>
<td>25 mile/h</td>
</tr>
<tr>
<td>All other vehicles</td>
<td>Greater than 20 tonnes and less than or equal to 25.5 tonnes</td>
<td>25 mile/h</td>
</tr>
<tr>
<td>All other vehicles</td>
<td>Up to 20 tonnes</td>
<td>30 mile/h</td>
</tr>
<tr>
<td>All vehicles fitted with wheels having a design diameter of less than 250 mm</td>
<td>Any weight</td>
<td>20 mile/h</td>
</tr>
</tbody>
</table>

9.3.5.2 Where the permissible speed through curves, switches and crossings is under normal conditions restricted to 30 mile/h or less, or at any obtuse crossing, the maximum speed of any vehicle fitted with a wheelskate shall be limited to 3 mile/h (walking pace).

9.3.5.3 In yards and sidings the maximum speed of any vehicle fitted with a wheelskate shall be limited to 3 mile/h (walking pace).
Part 10  Application of this document

10.1  Application - infrastructure managers
10.1.1  There are no requirements applicable to infrastructure managers.

10.2  Application - railway undertakings
10.2.1  Scope
10.2.1.1  The requirements of this document apply to all new vehicles, except as set out in 10.2.2.

10.2.1.2  Action to bring existing vehicle structures into compliance with the requirements of this document is not required.

10.2.1.3  Where a vehicle is subject to alteration and the nature of the alteration provides a reasonable opportunity to bring the vehicle into conformity, then the requirements of this document applicable to the alteration apply.

10.2.2  Exclusions from scope
10.2.2.1  The requirements in this document are not applicable to rolling stock authorised for placing into service under The Railways (Interoperability) Regulations 2006 (as amended), or any subsequent regulations replacing these regulations, unless the requirements in this document are a relevant notified national technical rule.

10.2.2.2  The requirements in this document are not applicable to vehicles falling within the scope of GM/RT2400.

10.2.3  General compliance date for railway undertakings
10.2.3.1  This Railway Group Standard comes into force and is to be complied with from 05 March 2011.

10.2.3.2  After the compliance dates or the date by which compliance is achieved if earlier, railway undertakings are to maintain compliance with the requirements set out in this Railway Group Standard. Where it is considered not reasonably practicable to comply with the requirements, authorisation not to comply should be sought in accordance with the Railway Group Standards Code.

10.2.4  Exceptions to general compliance date
10.2.4.1  It is permissible for vehicles to continue to be built to a particular design as a vehicle which already has an authorisation for placing into service or a Certificate of Engineering Acceptance until 03 June 2017.

10.3  Health and safety responsibilities
10.3.1  Users of documents published by RSSB are reminded of the need to consider their own responsibilities to ensure health and safety at work and their own duties under health and safety legislation. RSSB does not warrant that compliance with all or any documents published by RSSB is sufficient in itself to ensure safe systems of work or operation or to satisfy such responsibilities or duties.
Appendix A Derivation of Load Cases from Test or Service Data

The content of this appendix is mandatory

A.1 Introduction
A.1.1 This appendix sets out minimum requirements for the derivation of load cases from test or service data as permitted for example in Parts 3 and 4 of this document.

A.2 Data collection and processing
A.2.1 Data collection methods, sample sizes and processing methods employed shall be fully documented.
A.2.2 Due account shall be taken of all potential sources of error and limitations due to sample size.
A.2.3 It is permissible for data derived from calculation or simulations to be used where test or service data is not available.
A.2.4 Calculation methods and models shall be validated against experimental data and service experience where applicable.
A.2.5 It is permissible for historical load case data to be used where it can be demonstrated that this is applicable and that satisfactory service performance has been achieved.

A.3 Derivation of load cases
A.3.1 Derivation of load cases, from load cases used satisfactorily in past applications or from test data, shall include, as a minimum, assessment of the following factors:
   a) Suspension configuration.
   b) Variability of suspension components due to manufacture, wear, localised failure or degradation.
   c) Vehicle load due to passengers or payload.
   d) Vehicle speeds.
   e) Magnitudes and frequencies of traction and braking loads.
   f) Infrastructure on which the vehicle is to be operated.
   g) Variability of infrastructure due to maintenance and renewal cycles.
   h) Anticipated frequency of operation throughout the vehicle’s life.

A.4 Application and limitations of derived load cases
A.4.1 Where fatigue load cases are determined from test data any potential limitations to the operation of the vehicle in terms of design life shall be clearly identified.
A.4.2 For fatigue load cases derived from test data, it shall be determined if there are any particular combinations of load that act in phase. Where it can be demonstrated that particular loads do not act in phase, these can be treated as if acting separately and the damage from the individual cases summed.
Appendix B  Bodyside Windows - Small Missile Test Procedure

The content of this appendix is mandatory

B.1  Conditions of test

B.1.1  Six window units shall be tested: three units shall be tested at high temperatures and three at low temperatures in accordance with the requirements of B.3.

B.1.2  Three successive compliant tests at high temperature and three successive compliant tests at low temperature shall be required to demonstrate that an acceptable level of performance is achieved for impact by small missiles by the window glass across a representative temperature range.

B.2  Test windows

B.2.1  The window units tested shall be an actual window or glazing system, which is to be installed in the vehicle, or of samples having minimum dimensions of 1100 mm x 900 mm constructed in a manner representing their installed condition.

B.2.2  The window units or samples shall be tested with both panes installed in a manner representing their installed condition.

B.2.3  If samples are to be tested, they shall be mounted for testing in a manner representative of the installed condition for the complete unit.

B.2.4  The geometric centre of the window unit or sample shall be determined. In the case of window units which are sub-divided by glazing bars, a worst case position or positions for the effective geometric centre shall be determined prior to testing.

B.3  Temperature

B.3.1  For the high temperature tests, the window units or samples for testing shall be heat soaked at a minimum of 35°C for a minimum period of 6 hours immediately preceding the test. Under no circumstances shall the temperature of the inner surface of this pane of glass be lower than 35°C at the time of the test.

B.3.2  For the low temperature tests, the window units or samples for testing shall be heat soaked at a maximum of -17°C for a minimum period of 6 hours immediately preceding the test. The temperature of the test specimen, when installed in the test apparatus, shall be allowed to increase to give a nominal temperature of 0°C of the inner surface. Under no circumstances shall the temperature of the inner surface of the unit be higher than 0°C at the time of the test.

B.4  Impact test

B.4.1  The impacting object used for these tests shall be a solid steel ball of a mass of 0.25 kg.

B.4.2  For testing laminated safety glass or laminated double glazed window units the steel ball shall be travelling at a speed of 100 km/h, ± 3km/h, at the point of impact.

B.4.3  For testing toughened safety glass window units the steel ball shall be travelling at a speed of 50 km/h, ± 3km/h, at the point of impact.

B.4.4  The window units or samples tested shall be orientated such that the ball impacts the geometric centre of the unit.
B.4.5 The window units or samples shall be tested in such a way that the impacting object first strikes the sample perpendicular to the surface of the glazed unit representing the outside of the vehicle.

B.4.6 The total amount of spall from the inner surface of the window shall not exceed 40 g.

B.5 Penetration

B.5.1 Under the conditions of the high and low temperature requirements of this specification, the steel ball shall not fully penetrate the window unit or sample nor, in the case of laminated windows, rupture the laminating interlayer.

B.5.2 No part of the ball shall be exposed to the area representing the interior of the vehicle during the test.

B.6 Integrity

B.6.1 In the case of double glazed window units, there shall be no loss of structural integrity in the bonding between the inner and outer panes and spacer bars or any other fixing system between the window unit elements.
Appendix C  Bodyside Windows – Passenger Containment Test Procedures

The content of this appendix is mandatory

C.1  Conditions of test
C.1.1 Double glazed window systems representative of production quality and construction shall be tested.

C.1.2 Three successive compliant test sequences shall be required to demonstrate that an acceptable level of containment performance has been achieved.

C.2  Window test assembly
C.2.1 The window test assemblies shall consist of complete window units including frame (if this is part of the design) installed in an assembly representative of the vehicle installation. It is permissible to install the window unit in an appropriate section of the main vehicle structure where this is available.

C.2.2 The geometric centre of the window unit shall be determined. In the case of window units which are sub-divided by glazing bars, a worst case position or positions for the effective geometric centre shall be determined prior to testing.

C.3  Temperature
C.3.1 The temperature at the time of testing shall be between 15°C and 25°C. The test temperature shall be recorded for each test.

C.3.2 To ensure that the window units for testing are correctly conditioned, they shall be heat soaked at the specified temperature for a minimum period of 6 hours immediately preceding the test.

C.4  Impact testing
C.4.1 To determine the containment performance of the window unit, each window unit shall be subjected to the following sequence of tests which shall be undertaken in the following order:

a) The impact of a steel ball on the surface representing the exterior of the vehicle as set out in C.5.

b) A 50 kg pendulum impact from a height of 1200 mm, with a nominal impact energy of 588.6 J, to the surface representing the interior of the vehicle as set out in C.6.

c) A concentrated perpendicular load of 0.8 kN on the interior surface as set out in C.7.

C.5  Steel ball impact test
C.5.1 The ball shall have a mass of 5 kg and speed of 34 km/h ±3 km/h at the point of impact.

C.5.2 The ball shall impact the geometric centre of the glazed unit on the surface of the unit representing the exterior of the vehicle.

C.5.3 The initial impact shall be perpendicular to the surface of the specified pane.

C.5.4 The ball shall not fully penetrate the window unit. No part of the ball shall be exposed to the area representing the interior of the vehicle during the test.
C.5.5 The total amount of spall from the inner surface of the window shall not exceed 10 g.

C.6 Pendulum impact loads

C.6.1 The pendulum impactor design, mass and mechanical characteristics shall be as defined in BS EN 12600:2002. Where a rigid suspension is used, it is permissible to either reduce the mass of the impactor weights or to reduce the specified drop height to compensate for any change in effective mass due to the suspension. The impact energy shall under all circumstances be within ±1% of the nominal value of 588.6 J.

C.6.2 The window test assembly shall be installed in the test apparatus and rigidly clamped such that the impactor strikes the geometric centre of the internal face of the window test assembly within a tolerance of 50 mm radially.

C.6.3 The impact shall be perpendicular to the surface of the specified pane. With the impactor hanging freely the distance between the impactor and the surface of the window test assembly shall be in the range 5 mm to 15 mm.

C.6.4 The complete pendulum test rig shall be either:

a) Calibrated by using the clamping frame, calibration specimen and calibration procedure set out in BS EN 12600:2002.

Or

b) The initial pendulum position (height) and its release shall be calibrated to demonstrate that the impactor velocity immediately prior to impact is within a tolerance of ±2%.

C.6.5 The impactor tyres shall be inflated to a pressure of 0.35 ±0.2 MPa. The tyre pressures shall be checked before each impact test.

C.6.6 The impactor shall be raised to the specified height and released to fall with a pendulum movement without initial velocity. The impactor shall strike the test assembly once.

C.6.7 The impactor shall not penetrate the window test assembly.

C.7 Concentrated perpendicular load

C.7.1 A concentrated perpendicular load of 0.8 kN shall be applied over an area of 0.1 m x 0.1 m at the centre of the surface representing the interior of the vehicle.

C.7.2 The load shall be maintained for a period of 1 minute. The glazing unit shall remain fixed within its frame or retaining system.

C.8 Integrity

C.8.1 A compliant test sequence shall satisfy the requirements of C.5.4 and C.5.5, and C.6.7 and C.7.2.
Appendix D Bodyside Windows – Pressure Pulse Test Procedure

The content of this appendix is mandatory

D.1 Conditions of test

D.1.1 Double glazed window systems representative of production quality and construction shall be tested.

D.1.2 Three successive compliant tests shall be required to demonstrate that an acceptable level of performance has been achieved.

D.2 Window test assembly

D.2.1 Double glazed window units to be tested shall be in an actual window frame or glazing system of the same design and specification as used in service and shall be fixed to a blanking panel representative of the vehicle construction.

D.2.2 The blanking panel shall be installed in the test apparatus in such a way that the external pane of glass is to be exposed to the transient air pressure pulse.

D.3 Temperature

D.3.1 The temperature at the time of testing shall be between 15°C and 25°C. The test temperature shall be recorded.

D.3.2 To ensure that the window units for testing are correctly conditioned, they shall be heat soaked at the specified temperature for a minimum period of 6 hours immediately preceding the test.

D.4 Test procedure

D.4.1 Each window unit to be tested shall be damaged as follows:

a) The centre point of the outer glass pane, where the major and minor axes cross, shall be marked and the perpendicular distance from a suitable datum to the centre point of the outer pane shall be measured and recorded as distance $D_1$.

b) The assembly shall be positioned with the same vertical orientation as when installed on a vehicle.

c) The outer glass pane shall be crazed with an automatic centre punch, using the minimum of energy, at the centre point of the outer glass pane. It is permissible for no more than two glass fragments or dice to be dislodged or lost from the centre point of pane as a result of this process.

d) After a stabilising period of 10 minutes, the distance from the datum to the centre point shall be re-measured and recorded as distance $D_2$.

D.4.2 It is permissible for the crazed surface to be either flat or bowed but there shall be no sharp changes in contour. There shall be no edge or centre folds or out-of-plane displacement of the glass dice. The inner glass pane shall remain intact.

D.4.3 There shall be no failure of the bond between the outer glass pane and the spacer.
Requirements for Rail Vehicle Structures

D.4.4 For a window unit to be successfully damaged, the central deflection \((D_2 - D_1)\) or \((D_1 - D_2)\), as applicable, shall not exceed the values shown in Table D.1.

<table>
<thead>
<tr>
<th>Minor dimension of the unit</th>
<th>Maximum central deflection</th>
</tr>
</thead>
<tbody>
<tr>
<td>Up to and including 350 mm</td>
<td>5 mm</td>
</tr>
<tr>
<td>Over 350 mm up to 600 mm</td>
<td>7 mm</td>
</tr>
<tr>
<td>Over 600 mm up to 900 mm</td>
<td>10 mm</td>
</tr>
<tr>
<td>Greater than 900 mm</td>
<td>Minor dimension/100 + 1 mm</td>
</tr>
</tbody>
</table>

Table D.1 Bodyside window damage criteria for pressure pulse testing

D.4.5 Each successfully damaged window unit shall then be positioned with the same vertical orientation as installed on a vehicle and shall be subjected to a sequence of 25 differential air pressure pulses having the following characteristics:

a) The period between the initiation of successive pulses shall not be less than 10 seconds.

b) Each pulse shall start with a zero pressure differential across the glazing unit.

c) The relative air pressure on the crazed face of the unit shall be increased to a minimum of +500 Pa, decreased to a maximum of -800 Pa and then returned to zero.

d) All changes of pressure shall be accomplished at a constant nominal rate of 43 kPa/sec. As the air pressure is cycled, it is permissible for the time at which a given pressure occurs to deviate by ±5 ms from that given by the nominal rate (see Figure D.1).

e) There shall be no dwell period at the points of maximum and minimum relative pressure on the crazed surface.

f) It is permissible for the first five pulses in the test sequence to deviate by up to 5% from the specified limiting values.

g) A time history of the pressure pulses shall be included in the test report.

D.4.6 There shall be no additional loss of glass or glass particles from the glazed unit during the test or within 10 minutes of its completion after being damaged in accordance with D.4.1.
Figure D.1  Pressure pulse tolerances

NOTE: For all pulses, the specified pressure limits shall be complied with. The tolerance corridor shown is only applicable to the timing and shape (rate) of any given pulse.
Appendix E Dynamic Test Procedures for Passenger Seats or Tables

The content of this appendix is mandatory

E.1 Introduction
E.1.1 This appendix sets out the requirements for dynamically testing seats or tables for a longitudinal impact, using anthropomorphic test devices (ATDs) to determine:

a) Potential injury levels.

b) Structural integrity.

E.1.2 Cab seat zone dynamic test requirements are set out in Appendix F.

E.2 Preparation of seats or tables for dynamic testing
E.2.1 The seat or tables to be tested shall be mounted on a testing platform in a manner that is functionally representative of the vehicle interior for the purposes of the dynamic tests to be undertaken.

E.2.2 The anchorages on the testing platform provided for the test seats or tables shall be representative of those used in vehicles in which the seats or tables are intended to be used. It is permissible to provide anchorages which are mechanically equivalent or which can be demonstrated to represent a more onerous situation than will be encountered in practice.

E.2.3 For each test the seats and tables shall be positioned using the seat pitch, spacing and orientation required. Any additional items identified in determining the critical positions shall be installed in their locations relative to the seats and tables.

E.2.4 The seats to be tested shall be complete with all upholstery and accessories. If the seats are fitted with seat back tables, they shall be either in the stowed or fully deployed positions as required.

E.2.5 If adjustable, seat backs shall be in the upright position.

E.2.6 Seats completing the installation to be tested but which will not be impacted by the ATD shall be the same type as the seat being tested and shall be located in an identical arrangement to that used in vehicles in which the seat is intended to be used.

E.3 Preparation of ATDs
E.3.1 To determine the potential for passenger injury resulting from impact against seats or tables, an ATD representing a 50th percentile male shall be installed in each seating position where injury criteria data is required for the test.

E.3.2 To determine the structural integrity of seats or tables, an ATD representing a 95th percentile male shall be installed in each seating position required for the test.

E.3.3 ATDs shall be prepared and positioned for testing as set out in Appendix G.
E.4 Dynamic test

E.4.1 The test environment shall be maintained at a temperature between 19°C and 26°C.

E.4.2 The configuration and arrangement of each test installation shall be recorded, using measurements and photographs to enable the tests to be replicated by repeated testing or computer simulation. Details of the seat type, table type if applicable, build configuration of the seats and tables and details of all mountings and fixings shall be included in the test report.

E.4.3 The testing platform with ATDs installed shall be subjected to a simulated impact in accordance with the test pulse shown below (see Figure E.1 and Table E.1). Under these conditions a minimum free flight velocity of 5 m/s shall be attained.

E.4.4 The dynamic test shall be recorded using high speed cameras or imaging systems. The video data shall be sufficient for the dynamics of the test and the interaction of the ATDs with the seats or tables to be determined.

E.4.5 After the dynamic test at least the following items shall be determined and recorded:

a) For each ATD the specified injury criteria shall be evaluated.

b) For each ATD the location of points of impact shall be identified, located and photographed.

c) The maximum dynamic deflection longitudinally and the final position of the seats or tables longitudinally, laterally and vertically shall be measured and recorded.

d) Where parts have been moved or been deformed or damaged the extent of deformation shall be measured, photographed and recorded.

![Figure E.1 Test pulse](image-url)
### Requirements for Rail Vehicle Structures

<table>
<thead>
<tr>
<th>Point</th>
<th>Time (ms)</th>
<th>Acceleration (g)</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>10</td>
<td>0.0</td>
</tr>
<tr>
<td>B</td>
<td>20</td>
<td>5.0</td>
</tr>
<tr>
<td>C</td>
<td>100</td>
<td>5.0</td>
</tr>
<tr>
<td>D</td>
<td>110</td>
<td>0.0</td>
</tr>
<tr>
<td>E</td>
<td>0</td>
<td>7.5</td>
</tr>
<tr>
<td>F</td>
<td>150</td>
<td>7.5</td>
</tr>
<tr>
<td>G</td>
<td>210</td>
<td>0.0</td>
</tr>
</tbody>
</table>

**Table E.1**  Test pulse coordinates
Appendix F  Test Procedure for Cab Seat Zone

The content of this appendix is mandatory

F.1  Introduction

F.1.1 This appendix sets out the requirements for dynamically testing the cab seat zone to determine structural integrity and potential injury levels in the event of an accident.

F.1.2 The items to be tested shall be mounted on a test platform and subjected to a longitudinal acceleration pulse as set out below to simulate the effect of a collision on drivers and any other items in their vicinity.

F.2  Preparation of the cab seat zone for testing

F.2.1 The cab seat zone items to be tested shall be mounted on a testing platform in a manner that is functionally representative of the vehicle installation. The items tested shall include the driver’s seat, the cab windscreen and mounting frame, the console, foot rest and any other features which might affect the trajectory and impact velocity of the ATD.

F.2.2 Any devices which are to be used to reduce the impact effects (for example air bags, knee bolsters) shall be fitted as on a service vehicle.

F.2.3 The anchorages on the testing platform provided for the cab seat zone to be tested shall be representative of those used in vehicles in which the seats and relevant parts of the cab seat zone are intended to be used. It is permissible to provide anchorages which are mechanically equivalent or which can be demonstrated to represent a more onerous situation than will be encountered in practice.

F.2.4 The seat to be tested shall be complete with all upholstery and accessories.

F.2.5 The driver’s seat shall be positioned:

a) With the seat back in an upright position.

b) With the seat facing forward and adjusted vertically and longitudinally to place a 50th percentile male in an appropriate driving position for a person of that size.

F.2.6 Any other adjustable features (for example an adjustable driver’s vigilance device pedal) necessary for driving the train under normal conditions shall be positioned to be consistent with the requirements of F.2.5.

F.3  Preparation of ATDs

F.3.1 An ATD representing a 50th percentile male shall be installed in the driver’s seat.

F.3.2 The ATD shall be positioned and prepared for testing as set out in Appendix G.

F.4  Dynamic test

F.4.1 The test environment shall be maintained at a temperature between 19°C and 26°C.

F.4.2 The configuration and arrangement of each test installation shall be recorded, using measurements and photographs. Details of the build configuration of the cab desk, seats and the cab seat zone together with details of all mountings and fixings shall be included in the test report.
Requirements for Rail Vehicle Structures

F.4.3 The testing platform with the ATD installed shall be subjected to a simulated impact in accordance with the test pulse set out in Appendix E, subject to the lower limit of the crash pulse being not less than the mean deceleration level calculated for the cab according to the collision scenarios set out in BS EN 15227:2008.

F.4.4 The dynamic test shall be recorded using high speed cameras or imaging systems. The video data shall be sufficient for the dynamics of the test and the interaction of the ATD with the cab desk, seats and the cab seat zone to be determined.

F.4.5 After the dynamic test at least the following items shall be determined and recorded:

a) The specified injury criteria shall be evaluated.

b) The location of points of impact shall be identified, measured and recorded.

c) The maximum dynamic and final position of the driver’s seat and cab desk shall be measured longitudinally, laterally and vertically and recorded.

d) Where parts have been deformed the extent of deformation shall be measured, photographed and recorded.
Appendix G  Preparation and Setting Up Procedures for Anthropomorphic Test Devices (ATDs)

The content of this appendix is mandatory

G.1  ATDs
G.1.1 For the determination of injury criteria, except where permitted by G.1.4, Hybrid III 50th percentile male ATDs shall be used, equipped with sufficient instrumentation to determine the injury criteria required.

G.1.2 Hybrid III 50th percentile ATDs shall conform to U.S. Department of Transportation 49 CFR 572.30 and ECE 94, except for the following modifications and additions:

a) 45 degree dorsi-flexion ankles / feet with rubber bump stops and padded heels shall be fitted.

b) Roller ball-bearing knees, such as those supplied by ASTC, shall be fitted.

G.1.3 Hybrid III ATDs shall be re-certified after every 10 impact tests according to the certification procedure for the Hybrid III ATDs (see US Department of Transportation 49 CFR 572.30) and Annex 10 of ECE 94.

G.1.4 Where it is not reasonably practicable to measure parameters directly with a standard Hybrid III ATD, it is permissible for data to be used in support of the overall injury criteria assessment that is obtained using:

a) Modified Hybrid III ATDs (for example the Hybrid III RS ATD).

Or

b) Other test devices (for example other types of ATD or headform devices).

Or

c) Validated computer simulations.

G.1.5 Where modified ATDs are used the ATDs shall be re-certified as far as practicable according to G.1.3. Non-standard parts shall be calibrated according to the manufacturer’s instructions or a suitable calibration procedure shall be included in the injury criteria assessment.

G.1.6 Where other test devices are used, the devices shall be calibrated according to the manufacturer’s instructions or a suitable calibration procedure shall be included in the injury criteria assessment.

G.1.7 Where computer simulations are used, details of the software revision level and publisher shall be included in the injury criteria assessment.

G.1.8 Un-instrumented 95th percentile male ATDs shall be either Hybrid II or Hybrid III as specified in the dummy manufacturer’s user manual.

G.2  ATD preparation
G.2.1 Each ATD shall be clothed with form-fitting cotton stretch garments with short sleeves and pants which shall not cover the dummy’s knees.

G.2.2 Each ATD shall be fitted with shoes equivalent to those specified in MIL-S-13192P (size XW).
Requirements for Rail Vehicle Structures

G.2.3 Each ATD shall have a stabilised temperature in the range of 19°C to 26°C. This shall be achieved by the following procedure:

a) The ATD shall be heat soaked at the specified temperature range for at least 4 hours prior to the test.

b) The temperature of the ATD shall be measured using a recording electronic thermometer placed inside the dummy’s flesh.

c) The temperature shall be recorded at intervals not exceeding 10 minutes.

d) A printout of the temperature readings shall be supplied as part of the standard output of the test.

e) Subject to the ATD remaining within the test environment, it shall not be necessary to repeat the temperature stabilisation procedures set out in G.2.3 a) to d) for a sequence of tests or for repeat testing.

G.2.4 All constant friction joints shall have their ‘stiffness’ set by the following method:

a) The ATD temperature shall be stabilised in accordance with G.2.3.

b) The tensioning screw or bolt which acts on the constant friction surfaces shall be adjusted until the joint can just hold the adjoining limb in the horizontal. When a small downward force is applied and then removed, the limb shall continue to fall.

c) The ATD joint stiffnesses shall be set as close as possible to the time of the test and, in any case, not more than 24 hours before the test.

d) The ATD shall be maintained within the temperature range specified in G.2.3 between the time of setting the limbs and the time of the test.

G.3 ATD positioning

G.3.1 The ATD shall be positioned as follows:

a) The ATD shall be placed on the seat as close as possible to the required position so that its plane of symmetry corresponds to the plane of symmetry of the seating position in question.

b) A small rearwards force shall be applied to the lower torso and a small forwards force to the upper torso to flex the upper torso forwards from the seat back. The torso shall then be rocked left and right four times, going to between 14° and 16° to the vertical.

c) A small rearwards force shall be applied to the upper torso while maintaining the small rearwards force to the lower torso to return the upper torso to the seat back. This force shall be removed slowly.

d) The ATD’s hands shall rest on its thighs with its elbows touching the seat back. If seated at a table the ATD’s hands shall rest on the table top, with the arms aligned with the longitudinal axis of the dummy, palms down, with the wrist bolt in line with the edge of the table.

e) The legs shall be extended to the maximum and then lowered so the heels shall touch the floor. The feet shall be pushed 10 mm rearward and shall be adjusted so the foot lies flat on the floor. The heels shall be adjusted so they have the same longitudinal position.
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f) The separation between the knees shall be 170 mm.

g) The head transverse instrumentation platform shall be horizontal to within 2.5° from the horizontal.

G.3.2 Where it is not possible to correctly position 95th percentile ATDs for dynamic structural integrity testing, it is permissible to use 50th percentile ATDs which are ballasted to the mass of a 95th percentile ATD.

a) For forward tests, the ballast mass shall be placed in line with the pelvis and the ATD positioned to bring the knees in line with those of the outer ATDs.

b) For rearward tests, the ballast mass shall be placed on the ATD chest.

G.3.3 Using a fixed datum on the fixed seat structure, the following ATD reference positions shall be measured and recorded longitudinally, laterally and vertically:

a) ‘H-Point’ (see Figure G.1).

b) Head centre of gravity.

G.3.4 Measurements defining the ATD position relative to the seat shall be made to an accuracy of ±5 mm. The datum point shall be recorded.

G.3.5 The ATD pelvic angle shall be measured relative to the horizontal plane.

![Figure G.1 H-Point location on ATD](image)
G.4 Instrumentation

G.4.1 Measuring instruments and instrumentation cabling shall not in any way affect the movement of the ATD during impact.

G.4.2 The temperature of the system of measuring instruments shall be stabilised before the test and maintained within a range between 19°C and 26°C.
Appendix H  Injury Criteria and Survival Space

The content of this appendix is mandatory

H.1 Injury criteria assessment

H.1.1 Injury criteria shall be measured according to established European or international standards and testing protocols.

H.1.2 All measurements shall be taken in accordance with the positive sense (acceleration and force directions) and filtering specified in SAE J211-1.

H.1.3 Injury criteria from H.2 to H.7 below shall be selected according to the type of installation being assessed, previous test experience and initial test results or test observations.

H.1.4 Following a dynamic test (or equivalent simulation) the injury criteria shall be evaluated from the recorded data and an assessment made of the results obtained.

H.1.5 The injury criteria assessment shall:

a) Take into account the test equipment, test conditions, instrumentation characteristics and measurement accuracy and any other relevant parameters.

b) Account for any anomalies observed during testing due to for example loss of containment or unforeseen contact by the ATD against the items forming the test assembly.

c) Conclude if the results obtained are satisfactory or not with respect to the objectives of the test and the injury criteria specified.

H.1.6 It is permissible to make reference to previous testing or other relevant data in determining the acceptability of the results.

H.2 Head injury criteria

H.2.1 Head injury criteria shall be determined in accordance with the requirements of H.1.3.

H.2.2 The head injury criterion (HIC) shall not exceed a value of 500 over any time interval of 15 ms. The HIC shall be calculated using the following formula:

\[
HIC = \left( t_2 - t_1 \right) \left( \frac{\int_{t_1}^{t_2} A_R \, dt}{(t_2 - t_1)} \right)^{2.5}
\]

Where  

\( t_1 \) represents the start of the time interval  
\( t_2 \) represents the end of the time interval.  
\( A_R \) is the resultant acceleration

And  

\[
A_R = \sqrt{A_X^2 + A_Y^2 + A_Z^2}
\]

Where  \( A_X, A_Y, A_Z \) represent the accelerations in the X, Y, and Z directions.
H.2.3 The maximum acceleration of the head shall not exceed 80 g for more than 3 ms.

H.3 Neck injury criteria

H.3.1 Neck injury criteria shall be determined in accordance with the requirements of H.1.3.

H.3.2 The bending moment of the neck in flexion (M_Y) shall not exceed 310 Nm.

H.3.3 The bending moment of the neck in extension (M_Y) shall not exceed 135 Nm.

H.3.4 The peak tensile force on the neck (F_Z) shall not exceed 4170 N.

H.3.5 The peak compressive force on the neck (F_Z) shall not exceed 4000 N.

H.3.6 At any point in time the neck injury criterion (N_ij) shall not exceed 1.0. The N_ij shall be calculated using the following formula:

\[ N_{ij} = \frac{F_Z}{F_{ZC}} + \frac{M_Y}{M_{YC}} \]

Where
- \( F_{ZC} \) is 6806 N when \( F_Z \) is tensile
- \( F_{ZC} \) is 6160 N when \( F_Z \) is compressive
- \( M_{YC} \) is 310 Nm when \( M_Y \) is in flexion
- \( M_{YC} \) is 135 Nm when \( M_Y \) is in extension.

H.4 Upper chest (thorax) injury criteria

H.4.1 Thoracic injury criteria shall be determined in accordance with the requirements of H.1.3.

H.4.2 The maximum resultant chest acceleration (A_max) shall not exceed 60 g over any 3 ms interval.

H.4.3 The maximum chest deflection (D_max) shall not exceed 63 mm.

H.4.4 The viscous criterion (V*C) at any time t shall not exceed 1.0 m/s. The V*C shall be calculated using the following formula:

\[ V*C = 1.3 \times V(t) \times C(t) \]

Where
- \( V(t) \) is the instantaneous chest velocity (m/s)
- \( C(t) \) is the instantaneous chest compression

And
- \( C(t) = D(t) / 229 \)

Where \( D(t) \) is the instantaneous chest deflection in mm.

H.4.5 The combined thoracic index (CTI) shall not exceed a value of 1.0. The CTI shall be calculated using the following formula:

\[ CTI = \frac{A_{max}/A_{int} + D_{max}/D_{ext}}{A_{max}} \]

Where
- \( A_{int} \) is 90 g
- \( D_{int} \) is 103 mm
- \( A_{max} \) is defined in H.4.2
D_{\text{max}} is defined in H.4.3.

**H.5 Lower chest (abdomen) injury criteria**

**H.5.1** Abdomen injury criteria shall be determined in accordance with the requirements of H.1.3.

**H.5.2** If a frangible abdomen device is used, in conjunction with a standard Hybrid III ATD, the peak abdominal compressive deflection shall not exceed 40 mm.

**H.5.3** If the instantaneous abdominal deflection and velocity is measured, using an alternative test device as permitted by G.1.4, the V*C at any time t shall not exceed 1.98 m/s. The V*C shall be calculated using the following formula:

\[ V^*C = V(t) \times C(t), \]

Where \( V(t) \) is the instantaneous abdominal velocity (m/s)

\( C(t) \) is the instantaneous abdominal compression.

And \( C(t) = D(t) / D_{AB} \)

Where \( D(t) \) is the instantaneous abdominal deflection

\( D_{AB} \) the depth of the uncompressed abdomen test device.

**H.6 Leg injury criteria**

**H.6.1** Leg injury criteria shall be determined in accordance with the requirements of H.1.3.

**H.6.2** The tibial index (TI) shall be calculated using the following formula:

\[ TI = \left| \frac{M(t)}{M_C} \right| + \left| \frac{F(t)}{F_C} \right| \]

Where \( M_C \) is 240 Nm

\( F_C \) is 12 kN

\( M(t) \) is the instantaneous resultant tibial bending moment

\( F(t) \) is the instantaneous tibial compressive force.

**H.6.3** The maximum tibial compressive force shall not exceed 8 kN.

**H.6.4** The peak femur compressive force shall not exceed 4.3 kN and the TI at any time t shall not exceed a value of 1.3. It is permissible for the femur compressive force to exceed 4.3 kN up to a maximum value of 5.7 kN subject to the maximum permissible TI value linearly decreasing from 1.3 to 1.0 over the range 4.3 to 5.7 kN (see Figure H.1).

**H.6.5** The maximal knee displacement shall not exceed 16 mm.
Figure H.1 Leg injury criteria

H.7 Neck rotation (rear impact) criteria
H.7.1 Neck rotation criteria shall be determined for a rear impact in accordance with the requirements of H.1.3.

H.7.2 Posterior angular rotation between the head and torso of the ATD used to measure injury criteria shall not exceed 12°, for a rear impact.

H.8 Survival space
H.8.1 Survival space shall be determined assuming that at least a minimum space envelope is maintained that can accommodate any passenger in the range between a 5th percentile female and a 95th percentile male.

H.8.2 For seated occupants, their survival space shall be determined assuming that they are normally seated.

H.8.3 It is permissible to use one of the following methods or a combination of these to determine that sufficient survival space is maintained:

a) By including a 95th percentile male ATD or dimensionally equivalent dummy in a rearward dynamic test. After testing it shall be demonstrated that:
   i) The dummy has not been compressed or penetrated by any adjacent parts.
   ii) The dummy can be removed by hand without removing seats, tables or other items.

b) By including a 5th percentile female ATD or dimensionally equivalent dummy in a rearward dynamic test. After testing it shall be demonstrated that the dummy has not been compressed or penetrated by any adjacent parts.

c) By measurement, simulation or calculation.
d) By demonstrating for drivers' seats that the clearance zone requirements set out in BS EN 15227:2008 are satisfied.
Appendix J  Symbols for Lifting / Jacking Points

The content of this appendix is mandatory

J.1  Symbol colour

J.1.1  lifting jacking point symbols shall be coloured either golden yellow to BS 4800-08E51 or white or black.

J.2  Symbol for lifting or jacking at 4 points without running gear

![Diagram of 4-point lifting point without running gear]

J.3  Symbol for lifting or jacking at 4 points with or without running gear

![Diagram of 4-point lifting point with running gear]
J.4 Symbol for lifting or jacking at one end with or without running gear
Definitions

**General definitions**

**Access panel**
A panel or other part which can be opened or removed for maintenance using handles, a key or other simple hand tools.

**Anthropomorphic test device (ATD)**
Anthropomorphic test devices (ATDs) are full-scale crash test dummies that simulate the dimensions, articulation and mass distribution of the human body, and are usually instrumented to record acceleration, force and displacement data in simulated vehicle impacts.

**Barrier vehicle**
A vehicle intended to separate or segregate other vehicles within a train.

**Body side window**
Any window on the side of a vehicle, including cab side windows and windows in external doors.

**Freight vehicles**
Vehicles designed and used for carrying payloads which do not include people.

**Interlayer**
A layer or material acting as an adhesive and separator between plies of glass or plastic glazing material which can also give additional performance such as impact resistance.

**Laminated safety glass**
A sandwich construction comprising layers of glass or plastic glazing material joined together with one or more interlayers, where, in the case of breakage, the interlayer(s) retains the glass fragments, limits the size of any opening, offers residual resistance and reduces the risk of cutting or piercing injuries.

**Lifeguard**
A structural element positioned in front of a wheel with the objective of preventing small obstacles from entering the 'nip' between the wheel and the rail and thereby causing the wheel to lift with a consequent risk of derailment.

**Modification**
Engineering change to a rail vehicle that has the potential to affect a rail vehicle’s conformance with the mandatory requirements.

**Obstacle deflector**
A structural device placed at the leading end of a rail vehicle with the objective of shielding the leading wheelset and removing any large obstacles from the path of the train.

**Open point**
Requirements that are considered to be necessary but do not currently exist. In such cases a technical argument is to be formulated and documented that addresses the risk associated with the subject of the open point.

**Passenger vehicles**
Vehicles designed and used for carrying passengers who are fare-paying customers.
Place of safety
A location away from the immediate driving position of a vehicle to which the driver may escape for protection from the likely effects of a collision or derailment.

Post-yield plasticity
The ability of a material to continue deforming in a plastic manner after it has reached yield point, rather than suddenly fracturing.

Primary impact
The original or initial impact of a colliding vehicle with another vehicle or object.

Primary structures
For the purposes of this document, primary structures are considered to be those elements of a vehicle whose primary purpose is to withstand or distribute the loads seen in normal operation and in exceptional circumstances such as collisions or derailments. Primary structural elements include:

a) BodysHELL.
b) Bogies.
c) Structural elements required for crashworthiness.
d) Couplers and drawgear.
e) Equipment rafts and cases.
f) Jacking and lifting features.

Rail vehicle
A vehicle designed for operation on a railway, excluding those used within a possession only.

Refurbishment
A programme of interior/exterior work undertaken on a vehicle to restore or enhance the level of design, performance or the materials used in its construction.

Rigidly coupled rake
If adjacent vehicles in a rake are effectively rigidly coupled together in the longitudinal sense, all the vehicles may be considered to act as one when subjected to longitudinal shock loads due to rough shunting or collisions. In practical terms the requirement for rigid coupling may be met by the kind of very stiff element that is used in articulation joints, for example as fitted to class 373 vehicles. It is not met on vehicles equipped with automatic couplers or bar couplers where the drawgear permits large and easily visible relative movements between vehicles. In such cases the vehicles should be considered as acting separately when subjected to longitudinal shock loads.
Secondary structural elements
For the purposes of this document, secondary structural elements are considered to be those elements of a vehicle which interface directly with passengers or traincrew. Secondary structural elements include:
   a) Windscreens
   b) Windows
   c) Doors
   d) Gangways
   e) Interiors (for example seats, tables, panelling, partitions etc.).

Survival space
The minimum space occupied by a person necessary for that person to survive.

Traincrew
Staff and personnel such as drivers, guards and conductors employed on board a train who have responsibilities for its safe operation.

Translator vehicle
A barrier vehicle equipped with different type of coupler or inter-vehicle connections at each end to allow trains to be formed of otherwise incompatible vehicles.

Vehicle type
For the purposes of this document this shall mean a group of vehicles which have similar design and operating characteristics and with identical electrical circuitry associated with train wires and their function.

Definitions specific to Part 5 Secondary Structural Elements
External door
A door on the side or end of a vehicle which provides access between the outside and the inside.

Inter-vehicle gangway
A throughway between two adjacent vehicles.

Open wide gangway
A throughway between two adjacent vehicles without internal doors between the gangway and passenger areas and where the internal width exceeds 1000 mm in part or in full.

Windscreen
A forward facing window.

Definitions specific to Part 6 Vehicle Elements Interfacing with Passengers and Traincrew
Free flight velocity
The final or terminal velocity of an unrestrained object, when subjected to a given acceleration or acceleration pulse.

Grab rail
A predominately horizontal handrail provided for passenger support, typically of sufficient length for a number of passengers’ use.
Grab pole
A predominately vertical handrail provided for passenger support, typically of sufficient height for a number of passengers’ use.

Grab handle
A short handrail provided for passenger support, typically intended for a single user.

Hand hold
A shaped protrusion, typically fitted to seat backs, to provide passenger support but with limited grip compared to a grab handle, grab rail or grab pole.

Interior
Those areas of a vehicle, including all surfaces, furniture, fixtures and fittings, furnishings and other equipment, which are accessible to passengers, traincrew and personnel.

Interior door
A door which provides access from one part of the vehicle interior to another part.

Luggage rack
Rack provided at ceiling height intended for stowing of relatively light weight passenger items such as briefcases, holdalls and coats.

Luggage stack
A floor mounted unit intended for stowing relatively heavy items of passenger luggage such as suitcases.

Seat zone
The area occupied by a seated passenger bounded by the passenger’s seat and any table or seat situated in front, opposite and adjacent, or the area occupied by a seated crew member bounded by the crew member’s seat and any table, console or structure in front.

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.

Spalling
The detachment of particles or spall from the inner face of the windscreen or window, when the outer face is subject to impact.

Transverse seat
A seat, typically part of a group installed transversely across the vehicle, aligned with the longitudinal axis of a vehicle so that the occupant is either sitting facing or back to the direction of travel.

Trim panel
A panel the presence or absence of which does not materially change the strength or stiffness of the structure to which it is attached.

Definitions specific to Part 8 Mechanical Coupling of Vehicles
Adaptor coupling
A type of coupler which enables vehicles with incompatible couplers to be connected together for the purposes of rescue and/or transfer.
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Buffers
The fittings on the end of a railway vehicle, mounted at the sides as separate units, designed to enable longitudinal compressive forces to be transferred between adjacent vehicles.

Coupler
The element which mechanically connects the vehicles together.

Coupling system
The mechanical system, including buffers where fitted, drawgear and gangway where fitted, that connects two rail vehicles together, and the electrical and pneumatic connections where fitted between vehicles.

Drawgear
A set of fittings used to connect railway vehicles for the purpose of transmitting longitudinal forces between adjacent vehicles; connection can be made manually or automatically.

Definitions specific to Part 9 Lifting, Recovery and Emergency Movement of Vehicles

Flange-back
That part of the vertical surface of a wheel which forms the inside face of the wheel rim above rail level and which is the reference face for specifying all wheel profile dimensions. It is also used as a datum face for maintenance checking of a wheelset.

Jacking
The action of raising a vehicle or part of a vehicle by pushing upwards from underneath using appropriate equipment such as jacks.

Jacking or lifting point
Designated location or housing designed for supporting the weight of a vehicle, or part of a vehicle, when using lifting jacks, lifting brackets and slings, or other means of vertical or horizontal support.

Lifting
The action of raising a vehicle or part of a vehicle by pulling upwards from above using appropriate equipment such as cranes.

Recovery
The process of clearing the railway line of a vehicle that has been immobilised as a result of collision, derailment, accident or other incident.

Wheel profile
That part of the surface of the wheel or tyre between the flange-back and the outside face of the wheel or tyre.

Wheelskate
A device for rescuing crippled vehicles where a wheelset is not fit to rotate, by lifting the affected wheelset clear of the rails and providing alternative support and guidance through the device’s wheels.
References

The Catalogue of Railway Group Standards and the Railway Group Standards CD-ROM give the current issue number and status of documents published by RSSB. This information is also available from www.rgsonline.co.uk.

Documents referenced in the text

- **RGSC 01** The Railway Group Standards Code

**Railway Group Standards**

- GM/GN2685 Guidance on Lifting, Jacking, Recovery and Emergency Movement of Rail Vehicles
- GM/GN2686 Guidance on Rail Vehicle Bodyshell, Bogie and Suspension Elements
- GM/GN2687 Guidance on Rail Vehicle Interior Structure and Secondary Structural Elements
- GM/GN2688 Guidance on the Structural Design of Rail Freight Wagons including Rail Tank Wagons
- GM/GN2689 Guidance on Mechanical Coupling of Rail Vehicles
- GM/RT2130 Vehicle Fire, Safety and Evacuation
- GM/RT2400 Engineering Design of On-Track Machines
- GM/RT2466 Railway Wheelsets

**Other references**

- The Railways (Interoperability) Regulations 2006
- AV/ST9001 Vehicle Interior Crashworthiness (withdrawn)
- BS EN 12600:2002 Glass in building - Pendulum test - Impact test method and classification for flat glass
- BS EN 12663-1:2010 Railway applications - Structural requirements of railway vehicle bodies Part 1: Locomotives and passenger rolling stock (and alternative method for freight wagons)
- BS EN 12663-2:2010 Railway applications - Structural requirements of railway vehicle bodies Part 2: Freight wagons
- BS EN 15152:2007 Railway applications - Front windscreens for train cabs
- BS EN 15227:2008 Railway applications - Crashworthiness requirements for railway vehicle bodies
- BS EN 15663:2009 Railway applications - Definition of vehicle reference masses
- ECE 94 E/ECE/TRANS/505, Regulation No. 94, Uniform provisions concerning the approval of vehicles with regard to the protection of the
occupants in the event of a frontal collision, Revision 1, 2/2/2007, United Nations, Geneva.


Other relevant documents

Other references

BS 7608:1993 Code of practice for Fatigue design and assessment of steel structures
BS EN 13749:2005 Railway applications - Methods of specifying structural requirements of bogie frames
BS EN 15020:2006 Railway applications - Rescue coupler - Performance requirements, specific interface geometry and test methods
BS EN 15551:2009 Railway applications - Railway rolling stock - Buffers
PeopleSize 2008 [www.openerg.com](http://www.openerg.com) or Open Ergonomics Ltd, Melton Road, Hickling Pastures, Melton Mowbray, Leicestershire, LE14 3QG, UK