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Preface

This standard was prepared by the Rolling Stock Fire Safety – Part 3: Development Group, overseen by the ARISO Rolling Stock Standing Committee.

Objective

The objective of this Standard is to outline requirements to provide a minimum level of fire safety for passenger rolling stock operating in Australia.

The major changes from AS 7529.3:2014 are to:

- address new zero-emission technology such as lithium-ion batteries, hydrogen and ammonia;
- update material testing requirements, particularly for train seats;
- update detection requirements to align with industry developments; and
- update evacuation requirements to reduce the reliance on international standards.

Compliance

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

(a) Requirements.

(b) Recommendations.

(c) Permissions.

(d) Constraints.

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

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

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

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

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

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

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

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

Commentary

Commentary *C Preface*

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

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Section 1 Scope and general

1.1 Scope

This document applies to passenger rolling stock.

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

This document includes fire safety requirements for passenger rolling stock configured with zero-emission technology used for propulsion or auxiliary supply. This includes battery electric energy storage systems (ESS) and hydrogen fuel cell systems (HFS). These systems introduce distinct fire safety hazards compared to conventional diesel and electric traction.

Section 2 to Section 12 (inclusive) of this document apply to the design and construction of new passenger rolling stock.

Section 13 of this document applies to the maintenance, modification and refurbishment of existing passenger rolling stock.

Operation of rolling stock is not covered.

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

While it is not the intention to cover heritage rolling stock within the scope of this document, operators of heritage rolling stock fleets are encouraged to consider the requirements within this document and comply with them if reasonable to do so.

This document deals with explosion risks in the context of reducing the risk of a build-up of flammable gases that could result in an explosion. Mitigating the consequence of a blast from an explosion is not part of the scope of this document. Designers of HFS and ESS equipment could need to consider if blast consequence mitigation needs to be included to control these risks so far as is reasonably practicable (SFAIRP), separate to the requirements of this document.

The requirements of this document are aimed at reducing fire risk to life of passenger rail rolling stock occupants as well as the risks that a fire on such rolling stock could pose to the life safety of other users of the infrastructure.

Compliance with this document represents the minimum requirement under the designer's duties under *Rail Safety National Law*.

The requirements of this document do not address asset protection of either the passenger rolling stock or the infrastructure.

The requirements of this document do not contain any specific mitigations for fire safety risks associated with terrorism, or with fires following train-to-train collision and ignition.

1.2 General information

1.2.1 Zero-emission passenger rolling stock

Energy storage systems (ESS) and hydrogen fuel systems (HFS) present specific fire and explosion risks that are directly influenced by system size, configuration and chemical properties.

ESS capacity in rolling stock typically ranges from 50 kWh to over 15 MWh. The fire risk varies depending on the battery chemistry, housing, energy density and the battery management system. Battery chemistries with higher energy density typically present greater risks of thermal runaway, fire and gas release compared to chemistries designed for enhanced thermal stability and reduced propagation risk. Fire events can involve thermal propagation between cells, gas release, re-ignition after suppression or system failure due to inadequate thermal management.

Electric double-layer capacitors (EDLC) are also used in zero-emission rolling stock for regenerative braking, peak load reduction and short-term energy buffering. EDLCs provide high power density and rapid charge-discharge performance but have lower energy density compared to batteries. While their thermal runaway risk is typically lower than high-energy batteries, EDLCs contain electrolytes that can pose fire and gas release hazards under fault conditions.

HFS typically stores between 100 kg and 5,000 kg of hydrogen, depending on the rolling stock type, storage method and operational range. Storage can involve compressed gaseous hydrogen at pressures typically between 350 and 700 bar or alternatively, cryogenic or liquefied hydrogen for larger-capacity systems. The associated hazards include high-pressure storage failure, dispersion of flammable gas creating explosive atmospheres, jet fires from uncontrolled releases and boiling liquid expanding vapour explosion risks in cryogenic systems. Hydrogen combustion can result in flames that are difficult to detect visually, presenting additional challenges for fire detection systems and emergency response.

1.2.2 Alignment with evolving technologies and industry trends

The provisions in this document are based on current practices, acknowledging that national and international standards for zero-emission rolling stock are continually evolving. As new battery chemistries, hydrogen fuel systems and alternative fuels like ammonia are developed, additional or updated safety requirements could become necessary.

Currently, this document does not include specific technical requirements or detailed safety provisions for ammonia-fuelled rolling stock. However, the general fire safety principles outlined herein could be applied where relevant, at the discretion of designers and RSOs.

1.2.3 Operational context

While this document defines design requirements to support fire safety, it does not prescribe operational responses to fire events. Decisions related to train stopping, crew evacuation and response coordination are the responsibility of the RSO, in accordance with their safety management system (SMS) and applicable rail safety legislation.

Where performance-based solutions are applied, it is important that fire development timelines and evacuation timings are evaluated, as part of demonstrating that the fire safety risk has been reduced SFAIRP.

1.2.4 Fire behaviour and infrastructure considerations for enclosed environments

Hydrogen-powered rolling stock in enclosed environments (such as tunnels) introduce particular fire and explosion risks due to the properties of hydrogen. These risks influence aspects of rolling stock design and can also inform infrastructure planning and operational practices.

In confined spaces, leaked hydrogen can accumulate near tunnel ceilings, especially where ventilation is limited or airflow is disrupted. Effective dispersion and dilution of hydrogen are essential to avoid the formation of flammable concentrations. Tunnel ventilation characteristics, including minimum airflow rates and directional controls, impact both gas movement and the effectiveness of emergency responses.

Hydrogen can burn with a near invisible flame which will need to be taken into account when selecting an appropriate fire detection system. Further details and requirements are contained in Section 9.

Hydrogen power can introduce horizontal jet flame which will need to be taken into account for vehicle design including aspects such as egress.

Tunnel structural behaviour under exposure to hydrogen jet flames or lithium battery fires could also warrant assessment. High-temperature flames can cause localized degradation of structural

reinforcement and protective finishes. Heat-resistant materials or fire-resilient design features can help limit potential damage during prolonged fire exposure.

1.2.5 Fire risks from passenger carried consumer battery products

At the time of preparing this document, it is noted that fires involving passenger-carried battery-powered consumer products (e.g., power banks, battery-powered personal mobility devices, etc.) are an emerging fire risk for passenger railways globally. While a small set of research identifies the potential size and growth rates of fires from these products, there has been no research conducted to evaluate the appropriateness of various rolling stock design elements to manage the risk of such fires. Without such reference material available, it is noted that this document contains no explicit control measures for fires involving passenger-carried battery-powered consumer products. These hazards need to be considered by an operator as part of its RSNL and SFAIRP commitments.

1.3 Normative references

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

- AS 1319:1994, *Safety signs for the occupational environment*
- AS 1530.4:2014, *Methods for fire tests on building materials, components and structures, Part 4: Fire-resistance tests for elements of construction*
- AS 2444:2001, *Portable fire extinguishers and fire blankets – Selection and location*
- AS 5062:2022, *Fire protection for mobile and transportable equipmen*t
- AS 7501:2019, *Rolling Stock Compliance Certification*
- AS 7486:2022, *Railway energy storage: Rolling stock onboard electrical energy storage*
- AS 7495:2024, *Rolling Stock Communications Equipment*
- AS 7522:2025, *Access and Egress*
- AS 7528:2019, *Interior Communications*
- AS 7531:2023, *Rolling stock lighting and visibility*
- AS 7533:2021, *Driving cabs*
- AS/NZS 1841.1:2007, *Portable fire extinguishers, Part 1: General requirements*
- AS/NZS 3504:2006, *Fire blankets*
- AS/NZS ISO 31000:2018, *Risk Management – Principles and guidelines*
- AS/ISO 7240:2025, *Fire detection and alarm systems*
- IEC 60079-10-1:2020, *Explosive atmospheres – Part 10-1: Classification of areas – Explosive gas atmospheres*
- IEC 60079-29-1:2016, *Explosive atmospheres – Gas detectors – Part 1: Performance requirements of detectors for flammable gases*
- IEC 60079-29-2:2015, *Explosive atmospheres – Part 2: Gas detectors – Selection, installation, use and maintenance of detectors for flammable gases and oxygen*
- IEC 62619:2022, *Secondary cells and batteries containing alkaline or other non-acid electrolytes - Safety requirements for secondary lithium cells and batteries, for use in industrial applications*
- IEC 62928:2017, *Railway applications - Rolling stock - Onboard lithium-ion traction batteries*

- IEC 63341-1:2025, *Railway applications – Hydrogen and fuel cell systems for rolling stock – Part 1: Fuel cell power system*
- IEC 63341-2:2025, *Railway applications – Hydrogen and fuel cell systems for rolling stock – Part 2: Hydrogen fuel system*
- ISO 13943:2023, *Fire safety – Vocabulary*
- ISO 13985:2006, *Liquid hydrogen — Land vehicle fuel tanks*
- ISO 16111:2018, *Transportable gas storage devices — Hydrogen absorbed in reversible metal hydride*
- ISO 19880-1:2020, *Gaseous hydrogen — Fuelling stations — Part 1: General requirements*
- ISO 26142:2010, *Hydrogen detection apparatus — Stationary applications*
- EN 54 (all parts), *Fire detection and fire alarm systems*
- EN 45545-1:2013, *Fire protection on railway vehicles - Part 1: General*
- EN 45545-2:2020+A1:2023, *Fire protection on railway vehicles – Part 2: Requirements for fire behaviour of materials and components*
- EN 50155:2021, *Railway applications - Rolling stock - Electronic equipment*
- EN 50553: 2012 + A2:2020, *Railway applications – Requirements for running capability in case of fire on board of rolling stock*
- CSA TS-601:2024, *Hydrogen fuel cell power systems for rolling stock*
- CSA TS-602:2023, *Railway applications — Rolling stock — Onboard lithium-ion traction batteries*
- *Australian Fire Engineering Guidelines* (2021)EP191022:2026, *CSIRO Rail Seat 900g Crib Fire Test Specification Rev D*
- RISSB Guideline *Rolling Stock Safety Assessment* (2019)
- TSI-SRT:2014, *Technical specification for interoperability – Safety in railway Tunnels*
- UN ECE R134:2019, *Uniform provisions concerning the approval of motor vehicles and their components with regard to the safety-related performance of hydrogen-fuelled vehicles*

NOTE:

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

1.4 Defined terms and abbreviations

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

1.4.1
battery management system (BMS)
system that monitors and controls the battery's performance, ensuring safe operation and optimal efficiency

1.4.2
battery thermal management system (BTMS)
system dedicated to controlling the battery's thermal environment, managing heating and cooling functions to maintain the battery within its optimal operating temperature range

Note 1 to entry: While often integrated or coordinated with the BMS, the BTMS is functionally distinct and focused solely on thermal regulation.

1.4.3
CFD
computational fluid dynamics

1.4.4
commuter rolling stock
passenger rolling stock utilized for city commuter services, including outer suburban services, suburban services and metro

1.4.5
design category
design and layout characteristics of the railway vehicle

Note 1 to entry: As defined in EN 45545-1:2013.

1.4.6
electric double-layer capacitor (EDLC)
energy storage device that stores electrical energy through electrostatic charge accumulation at the interface between an electrode and an electrolyte

1.4.7
energy storage system (ESS)
physical systems consisting of one or more battery units and associated components required to connect the batteries to the direct current link

Note 1 to entry: This includes converters, control and monitoring systems, inductors, protection devices, and thermal management equipment. These systems are primarily intended to support traction.

1.4.8
energy storage unit (ESU)
physical equipment which is comprised of energy storage technologies such as batteries or EDLCs

1.4.9
FEB
fire engineering brief

1.4.10
FER
fire engineering report

1.4.11
fire resistance
ability of an element of construction, component or structure to fulfil, for a stated period of time, the required structural adequacy, integrity, thermal insulation or other expected duty specified during exposure to a fire

1.4.12
fire resistance – integrity (E)
ability of an element of construction to resist the passage of flames and hot gases from one space to another, when tested in accordance with AS 1530.4:2014

Note 1 to entry: This is expressed as a period of time in minutes for which the test failure criteria are not exceeded. The EN 45545 standard series expresses a similar fire resistance integrity level (E).

1.4.13
fire resistance – insulation (I)
ability of the surface of an element of construction not exposed to the furnace to maintain a temperature below the specified limits, when tested in accordance with AS 1530.4:2014

Note 1 to entry: This is expressed as a period of time in minutes for which the test failure criteria are not exceeded. The EN 45545 standard series expresses a similar fire resistance insulation level (I).

1.4.14
fuel cell module
assembly incorporating one or more fuel cell stacks and, if applicable, additional components that is intended to be integrated into a power system or a vehicle

1.4.15
fuel cell power system
generator system that uses one or more fuel cell modules to generate electric power and heat

1.4.16
GPO
general power outlet

1.4.17
fuel cell stack
assembly of cells, separators, cooling plates, manifolds and a supporting structure that electrochemically converts, typically, hydrogen-rich gas and air reactants to direct current power, heat and other reaction products

1.4.18
hazard level
level of hazard to differentiate material fire safety requirements derived from operation and design categories

Note 1 to entry: As defined in EN 45545-2:2020+A1:2023.

1.4.19
high power equipment
equipment with circuits operating with a rated power greater than 20 kW

1.4.20
high voltage
nominal voltage exceeding 1,000 V AC or exceeding 1,500 V DC

1.4.21
HVAC
heating, ventilation and air conditioning

1.4.22
hydrogen fuel system (HFS)
system designed to store hydrogen and to process it to supply the fuel cell power system

Note 1 to entry: It includes the refuelling onboard devices, fuel lines and the associated monitoring, control and safety devices.

1.4.23
Intumescent
swelling or expanding as a result of heat exposure

1.4.24
lithium iron phosphate (LFP)
LiFePO4
battery chemistry that uses a lithium iron phosphate cathode, a carbon-based anode, and a lithium salt electrolyte

1.4.25
lower explosive limit (LEL)
lowest concentration of a flammable gas or vapor in the air that will ignite if an ignition source is present

1.4.26
long-distance passenger rolling stock
passenger rolling stock utilized for inter-urban, intercity and interstate passenger operations

Note 1 to entry: Long-distance passenger rolling stock can include diesel-electrical, fixed-formation consists with dedicated power-car locomotives, fixed-formation consists with distributed power (e.g., multiple unit rolling stock) and locomotive-hauled coaches/carriages.

1.4.27
lower flammability limit (LFL)
minimum concentration of a combustible gas or vapor in air that can ignite and propagate a flame

1.4.28
NATA
National Association of Testing Authorities in Australia

1.4.29
nickel-cobalt-aluminium (NCA)
LiNixCoyAlzO2
lithium-ion battery chemistry that uses a lithium nickel cobalt aluminium oxide cathode to store energy

1.4.30
National Professional Engineers Register (NPER)
register maintained by the Institution of Engineers Australia that lists individuals who have been assessed as meeting professional and ethical standards in a recognised area of practice, including fire safety engineering

1.4.31
nickel manganese cobalt (NMC)
lithium-ion battery chemistry that uses a lithium nickel manganese cobalt oxide cathode to store energy

1.4.32
operation category (OC)
category that characterises the operating environment of the railway vehicles with regard to the fire safety requirements

Note 1 to entry: As defined in EN 45545-1:2013.

1.4.33
place of safety
temporary location that is free from immediate danger from the effects of fire

Note 1 to entry: As defined in ISO 13943:2023.

1.4.34
running capability
ability of the train to reach a safe area which is defined in the TSI-SRT:2014 as a temporary survival space

1.4.35
rail infrastructure manager (RIM)
As defined in Rail Safety National Law.

1.4.36
rolling stock operator (RSO)
As defined in Rail Safety National Law.

1.4.37
safe refuge
temporary location within a train that is free from the immediate danger from the effects of fire as defined in ISO 13943:2023

1.4.38
self-rescue device
personal protective device that provides short-duration respiratory protection to train crew during evacuation through smoke-filled or toxic environments

1.4.39
so far as is reasonably practicable (SFAIRP)
As defined in Rail Safety National Law.

1.4.40
state of charge (SOC)
ratio of remaining charge in the battery compared to the maximum charge capacity of the battery

Note 1 to entry: SOC is normally expressed as a percentage. For example, 0% is empty, 100% is full.

1.4.41
TPRD
thermally activated pressure relief devices

1.4.42
zero-emission (ZE) rolling stock
rolling stock system or vehicle that does not produce tailpipe emissions of greenhouse gases or regulated pollutants during normal operation

Note 1 to entry: Zero-emission vehicles include battery-electric, hydrogen fuel cell, or other technologies where the propulsion energy source does not result in direct atmospheric discharge of carbon dioxide, nitrogen oxides, particulate matter, or hydrocarbons.

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

Section 2 Conditions on use of performance and deemed to satisfy provisions, and laboratory testing

2.1 General approach

This document permits compliance through either deemed-to-satisfy provisions or performance-based solutions, provided that mandatory fire safety outcomes are achieved.

Where verification of compliance with this document is not solely achieved by application of deemed-to-satisfy provisions, the following conditions apply:

(a) Verification shall be completed by or independently assessed and agreed as compliant by, a registered fire engineer experienced in rolling stock fire safety. This includes practitioners registered on the National Engineering Register (NER) in the category of fire safety engineering or equivalent.

(b) A holistic fire safety assessment shall be undertaken to confirm that the overall level of fire safety achieved by the passenger rolling stock design is SFAIRP for locomotive and freight rolling stock types.

2.2 Holistic fire safety assessment

The holistic fire safety assessment required according to Clause 2.1(b) shall:

(a) apply the process and principles of fire engineering design, evaluation and analysis as outlined in the *Australian Fire Engineering Guidelines* (2021); and

(b) incorporate fire hazard and risk analysis in accordance with the *RISSB Guideline Rolling Stock Safety Assessment* and AS/NZS ISO 31000:2018. The analysis shall document the evaluated risk levels and the reasoning used to demonstrate that fire risks have been reduced SFAIRP.

2.3 Fire safety documentation process

The holistic fire safety assessment required according to Clause 2.1(b) shall include:

(a) a structured fire safety documentation process implemented for all new rolling stock projects and for modifications that impact fire safety; and

(b) a process undertaken in accordance with the methodology outlined in AFEG (2021).

The process shall include but not be limited to:

(c) preparation of a fire engineering brief (FEB) to establish fire safety objectives, key assumptions and the compliance strategy at the early design phase;

(d) progressive fire engineering risk analysis throughout the project lifecycle, irrespective of whether a deemed-to-satisfy or performance-based approach is used; and

(e) preparation of a fire engineering report (FER) to document the final fire safety design, verify that risks have been addressed and demonstrate compliance prior to commissioning and operation.

For modifications to existing rolling stock, a risk assessment/analysis shall be conducted to evaluate the impact on fire safety. The level of detail shall be proportionate to the scale and safety impact of the change and can require reviewing the original fire safety design basis to confirm that the modification does not compromise previous fire safety verifications or critical safety design elements.

2.4 Competency for fire safety documentation

All fire safety documentation and modification risk assessments shall be prepared, reviewed and approved by individuals with demonstrable competency in rolling stock fire safety engineering. This shall include:

(a) registration on the NER in the category of fire safety engineering or equivalent qualifications; and

(b) experience in rolling stock fire risk assessment, system integration and compliance with rail fire safety standards.

2.5 Novel design features

Where a proposed vehicle design incorporates novel features or technologies that depart significantly from established practice, a performance-based assessment shall be undertaken to address potential fire safety risks. This shall include but not be limited to, designs involving reinforced plastic primary structures, novel battery chemistries or novel hydrogen storage configurations.

The assessment shall include, where applicable, representative full-scale fire testing, fire engineering modelling or calculations or computational fluid dynamics (CFD) analysis of the novel feature.

Commentary *C2.5*

The purpose of this assessment is to ensure that the proposed design does not introduce unacceptable fire safety risks beyond the scope of the existing provisions of this document.

2.6 Laboratory reports and test certificates

All testing, including material fire performance tests, fire resistance tests and ESS or HFS safety tests shall be conducted by laboratories accredited to ISO/IEC 17025 for the relevant test methods except where an exemption to apply test reports by laboratories without accreditation has been agreed by the RSO and/or RIM.

Accreditation shall be by NATA or an equivalent body recognized under the *ILAC Mutual Recognition Arrangement*.

Material fire performance test, fire resistance test and ESS or HFS safety test results/certificates that are older than five (5) years from the project contract award date shall be confirmed for validity by the respective supplier/manufacturer.

Where fire resistant compartmentation or separation element design have minor variations from the actual tested assemblies, the compliance of these constructions to the deemed to satisfy requirements shall be assessed by a registered fire testing authority or a registered fire engineer experienced in rolling stock fire safety (e.g., NER in the category of fire safety engineering).

Commentary *C2.6*

The reference fire resistance test standard for fire resistance for this document is AS 1530.4:2014. Other European standards (e.g., the EN 45545 series) referenced by this document refer to other fire resistance test methods which have an equivalent time temperature curve but could have technical differences in instrumentation, method and criteria.

Fire resistance tests to standards other than AS 1530.4:2014 shall only be accepted for deemed to satisfy compliance where the suitability and equivalence of the test to the deemed to satisfy provision has been assessed by a registered fire testing authority or a registered fire engineer experienced in rolling stock fire safety (e.g., NPER in the category of fire safety engineering).

Section 3 Ignition risk mitigation measures

3.1 General

Ignition risk mitigation is a key component of fire prevention in rolling stock.

Potential ignition hazards, including but not limited to electrical systems, ESS, HFS, fuel storage, arson, mechanical components, and trackside sources, shall be systematically identified and effectively managed through the implementation of appropriate design, protection, and monitoring controls.

Fire prevention measures should align with current best practices and follow system-specific requirements outlined in relevant standards.

Where GPOs are accessible to passengers, risk assessment should be conducted to ensure ignition risks associated with this provision are minimized.

NOTE:

AS 7486:2026 provides informative guidance on onboard electrical energy storage in rolling stock. IEC 63341:2025 addresses hydrogen fuel systems on rolling stock.

3.2 Performance requirements

The design of passenger rolling stock shall, if reasonably practicable to do so, include measures in the vehicle design to mitigate:

(a) reasonably foreseeable vehicle ignition events; and

(b) reasonably foreseeable track-side ignition events caused by vehicles.

3.3 Deemed to satisfy provisions

3.3.1 General

The performance requirement of Clause 3.2(a) shall be deemed to be satisfied by the demonstration of compliance with the following:

(a) Resistors, exhaust from combustion engines, heating elements, catering/cooking equipment, and other radiant heat sources on the vehicle are suitably separated or protected from adjacent combustible component materials such that the heat sources do not pose an ignition risk.

(b) Equipment which has the potential to operate at high temperatures is fitted with systems to ensure that over temperature conditions are detected and controlled to prevent fire generating conditions from occurring.

(c) Electrical circuits are designed such that wire sizes are adequate and appropriate given their associated circuit protection and the magnitude of potential fault currents.

(d) Compartments that contain batteries which could release flammable gases under normal, or fault conditions are vented to the rolling stock exterior to prevent such compartments presenting an explosion hazard.

Commentary *C3.3.1(d)*

Relevant standards for battery compartments to mitigate explosion risks include AS 7486, AS 2676.2 (guidance on battery ventilation of traditional lead acid or nickel cadmium batteries), IEC 62928, and IEC 62619. These standards require that compartments housing batteries—particularly those capable of releasing flammable gases under normal or fault conditions—be vented to the exterior of the rolling stock to prevent gas accumulation and associated explosion risks.

IEC 62619 specifies safety test requirements for secondary lithium cells and batteries for use in industrial applications, including fault tolerance and thermal runaway containment.

IEC 61881-3 is also relevant, particularly for rolling stock energy storage systems that use EDLCs, providing design and performance guidelines specific to capacitor-based ESS technologies.

Battery compartment design and fire mitigation measures are driven by the specific battery chemistry used (e.g., NMC, LFP, NCA), as different chemistries exhibit varying flammability, gas emission, and thermal stability characteristics.

(e) Circuits including components such as resistors, contactors, or relays are designed to operate without causing an ignition event under normal and reasonably foreseeable fault conditions.

(f) Suitable shielding is provided to ensure that sparks from cast iron brake blocks, if fitted, do not pose an ignition risk to underframe mounted combustible component materials or locations on the underframe where litter, leaf matter, or other inflammable debris can accumulate.

(g) Engine and exhaust systems are designed to eliminate spark emissions which could cause ignition of track side materials.

(h) Brake systems, forced ventilation systems and current collectors are designed to eliminate spark emissions which could cause ignition of track side materials.

3.3.2 HFS, ESS & EDLC-powered passenger rolling stock

In addition to the requirements outlined in Clause 3.3.1, the following clauses specify provisions for mitigating ignition risk applicable to HFS and ESS:

(a) ESS systems and circuits shall comply with AS 7486:2026.

(b) As a minimum requirement, ESS which contain lithium-ion battery cells shall be tested and assessed for compliance with all requirements of IEC 62619:2022, including BMS safety performance, cell level abuse tests and fire propagation test at module or pack scale.

(c) As part of IEC 62619:2022 testing requirements, the fire propagation test shall be performed with all cells at 100% SOC, with BMS disconnected and any cooling system not functioning.

(d) Risk assessment shall also be conducted to determine if further battery module or pack scale testing needs to be undertaken with a worse case event of multiple cells forced into thermal runaway as an initiating event.

(e) Passenger rolling stock with ESS shall include a BMS and BTMS capable of continuous monitoring at the cell, module and string levels.

(f) The BMS and BTMS shall be able to detect indicators of battery degradation or abnormal conditions and initiate automatic mitigation actions, such as isolation of affected cells or modules, prior to the onset of a thermal runaway.

NOTE:

Relevant standards for battery management systems' thermal management to prevent thermal runaway include AS 7486, IEC 62928 and IEC 62619.

(g) Faults and alarms from the BMS and BTMS shall be clearly perceptible to the train crew or remote operations monitoring location for driver-less trains under all operating conditions and comply with AS 7533:2021.

(h) Batteries that have the potential to release flammable gases shall be provided with adequate ventilation systems designed to maintain hydrogen concentrations below critical safety thresholds, in compliance with the requirements specified in Section 11.

(i) The fire prevention and suppression system design shall address coolant system leaks where combustible liquids such as ethylene glycol are used in ESS cooling systems.

(j) Any ESS or HSS cooling system shall be monitored for both the coolant temperature and flow.

(k) If monitoring indicates a cooling system fault or loss/leak, then this shall be communicated as a fault alarm to the train crew and/or remote-control centre.

(l) Hydrogen fuel cell enclosures and hydrogen storage compartments (including high-pressure storage tanks, underfloor housings, roof-mounted modules, pipe runs and associated enclosures) shall be designed and managed to prevent the uncontrolled accumulation of hydrogen gas due to leaks.

Commentary *C3.3.2-1*

Potential accumulation points include confined spaces around enclosures where hydrogen leakage could create a flammable or explosive atmosphere if not properly ventilated, monitored and controlled.

For HFS, ventilation systems are designed to maintain hydrogen concentrations below specified safety thresholds outlined in IEC 63341 to ensure operational safety. According to IEC 63341-2, the maximum allowable hydrogen concentration in enclosures is 1% H_2 in air (25% of the LEL).

Additionally, IEC 63341-1, specifies that the absolute peak hydrogen concentration in exhaust gases does not exceed 8% at any time, while the maximum average concentration remains below 4% over a 3-second moving window LEL. IEC 63341-1 outlines requirements for continuous hydrogen releases from components under normal operation, ensuring concentrations remain within safe levels.

Explosive atmosphere management shall include hazardous area classification, ventilation assessment and integration of control measures to limit hydrogen accumulation as defined in IEC 60079 (all parts).

Electrical circuits and systems in compartments or enclosures where explosive atmospheres can occur shall be designed and installed in accordance with IEC 60079:2017.

Hydrogen detection systems shall be installed and configured to automatically isolate or shut down the hydrogen supply in the event of a leak.

External ventilation and gas management under various operational modes, including standstill, motion and confined spaces, as well as limits in open and semi-closed environments (e.g., tunnel conditions), shall be defined and agreed upon by the manufacturer, RIM and RSO.

Venting into tunnels or confined spaces shall be avoided wherever practicable. Where venting cannot be eliminated, emission limits and management strategies shall be implemented to ensure hydrogen concentrations remain below an agreed LEL), particularly in locations where accumulation of hydrogen could occur (e.g., station caverns).

Commentary *C3.3.2-2*

NFPA 130, Section 7 outlines ventilation management methods such as airflow rates and smoke control strategies that could be relevant for managing hydrogen dispersion and preventing hazardous gas accumulation in tunnels.

IEC 60079-10-1 provides guidance on explosive atmosphere management, requiring the use of leak detection systems that trigger automatic shutdowns in the event of a hydrogen leak. These standards

also establish safety protocols for hydrogen exhaust to prevent exposure to potential ignition sources, ensuring that hydrogen is released in a controlled manner to mitigate fire and explosion risks.

Other relevant documentation include CSA TS-601, where mechanical ventilation with air dilution can maintain hydrogen concentrations below the LEL or LFL, with real-time flow monitoring to verify ventilation effectiveness. Dilution boundaries are found using IEC 60079-10-1, NFPA 497, IEC 63341 and UN ECE R134.

IEC 63341 categorizes hydrogen release management into different types (A, B and C), specifies acceptable release rates and outlines mitigation strategies to prevent hydrogen accumulation and ignition risks.

Flammable gases shall be vented away from potential ignition sources, particularly within confined or semi-enclosed environments. Additional requirements for managing the release of flammable gases are detailed in Section 11.

Section 4 Fire development mitigation measures

4.1 General

The presence of combustion engines, high-voltage electrical systems, HFS and ESS introduces risks of fire spread that needs to be effectively controlled. This section defines measures to limit fire propagation, contain thermal hazards and protect critical systems for passenger rolling stock.

4.2 Performance requirements

The design of passenger rolling stock shall, through hazard assessment, identify mechanisms whereby fire development could occur and wherever reasonably practicable to do so, include in the vehicle design measures to mitigate such events.

4.3 Deemed to satisfy provisions

4.3.1 Passenger rolling stock

The performance requirement of Clause 4.2 shall be deemed to be satisfied by the demonstration of compliance with the following:

(a) Unless security provisions mandate requirements which would prevent compliance, litter bins on passenger rolling stock are to be constructed with a self-closing lid and with a housing and lid material which is capable of providing at least 10 min fire integrity when tested in accordance with AS 1530.4:2014.

(b) There are no litter traps on the interior of passenger rolling stock, particularly around passenger seats.

(c) Over seat luggage storage (i.e. luggage racks) and dedicated bays of luggage shelving (i.e. luggage stacks) on the interior of passenger rolling stock are designed so that passengers have visibility of their belongings from seated positions.

(d) Heating, ventilation, and air conditioning system ducting has access for cleaning to prevent the build-up of dust which could aid fire propagation.

(e) The underframe equipment layout, wherever practicable, avoids traps where debris such as litter or leaf matter can accumulate.

(f) Equipment and pipework containing flammable fluids are protected against puncture.

(g) Filling and drainage points for flammable fluids are positioned so that the accumulation of spilt/discharged fluid is prevented.

(h) Reservoirs for flammable fluids are designed to ensure that they do not drain their contents in the event of vehicle rollover.

(i) Equipment and pipework for flammable fluids or gases, such as hydrogen lines, HFS and ESS enclosures, is shielded against puncture or mechanical damage.

Commentary *C4.3.1*

Derailments and low-speed collisions can create fire hazards, particularly where rolling stock incorporates underframe mounted fuel tanks, battery systems or hydrogen storage. Structural protection measures such as shielding, reinforced housings and rupture-resistant enclosures can reduce the likelihood of puncture, fluid release or uncontrolled gas discharge in these events. Designers are encouraged to assess these risks early in the design process and adopt protective measures proportionate to the hazard and operating context.

Fluid and gas containment systems can incorporate reinforced structures and mechanical safeguards to reduce the risk of rupture or sudden release, with integrity confirmed by impact and rollover testing. Safety features include automatic isolation devices, flow-limiting valves and drainage prevention measures to control the release of hazardous contents in rollover events.

4.3.2 HFS, ESS & EDLC-powered passenger rolling stock

In addition to the requirements in Clause 4.3.1, HFS- or ESS-powered multiple units are required to comply with the following:

(a) HFS and ESS shall be protected from exposure to train borne and external heat and ignition sources SFAIRP. Hazards can include track-side fires and embers from a bushfire.

(b) Fire suppression, compartmentation and ventilation strategies shall be adopted where appropriate to reduce the fire hazard SFAIRP and be designed to tested industry standards.

(c) A BMS and BTMS shall be installed that provides appropriate monitoring, control fault detection and alarms clearly visible to crew in all operating conditions and interfaces with the fire detection system.

Commentary *C4.3.2(c)*

Additional fire mitigation strategies for ESS to prevent escalation of thermal events can include:

1. Isolation of faulty cells or modules using solid-state switches to stop fault propagation.
2. Passive propagation barriers such as thermal matting between cells to limit heat transfer and contain thermal runaway.
3. Controlled degassing channels to direct and vent flammable gases safely during thermal events, reducing the risk of explosion or re-ignition.

(d) HFS and ESS compartments shall have systems to disperse heat and gases effectively.

Commentary *C4.3.2(d)*

To effectively remove hydrogen and prevent accumulation, exhaust vents can be positioned to facilitate proper dispersion, considering hydrogen's buoyancy in air.

(e) Hydrogen leak detection systems shall initiate emergency management systems which can include shutdown procedures and ventilation systems.

Commentary *C4.3.2(e)*

The reaction of the HFS in a fire event is to be coordinated with the evacuation and emergency response strategy.

(f) Hydrogen containers shall be equipped with TPRDs to safely vent gas before the liner reaches critical temperatures.

Commentary *C4.3.2(f)*

Temperature thresholds for TPRD activation from IEC 63341-2:2025 are 85°C average and 100°C peak liner temperature.

(g) While automatic fire suppression systems can assist in reducing the impact of external heat sources, primary protection of the HFS and ESS from external fires shall be provided by fire-rated barriers or enclosures designed to prevent heat and flame ingress as part of the overall fire containment strategy.

Commentary *C4.3.2(g)*

Any onboard suppression system needs to be carefully considered with respect to the space required, the duration of suppression it provides, the weight it adds to the rolling stock, the risk of unwanted discharge and the ongoing maintenance costs.

Section 5 Material fire performance

5.1 General

Material fire performance plays a key role in limiting fire growth, smoke generation and toxic gas production in passenger rolling stock.

Effective control of combustible materials supports safe evacuation by reducing fire severity and maintaining survivable conditions during incidents involving passenger rolling stock.

Material selection is based on factors such as the quantity and location of combustibles, the operating environment (e.g., tunnel or open track) and the time available for fire detection, train stoppage and evacuation.

5.2 Performance requirements

Combustible component materials used on the interior and exterior of passenger rolling stock shall have properties which:

(a) prevent significant fire propagation occurring when exposed to small ignition sources of the order of 1 kW;

(b) limit the propagation of the fire when exposed to large ignition sources greater than 50 kW; and

(c) limit the rate of heat release of the fire when exposed to large ignition sources greater than 50 kW.

The degree of material performance provided shall be commensurate with:

(d) the nature and location of the fire hazards present on the rolling stock (including the potential for arson);

(e) whether the potential ignition sources are piloted or non-piloted;

(f) the quantity of combustible material within the passenger rolling stock;

(g) the location and configuration of the combustible material within the passenger rolling stock;

(h) the time required to detect the fire;

(i) the time required for occupants to move to a safe refuge within the rolling stock (if provided);

(j) the time required for the rolling stock to travel to and stop at a suitable location for evacuation; and

(k) the time required for evacuation of rolling stock occupants to a place of safety.

Where applicable, the level of rolling stock material fire performance should support the specification of design fire being used for the rail infrastructure.

Commentary *C5.2*

The design fire is an estimated maximum heat release rate generated from a fully developed train fire and is typically based on a single rail car. This design fire is used as a design basis for fire engineering and tunnel ventilation, including fan sizing.

Where a design fire is required to be defined for a project, this and the method of calculation, should be determined by the project team and RTO and can benefit from input from other stakeholders such as the fire brigade.

Rolling stock designers/manufacturers should then provide evidence and validated data that supports the nominated design fire.

5.3 Deemed to satisfy provisions

5.3.1 General

Where different variants of passenger seating are to be installed on a vehicle (e.g., transverse; longitudinal; tip-up), each variant shall be tested to the complete passenger seating requirements in Clause 5.3.2 or Clause 5.3.3.

Integrity and insulation periods when tested to AS 1530.4:2014 are deemed equivalent to the integrity and insulation period requirements stated in EN45545-2:2020+A1:2023 for technical cabinets and fire barriers.

In addition to the product classifications listed under EN 45545-2:2020+A1:2023 Clause 4.2(a), material classified as non-combustible in accordance with AS 1530.1:1994 may be used without the need for further fire performance testing.

Where a different operation category (e.g., reduction in the numerical value from OC4 to OC3) and corresponding hazard level is deemed more appropriate for the rolling stock operation than that designated under EN 45545-1:2013, agreement shall be sought from the RSO and RIM.

5.3.2 Commuter rolling stock

5.3.2.1 Materials

The performance requirements of Clause 5.2 shall be deemed to be satisfied by demonstration of the following:

(a) Combustible materials comply with the requirements of EN 45545-2:2020+A1:2023 Hazard Level 2, unless a higher hazard level is required due to the rolling stock operation category and design category.

(b) Ceiling and wall linings panels comply with the requirements of EN 45545-2:2020+A1:2023 Hazard Level 3, regardless of the hazard level defined by the rolling stock design category and operation category.

(c) Passenger seating components (e.g., upholstered cushions, head rests, arm rests, seat shells, etc.) for all seating variants comply with the requirements for listed product numbers F1A, F1B, F1C, F1D, F1E and F1F under Table 2 of EN 45545-2:2020+A1:2023 Hazard Level 2, unless a higher hazard level is required due to the rolling stock operation category and design category.

(d) Passenger seating complies with the complete passenger seat requirements contained in Clause 5.3.2.2.

5.3.2.2 Complete passenger seats

Complete passenger seats shall be tested in accordance with one of the following two requirement sets:

(a) Requirement set A – as per the F1 product number requirements under Table 2 of EN 45545-2:2020+A1:2023 with the qualifications outlined in this clause; or

(b) Requirement Set B – as per the CSIRO 900g Timber Crib Test EP191022 (2026).

Complete passenger seats tested in accordance with requirement set A shall:

(c) comply with the requirements of EN 45545-2:2020+A1:2023 Hazard Level 2, unless a higher hazard level by the rolling stock operation category and design category; and

(d) be tested in both a vandalized and non-vandalized state, irrespective of whether the maximum vandalization test forces specified in EN16989:2018 are exceeded; and

(e) only be accepted if the test requirements are passed in both the non-vandalized and vandalized states.

Complete passenger seats testing in accordance with requirement set B shall:

(f) be tested in both a vandalized and non-vandalized state; and

(g) comply with all the below acceptance criteria for all tests, within the maximum test time of 20 min:

(i) The peak heat release rate, excluding the peak heat release rate from the ignition source does not exceed 100 kW.

(ii) There is no fire spread (flaming or smouldering) to adjacent seats, which extends beyond the centre line of the adjacent seats (locations defined by line ‘A’ in Figure 1).

(iii) There is no dripping or falling of burning seat material which sustains flaming at floor level for a period exceeding 10 seconds. Burning crib stick material that could fall to the floor is excluded from this criterion.

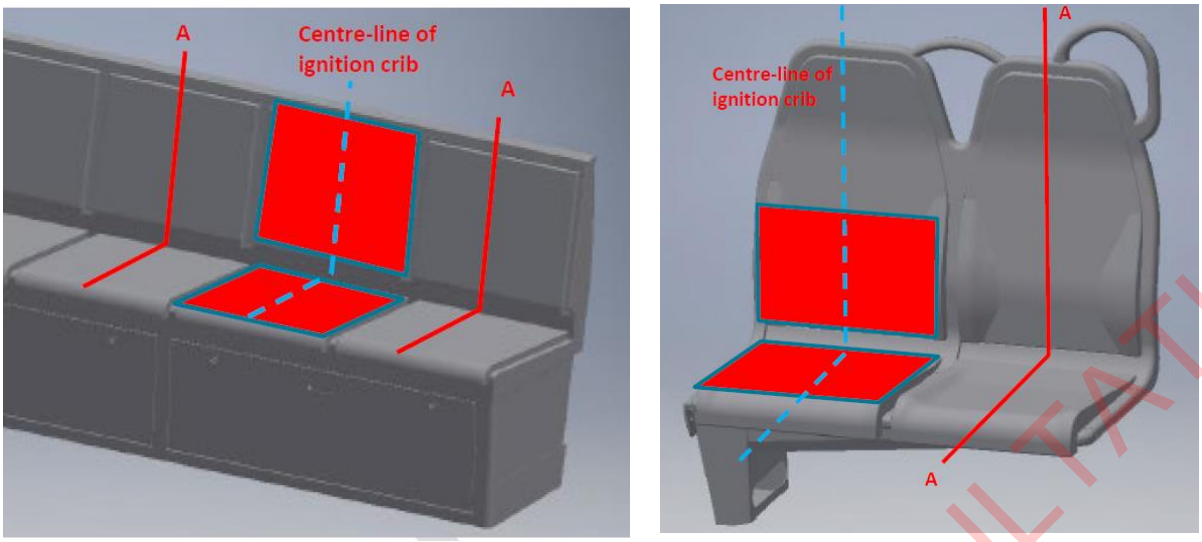

Figure 1 900 g Timber crib mounting location and maximum acceptable fire spread for commuter rolling stock

Acceptance of complete passenger seat tests that have not included full vandalization shall be supported by a performance-based assessment.

5.3.3 Long distance passenger rolling stock

5.3.3.1 Materials

The performance requirements of Clause 5.2 shall be deemed to be satisfied by demonstration of all the following:

(a) Combustible materials comply with the requirements of EN 45545-2:2020+A1:2023 Hazard Level 2, unless a higher hazard level is required due to the rolling stock operation category and design category.

(b) Passenger seating components (e.g., upholstered cushions, head rests, arm rests, seat shells, etc.) for all seating variants for all seating variants comply with the requirements for listed product numbers F1A, F1B, F1C, F1D, F1E, and F1F under Table 2 of EN 45545-2:2020+A1:2023 Hazard Level 2, unless a higher hazard level is required due to the rolling stock operation category and design category.

(c) Passenger seating complies with the complete passenger seat requirements contained in Clause 5.3.3.2.

5.3.3.2 Complete passenger seats

Complete passenger seats shall be tested in accordance with one of following two requirement sets:

(a) Requirement Set A – as per the F1 product number requirements under Table 2 of EN 45545-2:2020+A1:2023 with the qualifications outlined in this clause; or

(b) Requirement Set B – as per the CSIRO 900g Timber Crib Test EP191022:2026 with the qualifications outlined in this clause.

Complete passenger seats tested in accordance with requirement set A shall:

(c) comply with the requirements of EN 45545-2:2020+A1:2023 Hazard Level 2, unless a higher hazard level is required due to the rolling stock operation category and design category; and

(d) be considered acceptable without being tested in a vandalized state on the condition that the EN 16989:2018 criteria for partial or full vandalization are not exceeded.

Complete passenger seats testing in accordance with requirement set B shall:

(e) be tested in a non-vandalized state only; and

(f) comply with the below acceptance criteria for all tests within the maximum test time of 20 min:

(i) There is no fire spread (i.e. flaming or smouldering) to adjacent seats, which extends beyond the opposite edge of the adjacent seats (locations defined by line B in Figure 2).

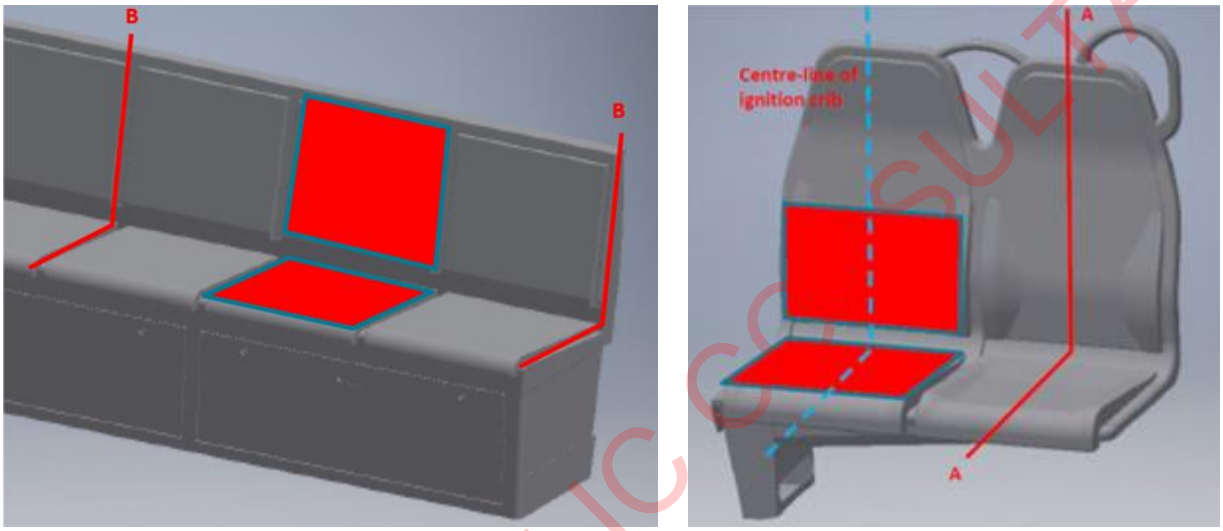

Figure 2 900 g timber crib mounting location and maximum acceptable fire spread for long-distance passenger rolling stock

Commentary *C5.3.3.2*

The complete seat fire test requirements are less stringent for long distance passenger rollingstock compared to commuter rolling stock due to long-distance seats generally requiring a higher level of comfort and having an expected lower risk of exposure to vandalism and arson.

5.3.4 HFS, ESS & EDLC-powered commuter and long-distance passenger rolling stock

The following requirements apply to rolling stock powered by HFS or ESS, in addition to the requirements under Clause 5.3.1, Clause 5.3.2 and Clause 5.3.3:

(a) The use of combustible materials within areas containing hydrogen storage tanks, fuel cells, and batteries shall be minimized SFAIRP, however shall comply with the requirement of EN 45545-2:2020+A1:2023 Hazard Level 3 when used to reduce fire spread, smoke and toxic gas following ignition or thermal runaway.

Commentary C5.3.4(a)

The phrase within areas refers to the following with respect to the fire-resistant enclosures (specified in Section 6) that contain the hydrogen storage tanks, fuel cells, or batteries:

- Internal and external surfaces of the enclosure

- Components within the enclosure (noting containment rules under EN 45545-2:2020+A1:2023 Clause 4.2(h).

More specifically, the above clause applies to structural panels, internal linings and equipment mounting surfaces that can be subject to direct flame impingement or elevated temperatures arising from a fire within the compartment. It does not extend to battery or HFS equipment for which Hazard Level 3 might not be reasonably practicable, or to remotely located equipment connected via piping (e.g., underfloor or roof-mounted lines), unless such equipment is situated within the same defined compartment.

(b) Materials within 3 m of vents for enclosures containing HFS and ESS used for traction shall comply with the requirements of EN 45545-2:2020+A1:2023 Hazard Level 3 to reduce fire spread, smoke and toxic gas following ignition or thermal runaway.

Commentary *C5.3.4(b)*

The phrase within 3 m of vents for enclosures applies to any material that could reasonably be exposed to vented gases or ejected hot particles during an ignition or thermal runaway event. This includes cable trays, ducting and any material located in the projected path of the venting flow whether oriented laterally, vertically or otherwise. Structures mounted underfloor or on the roof could fall within this scope, depending on the venting arrangement and direction. All vents are to be on the exterior of the train, not to the interior of the train. Therefore, the clause only applies to exterior materials, not to interior materials.

Section 6 Fire resistance

6.1 General

Key assemblies, including flooring, cab partitions and equipment compartments, are designed to limit fire spread, particularly in areas impacting crew safety and emergency egress routes. This includes fire hazards from underfloor equipment, adjacent technical compartments and high-energy systems such as ESS and HFS.

This section outlines minimum fire resistance performance for these compartmentation and separation elements, with deemed-to-satisfy provisions suited to various passenger vehicle configurations.

The deemed-to-satisfy provisions are based upon the assumption of a steel bodyshell.

6.2 Flooring

6.2.1 Performance requirements

Flooring assemblies shall resist the spread of potential under floor fires to the passenger and crew compartments.

The degree of fire resisting protection provided by the flooring assembly shall be proportionate to:

(a) the nature of the under-floor fire hazards;

(b) the location of the under-floor fire hazards;

(c) the time required to detect the fire;

(d) the time required for occupants to move to a safe refuge within the rolling stock (if provided);

(e) the time required for the rolling stock to travel to and stop at a suitable location for evacuation; and

(f) the time required for evacuation of rolling stock occupants to a place of safety.

6.2.2 Deemed to satisfy provisions

6.2.2.1 General

The performance requirement of Clause 6.2.1 shall be deemed to be satisfied by the demonstration of compliance with the following for single deck passenger rolling stock:

(a) When test samples complying with Clause 6.2.2.2 are tested in a horizontal orientation in accordance with AS 1530.4:2014, the flooring assembly achieves at least 15 min integrity and 15 min insulation.

The performance requirement of Clause 6.2.1 shall be deemed to be satisfied by the demonstration of compliance with the following for double deck passenger rolling stock:

(b) When test samples of end saloon flooring assemblies and lower saloon flooring assemblies complying with Clause 6.2.2.2 are tested in a horizontal orientation in accordance with AS 1530.4:2014, the flooring assembly achieves at least 15 min integrity and 15 min insulation.

(c) Where the end saloon flooring and lower saloon flooring assemblies are not identical, the separate representative specimens are tested.

Commentary *C6.2.2.1*

There is no fire resistance requirement for the upper saloon floor.

The performance requirement of Clause 6.2.1 shall be deemed to be satisfied by the demonstration of compliance with the following for gangway floors:

(d) When the gangway has inter-vehicle partition walls with inter-vehicle doors complying with Clause 6.4 installed to both ends of the gangway, then the gangway is considered to be fire separated from the passenger interior in the event of a detected fire and no tested fire resistance is required for the gangway floor.

(e) When the gangway has inter-vehicle partition walls with inter-vehicle doors complying with Clause 6.4 installed to only one end of the gangway, then the gangway is considered to be part of the passenger interior fire compartment. In this case a gangway floor specimen complying with Clause 6.2.2.2 is tested in a horizontal orientation in accordance with AS 1530.4:2014, and the gangway flooring assembly achieves at least 15 min integrity (no insulation requirement).

6.2.2.2 Test sample construction

Floor fire resistance test samples shall meet the following requirements:

(a) The primary test sample shall:

(i) be at least 3 m long x the full vehicle width in size;

(ii) be representative in construction of the vehicle passenger area flooring; and

(iii) contain any representative service penetrations, if such elements form part of the vehicle design.

(b) The gangway floor specimen:

(i) shall be separate to the above primary and secondary floor specimens;

(ii) shall be a full-sized gangway floor extending the full width and length of the gangway include the areas which are trafficable and/or covered by solid flooring or treadplate;

(iii) may exclude any flexible bellows areas to the sides of the trafficable treadplate; and

(iv) shall include all representative materials and methods of construction present in the gangway cross-section extending from the underside (typically including underside flexible bellows) to the top trafficable surface, including any seals, insulation and floor linings.

(c) All floor test specimens shall be tested in a horizontal orientation with the fire exposure applied to the underside of the floor only.

(d) A representative loading is not required to be applied to the gangway floor or secondary floor specimens during testing.

Commentary *C6.2.2.2(d)*

A representative loading is not required for typical metal framed train flooring systems with external metal skin. Where a design adopts primarily non-metallic floor structures, such as composite polymer structures, then these can be addressed as performance-based assessments and give consideration to impact of load on fire resistance structural adequacy.

NOTE:

Fire resistance structural adequacy refers to the ability of a loadbearing element of construction to support a load, when tested in accordance with AS 1530.4:2014. This is expressed as a period of time, in minutes for which the test failure criteria are not exceeded.

6.3 Drivers cab

6.3.1 Performance requirements

The design of the partition at the rear of the driver's cab, inclusive of cab door (if present), shall:

(a) prevent the spread of fire into the cab, such that in the event of a fire in the passenger compartment, the driver is protected from the fire while the rolling stock is driven to a place of safety and occupant evacuation completed; and

(b) prevent the spread of fire into the passenger compartment, such that in the event of a fire in a driver's cab, the passengers are protected from the fire while the rolling stock is driven to a place of safety and occupant evacuation completed.

The degree of fire resisting protection provided by the cab rear wall partition assembly shall be proportionate to:

(c) the nature of the fire hazard in the passenger compartment and driver's cab;

(d) the time required to detect the fire;

(e) the time required for the rolling stock to travel to and stop at a suitable location for evacuation; and

(f) the time required for evacuation of rolling stock occupants to a place of safety.

It shall not be possible for fire to spread through the cavity above the passenger ceiling into the driver's cab.

It shall not be possible for fire to spread through the cavity above the driver's cab into the passenger ceiling.

6.3.2 Deemed to satisfy provisions

6.3.2.1 General

The performance requirements of Clause 6.3.1 shall be deemed to be satisfied by the demonstration of compliance with the following:

(a) when test samples complying with Clause 6.3.2.2 are tested in a vertical orientation in accordance with AS 1530.4:2014, the cab rear wall partition assembly achieves at least 15 min integrity and 15 min insulation; and

(b) if the test sample construction is not symmetrical, the testing identified in Clause 6.3.2.1(a) above is repeated to demonstrate that fire resistance is provided from both directions.

6.3.2.2 Test sample construction

Test samples shall be full size, including representative constructions extending from the top of the fire resisting floor to the underside of the vehicle roofline.

If the dimensions of the full-size test samples exceed that of the furnace opening, the maximum dimension of the samples in either direction shall be 3 m.

Test samples shall contain representative service penetrations and doors, if such elements form part of the vehicle design, and if necessary to demonstrate the insulation performance of the design.

Any items attached to the wall (e.g., advertising panels) shall be included in the test sample.

6.4 Inter-vehicle partitions

6.4.1 Performance requirements

Inter-vehicle partitions shall be provided, where appropriate, between passenger vehicles, to limit the spread of fire and smoke between vehicles.

The number of inter-vehicle partitions and the degree of fire resisting protection provided by the inter-vehicle partitions shall be proportionate to:

(a) the risk of fire and smoke spreading to a passenger compartment from an adjacent vehicle or from the underframe area through the gangway;

(b) the time required to detect the fire;

(c) the time required for occupants to move to a safe refuge within the rolling stock (if provided);

(d) the time required for the rolling stock to travel to and stop at a suitable location for evacuation; and

(e) the time required for evacuation of rolling stock occupants to a place of safety.

Any inter-vehicle partitions shall include provisions for egress as required by Section 12.

Commentary *C6.4.1*

Inter-vehicle partitions doors can be normally closed or normally held open and closed upon fire detection.

6.4.2 Deemed to satisfy provisions

6.4.2.1 General

The performance requirement of Clause 6.4.1 shall be deemed to be satisfied by the demonstration of compliance with the following:

(a) At least one fire and smoke resistant inter-vehicle partition is provided between every vehicle.

(b) Inter-vehicle partitions extend across the whole vehicle cross-section including any wall or ceiling cavities.

(c) Inter-vehicle partition wall assembly test samples complying with Clause 6.4.2.1 and tested in a vertical orientation in accordance with AS 1530.4:2014 inter-vehicle partition wall assembly test samples complying with Clause 6.4.2.2 achieving at least 15 min integrity (no insulation requirement).

(d) Each inter-vehicle partition contains a window or vision panel with a minimum total area of 0.5 m^2. Where an inter-vehicle partition is provided on both sides of a gangway, the windows or vision panels are to align to provide a line of sight into the adjacent vehicle.

(e) Any doors within the inter-vehicle partition are fitted with medium temperature rated smoke seals, tested to a minimum of 200°C.

(f) Any doors within the inter-vehicle partition comply with the requirements of Section 12.

Commentary *C6.4.2*

The deemed to satisfy provision requires a minimum of one inter-vehicle partition between every vehicle. However, this does not prevent other arrangements where suitably assessed as performance-based solutions.

It might not be cost effective or practical to achieve 15 min insulation for the inter-vehicle partition given that windows are required and therefore 15 min integrity only is required.

Inter-vehicle partition wall assembly test samples complying with Clause 6.4.2.1 shall be tested in a vertical orientation in accordance with AS 1530.4:2014 and shall achieve at least 15 min integrity (no insulation requirement).

6.4.2.2 Test sample construction

Test samples shall be full size and be representative of the vehicle end assembly. This includes the space above the passenger ceiling to the underside of the roofline.

If the dimensions of the full-size test samples exceed that of the furnace opening, the maximum dimension of the sample shall be reduced so that the maximum dimension in either direction shall be 3 m.

If the sample is reduced in size, it shall include all representative elements of construction.

Test samples shall contain representative service penetrations, doors and windows and the representative door hardware and closing/latching mechanisms.

The requirements of AS 1530.4:2014, Section 4 for non-load bearing walls shall be applied to the wall components of the test specimen, except that the size of the wall specimen may be reduced to be representative of the actual train design.

The requirements of AS 1530.4:2014, Section 7 shall be applied to the door components of the test specimen.

The requirements of AS 1530.4:2014, Section 8 shall be applied to the window components of the test specimen.

Where the inter-vehicle partition wall and door system layout is not the same on both sides, (e.g., due to equipment cupboards), then two separate fire resistance tests shall be undertaken to test with fire exposure on each side separately.

6.5 Checked luggage compartments

6.5.1 Performance requirements

Compartments onboard passenger rolling stock that are unmanned and intended for the storage of passenger luggage or consigned freight shall be separated from adjacent compartments by fire resisting partitions.

The degree of fire resisting protection provided by the luggage compartment partitions shall be proportionate to:

(a) the fire load within the luggage compartment when filled with luggage to design capacity;

(b) the potential for a fire in the luggage compartment to be detected in its early stages of development;

(c) the potential for a fire within the luggage compartment to be extinguished in its early stages of development; and

(d) the hazard presented by a fire in the luggage compartment to rolling stock occupants and other users of the infrastructure.

It shall not be possible for fire to spread through any cavities above the luggage compartment into adjacent compartments.

6.5.2 Deemed to satisfy provisions

6.5.2.1 General

The performance requirement of Clause 6.5.1 shall be deemed to be satisfied by the demonstration of compliance with the following:

(a) When test samples complying with Clause 6.5.2.2 are tested in a vertical orientation in accordance with AS 1530.4:2014, each luggage compartment partition achieves at least 30 min fire integrity.

6.5.2.2 Test sample construction

The test samples shall be full size.

If the dimensions of the full-size test samples exceed that of the furnace opening, the maximum dimension of the samples in either direction shall be 3 m.

Test samples shall contain representative service penetrations and doors, if such elements form part of the vehicle design, and if necessary to demonstrate the insulation performance of the design.

6.6 Compartments containing sleeping facilities

6.6.1 Performance requirements

Compartments onboard passenger rolling stock where sleeping facilities are provided shall be separated from one another, and the corridor, by fire resisting construction.

The degree of fire resisting protection provided by the sleeping compartment partitions shall be proportionate to:

(a) the nature of the fire hazard in the sleeping compartment;

(b) the time required to detect the fire;

(c) the time required for occupants in the vicinity at risk compartments to be made aware of the fire;

(d) the time required for evacuation of rolling stock occupants to be completed from at-risk compartments to a safe refuge; and

(e) the time required for evacuation of rolling stock occupants to a place of safety.

The fire resisting construction shall extend into the cavity between the passenger compartment ceiling and the roofline to ensure that the roof space does not present a route for fire spread from one compartment to the next.

Doors in fire resisting sleeping compartment partitions shall include appropriate smoke seals on vertical and header planes to prevent the transfer of ambient and medium temperature (i.e. ≤200°C) smoke.

6.6.2 Deemed to satisfy provisions

6.6.2.1 General

The performance requirements of Clause 6.6.1 are deemed to be satisfied by the demonstration of compliance with the following:

(a) when test samples complying with Clause 6.6.2.2 are tested in a vertical orientation in accordance with AS 1530.4:2014, each sleeping compartment partition shall achieve at least 20 min integrity and insulation.

(b) sleeping compartment doors shall be fitted with medium temperature rated smoke seals, tested to a minimum 200°C.

6.6.2.2 Test sample construction

Test samples shall be full size.

If the dimensions of the full-size test samples exceed that of the furnace opening, the maximum dimension of the samples in either direction shall be 3 m.

Test samples shall contain representative service penetrations and doors, if such elements form part of the vehicle design, and if necessary to demonstrate the insulation performance of the design.

6.7 Cubicles or equipment enclosures containing high power equipment

6.7.1 Performance requirements

Enclosures (i.e. compartments, cubicles or equipment cases) containing high-power electrical power equipment or batteries shall be separated from passenger and crew compartments by fire resisting construction.

The degree of fire resisting protection provided shall be proportionate to:

(a) the potential growth rate and size of fires which could occur in the enclosure;

(b) the time required to detect the fire;

(c) the time required for occupants to move to a place of relative safety within the rolling stock (if provided);

(d) the time required for the rolling stock to travel to and stop at a suitable location for evacuation; and

(e) the time required for evacuation of rolling stock occupants to a place of safety.

6.7.2 Deemed to satisfy provisions

The performance requirement of Clause 6.7.1 shall be deemed to be satisfied by the demonstration of compliance with the following:

(a) Enclosures (i.e. compartments, cubicles or equipment cases) containing high-power electrical voltage traction circuit equipment shall be separated from passenger and crew compartments by construction which provides 15 min fire resisting integrity.

(b) Demonstration of the level of fire resistance achieved between enclosures containing high-voltage traction circuit equipment and passenger and crew compartments shall be provided. It shall include:

(i) The materials of enclosure construction and their fire resistance level. Where an official level of fire resistance is not available from literature, testing to AS 1530.4:2014 is to be performed.

(ii) Any penetrations into the enclosure to be fire sealed to prevent the passage of fire by materials which have been tested to AS 1530.4:2014 and achieved at least 15 min fire resisting integrity

(iii) The ability of the enclosure to maintain its containment and shape when exposed to the elevated temperatures associated with a fire. Where any doubt exists, ad-hoc testing to be completed on full size assemblies and no gaps shall open up which would cause a loss of fire resisting integrity as defined by AS 1530.4:2014.

6.8 Compartments containing combustion engines

6.8.1 Performance requirements

Compartments of passenger rolling stock containing combustion engines shall be separated from passenger and crew compartments by fire resisting construction.

The degree of fire resisting protection provided shall be proportionate to:

(a) the potential growth rate and size of fires which could occur in the engine compartment;

(b) the time required to detect the fire;

(c) the time required for occupants to move to a safe refuge within the rolling stock (if provided);

(d) the time required for the rolling stock to travel to and stop at a suitable location for evacuation; and

(e) the time required for evacuation of rolling stock occupants to a place of safety.

6.8.2 Deemed to satisfy provisions

The performance requirement of Clause 6.8.1 shall be deemed to be satisfied by the demonstration of compliance with the following:

(a) When test samples complying with Clause 6.8.2.1 are tested in a vertical orientation in accordance with AS 1530.4:2014, the partition wall that separates

engine compartments onboard passenger rolling stock from passenger and staff compartments achieves 15 min integrity and 15 min insulation.

(b) The fire resisting construction extends to the roofline of the vehicle.

6.8.2.1 Test sample construction

Test samples shall be full size.

If the dimensions of the full-size test samples exceed that of the furnace opening, the maximum dimension of the samples in either direction shall be 3 m.

Test samples shall contain representative service penetrations and doors, if such elements form part of the vehicle design, and if necessary, to demonstrate the insulation performance of the design.

6.9 ESS, HFS & EDLC equipment fire resistance compartmentation

6.9.1 Performance requirements

ESS and HFS equipment for propulsion or auxiliary power shall be separated from passenger and crew compartments, and from exterior areas that can impact egress or life safety, by fire resisting construction.

The degree of fire resisting protection provided shall be proportionate to:

(a) the potential growth rate and size of fires which could occur in these compartments;

(b) the time required to detect the fire;

(c) the time required for occupants to move to a safe refuge within the rolling stock (if provided);

(d) the time required for the rolling stock to travel to and stop at a suitable location for evacuation; and

(e) the time required for evacuation of rolling stock occupants to a place of safety.

Additionally, support framing for HFS systems shall provide structural integrity under the fire case to avoid escalation of any initial events.

6.9.2 Deemed to satisfy provisions

6.9.2.1 General

The performance provision of Clause 6.9.1 shall be deemed to be satisfied by the demonstration of compliance with the following sections.

6.9.2.2 ESS, HFS & EDLC equipment below floors or behind cab partition walls

Where ESS or HFS equipment is installed below floor level, or where underframe/bogie equipment is required to be separated from a potential fire in ESS or HFS equipment installed above floor level, the level of fire resistance provided by the vehicle flooring shall be demonstrated by the following:

(a) be validated by a formal risk assessment; and

(b) not be less than 30 min integrity and 30 min insulation when samples complying with Clause 6.2.2 are verified by testing in a horizontal orientation in accordance with AS 1530.4:2014.

Where ESS or HFS equipment is installed adjacent to or directly behind the cab partition wall, the level of fire resistance provided by that wall shall be demonstrated by Clause 6.9.2.2(a) and Clause 6.9.2.2(b).

Commentary *C6.9.2.2*

The above is in addition to the ESS or HFS equipment enclosure fire resistance requirements and has been included to cater for higher battery capacity burning hotter.

The above does not apply to auxiliary power batteries if each battery pack enclosure (not module) does not exceed 50 kWh total capacity.

6.9.2.3 ESS, HFS & EDLC equipment enclosure fire resistance

ESS and HFS equipment shall be contained within separate equipment enclosure fire compartments.

Any vents from the equipment enclosure shall:

(a) discharge only to the train exterior and not discharge to the passenger or crew interior area or any other interior area;

(b) not discharge to external areas which are in close proximity to vehicle exits, external evacuation paths or HVAC intakes; and

(c) not be located within 400 mm of any combustible material either on the exterior of the enclosure or anywhere else on the train, excluding the combustible contents internal to the equipment enclosure.

Where the equipment enclosure is located within the train interior, the level of fire resistance provided by the equipment enclosure shall:

(d) be validated by a formal risk assessment; and

(e) be tested in their corresponding orientation in accordance with AS 1530.4:2014 and achieving not less than 30 min integrity and 30 min insulation.

Where the equipment enclosure is located on the train exterior, the level of fire resistance provided by the equipment enclosure shall comply with Clause 6.9.2.2(d) and Clause 6.9.2.2(e).

Where the ESS is for auxiliary power only and each battery pack enclosure (not module) does not exceed 50 kWh total capacity, then the fire resistance of the battery enclosure is permitted to be reduced to the following:

(f) Enclosures located within the train interior shall be tested in their corresponding orientation in accordance with AS 1530.4:2014, applying the AS 1530.4:2014 standard time vs temperature exposure curve, and achieving not less than 15 min integrity and 15 min insulation.

(g) Enclosures located on the train exterior shall be tested in their corresponding orientation in accordance with AS1530.4:2014, applying the AS 1530.4:2014 standard time vs temperature exposure curve, and achieve not less than 15 min integrity (no insulation requirement).

Test samples shall:

(h) be full size;

(i) if the dimensions of the full-size test sample exceed that of the furnace opening, have maximum dimensions in either direction of 3 m and the specimen designed to incorporate all representative elements of the full sized design;

(j) contain representative vents, services penetrations, doors and access panels, if such elements form part of the vehicle design;

(k) allow the fire exposure in the test to be from the interior; and

Commentary *C6.9.2.3(k)*

To enable this exposure, the enclosure specimen may be cut so that one side or cross-section of the enclosure is fully open and this open side/section is installed and sealed into the test furnace.

(l) not extend more than 2 m outside the test furnace.

The AS 1530.4:2014 requirements for test method, measurements and acceptance criteria shall be applied with the following modifications:

(m) No thermocouples applied within 400 mm of any vent.

(n) The cotton pads are not applied in assessing integrity of any vent. However, the AS 1530.4:2014 gap gauge and flaming criteria for integrity is to be applied to all vents.

Section 7 Portable fire extinguishers and fire blankets

7.1 General

Portable fire extinguishers provide a first line of defence against small, accessible fires in rolling stock.

They are suited to incidents involving combustible materials, oils or low-voltage electrical equipment, where rapid manual intervention can contain the fire and prevent escalation.

7.2 Fires involving HFS, ESS and EDLC

HFS fires can produce high heat and low-visibility flames that persist in low-oxygen environments, reducing the effectiveness of conventional agents such as CO_2 or foam. Depending on the storage design and failure mode, HFS events could also involve high-velocity jet-flame discharge or the mechanical ejection of components following rapid gas expansion.

ESS fires can involve thermal runaway, generating intense heat and toxic gases, with the potential for delayed re-ignition. Thermal-runaway events could also result in the release of flammable vapours, rapid gas discharge or the mechanical ejection of cell or enclosure components.

In these cases, portable extinguishers are not suitable for suppressing the primary fire and manual intervention by train crew with portable fire extinguishers might not be safe.

Nonetheless, extinguishers remain valuable for managing secondary fires in adjacent components, such as cabling, linings or equipment affected by heat or flame spread. Their use in these circumstances can limit further damage and assist safe evacuation.

7.3 Performance requirements

Passenger rolling stock shall be provided with an adequate number of suitably sized portable fire extinguishers compliant with AS/NZS 1841.1:2007.

The number, size, type and installation location of portable fire extinguishers shall take into consideration:

(a) the nature of the fire hazards within the rolling stock;

(b) the potential size of any fires which might occur on the rolling stock; and

(c) the type of fire fuel present, ensuring that suppression methods are appropriate for specific risks, such as:

(i) oil-based fires requiring wet chemical extinguishers;

(ii) fire blankets to prevent spread and flashover;

(iii) where cooking facilities involving the heating of oils or fats are provided, fire blankets to be fitted in appropriate locations; and/or

(iv) the accessibility of fire extinguishers in case of an emergency, ensuring placement and signage comply with relevant safety standards for rapid response.

7.4 Deemed to satisfy provisions

Commuter rolling stock shall be equipped with not less than one 4.5 kg dry powder fire extinguisher, compliant with AS/NZS 1841.1:2007 in:

(a) each driver's cab; and

(b) the passenger area within each vehicle.

Fire extinguishers located in passenger areas on commuter rolling stock:

(c) shall not be located under priority seating; and

(d) may be stored in a locked or alarmed cabinet to deter vandalism and theft.

Long distance passenger rolling stock shall be equipped with not less than one 4.5 kg dry powder fire extinguisher.

Long distance passenger rolling stock with sleeping facilities shall be equipped with not less than two 4.5 kg dry powder fire extinguishers, with one positioned at each end of the vehicle.

Where cooking facilities are located, an additional fire extinguisher shall be provided.

Where cooking facilities involving heating of oils or fats on open heating elements are provided, fire blankets compliant with AS/NZS 3504:2006 shall be fitted in locations compliant with the requirements of AS 2444:2001.

Fire extinguishers shall remain functional and accessible during all operating conditions.

Signage for fire extinguishers and fire risk areas shall comply with AS 1319:1994.

Section 8 Crew/passenger ventilation system control

8.1 General

Effective airflow management during a fire helps isolate smoke, protect occupants and support safe evacuation.

8.2 Performance requirements

In the event of fire internal or external to the rolling stock, it shall be automated or possible for the driver or train crew to control the ventilation systems to reduce smoke spread and assist with smoke hazard management.

8.3 Deemed to satisfy provisions

Where passenger or staff areas are protected by a fire detection system, ventilation system response upon activation of that system is defined in Section 9.

It shall be possible for the driver or train crew to manually over-ride the automated response.

To prevent smoke from outside the train entering the vehicle, it shall be possible for the driver or train crew to shut off means of external ventilation.

The shutdown of external ventilation can also, in addition to manual control from the driver or train crew, be triggered automatically by external smoke detectors positioned in the fresh air intakes of the

ventilation system. The response to activation from these detectors can be at a vehicle level or a train level.

In either case, with or without an external smoke detection system, the design should allow for the automatic reopening of the external ventilation outlets after a pre-determined time to ensure that fresh air requirements of passengers and crew are met.

Section 9 Fire detection and suppression systems

9.1 General

Fire detection and suppression systems minimize the impact of onboard fires in passenger rolling stock. Integration with control systems, including BMS and hydrogen safety protocols, supports hazard response and maintains operational safety.

Detection and suppression in high-risk areas enable early intervention, prevent escalation and support safe train operations and evacuation.

Performance-based and deemed-to-satisfy requirements apply to detection and extinguishing systems in passenger rolling stock.

9.2 Performance requirements

9.2.1 Fire detection and alarm systems

Fire detection systems shall be fitted to passenger rolling stock.

The type and arrangement of detectors shall be designed and tested to achieve a high level of reliability in detecting fires and/or gases and minimize the frequency of unwanted alarms.

When actuated, fire detection systems shall provide a visual and audible alarm to the train crew at their normal working locations, or to the control centre for driverless trains.

Faults and alarms shall be clearly perceptible to the train crew or remote operations monitoring location for driver-less trains under all operating conditions and comply with AS 7533:2021, Section 14.

If the fire detection system has a fault or is inoperative for any reason, this shall be indicated to the driver or train crew, or to the control centre for driverless trains.

Commentary *C9.2.1*

Onboard fire or smoke detection is required due to the benefit this provides in early detection and response to fires. Avoidance of unwanted alarms under all credible conditions including localised interior or exterior smoke sources or high atmospheric smoke conditions (e.g., from bushfires) is not reasonably practicable. The type, arrangement and sensitivity of the detection system needs to optimally balance early detection but also minimise the frequency of unwanted alarms.

NOTE:

It is expected that RSOs have procedures in place to enable safe continued operation of rolling stock during times of high atmospheric smoke conditions (e.g., from bushfires) which expects that detection system unwanted alarms are possible. Such procedures can require additional temporary measures to monitor the safety of the rollingstock in the event of such unwanted alarms.

Fire detection devices shall be reliable and activate consistently in all modes of service.

Fire detection devices shall be functionally suitable for the expected fire products, for example, flames, smoke and heat.

9.2.2 Fixed fire extinguishing systems

Fixed fire extinguishing systems shall be fitted to areas of rolling stock containing combustion engines.

Provision of fixed fire extinguishing systems to other areas shall be determined through a risk assessment that takes into account the:

(a) likelihood and consequence of a fire that it would address;

(b) space required;

(c) duration of suppression it provides;

(d) the weight it adds to the rolling stock;

(e) risk of unwanted discharge;

(f) ongoing maintenance costs; and

(g) testing and certification that the system has achieved.

If the fixed extinguishing system has a fault or is inoperative for any reason, this shall be indicated to the driver or train crew. For HFS and ESS passenger rolling stock, these requirements do not apply to auxiliary battery power systems. These requirements only apply to ESS and HFS equipment for traction power.

9.2.3 ESS, EDLC & HFS equipment

In addition to Clause 9.2.1 and Clause 9.2.2, fire protection measures applied to ESS and HFS shall detect, contain and mitigate thermal events or gas releases before they reach hazardous levels.

When actuated, gas detection alarm systems shall provide a visual and audible alarm to the train crew at their normal working locations, or to the control centre for driverless trains.

Where hydrogen or battery-powered propulsion systems are present, a gas detection system shall be installed within the enclosure in addition to the fire detection system.

Gas detection alarms shall be clearly perceptible to the train crew or remote operations monitoring location for driver-less trains under all operating conditions and comply with AS 7533:2021, Section 14.

If the gas detection system has a fault or is inoperative for any reason, this shall be indicated to the driver or train crew or to the control centre for driverless trains.

Where the documented fire risk assessment identifies that credible ESS/HFS fire scenarios could require an onboard extinguishing or system, the system shall be designed to prevent the escalation of thermal events and limit the release of hazardous substances.

In addition, the fire safety strategy shall:

(a) define the intended outcome of installed systems (e.g., control, containment, prevention of propagation); and

(b) provide design provisions to support emergency responder operations, including provision of an external firefighting access/interface where appropriate.

Fire detection for ESS and HFS shall include detection of the specific failure phenomena associated with these technologies, including:

(c) hydrogen gas leaks below the lower flammability limit;

(d) hydrogen flame detection using technology suitable for low-visibility flames; and

(e) ESS thermal runaway indicators such as off-gas detection or abnormal temperature rise.

Fire detection and suppression for ESS and HFS shall be integrated with relevant control systems, including the BMS and hydrogen safety controls, to support isolation, controlled venting and automatic shutdown where appropriate.

Detection systems for ESS and HFS shall be capable of identifying early-stage events such as hydrogen accumulation or ESS off-gas emissions prior to ignition.

Commentary *C9.2.3*

Asset protection is excluded from the scope of this document. However, faults during charging or re-fuelling activities for ESS and HFS can present an increased risk of fire or deflagration. If such events occur whilst stabled at depots in close proximity to adjacent assets, there could be a risk of fire spread between assets and increased asset loss. Consideration can be given to providing fire and gas detection systems which continue to operate during charging, re-fuelling and un-manned stabling. Consideration can be given to providing automatic notification to depot site fire detection control and indication equipment, depot security offices, or network operations centres for such events.

9.3 Deemed to satisfy provisions

9.3.1 Fire and gas detection and alarm systems

Fire detection and alarm equipment shall be provided to monitor the areas specified in Table 1. The type of detection required in each area is also specified in Table 1.

Table 1 – Areas requiring fire detection

Train Type	Passenger areas	Toilets	Staff areas	Sleeper compartments	Luggage compartment	Cooking or catering areas	Combustion engines	Technical cabinets containing traction equipment [b]	Lithium ion batteries for auxiliary power	ESS Or HFS compartments for High Power [e]
Commuter rollingstock	SD[d]	SD	SD	N/A	SD	TD[d]	TD	TD	TD	TD GD
Long distance passenger rolling stock	SD	SD[a]	SD	SD	SD	TD	TD	TD	TD	TD GD

- SD indicates smoke detection required
- TD indicates thermal detection requirement
- GD indicates gas detection as defined in 9.3.1
- [a] There are no requirements to include detection in toilets located inside sleeper compartments. However, the sleeper compartment shall be provided with smoke detection.
- [b] Does not apply to traction motors exterior to train. Does apply to traction transformers/power converters at any location on train.
- [c] Open or enclosed gangways are not considered corridors and do not typically need monitoring by fire detection.
- [d] These areas are unlikely to be present on these types of trains. If they are present, then detection is required.
- [e] For HFS it is recommended that hydrogen flame detection is installed.

Fire detection and alarm systems shall also be provided to monitor the following other areas:

(a) In nominally unoccupied compartments intended for in-service storage of freight parcels.

(b) Diesel burning or combustion heaters.

(c) Areas of vehicles where required to ensure the compliance of the running capability concept defined in Section 10 of this document.

Fire detection and alarm equipment shall:

(d) be functionally suitable for the expected fire products (e.g., flames, smoke and heat);

(e) be tested and certified by an accredited authority for compliance with the relevant parts of either:

(i) AS/ISO 7240:2025; or

(ii) EN 54 (all parts).

(f) be certified as compliant with EN 50155:2021;

(g) be selected to have a suitable activation threshold to reliably provide early detection whilst minimizing frequency of unwanted alarms due to the range of normal expected equipment operating temperatures or small smoke incidents such as cigarette smoke at platforms;

(h) include control and indicating equipment to monitor the status of the detection devices and indicate and alarm;

(i) provide audible and visual alarm devices in the crew cab at the crew working position;

(j) for driverless trains, include communication facilities for all alarms and CCTV video to be communicated immediately to the operational control centre. The control centre is to be provided with audible and visual alarm devices at a human operated monitoring station;

(k) be operational when the rolling stock is operational and in service; and

(l) automatically indicate any faults for any fire detection and alarm equipment to the crew and/or operational control centre.

During design and commissioning, functional testing should be conducted in accordance with AFEG.

Testing should be conducted on a complete fire detection and alarm system installed to a complete carriage under the various different locations and HVAC operational conditions specified by AFEG for smoke detection in passenger and staff compartments.

The smoke detection system in passenger and staff compartments shall respond in accordance with AFEG (2021) requirements or other suitable methods after beginning smoke release under all operational conditions.

Fire detection systems shall automatically initiate the following actions upon activation:

(m) Activate an audible and visual alarm to alert the driver or train crew at their working position. The audible alarm is to be clearly perceptible to the train crew or remote operations monitoring location for driver-less trains under all operating conditions and comply with AS 7533:2021.

(n) Provide a visual alarm to the driver or train crew indicating in which zone of the vehicle the fire detection system has activated.

(o) Where CCTV coverage is provided, automatically display the zone in which the fire detection system has activated.

(p) In sleeping compartments, activate an additional local alarm fitted in the vicinity of the activated fire detector. The volume of this local alarm to be 15 dB greater than background noise levels to enable it to wake a sleeping person.

(q) Other than for sleeping compartments, an automated alarm does not need to be provided to passenger areas where there are facilities and procedures for crew or operational control centre to alert and direct passengers via PA system and visual information displays.

(r) Initiate appropriate automatic actions to minimize the hazard posed by the fire which includes:

(i) stopping HVAC in the passenger areas or staff area for the car of fire detection;

(ii) closing all inter-vehicle partition doors that could be held open and disengaging any automatic optical proximity detectors that can re-open inter-vehicle doors;

(iii) selective isolation of fuel supply to the relevant equipment for fire detection in combustion engines or fuel burning equipment;

(iv) selective isolation of hydrogen supply to relevant HFS equipment where fire is detected;

(v) selective isolation of electrical power to/from the relevant equipment for fire detection in traction equipment, auxiliary battery equipment, ESS or HFS equipment for traction power or other electrotechnical equipment fitted with fire detection; and

(vi) activate fixed fire extinguishing systems, if installed.

Such automatic actions shall be consistent with the running capability objectives defined in Section 10 of this document.

Where a detection system can isolate equipment, it shall be ensured that running capability is maintained either by separate redundant systems or continued operation in a degraded mode.

In designing the fire alarm system for the passenger compartment, reference shall also be made to the *Disability Discrimination Act* (1992) which contains additional requirements.

Gas detection systems installed for HFS and ESS traction equipment shall be compliant to ISO 26142:2010, IEC 60079-29-1:2016 or IEC 60079-29-2:2015 and be fitted:

(s) near storage, piping, enclosures, roof ducts, equipment cabinets, and any area where hydrogen can accumulate; and

(t) in the exhaust of the battery storage.

Gas detection systems, upon activation at lower alarm level, shall:

(u) activate an audible and visual alarm to alert the driver or train crew at their working position;

(v) emit an audible alarm that is 10 dB greater than background noise levels.

Gas detection systems, upon activation at higher alarm level, shall:

(w) trigger automatic shutdown of hydrogen supply (in case of fuel cell); and

(x) send emergency messages to train control warning.

Commentary *C9.3.1*

The risk of gas build up can be reduced by increasing the monitoring of the ventilation gas detection and ventilation boost.

Reliability of fire and gas detection systems shall be considered as part of vehicle level reliability studies.

9.3.2 Fire extinguishing systems

Fixed fire extinguishing systems, compliant to AS 5062:2022, shall be fitted to:

(a) underframe mounted diesel engines of multiple unit passenger rolling stock;

(b) underframe mounted diesel burning air heaters;

(c) electrical cabinets and equipment cases containing traction circuit power equipment such as traction converters, auxiliary converters, and transformers on automatic, unstaffed, passenger rolling stock; and

(d) areas of vehicles required to ensure the compliance of the running capability concept defined in Section 10 of this document.

The design of the extinguishing system, shall assess the:

(e) impact of train speed on fire extinguishing capability;

(f) status of other train systems which can make fire extinguishing difficult or ineffective (e.g., forced ventilation and pressurised fuel supply systems); and

(g) objectives of running capability defined in Section 10 of this document.

Fixed fire extinguishing systems shall operate in all vehicle orientations.

If the fixed fire extinguishing system has a fault or is inoperative for any reason, this shall be indicated to the driver or train crew or to the control centre for driverless trains.

9.3.3 Additional requirements for HFS, ESS and EDLC-powered multiple unit rolling stock

These requirements do not apply to auxiliary battery power systems. These requirements only apply to ESS and HFS equipment for traction power.

These requirements apply:

(a) where fire suppression is necessary;

(b) based on the outcomes of a documented fire risk assessment; or

(c) as required by operational conditions, such as tunnel operations or the carriage of flammable gases.

These requirements are in addition to the requirements of Clause 9.3.1 and Clause 9.3.2.

ESS and HFS equipment for traction power shall be provided with:

(d) thermal fire detection as per Clause 9.3.1 to indicate when a fire is detected; and

(e) gas detection as per this section.

For HFS, hydrogen gas detection shall be provided within HFS enclosures.

The type of gas detection for ESS shall be determined by risk assessment to be suitable for the specific type of battery technology used to detect onset of thermal runaway at an early time.

NOTE:

For ESS, gas detection can include either hydrogen gas, carbon monoxide gas or hydrogen fluoride gas detection, or other gas species detection.

Fire protection measures for ESS shall be designed in accordance with recognized standards addressing the unique hazards of these technologies.

NOTE:

Suitable reference standards include AS 7486:2026 and international standards such as IEC 62928:2017 and CSA T-S 602:2023.

The suppression system shall be compatible with the configuration and failure characteristics of the ESS and shall be validated for effectiveness under representative fault and fire conditions.

Commentary *C9.3.3-3*

Fire suppression strategies for ESS are influenced by the specific failure behaviours of the battery system, including thermal runaway, release of flammable vapours, re-ignition and emission of hazardous substances. Lithium-ion batteries using fluorinated electrolytes (e.g., $LiPF_6$) can produce hydrogen fluoride (HF)—a corrosive and toxic gas—through reaction with moisture during thermal events. Fires can also generate combustible vapours and phosphorus oxides, which could present additional health and equipment risks, particularly in enclosed or poorly ventilated environments.

UL 9540A is a test method, not a certification, that evaluates thermal runaway behaviour in energy storage systems. It characterizes propagation, heat release rate and hazardous gas emissions (including HF) and can be used to assess the effectiveness of suppression or containment under representative fault conditions. In the context of rolling stock, UL 9540A provides a recognized verification pathway for risks associated with ESS fire events that are not fully addressed in the EN 45545 series or other railway standards.

Integration of fire suppression with the BMS shall support effective fault response, including isolation, alerting and mitigation of gas release or thermal propagation.

For HFS, fire protection design shall follow established and emerging standards, such as IEC 63341-2:2025, CSA TS-601:2024, ISO 16111:2018 and ISO 13985:2006. These standards provide requirements for safety, fire protection and system design relevant to hydrogen applications in rail and other land transport vehicles.

NOTE:

NFPA 2 can also be used to inform general hydrogen safety provisions where rail-specific standards are not available.

The principles of AS 5062:2022 shall be applied to support hazard identification, system classification and the selection of suppression technologies appropriate to the environment and fuel type.

The following requirements are derived from and extend the application of the referenced HFS and ESS standards. These requirements apply to support the compliant implementation of fire protection measures in the following cases:

(f) In compartments containing or exposed to hydrogen emissions—whether from hydrogen fuel systems, energy storage systems or as a by-product of thermal events—fire suppression shall be integrated with controlled venting, battery system isolation and automatic shutoff functions.

(g) Where passive venting is incorporated into battery designs, the compartment shall be configured to safely disperse gases and prevent accumulation.

(h) Detection methods shall be appropriate to the hazards present. Methods can include:

(i) off-gas and thermal runaway indicators for ESS; and

(ii) hydrogen sensors, high-temperature sensors, flame detectors for HFS systems.

(i) Fire detection and suppression systems shall be integrated with other onboard systems, including other fixed fire suppression systems, BMS, BTMS, hydrogen safety controls and ventilation.

For HFS, the fire protection strategy shall include hydrogen detection, ventilation control, automatic shutoff of the hydrogen supply and integration with pressure relief devices, TPRD and compartment venting systems.

Section 10 Running capability in the event of fire

10.1 General

The rail vehicle shall maintain sufficient operational capability to reach a designated safe stopping location in the event of a developing fire.

Commentary *C10.1*

The objective is to reduce risks to passengers, crew and infrastructure by supporting continued controlled movement under initial fire conditions. The requirements address the differing operational contexts of passenger and freight locomotives and include deemed-to-satisfy provisions.

10.2 Availability of essential train systems

10.2.1 Performance requirements

Traction and braking systems onboard passenger rolling stock shall be designed such that in a developing fire event the rolling stock can proceed to a place of safety on the network to evacuate its occupants.

The degree of protection provided to the traction and braking systems shall be proportionate to the:

(a) nature of the fire hazards facing these systems;

(b) time required to detect the fire;

(c) time required for the rolling stock to travel to and stop at a suitable location for evacuation; and

(d) time required for evacuation of rolling stock occupants to a place of safety.

Fires which could occur within equipment cases considered fire sealed in accordance with Clause 6.7.2(b)(ii) above do not need to be considered developing fires for the purposes of assessment against this clause.

10.2.2 Deemed to satisfy provisions

The performance requirements of Clause 10.2.1 shall be deemed to be satisfied by demonstration of 15 min continued running capability in event of fire, assessed in compliance with EN 50553:2012 + A2:2020.

Running capability shall be maintained for the following fire types:

(a) Interior Type 2 fires.

(b) Exterior Type 2 fires.

(c) Any fire involving ESS or HFS.

NOTE:

Type 2 fires are defined by EN50553:2012+A2:2020 but includes the above listed fire types for the purpose of this document.

10.2.2.1 Additional requirements for HFS and ESS-powered passenger rolling stock

The following shall be used to demonstrate compliance for passenger rolling stock powered by HFS and ESS:

(a) Demonstration that ESS thermal management systems can prevent thermal runaway and maintain sufficient energy reserves by operating in reduced power mode.

(b) Demonstration that HFS is equipped with active hydrogen leak detection-controlled venting and emergency hydrogen isolation systems, ensuring that hydrogen storage and controlled venting mechanisms operate safely in tunnels and enclosed spaces without compromising rolling stock functionality.

(c) Demonstration that HFS propulsion systems can maintain operational capability in degraded mode without immediate train stoppage unless required for safety reasons.

Section 11 Flammable gas release management

11.1 Performance Requirements

Compartments housing equipment that can emit flammable gases during normal operation or under fault conditions shall be provided with venting arrangements designed to control internal gas concentrations and ensure safe discharge to the exterior of the rolling stock.

For hydrogen gas, venting shall be designed to limit release concentrations to levels that do not create hazardous explosive atmospheres, taking into account the system configuration (e.g., roof-mounted vs enclosed cabinet installations).

11.2 Deemed to satisfy provisions

Release types shall be classified in accordance with IEC 60079-10-1:2020 for the following release types:

(a) Continuous release – expected under normal operation, including permeation or minor leaks, release limits comply with agreed standards (e.g., UN ECE R134:2019, ISO 19881:2018) and are to be validated at both component and system levels.

(b) Primary release – occasional or periodic is be avoided by design.

(c) Secondary release – through designated vent lines typically triggered by overpressure or overtemperature, manufacturers are to provide expected rates based on component design.

(d) Other release – caused by abnormal conditions (e.g., component failure or poor maintenance).

The manufacturer and operator shall jointly define credible failure scenarios, expected release locations and flow rates as part of a hazard identification process, ensuring residual risks are addressed where standard mitigation is insufficient.

The venting system shall be designed to:

(e) prevent gas accumulation in enclosed spaces;

(f) avoid discharging toward the train crew or passenger evacuation paths;

(g) avoid discharge towards HVAC intakes; and

(h) mitigate explosion, fire propagation and toxic exposure risks during credible failure scenarios.

For hydrogen gas, the direction, location and integrity of the venting paths shall be validated through analysis and, where applicable, tested against relevant standards such as AS 1530.4:2014 for fire resistance and UN ECE R134:2019 or ISO 19880-1:2020 for gas container integrity under thermal load.

A dedicated hazard analysis shall confirm the effectiveness of the design in protecting personnel and enabling safe egress in the event of gas release or fire.

Section 12 Rolling stock evacuation measures

12.1 Performance requirements

Rolling stock shall be designed to facilitate evacuation or provide safe refuge for all train occupants, including the mobility impaired, in all credible stopping locations including at stations, at-grade corridors, in tunnels and on viaducts.

Commentary *C12.1-1*

If a station platform is fitted with platform screen doors (PSDs) or platform edge barriers (PEBs), evacuation of a train could be impeded if the doors are not aligned or the platform doors fail to open. This hazard is typically addressed within the PSD/PEB system and incident management procedures and can be considered as part of the overall fire safety strategy.

Evacuation to an elevated side walkway will involve the navigation of a gap between the train door threshold and the walkway which could be significant, particularly on curved sections of track. The location of exit doors with respect to the train bogies will impact the size of the gap.

Fire safety systems shall support self-evacuation from the rolling stock with minimal reliance on train staff or emergency services.

The fire safety measures provided to facilitate emergency evacuation from the rolling stock shall reduce the risk to occupants in a fire, SFAIRP, and shall assess the:

(a) maximum train population based on:
  (i) for commuter rolling stock – AW3 as defined in AS 7501:2019;
  (ii) for long distance rolling stock – AW1 as defined in AS 7501:2019.
(b) means to evacuate or provide safe refuge to persons with restricted mobility including those in wheelchairs and motorized mobility scooters;
(c) location and nature of fire hazards;
(d) time required to detect the fire;
(e) time required for occupants to move to a place of safety or safe refuge within the rolling stock (if provided);
(f) ventilation systems and compartmentation that can affect smoke spread within the rolling stock;
(g) time required for the rolling stock to travel to and stop at a suitable location for evacuation; and
(h) time required for detrainment of rolling stock occupants.

Where it is not feasible or reasonably practicable to achieve self-evacuation (e.g., for the mobility impaired), the rolling stock design can provide a safe refuge that creates a temporary survivable space for those occupants who have to remain on the train until such time as their evacuation can be assisted by staff or emergency services.

Safe refuges do not have to be a dedicated space and may utilise the inter-vehicle partitions that divide the train into separate compartments. The design of any safe refuge should assess:

(i) the ability for occupants to reach the safe refuge from anywhere in the train;

(j) the space provided for a reasonable number of wheelchairs and other mobility impaired occupants based on the latest available census and patronage data;

(k) the time that occupants can need to stay in the safe refuge;

(l) the degree of fire and smoke separation provided by the safe refuge;

(m) the lighting provided;

(n) means of communication with both the train driver and remote network control centre;

(o) ventilation to maintain survivable conditions within the safe refuge;

(p) CCTV coverage of the safe refuge; and

(q) backup power for safety systems serving the safe refuge.

12.2 Deemed to satisfy provisions

12.2.1 General

The performance requirement of Clause 12.1 shall be deemed to be satisfied by the demonstration of compliance with:

(a) AS 7522:2025 for access and egress;

(b) AS 7531:2023 for emergency lighting; and

(c) AS 7528:2019 and AS 7495:2024 for communication equipment including PA, onboard CCTV, passenger emergency intercom (PEI), radio and onboard CCTV

and the additional requirements contained in the sections below.

12.2.2 Emergency exits

All exterior passenger doors shall be assessed as emergency exits.

An internal emergency door release mechanism shall be provided at every exterior passenger door which could be used as an emergency exit.

There shall be at least one emergency exit from the side of each vehicle leading to the exterior of the vehicle.

Carriages designed to carry up to 40 passengers (sitting, standing or sleeping) shall have at least two emergency exits (e.g., one on each side of the vehicle). Vehicles designed to carry more than 40 passengers (sitting, standing, or sleeping) shall have at least four emergency exits (e.g., two on each side of the vehicle).

Compartments for short term use or which are normally unoccupied during operation (e.g., toilets, luggage compartments) shall have an emergency exit but are not required to open to the exterior of the vehicle.

In passenger or staff areas normally occupied in service but which cannot be used as a through route (e.g., compartments), the distance for passengers or staff to the nearest emergency exit shall be no more than 6 m.

In passenger or staff areas which can be used as a through route, the distance for passengers or staff to the nearest emergency exit shall be no more than 16 m.

In restaurant/dining cars, an emergency exit shall be located within 16 m from all locations inside the vehicle, measured along the longitudinal axis of the vehicle.

Commentary *C12.2.2*

AS 7522:2025 includes requirements for gap fillers and door threshold strips designed to minimise the gap between the train door threshold and the platform. Consideration could also be given to the use of gap fillers to minimise the gap between the door threshold and any elevated side walkway along the alignment.

When tools for opening emergency exits (e.g., breakout hammers) are provided on the interior of the vehicle, the following shall apply:

(a) Tools are to be positioned close to the emergency exit.

(b) Tools are to be easily found even when the main lighting has failed.

(c) Clear instructions for their use are to be displayed close to each emergency exit.

(d) Tools and instructions are to be placed so that they are always visible, and so that blinds, curtains or clothes hanging on coat hooks do not hide them.

Where end-door detrainment is installed, doors shall be provided at each end of the train for use in an emergency. End doors shall be capable of being open from inside the train by passengers without assistance from staff.

Where end-door detrainment is provided, ramped access shall be provided down to ground level that can be utilized by a wheelchair. These ramps shall:

(e) be fitted with a handrail;

(f) have a maximum gradient of 1:8;

(g) be stable, provide a rigid and solid trafficable surface and avoid a step down at the end, SFAIRP; and

(h) be able to be fully deployed by a passenger in less than 60 seconds.

12.2.3 Evacuation routes

An unobstructed evacuation route shall be provided through the full length of the passenger areas of each carriage.

Seats or other passenger amenities (e.g., tables or beds) located on the route towards an emergency exit shall not prevent the use of the emergency exit and not obstruct the opening.

Hinged doors placed across a corridor that is part of an evacuation route shall be arranged to open in both directions.

Hinged compartment doors which open into a corridor that is part of an evacuation route shall, when fully open, not reduce the corridor width by more than 100 mm.

Door locks for sleeping compartments, toilets and washrooms shall allow train staff to unlock them in an emergency.

With the exception of single vehicle consists, inter-vehicle connections shall be provided to permit evacuation from one vehicle to another throughout the entire length of the train.

12.2.4 Doors through inter-vehicle partitions

Where provided, doors through inter-vehicle partitions shall:

(a) self-close upon fire or smoke detection if held open during normal operations;

(b) unless locked for security or maintenance reasons, be manually openable with a single-handed action with an opening force not exceeding 150 N when in a closed position, including in the event of loss of power or air;

(c) automatically re-close when released if fire or smoke has been detected, including in the event of loss of power or air;

(d) have an electrical or pneumatic/mechanical-powered opening/closing mechanism that fails safe closed and remain manually openable and self-closing in the event of failure of such a mechanism;

(e) include the ability to test the above functional requirements as part of the maintenance schedule;

(f) have the ability to be locked for security or maintenance reasons; and

(g) be tested as part of the inter-vehicle partition to achieve the fire resistance requirements as stated in Clause 6.4

Section 13 Maintenance, modifications and refurbishment

13.1 General

Maintenance, modification, refurbishment or changes in operational conditions shall not reduce the fire performance of rolling stock below the level required by this document.

The deemed-to-comply provisions provide guidance on how compliance can be achieved.

Where these provisions are not met, a performance-based approach shall be applied in accordance with Section 2.

13.2 Performance requirements

Rolling stock shall be maintained, modified, and refurbished such that the vehicle's level of fire performance, measured by the requirements of this document is:

(a) not reduced from its initial level; nor

(b) reduced below the deemed to satisfy requirements specified by Section 3 to Section 12 of this document.

If the maintenance, modification or refurbishment of a vehicle results in the fire performance of any given component being reduced from its initial level, this change shall be considered a performance based solution. The process defined in Section 2 of this document shall be followed to demonstrate that the overall level of fire safety remains acceptable.

Where a change in operational use occurs, the fire safety performance of the rolling stock shall be reassessed to confirm continued compliance with this document.

Operational changes requiring reassessment include, but are not limited to:

(a) occupant loading;

(b) vehicle layout;

(c) the introduction of new tunnel infrastructure on existing routes;

(d) reassignment to networks with different tunnel or infrastructure characteristics; and

(e) reclassification of service type.

Any reassessment shall assess the suitability of fire protection systems, evacuation capability and supporting equipment (e.g., self-rescue devices) and result in updates where required to maintain compliance with the performance objectives of this document.

Where a change in operational use occurs, the fire safety performance of the rolling stock shall be reassessed to confirm continued compliance with this document.

Operational changes requiring reassessment include, but are not limited to:

(f) occupant loading;

(g) vehicle layout;

(h) the introduction of new tunnel infrastructure on existing routes;

(i) reassignment to networks with different tunnel or infrastructure characteristics; and

(j) reclassification of service type.

13.3 Deemed to satisfy provisions

13.3.1 Maintenance

The requirements of Clause 13.2 in relation to maintenance shall be deemed to be satisfied where the following provisions are demonstrated to maintain the fire safety performance of the rolling stock:

(a) Component replacement is like-for-like to maintain the original fire performance level. Any change that is not like-for-like is considered a modification and shall meet the relevant requirements under Clause 13.3.2.

(b) Rolling stock is maintained to minimize spark emissions SFAIRP, which could cause ignition of trackside materials.

(c) Where spark emissions are identified, short and long term mitigation measures (e.g., modifications) are implemented to effectively manage these occurrences.

(d) Maintenance activities include periodic inspections, functional testing and compliance verification to prevent system degradation, leaks or thermal hazards.

Cleaning processes used as part of rolling stock maintenance shall not degrade the fire performance of component materials or assemblies. Particularly the following applies:

(e) Cleaning practices associated with fabrics used in seats and bedding in sleeper vehicles shall not degrade the fire performance of these materials.

(f) Aggressive cleaning agents shall not be used in areas where there is a risk that they could result in the degradation of intumescent materials employed to provide passive fire protection.

(g) Cleaning processes shall not leave behind residues which in a fire event could promote flame spread.

(h) Fire barriers, insulation layers and vented hydrogen enclosures shall be checked for wear, damage or gaps that could compromise fire containment.

Where the fire performance of material assemblies such as seat trim and floor assemblies is reliant on the integrity or thickness of one particular layer, rolling stock maintenance practices shall include the periodic inspection of such parts with rectification works undertaken if required.

Where spark emissions are identified, short and long term mitigation measures (e.g., modifications) shall be implemented to effectively manage these occurrences.

Maintenance activities shall include periodic inspections, functional testing, and compliance verification to prevent system degradation, leaks or thermal hazards.

Operation and maintenance manuals shall be provided on the rolling stock for all any fire safety measures described in this document.

These manuals shall include all relevant maintenance procedures including ongoing checks and testing, and the intervals at which these are to be undertaken.

AS 1851:2012 shall be applied as guidance in establishing required maintenance and testing procedures and intervals, noting that requirements might need to be modified to best suit the rail environment.

Fire-resistant components, including thermal barriers and fire-rated wiring, shall undergo periodic inspection to maintain compliance.

Reservoirs and piping containing fuel, oil and other flammable fluids shall be periodically inspected for leaks or defects, and rectified if defective to minimize the fire risk.

13.3.2 HFS, ESS & EDLC-powered passenger rolling stock

ESS and HFS shall be maintained in accordance with manufacturer instructions to ensure operational safety and fire risk mitigation.

ESS maintenance procedures shall be developed with input from an independent fire safety subject matter expert and include:

(a) periodic battery cell health checks to identify defective or degraded cells, leak-checks;

(b) BMS/BTMS health monitoring;

(c) gas sensor calibration/recalibration;

(d) ventilation integrity verification requirements; and

(e) monitoring of cell/module imbalance and cooling performance.

Fire suppression systems in ESS, HFS and combustion engine enclosures shall undergo functional testing to verify response time and effectiveness.

Hydrogen containment systems and pressure relief devices shall be tested and inspected for leak prevention and controlled venting integrity.

13.3.3 Modification and refurbishment

The requirements of Clause 13.2 in relation to modification and refurbishment shall be deemed to be satisfied where the following provisions are demonstrated to maintain the fire safety performance of the rolling stock.

New components introduced to a vehicle as part of a modification or refurbishment program for the first time shall be compliant to the applicable deemed to satisfy provisions of this document.

Where existing components or materials are replaced as part of a modification or refurbishment program (e.g., obsolescence, product improvement, supplier change), the replacement component or material shall be demonstrated to provide equivalent or improved fire safety performance. This can be achieved by following the methods below:

(a) If the original component or material is certified to an internationally recognized railway fire performance standard (e.g., EN 45545-2:2020+A1:2023), then it is acceptable to replace it with another equivalent-type component or material that:

  (i) is certified to the same standard with the same or higher level of performance; or

  (ii) complies with the deemed to satisfy requirements of Section 5.

(b) If the original component or material is not certified to an internationally recognized railway fire performance standard (e.g., EN 45545-2:2020+A1:2023), then it is acceptable to replace it with an equivalent-type component or material that:

  (i) complies with the deemed to satisfy requirements of Section 5; or

(ii) has been demonstrated to have equivalent or better performance than the existing via comparative testing using the relevant EN 45545-2:2020+A1:2023 product category testing requirements.

NOTE:

EN 45545-2:2020+A1:2023 compliance is not required for either existing or replacement but is rather used as a method to perform a comparison.

(c) Modifications affecting ESS, HFS or high-voltage electrical systems shall be assessed for thermal stability, fire containment and explosion risks.

(d) Any penetrations made through fire-resistant structures during modifications shall be fire-sealed to maintain barrier integrity.

(e) Changes to ventilation and gas dispersal systems shall be evaluated to ensure they do not increase the risk of explosions or fire spread.

(f) Thermal management and suppression systems shall be reassessed to confirm effectiveness in the modified configuration.

(g) Following any modification, fire protection systems shall undergo functional validation and testing, ensuring continued compliance with this document.

Any new penetrations made as part of modification or refurbishment program through planes of the vehicle that are manufactured from fire resisting construction shall be fire sealed to ensure the modified fire barrier continues to be compliant with the deemed to satisfy provisions of Section 6 of this document.

13.3.4 Operational changes

The requirements of Clause 13.2 regarding operational change shall be deemed to be satisfied by demonstrating the following:

(a) Completion of a formal fire safety impact assessment by a competent person to evaluate whether existing fire protection, evacuation and crew support measures remain appropriate under the revised operational conditions.

(b) Revalidation of fire protection systems in the new context, taking into account:

(i) fire detection and suppression adequacy;

(ii) traction and braking capability to support evacuation in tunnels or constrained environments; and

(iii) updating of maintenance, training and emergency response procedures to reflect changes in system risk.

Where a reduction in fire safety performance is identified, the performance-based approach outlined in Section 2 shall be applied to determine the appropriate mitigation or justification for continued operation.

Appendix A Hazard Register (Informative)

Hazard number	Hazard
5.1.1.6	Sparks from exhausts causing fire
5.1.1.7	Sparks from brake equipment causing fire
5.1.1.8	Combustible wayside material causing fire
5.1.1.14	Fire causing (excessive pollution)
5.1.1.15	Fire caused by rolling stock
5.3.1.23	Fire causing burns by thermal radiation
5.4.3	Explosion
5.32.1.1	No separation or barrier existing between sources and fuel causing the heat source to interact with combustible material (Fire not prevented)
5.32.1.2	The environment not being controlled to reduce smoke and heat production (Smoke and heat not controlled - Fire not controlled)
5.32.1.3	Properties, quantity or distribution of combustible materials not being controlled (Smoke and heat not controlled - Fire not controlled)
5.32.1.4	Fire not being vented (Fire propagation not controlled - Fire not controlled)
5.32.1.5	Fire not being detected (Fire not suppressed - Fire not controlled)
5.32.1.6	No or insufficient suppressant being available (Fire not suppressed - Fire not controlled)
5.32.1.7	Fire not being contained (Fire propagation not controlled - Fire not controlled)
5.32.1.8	In traction systems the heat source is not eliminated or the rate of heat release is not sufficiently reduced causing the heat source to interact with combustible material (Fire not prevented)
5.32.1.9	In braking systems the heat source is not eliminated or the rate of heat release is not sufficiently reduced causing the heat source to interact with combustible material (Fire not prevented)
5.32.1.10	In electrical systems the heat source is not eliminated or the rate of heat release is not sufficiently reduced causing the heat source to interact with combustible material (Fire not prevented)
5.32.1.13	In the event of a malicious act the heat source is not eliminated or the rate of heat release is not sufficiently reduced causing the heat source to interact with combustible material (Fire not prevented)
5.32.1.17	Fuel - Combustible material not being eliminated or combustibility not being sufficiently reduced causing the heat source to interact with combustible material (Fire not prevented)
5.32.1.20	Interior surfaces - Combustible material not being eliminated or combustibility not being sufficiently reduced causing the heat source to interact with combustible material (Fire not prevented)

Hazard number	Hazard
5.32.1.21	Exterior surfaces - Combustible material not being eliminated or combustibility not being sufficiently reduced causing the heat source to interact with combustible material (Fire not prevented)
5.32.1.22	Oil - Combustible material not being eliminated or combustibility not being sufficiently reduced causing the heat source to interact with combustible material (Fire not prevented)
5.32.1.23	Waste / rubbish - Combustible material not being eliminated or combustibility not being sufficiently reduced causing the heat source to interact with combustible material (Fire not prevented)
5.32.1.26	Fire products harming persons or property causing risk to Immobile property or persons (Persons or property not protected from fire)
5.45.1.15	Being overcome by fire products (Unable to reach exit safely - Unable to successfully evacuate)
5.45.1.17	Being overcome by fire products (Unable to use exit safely - Unable to successfully evacuate)
5.45.1.5	No functioning fire / smoke detection systems so the need for evacuation is not detected (Evacuation not successfully initiated)
5.53.1.2	Human error
5.53.1.3	Invalid test procedures
5.53.1.9	Incorrect analysis methods (Design error)
TBC	Thermal runaway initiation within electrochemical battery cells or modules, resulting in rapid heat release and fire escalation.
TBC	Thermal propagation between adjacent battery cells, modules, or packs, resulting in uncontrolled spread of the battery fire event.
TBC	Release of flammable, toxic and/or corrosive gases during battery cell failure (including pre-ignition off-gas emissions), creating secondary ignition and toxicity hazards.
TBC	Internal over-pressure within battery enclosures during failure events, leading to rupture, explosion and/or uncontrolled venting, creating fire and projectile hazards.
TBC	Jet flames and/or high-velocity flame fronts resulting from venting or rupture of pressurised gas storage or distribution components, causing rapid fire spread and severe thermal exposure.
TBC	Ejection of battery fragments, cell components and/or high-temperature debris during failure events, causing secondary ignition and injury hazards.
TBC	Re-ignition following initial suppression due to residual thermal energy and/or delayed battery cell failure, resulting in renewed fire development.

Hazard number	Hazard
TBC	Electrical arcing, short-circuiting and/or persistent voltage hazards during and after electrical energy storage failure events, creating ignition sources and impeding suppression or intervention.
TBC	Leakage of hydrogen from storage vessels, pipework or fuel cell system components, creating flammable gas release and ignition potential.
TBC	Accumulation of hydrogen in confined or semi-enclosed spaces, leading to flammable or explosive atmospheres.
TBC	Hydrogen flames that are difficult to detect visually due to low luminosity, resulting in delayed recognition and delayed or ineffective response.
TBC	High-pressure hydrogen storage failures, including structural rupture and rapid decompression, resulting in immediate fire and/or explosion hazards.

Bibliography (Informative)

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- EN 45545-3, *Fire protection on railway vehicles – Part 3: Fire resistance requirements for fire barriers*
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- NFPA 130, *Standard for fixed guideway transit and passenger rail systems* (2020)
- NFPA 497, *Recommended Practice for the Classification of Flammable Liquids, Gases, or Vapours and of Hazardous (Classified) Locations for Electrical Installations in Chemical Process Areas* (2024)
- UL 9540A, *Standard for Test Method for Evaluating Thermal Runaway Fire Propagation in Battery Energy Storage Systems* (2025)

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