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Preface

This standard was prepared by the Rolling Stock Fire Safety – Part 1: Locomotives and Freight Development Group, overseen by the RISSB Rolling Stock Standing Committee.

Objective

The objective of this document is to provide requirements, recommendations and guidance for fire safety for locomotive & freight rolling stock operating in Australia.

The main purpose of the requirements is to provide a minimum level of fire safety for rail rolling stock operating in Australia.

The major change from AS 7529.1:2014 is the consolidation of AS 7529.2:2014 into this document. Additionally, the document has been updated to address new zero emission technology such as lithium-ion batteries, hydrogen and ammonia.

Compliance

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

(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.

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

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

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

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

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

Commentary

Commentary *C Preface*

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

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Section 1 Scope and general

1.1 Scope

This document outlines fire safety requirements for locomotive & freight rolling stock. These requirements are intended to form part of a broader rolling stock fire safety strategy aimed at minimizing the risk of harm to train crew and passengers, including those in coupled vehicles and reducing the risks that a fire on such rolling stock can pose to the safety of other persons who might be affected — such as emergency responders, infrastructure workers and nearby passengers.

Fire safety is achieved through design, construction and maintenance measures, including compartmentation, fire-resistant materials, fire suppression systems and features that support evacuation.

This document applies to the design, construction, modification and maintenance of locomotive & freight rolling stock, including locomotive & freight rolling stock fitted with zero emission (ZE) energy propulsion systems such as energy storage systems (ESS) and hydrogen fuel systems (HFS). The document covers requirements for fire prevention, fire detection, fire suppression systems, material flammability and evacuation.

This document does not cover operation of rolling stock, refuelling and handling of flammable liquid and flammable gas installations.

Locomotives with liquified petroleum gas (LPG), liquified natural gas (LNG) or compressed natural gas (CNG) as propulsion fuel.

This document is not specifically intended to cover rolling stock used on heritage, light rail and cane railways, but items from this document can be applied to such systems as deemed appropriate by the relevant RIM and/or RSO.

The requirements of this document do not address asset protection for either the rolling stock or the infrastructure, nor do they include any specific mitigations for fire safety risks associated with terrorism or fires resulting from major collision events beyond the crashworthiness design scenarios of the rolling stock.

1.2 General information

1.2.1 Application by rolling stock type

A locomotive or non-passenger-carrying power car that is operated in passenger service at any stage during its service life shall comply with the fire safety requirements specified for locomotives in this document.

A locomotive that is intended and configured exclusively for freight operations, with no operational scenario involving passenger service, is considered a freight locomotive and shall comply with the fire safety requirements specified for freight locomotives.

Where locomotives are designed primarily for freight operations, designers should consider the potential for future use in passenger operations. In such cases, locomotives should be designed to meet the requirements for locomotives specified in this document to avoid restricting future operational use.

Fire safety requirements for passenger-carrying rolling stock are specified in AS 7529.3.

Sections 2 to 11 (inclusive) of this document apply to the design and construction of new locomotive rolling stock.

Sections 2 to 6, 9 and 11 (inclusive) of this document apply to the design and construction of new freight rolling stock.

Section 12 of this document applies to the maintenance, modification and refurbishment of existing locomotive & freight rolling stock.

1.2.2 Zero emission locomotive & freight rolling stock

This document includes fire safety requirements for locomotives and freight rolling stock configured with zero emission propulsion, including battery-electric and hydrogen fuel cell technologies. These systems introduce distinct fire safety hazards compared to conventional diesel and electric traction.

ESS and 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 2,000 kWh. 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 locomotive 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.

1.2.3 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.

1.2.4 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, ensuring available safe egress time (ASET) exceeds required safe egress time (RSET), as referenced in the international fire engineering guidelines.

1.2.5 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.

Conventional fire detection systems might not be effective in detecting hydrogen flames. Optical flame detection or dedicated gas sensors could be used to supplement existing systems where appropriate. Similarly, suppression strategies in enclosed environments could consider inert gas agents such as nitrogen or argon, where water-based systems are less effective.

Tunnel structural behaviour under exposure to hydrogen jet flames or lithium battery fires could also warrant consideration. 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.

1.3 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 1530.4, *Methods for fire tests on building materials, components and structures – Part 4: Fire-resistance test of elements of construction*
- AS 2444, *Portable fire extinguishers and fire blankets – Selection and location*
- AS 5062, *Fire protection for mobile and transportable equipment*
- AS 7486, *Railway rolling stock energy storage – Onboard electrical energy storage systems*
- AS 7522, *Access and egress*
- AS/NZS ISO 31000, *Risk management – Principles and guidelines*
- AS/NZS 3504, *Fire blankets*
- IEC 60077, *Railway applications – Electric equipment for rolling stock*
- IEC 60079-10-1, *Explosive atmospheres – Part 10-1: Classification of areas – Explosive gas atmospheres*
- IEC 60571, *Railway applications – Electronic equipment used on rolling stock*
- IEC 61991, *Railway applications – Rolling stock – Protective provisions against electrical hazards*
- IEC 62497-1, *Railway applications – Insulation coordination – Part 1: Basic requirements – Clearances and creepage distances for all electrical and electronic equipment*
- IEC 62928, *Railway applications – Rolling stock – Onboard lithium-ion batteries*
- IEC 62995, *Railway applications – Rolling stock – Rules for installation of cabling*
- ISO 834-1, *Fire-resistance tests – Part 1: General requirements*
- EN 403, *Respiratory protective devices for self-rescue – Filtering devices with hood for escape from fire*

- EN 1363-1, *Fire resistance tests – Part 1: General requirements*
- EN 1363-2, *Fire resistance tests – Part 2: Alternative and additional procedures*
- EN 45545-1, *Railway applications – Fire protection on railway vehicles – Part 1: General*
- EN 45545-2, *Railway applications – Fire protection on railway vehicles – Part 2: Requirements for fire behavior of materials and components*
- EN 45545-3, *Railway applications – Fire protection on railway vehicles – Part 3: Fire resistance requirements for fire barriers*
- EN 45545-4, *Railway applications – Fire protection on railway vehicles – Part 4: Fire safety requirements for railway rolling stock design*
- EN 45545-6, *Railway applications – Fire protection on railway vehicles – Part 6: Fire control and management systems*
- EN 50553, *Railway applications – Requirements for running capability in case of fire on board rolling stock*
- CSA T/S 601, *Safety and fire control for hydrogen-powered passenger rail vehicles*
- CSA T/S 602, *Fire protection for lithium-ion batteries in railway vehicles*
- *RISSB Guideline Rolling stock safety assessment*
- *International Fire Engineering Guidelines (IFEG), Edition 2005 – Guidance on fire safety engineering principles and holistic fire assessment*

NOTE:

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

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
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

1.4.4
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 applications—including propulsion and braking.

1.4.5
energy storage unit (ESU)
physical equipment which is comprised of energy storage technologies such as batteries or EDLCs

1.4.6
freight locomotive
locomotive used exclusively for hauling or propelling freight rolling stock

Note 1 to entry: A freight locomotive is not intended or configured for operation with passenger rolling stock during normal service.

1.4.7
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

1.4.8
fuel cell power system
generator system that uses one or more fuel cell modules to generate electric power and heat

1.4.9
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

1.4.10
high power equipment
equipment with circuits operating with a rated power greater than 20 kW

1.4.11
hybrid vehicles
vehicle that can store energy in an onboard energy storage system and is driven by using the stored energy as well as electric power from a generator or overhead lines.

1.4.12
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 on-board devices, fuel lines and the associated monitoring, control & safety devices.

1.4.13
National Engineers Register (NER)
register maintained by the Institution of Engineers Australia that lists individuals who have been assessed as meeting professional and ethical standards in a recognized area of practice, including fire safety engineering

1.4.14
place of safety
a location that is free from danger and from which it is possible to move freely without threat from a fire

1.4.15
relative place of safety
temporary location that is free from immediate danger from the effects of fire

1.4.15
RIM
rail infrastructure manager as defined in Rail Safety National Law

1.4.15
RSO
rolling stock operator as defined in Rail Safety National Law

1.4.16
running capability
ability of the train to reach a 'place of safety' with a fire on- board

1.4.17
self-rescue device
personal protective device that provides short-duration respiratory protection to train crew during evacuation through smoke-filled or toxic environments.

1.4.18
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 may 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 RISSB Glossary. Refer to: https://www.rissb.com.au/glossary/

Section 2 Conditions on use of performance & deemed to satisfy provisions

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; and

(b) A holistic fire safety assessment shall be undertaken to confirm that the overall level of fire safety achieved so far as is reasonably practicable (SFAIRP) for all rolling stock types covered by this document. This assessment shall demonstrate that the use of performance-based solutions in one area does not reduce the level of fire safety achieved in other areas, nor create new unintended hazards.

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 International Fire Engineering Guidelines (IFEG); and

(b) incorporate fire hazard and risk analysis in accordance with the *RISSB Guideline – Rolling Stock Safety Assessment* and AS/NZS ISO 31000:2009. The analysis shall include the residual risk and tolerable risk criteria to support SFAIRP decision-making. This assessment shall be completed to the satisfaction of the relevant RIM.

2.3 Fire safety documentation process

A structured fire safety documentation process shall be implemented for all new rolling stock projects and for modifications that impact fire safety. This process shall be undertaken in accordance with the methodology outlined in IFEG.

The process shall include but not be limited to:

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

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

(c) 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 Evacuation and access requirements

Evacuation features shall comply with AS 7522:2025.

Deemed-to-satisfy solutions under this document shall only be applied where these features, such as emergency exits, ladders, escape paths, signage and lighting, meet or exceed the minimum requirements specified in AS 7522:2025.

Where alternative evacuation arrangements are proposed, their effectiveness under fire conditions shall be demonstrated through a performance assessment.

This assessment shall show that evacuation performance is equivalent to or better than, the standard defined in AS 7522:2025 and EN 45545-4:2024.

2.6 Novel design features

Where a proposed vehicle design incorporates novel features or technologies that depart significantly from established practice, an 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, pyrolysis modelling or computational fluid dynamics (CFD) analysis. 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.

2.7 Functional integration of HFS & ESS freight rolling stock

Freight rolling stock configured to carry a HFS or ESS to supply traction power to a locomotive and forming part of a tethered consist, is considered functionally integrated with the locomotive. Such rolling stock shall comply with fire safety requirements applicable to locomotives, including ignition risk mitigation, fire development mitigation, material performance and fixed fire protection provisions.

Section 3 Ignition risk mitigation measures

3.1 General

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

Potential ignition hazards, including but not limited to electrical systems, ESS, HFS, fuel storage, 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.

Commentary C3.1

AS 7486 provides informative guidance on onboard electrical energy storage in rolling stock. IEC 63341 is intended to address hydrogen fuel systems on rolling stock.

3.2 Performance requirements

3.2.1 Locomotive & freight rolling stock

The design of locomotive & freight rolling stock shall, so far as reasonably practicable, 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.

The performance requirement of Clause 3.2 shall be deemed to be satisfied by the demonstration of compliance with Clause 3.3.1 and Clause 3.3.2.

3.3 Deemed to satisfy provisions

3.3.1 Locomotive & freight rolling stock

Resistors, exhaust from combustion engines, heating elements, catering or cooking equipment and other radiant heat sources shall be adequately separated or protected from nearby combustible materials to ensure that these heat sources do not pose an ignition risk.

Equipment that has the potential to operate at a surface or internal temperature that exceeds a threshold that can result in ignition, damage to adjacent materials or thermal degradation of components shall be fitted with thermal management systems to prevent fire-generating conditions from occurring. Effective methods for controlling equipment temperatures include passive air cooling, active liquid cooling, active air cooling and the use of fire-resistant enclosures.

Heat-generating onboard equipment, such as catering appliances (e.g. ovens, microwave ovens, refrigerators), battery chargers and inverters, shall be installed with OEM-specified ventilation clearances.

Where such equipment is installed inside or outside the vehicle, the layout design shall incorporate the differing ventilation requirements specific to each environment.

Electrical circuits shall be designed and installed to minimize the risk of overheating, arcing and electrical fires by applying appropriate wire size, short-circuit and overload protection, thermal insulation and protective circuit design in accordance with recognized railway standards, including IEC 62995:2018, IEC 61991:2019 and IEC 62497-1:2010.

Circuit components, including resistors, contactors, switches and relays, shall be designed and installed to minimize the risk of ignition under normal operation and reasonably foreseeable fault conditions. This includes appropriate selection, protection and coordination of components in accordance with recognized railway standards, including IEC 62497-1:2010, IEC 60571:2012 and IEC 60077:2017.

High-voltage equipment shall be designed and installed to minimize the risk of ignition from arcing or dielectric failure. This includes appropriate insulation coordination, clearance, creepage and protective design in accordance with IEC 62497-1:2010.

Vents on tanks or systems containing flammable liquids or gases shall be fitted with flame arresters or equivalent devices to prevent ignition of the vapour space through flashback.

Compartments containing equipment, such as batteries, that could release flammable gases under normal or fault conditions shall be vented to prevent these compartments from presenting an ignition or explosion hazard, in compliance with Section 11.

Commentary C3.3.1

Relevant standards for battery compartments to mitigate explosion risks include AS 7486, AS 2676.2 (guidance on battery ventilation), 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 Electric Double-Layer Capacitors (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.

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

(a) Engine and exhaust systems shall be designed to eliminate spark emissions SFAIRP, which could cause ignition of trackside materials.

Commentary C3.3.1

Mitigation measures include the use of spark arrestors, particulate filters or flame traps, heat shielding, careful positioning of exhaust outlets away from combustible materials and regular maintenance to prevent carbon build-up or leaks.

(b) Brake systems, forced ventilation systems and current collectors shall be designed to eliminate spark emissions SFAIRP, which could cause ignition of trackside materials.

(c) Suitable shielding shall be 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.

3.3.2 HFS & ESS – Locomotive & freight rolling stock

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

ESS systems and circuits shall comply with AS 7486:2022.

Locomotives & freight rolling stock with ESS shall include a BMS and BTMS capable of continuous monitoring at the cell, module and string levels.

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.

Commentary C3.3.2-1

Relevant standards for Battery Management Systems' thermal management to prevent thermal runaway include AS 7486, IEC 62928 and IEC 62619.

Faults and alarms from the BMS and BTMS shall be clearly perceptible to the train crew under all operating conditions and comply with AS 7533:2021.

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.

The fire prevention and suppression system design should address coolant system leaks where flammable liquids such as ethylene glycol are used in ESS cooling systems,

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 accumulation of hydrogen gas.

Commentary C3.3.2-2

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.

Explosive atmosphere management shall include hazardous area classification, ventilation assessment and integration of control measures to limit hydrogen accumulation as defined in IEC 60079-10-1:2020.

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

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 both the manufacturer, RIM and RSO.

Venting into tunnels or confined spaces should 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 lower explosive limit (LEL).

Commentary C3.3.2-3

NFPA 130 Section 7 outlines ventilation requirements such as airflow rates and smoke control strategies. It is particularly relevant for managing hydrogen dispersion and preventing hazardous gas accumulation in tunnels.

IEC 60079-10-1 4 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 standards include CSA TS 601, where mechanical ventilation with air dilution should maintain hydrogen concentrations below the lower explosive limit (LEL) or lower flammability limit (LFL), with real-time flow monitoring to verify ventilation effectiveness. Dilution boundaries are found using IEC 60079-10-1; NFPA 497 or IEC 63341/UNR134.

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, EES introduces risks of fire spread that must be effectively controlled. This section defines measures to limit fire propagation, contain thermal hazards and protect critical systems for locomotive & freight rolling stock.

4.2 Performance requirements

4.2.1 Locomotive & freight rolling stock

The design of locomotives and freight rolling stock shall, through hazard assessment, identify potential mechanisms for rapid fire development and incorporate fire mitigation measures, so far as is reasonably practicable, to reduce the likelihood and severity of such events.

While major collisions are difficult to mitigate through design alone, a risk-based safety assessment shall be undertaken to assess the impact of minor impact events and derailments. Deemed to satisfy provisions

4.2.2 Locomotive & freight rolling stock

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

(a) The underframe equipment layout shall, wherever practical, avoid traps where debris such as litter or leaf matter can accumulate.

(b) All areas where dust or debris can accumulate and contribute to fire propagation—such as HVAC ducting, dynamic brake grids and components exposed to ignition sources- shall be designed to allow adequate access for cleaning and maintenance.

(c) Filling and drainage points for flammable fluids shall be positioned so that the accumulation of spilled or discharged fluid is prevented.

(d) Fuel and fluid piping systems shall incorporate cut-off devices or isolation valves designed to automatically shut off the flow of flammable liquids or gases in the event of a fire, vehicle rollover or system failure that poses a fire hazard.

(e) Reservoirs for flammable fluids or gases shall be designed to prevent full drainage or gas release in case of vehicle rollover or derailment.

Commentary C4.3.1-1

Derailments and low-speed collisions can create fire hazards, particularly where rolling stock incorporates under-slung 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.

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

Commentary C4.3.1-2

Intercar connections present additional challenges in meeting fire safety requirements. Moving and exposed hoses are more susceptible to mechanical damage, wear and potential exposure to ignition sources. These risks are assessed and mitigated through the implementation of appropriate design measures, such as shielding, automatic shut-off valves and leak detection systems. The suitability of such systems for specific applications are determined through a documented risk assessment and in accordance with applicable standards and operational requirements.

4.2.3 HFS & ESS – Locomotives & freight rolling stock

The performance requirement in Clause 4.2 is deemed satisfied by compliance with the following for locomotives and freight rolling stock with HFS or ESS, in addition to the mitigation measures in Clause 4.3.1:

(a) HFS and ESS shall be mounted in areas with minimal exposure to external heat sources.

(b) Fire suppression, compartmentalisation and ventilation strategies shall be aligned with current best practices and follow specific system requirements.

(c) BMS and BTMS shall include fault isolation, cooling and fire suppression mechanisms to mitigate the risk of thermal runaway and fire propagation.

Commentary C4.3.2-1

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 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 EES compartments shall have systems to disperse heat and gases effectively.

Commentary C4.3.2-2

For HFS, ventilation systems are designed to maintain hydrogen concentrations below specified safety thresholds outlined in IEC 63341 (in development) to ensure operational safety. IEC 63341-2, the maximum allowable hydrogen concentration in enclosures is 1% H_2 in air (25% of the Lower Explosive Limit - 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 limit). IEC 63341-1, outlines requirements for continuous hydrogen releases from components under normal operation, ensuring concentrations remain within safe levels. To effectively remove hydrogen and prevent accumulation, exhaust vents are positioned to facilitate proper dispersion, considering hydrogen's buoyancy in air.

(e) Hydrogen leak detection systems shall automatically trigger shutdown procedures and activate ventilation systems when hazardous gas levels are detected.

Commentary C4.3.2-3

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

(f) If a fire is detected in the vehicle, the hydrogen shut-off valves shall automatically close.

(g) Explosion-proof enclosures and pressure relief valves shall be incorporated into HFS to prevent pressure buildup and mitigate explosion risks.

(h) Hydrogen containers shall be equipped with thermally activated pressure relief devices (TPRDs) to safely vent gas before the liner reaches critical temperatures.

Commentary C4.3.2(h)

Temperature thresholds for TPRD activation from IEC 63341-2 (currently under development) are 85°C average and 100°C peak liner temperature.

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 should be provided by fire-rated barriers or enclosures designed to prevent heat and flame ingress, as part of the overall fire containment strategy.

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 locomotive & freight rolling stock.

Effective control of combustible materials supports safe evacuation by reducing fire severity and maintaining survivable conditions during incidents involving locomotives, freight locomotive & freight rolling stock fitted with ESS or HFS.

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.

Material fire performance testing shall be conducted by laboratories accredited to ISO/IEC 17025 for the relevant test methods. Accreditation shall be by NATA or an equivalent body recognized under the ILAC Mutual Recognition Arrangement.

Materials classified as non-combustible under EN 45545-2 are exempt from additional fire performance testing under this document.

Commentary C5.1

EN 45545-2 defines non-combustibility based on EN 13501-1 Class A1 and materials listed in Commission Decision 96/603/EC. Materials that are classified as non-combustible under Australian or other international building and construction standards, where appropriate for the intended railway application, could also be considered exempt from additional fire performance testing

5.2 Performance requirements

5.2.1 Locomotive & freight rolling stock

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

(a) prevent significant fire propagation from 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;

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

(d) when exposed to large ignition sources greater than 50 kW, limit the production of optically dense smoke and large quantities of toxic fumes, which could impair the ability of rolling stock occupants, including passengers (if applicable), to evacuate to a place of ultimate safety.

Commentary C5.2.1

In defining the material fire safety requirements, particular attention was given to the nature of ignition sources that materials can be exposed to during service. The following quantitative benchmarks are established for design reference:

a) small ignition source → 1 kW consistent with Bunsen burner-type material tests; and

b) large ignition source → 50 kW, representative of common rolling stock fire loads, such as burning newspapers. This benchmark is positioned between the ignition source reference values used in UIC guidelines and BS 6853.

In addition, the degree of material performance provided shall be commensurate with:

(e) the nature and location of the fire hazards present on the rolling stock;

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

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

(h) the time required to detect the fire;

(i) the time required for the rolling stock to travel to and stop at a safe place for evacuation; and

(j) the time required for the evacuation of rolling stock occupants, such as crew, including passengers (if applicable), to be completed.

Combustible materials that are fitted inside equipment enclosures that are manufactured and certified with fire-resistant construction shall not be required to have a qualified level of fire performance if:

(k) the construction of the enclosure will protect the internal materials from becoming involved in a fire external to the enclosure for a duration not less than the time required for the rolling stock to travel to and stop at a safe place plus the additional time for occupants to evacuate; and

(l) the construction of the enclosure will prevent a fire that starts within the enclosure from propagating outside the enclosure for a duration not less than the time required for the rolling stock to detect, travel to and stop at a safe place plus the additional time required for occupants to evacuate.

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

Where applicable, the level of rolling stock material fire performance shall be commensurate with the maximum credible fire load and hazard associated with HFS or ESS, ensuring materials can limit propagation, heat release and toxic emissions under these conditions.

Where compliance with the material fire performance requirements of this document or with EN 45545-2, is not achievable due to functional necessity, non-compliant materials may be used when:

(m) the essential fire safety objectives of this document are maintained;

(n) a documented risk assessment confirms that the overall fire risk remains acceptable and controlled;

(o) the decision is based on functional necessity, considering the availability of compliant products; and

(p) approved by the RSO.

5.3 Deemed to satisfy provisions

5.3.1 General

Fire test reports and certificates shall remain valid as long as they accurately represent the material, production and assembly process in current use and the rolling stock has been maintained and cleaned in accordance with the technical maintenance plan.

Where fire test reports are more than 5 years old, the validity of the test report should be reviewed to confirm they remain representative of the current product and installation. If there is no change in the product characteristics, manufacturing process and requirements, new testing of the material is not required.

5.3.2 Locomotive

The performance requirement of Clause 5.2 shall be deemed to be satisfied by the demonstration of compliance with the following for a locomotive:

(a) Combustible materials shall comply with the requirements of EN 45545-2:2020, as set by the operation category relevant to the location where the rolling stock will operate.

Commentary C5.3.2-1

Hazard levels (HL1 to HL3) are defined in EN 45545-1 based on operational and design risk and are applied in EN 45545-2 to set material performance requirements. ASTM E2061 provides a performance-based alternative for demonstrating equivalent fire safety.

(b) Combustible materials fitted within technical cabinets of the locomotive, including the cab, shall be exempt from the EN 45545-2:2020 material fire performance requirements where the cabinet is protected by an automatic fire detection and fire extinguishing system in accordance with Section 9 of this document.

Commentary C5.3.2-2

The use of fire detection and fire extinguishing systems within the technical cabinet can provide an alternative means of fire risk mitigation. In such cases, the materials within the compartment might not need to meet the EN 45545-2 material performance requirements, where the suppression system is designed to detect and control fire for a duration comparable to the time needed for the rolling stock to reach a safe stopping location and allow occupants to evacuate. This approach supports the adoption of active fire protection measures in place of passive material compliance.

5.3.3 Freight locomotive

The performance requirement of Clause 5.2 shall be deemed to be satisfied by the demonstration of compliance with the following for a freight locomotive:

(a) Combustible materials shall comply with the requirements of EN 45545-2:2020, as set by the operation category relevant to the location where the rolling stock will operate.

Commentary C5.3.3-1

For freight locomotives, the evacuation scenario is simpler than for locomotives used with passenger rolling stock. Evacuation of crew can generally be without delay or complex evacuation procedures. This supports the application of OC1 and HL1 for most Australian freight operations, where the infrastructure allows for immediate egress.

While EN 45545-1 references 1 km tunnel lengths for passenger evacuation, this threshold is not directly applicable to freight locomotives. For freight locomotives, the decision to apply OC1 or OC2 should also be based on the specific evacuation conditions. Where longer tunnels exist or where evacuation can be delayed, OC2 and HL2 may be considered.

(b) Non-listed products, as defined in EN 45545-2:2020, Section 4.5, with a grouped mass less than 1000 grams and an exposed surface area less than 0.2 m^2, mounted to the exterior of the locomotive or compartments considered external under EN 45545-2:2020, shall not be required to be qualified for their fire performance.

(c) Non-listed products, as defined in EN 45545-2:2020, Section 4.5, with a grouped mass greater than 1,000 grams or exposed surface area greater than 0.2 m^2, mounted to the exterior of the locomotive or in compartments considered external under EN 45545-2:2020, shall be required to be qualified for their fire performance in accordance with EN 45545-2:2020.

Commentary C5.3.3-2

These clauses introduce a simplified exemption for small external components on freight locomotives (mass <1,000 g or surface area <0.2 m^2), recognising their minimal fire risk. This is less restrictive than EN 45545-2, which limits exemptions to 400 g. This exemption does not apply to components above this threshold where the EN 45545-2 requirements would apply. ASTM E2061 applies a performance-based approach, assessing components within full vehicle fire scenarios. Exemptions or acceptance are based on demonstrated fire impact, not fixed thresholds.

(d) Combustible materials fitted within technical cabinets of the locomotive, including the cab, shall be exempt from the EN 45545-2:2020 material fire performance requirements where the cabinet is protected by an automatic fire detection and fire extinguishing system in accordance with Section 9 of this document.

5.3.4 Freight rolling stock

The performance requirement of Clause 5.2 shall be deemed to be satisfied by the demonstration of compliance with the following for freight rolling stock:

(a) Combustible materials shall comply with the requirements of EN 45545-2:2020 for Hazard Level 1 rolling stock.

(b) Non-listed products, as defined in EN 45545-2:2020, Section 4.5, of grouped mass less than 1,000 grams, mounted to the exterior of the freight vehicle or compartments of the freight rolling stock which, under EN 45545-2:2020 can be considered external, shall not be required to be qualified for their fire performance.

(c) Combustible materials fitted within technical cabinets shall be exempt from the EN 45545-2:2020 material fire performance requirements where the cabinet is protected by an automatic fire detection and fire extinguishing system in accordance with Section 9 of this document.

Commentary C5.3. 4

There are no requirements for flexible covers fitted to freight rolling stock. There are no requirements for goods carried on freight wagons.

5.3.5 HFS and ESS locomotives & freight rolling stock

The following deemed-to-satisfy provisions apply specifically to locomotives and freight rolling stock equipped with HFS and ESS. The performance requirement of Clause 5.2 shall be deemed to be satisfied

by the demonstration of compliance with the following for locomotives and freight rolling stock containing HFS or ESS in addition to requirements in Section 5.3.2, Section 5.3.3, Section 5.3.4:

(a) Combustible materials within areas containing hydrogen storage tanks and fuel cells shall comply with EN 45545-2:2020 HL3 to reduce fire spread, smoke and toxic gas following ignition.

(b) Battery enclosures and materials within 3 m of the battery enclosure vents shall comply with EN 45545-2:2020 HL3 to reduce fire spread, smoke and toxic gas following thermal runaway.

Commentary C5.3.5

For HFS, the phrase “within areas” refers to internal surfaces of the compartment that contain the hydrogen storage tanks or fuel cells. This includes 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 remotely located equipment connected via piping (e.g. underfloor or roof-mounted lines), unless such equipment is situated within the same defined compartment.

For ESS, the phrase “within 3 m of the battery enclosure vents” applies to any material that could reasonably be exposed to vented gases or ejected hot particles during a thermal runaway event. This includes internal surfaces of adjacent compartments, 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.

Section 6 Fire resistance

6.1 General

Fire resistance of structural assemblies is a critical component of fire containment in locomotive & freight rolling stock.

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.

Material fire resistance testing shall be conducted by laboratories accredited to ISO/IEC 17025 for the relevant test methods. Accreditation shall be by NATA or an equivalent body recognized under the ILAC Mutual Recognition Arrangement.

This section outlines minimum fire resistance performance for these structural elements, with deemed-to-satisfy provisions suited to various locomotive & freight vehicle configurations.

6.2 Flooring

6.2.1 Performance requirements

6.2.1.1 Locomotive

Flooring assemblies shall resist the spread of potential underfloor fires into the driver's cab and any other compartment that the driver is required to travel through as part of their emergency egress route.

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

(a) the nature of the under-floor fire hazards (including potential external fire scenarios such as level crossing collision with a road vehicle and subsequent fire);

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

(c) the time required to detect the fire;

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

(e) the time required for evacuation of the rolling stock occupants to be completed.

6.2.2 Deemed to satisfy provisions

6.2.2.1 Locomotive

The performance requirement of clause 6.2.1 shall be deemed to be satisfied where the flooring assembly demonstrates compliance with achieving a minimum of 15 min integrity and 15 min insulation as per EN 45545-3:2024, verified by one of the following:

(a) testing of the flooring assembly in a horizontal orientation in accordance with AS 1530.4:2014 or an equivalent recognized international standard under comparable test conditions and acceptance criteria;

(b) construction from materials, such as those listed in EN 45545-3:2024, which have been pre-qualified as achieving the required integrity and insulation requirements. Penetrations shall be sealed using systems pre-qualified to the same performance level. Flooring assemblies shall resist the spread of underfloor fires into the driver's cab and any passageways used for emergency egress.

Test specimens for locomotive assemblies shall be not less than 1 m × 1 m in size and representative of the installed flooring construction. Larger or full-scale specimens shall be used where construction features, penetrations, interfaces or risk factors require to ensure validity of the fire resistance performance.

6.2.2.2 HFS and ESS locomotive

The following deemed-to-satisfy provisions apply specifically to locomotives equipped with HFS and ESS. The performance requirement of Clause 6.2.1 shall be deemed to be satisfied by the demonstration of compliance with the following for locomotives containing HFS or ESS:

(a) Where ESS or HFS equipment is installed above or beneath the floor, the flooring assembly shall comply with the fire resistance requirements specified for locomotives in Clause 6.2.2.1. This includes cases where the floor forms part of an emergency evacuation route or is adjacent to systems supporting safe egress. This approach shall be supported by a documented risk assessment.

Commentary C6.2.2.2

Where credible fire scenarios indicate that detection, shutdown and evacuation can exceed 15 minutes, increasing the fire barrier rating to align with the maximum expected exposure time provides an additional safety margin. If the expected fire temperature exceeds the standard test profile (i.e. approximately 738°C at 15 minutes per ISO 834-1), additional assessment might also be required to confirm barrier performance under elevated thermal exposure.

6.3 Cab partition wall & internal partitions

6.3.1 Performance requirements

6.3.1.1 Locomotive

The design of the partition at the rear of the cab, inclusive of cab door (if present) and internal partition adjacent to an internal escape route (such as a vestibule backwall), shall prevent the spread of fire into the cab and internal escape route such that in the event of a fire in the adjacent technical compartment, the crew is protected from the fire and combustion products while the rolling stock is stopped at a safe place and occupant evacuation completed.

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

(a) the nature of the fire hazard in the technical compartments adjacent to the driver's cab and internal partitions adjacent to an internal escape route;

(b) the time required to detect the fire;

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

(d) the time required for evacuation of rolling stock occupants, including passengers (if applicable), to be completed.

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

6.3.2 Deemed to satisfy provisions

6.3.2.1 Locomotive

The performance requirement of clause 6.3.1 shall be deemed to be satisfied where the cab rear wall partition and internal partition adjacent to an internal escape route (such as a vestibule backwall) achieve a minimum of 15 min integrity and 15 min insulation, verified by one of the following:

(a) the assembly is tested in a vertical orientation in accordance with AS 1530.4:2014 or an equivalent recognized international standard under comparable test conditions and acceptance criteria.

(b) partitions constructed from materials, such as those listed in EN 45545-3, which have been pre-qualified as achieving the required integrity insulation requirements. Penetrations shall be sealed using systems pre-qualified to the same performance level. This option is only applicable to freight locomotives.

(c) Test specimens shall be full-size, extending from the fire-resisting floor to the underside of the vehicle roof.

(d) Where full-size dimensions exceed the furnace opening, the maximum specimen dimension shall be 3 m in either direction.

(e) Representative penetrations, doors, escape route enclosures and adjacent partitions shall be included where these form part of the design.

(f) Design features that could compromise fire resistance performance shall be verified by assessment.

6.3.2.2 HFS and EES locomotive

The performance requirement of Clause 6.3.1 shall be deemed to be satisfied by demonstrating compliance with the following for locomotives incorporating HFS or ESS:

(a) Where HFS or ESS equipment is located adjacent to or directly behind the cab partition wall or adjacent to an escape route, the fire resistance of the partition wall shall be determined by a documented risk assessment;

Commentary C6.3.2.2-1

Given the elevated fire load and temperature profile of HFS and ESS fires, the expected level of protection is EI 30 (30 min integrity and insulation). EI 15 might be insufficient to maintain cab survivability during the evacuation period.

If higher risk is identified, the designer could choose to increase the cab backwall fire resistance level to 30 min integrity and 30 min insulation.

(b) Where HFS or ESS equipment compartment is separated from the cab and internal escape route partitions, the cab and escape-route partition shall achieve at least 15 min of integrity and insulation consistent with locomotive requirements. This approach shall be supported by a documented risk assessment which has assessed the following:

(i) The fire-resisting capability of the HFS/ESS compartment.

(ii) The likelihood of heat or flame impingement on the cab or escape-route partition.

(iii) The evacuation time required for crew safety.

Commentary C6.3.2 (b)

The EI 15 requirement is considered potentially sufficient in this case because a physical separation exists. Fire would need to develop within the HFS/ESS compartment, breach its own boundary and then act upon the cab or escape-route partition. This progression provides an inherent delay, meaning a 15-min integrity and insulation rating is typically expected to maintain survivability during the evacuation period.

6.4 Compartments containing combustion engines, high-power equipment, HFS and ESS

6.4.1 Performance requirements

6.4.1.1 Locomotives & freight rolling stock

Compartments within locomotive & freight rolling stock containing internal combustion engines, hydrogen tanks, fuel cells, lithium-ion batteries or high voltage traction circuit electrical equipment shall be separated from any adjacent occupied crew compartments or compartments that form part of the crew's escape route by fire-resistant construction.

Hot zones of combustion engines on-board locomotives & freight rolling stock shall be separated from fuel or hydraulic oil tanks by fire-resisting construction.

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

(c) the nature of the fire hazard in the compartment containing the engine and/or high-powered electrical equipment;

(d) the time required to detect the fire;

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

(f) the time required for evacuation of rolling stock occupants, including passengers (if applicable), to be completed.

6.4.2 Deemed to satisfy provisions

6.4.2.1 Locomotives & freight rolling stock

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

(a) When test samples complying with clause 6.4.2.1 are tested in a vertical orientation in accordance with AS 1530.4:2014 or an equivalent recognized international standard under comparable test conditions and acceptance criteria, the compartment partition shall achieve at least 15 min integrity.

(b) The compartment partition shall be constructed from a material, such as those listed in Table 2 of EN 45545-3:2024, which has been pre-qualified as achieving at least 15 min fire resisting integrity.

(c) Where penetrations are made through the plane of fire resistance (e.g. for doors or piping/electrical connections) to ensure that the integrity of the entire fire resisting plane is not compromised, these penetrations shall be fire sealed using a system that has been tested in accordance with AS 1530.4:2014 or an equivalent recognized international standard under comparable test conditions and acceptance criteria; and has achieved a minimum fire resistance level of 15 min integrity.

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

(e) 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.

6.4.2.2 HFS and ESS

In addition to the above, the performance requirement of Clause 6.4.1 shall be deemed to be satisfied by the demonstration of compliance with one of the following:

(a) Compartments containing hydrogen tanks, fuel cells or lithium-ion batteries shall provide at least 15 min of integrity and insulation performance.

(b) The structural support frame for the HFS shall maintain its integrity under fire exposure for a minimum duration of 30 min, as specified in ISO 834-1, Clause 6.1.1.

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 locomotives.

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 and ESS

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. ESS fires can involve thermal

runaway, generating intense heat and toxic gases, with the potential for delayed re-ignition. 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

7.3.1 Locomotive

The locomotive shall be provided with an adequate number of suitably sized portable fire extinguishers compliant with AS/NZS 1841:2007 and AS/NZS 1850:2009.

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

(a) the nature of the fire hazards within the locomotive;

(b) the potential size of any fires which might occur on the locomotive;

(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 shall 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

7.4.1 Locomotive

In addition to the above, the performance requirement of clause 7.3 shall be deemed to be satisfied by the demonstration of compliance with one of the following:

(a) Locomotives shall be equipped with at least one 4.5 kg dry powder fire extinguisher compliant with AS/NZS 1841:2007 in each cab.

(b) Additional portable fire extinguishers shall be fitted in other crew operation spaces on board the locomotive (e.g. sleeping/rest areas; monitoring stations). Spaces only used transiently (e.g. toilets; passageways; engine bays) are not considered an operational area for this purpose.

(c) Where cooking facilities are provided, open heating elements involving the heating of oils or fats are not recommended due to associated fire risks. Where unavoidable, such installations shall be minimized and risk managed. Fire blankets compliant with AS/NZS 3504 are to be provided in accordance with AS 2444.

Commentary C7.4.1

Modern onboard catering practices generally rely on safer alternatives, such as induction cooktops or microwave ovens, which reduce ignition hazards and improve temperature control.

Induction cooktops eliminate open flames and limit residual surface temperatures, making them a preferred solution for heating applications in rolling stock environments where fire safety is critical.

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

(e) 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

8.2.1 Locomotive & freight rolling stock

In the event of fire, whether internal or external to the rolling stock, the driver or train crew shall have the capability to control the ventilation systems to manage the risk posed by smoke to train occupants (passengers and crew).

8.3 Deemed to satisfy provisions

8.3.1 Locomotive & freight rolling stock

The performance requirements of Clause 8.2 shall be deemed to be satisfied by the demonstration of compliance with the following:

(a) It shall be possible for the driver or the train crew to:

(i) close all means of external ventilation into the passenger or crew compartments.

(ii) shut down air conditioning or ventilation systems to prevent the recirculation of smoke within passenger or crew compartments.

Section 9 Fixed fire protection systems

9.1 General

Fixed fire protection systems minimize the impact of onboard fires in locomotive & freight 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 fixed fire detection and extinguishing systems for locomotives and freight rolling stock.

In freight applications, where locomotives can be remote from train crews or operate unmanned, automatic suppression provides an added layer of protection.

9.2 Performance requirements

9.2.1 Locomotives

Fire detection shall be implemented in any other compartment where an undetected fire could pose a hazard to the locomotive crew, passengers in coupled vehicles or infrastructure users, including in sleeping facilities for passengers/crew.

Fire detection systems shall be designed and arranged to minimize false alarms while ensuring reliable detection of thermal events, smoke and gas leaks.

Commentary *C9.2.1*

Excessive false alarms could result in a loss of credibility in the system.

Detection methods shall be appropriate for the specific risks and properties associated with the energy storage and fuel source.

Upon activation, fire detection systems shall provide both visual and audible alarms to the train crew at their designated work locations.

Upon detection of a fault, failure or inoperative condition in the fire detection system, both visual and audible alarms shall be provided to the train crew at their designated work locations.

Faults and Alarms shall be clearly perceptible under all operating conditions and comply with AS 7533:2021, Section 14.

Appropriate fixed fire extinguishing systems shall be fitted to areas of locomotive rolling stock containing combustion engines, compartments containing high-power electrical equipment, ESS, HFS and any other compartment or area where a fire could develop unnoticed in a magnitude that could be hazardous to the locomotive crew, passengers in coupled vehicles or other users of the infrastructure.

If the fire extinguishing system fails, has a fault or is inoperative for any reason, this shall be indicated to the driver.

In heavy haul freight operations, where locomotives can operate unmanned and be positioned hundreds of metres from the train crew, an automatic fire suppression system shall be installed in high-risk areas, including those containing combustion engines, ESS or HFS. Automatic fire suppression systems significantly reduce response times and mitigate the risk of fire escalation, thereby improving overall safety and asset protection.

Fixed fire extinguishing systems shall function effectively in all vehicle orientations.

9.2.2 HFS and ESS locomotives & freight rolling stock

In addition to 9.2, fire protection measures applied to ESS and HFS shall detect, contain and mitigate thermal events or gas releases before they reach hazardous levels. Systems shall be capable of responding to failure modes specific to the energy source, including thermal runaway, gas venting and explosion risk.

9.3 Deemed to satisfy provisions

9.3.1 Locomotive

9.3.1.1 Fire detection systems

The performance requirements of Clause 9.2 shall be deemed to be satisfied by the demonstration of compliance with the following:

(a) Fire detection systems compliant to AS 5062:2022 and EN 45545-6:2024 shall be fitted to the following areas of locomotive rolling stock:

Commentary C9.3.1.1-1

AS 5062 emphasizes hazard identification, risk analysis and fire suppression, primarily for hydrocarbon fuel and electrical fires. Zero-emission rolling stock introduces new fire hazards, including thermal runaway in lithium-ion batteries, hydrogen leaks that present explosion risks and high-voltage electrical systems that require insulation monitoring and arc fault detection. Managing energy storage systems effectively involves considerations such as venting, cooling and compartmentalisation.

(i) Compartments containing combustion engines, where fuel and lubricant fires pose a risk.

(ii) Compartments or cabinets containing high-power equipment such as inverters.

(iii) Compartments or cabinets containing ESS.

(iv) Compartments or cabinets containing hydrogen storage tanks and fuel cell modules.

(v) Radiator compartments, if they contain fuel system components or non-metallic piping containing engine oil.

(vi) Compartments containing fuel-burning air heaters.

(vii) In nominally unoccupied compartments intended for in-service storage of passenger luggage or freight parcels.

(viii) In sleeping or rest facilities for crew.

(ix) Areas of vehicles that are required to ensure the compliance of the running capability concept defined in Section 10.1 of this document.

(b) The fixed fire detection system shall provide continuous monitoring of designated fire zones, including:

(x) compartments containing combustion engines, traction converters or high-power electrical equipment;

(xi) ESS including lithium-ion battery enclosures;

(xii) HFS components and enclosures; and

(xiii) other enclosed or unoccupied compartments where fire could develop undetected.

(c) The system shall support zonal detection and indicate the affected zone or compartment.

(d) Detection methods shall be appropriate to the hazards present and may include heat or smoke detection for mechanical and electrical equipment.

(e) The design of fixed fire detection systems shall be designed to:

(xiv) minimize false alarms through appropriate placement, filtering or logic;

(xv) maintain functionality and demonstrate reliable detection under representative railway operating conditions, including vibration, humidity and temperature extremes; and

(xvi) integrate with other onboard systems, including fixed fire suppression systems.

(f) Fixed fire detection systems, when activated, shall:

(xvii) activate an audible and visual alarm at all driver working positions;

(xviii) audible and visual alarms shall comply with the requirements of AS 7533:2021;

(xix) display the affected zone and, in coupled locomotives, the specific vehicle where the fire was detected;

Commentary C9.3.1.1-2

In multiple-unit locomotive consists, the standard 27-pin MU jumper allows fire alarms to be transmitted trainline-wide but does not provide any means of identifying which locomotive originated the signal. This limitation is characteristic of conventional platforms where the alarm circuit operates as a single-wire loop shared across all connected units. Newer locomotives can utilize Ethernet-based train communication networks capable of transmitting detailed fault information, including the origin of the fire alarm, to the lead cab. Initiate appropriate automatic actions to minimize the hazard posed by the fire. Such automatic actions should, however, be consistent with the running capability objectives defined in section 10 of this document.

(xx) automatically isolate, shut down power sources, HVAC, in affected compartments where feasible to prevent fire escalation. Such automatic actions should however be consistent with the running capability objectives defined in Section 10 of this document.

9.3.1.2 Fire Extinguishing Systems

The performance requirements of Clause 9.2 shall be deemed to be satisfied by the demonstration of compliance with the following:

(a) Fixed fire extinguishing systems, compliant to AS 5062:2022 principles, shall be fitted to:

(i) compartments containing combustion engines on locomotives;

(ii) areas of the vehicle as required to ensure the compliance of the running capability concept defined in Section 10 of this document.

(b) The design of the fixed extinguishing system shall take into account:

(iii) train speed and airflow impact on fire extinguishing effectiveness;

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

(v) the objectives of running capability defined in Section 10 of this document, ensuring that fire suppression measures do not introduce safety-critical operational risks.

(c) Extinguishing systems shall be sized to suppress the maximum credible fire load of the protected compartment.

(d) Fixed fire extinguishing systems shall operate in all vehicle configurations and orientations.

9.3.2 HFS and ESS Locomotive & freight rolling stock

In addition to 9.3.1, fire protection measures applied to ESS and HFS shall address the specific hazards associated with these technologies.

These requirements apply where fire suppression is necessary, based on the outcomes of a documented fire risk assessment or where required by operational conditions, such as tunnel operations or the carriage of flammable gases.

Fire protection measures ESS shall be designed in accordance with recognized standards addressing the unique hazards of these technologies. Suitable reference standards include AS 7486 and international standards such as IEC 62928 and CSA T/S 602.

ESS shall be provided with fire suppression systems designed to prevent the escalation of thermal events and limit the release of hazardous substances.

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 C9.3.2

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 EN 45545 or other railway standards.

Integration of fire suppression with the BMS could 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 (in development), CSA T/S 601, 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. NFPA 2 may also be used to inform general hydrogen safety provisions where rail-specific standards are not available.

The principles of AS 5062 should 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. They shall be applied to support the compliant implementation of fire protection measures for these systems:

(a) 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.

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

(c) Detection methods shall be appropriate to the hazards present and may include:

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

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

(d) 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 locomotive shall maintain sufficient operational capability to reach a designated safe stopping location in the event of a developing fire. 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 Performance requirement

10.2.1 Locomotive

Traction and braking systems on-board the locomotive shall be designed to enable the train to continue operation in the event of a developing fire, allowing the train to reach a suitable location on the network for the safe evacuation of occupants.

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

(a) the nature and location of potential fire hazards affecting these systems;

(b) the time required to detect the fire;

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

(d) the time required to safely evacuate passengers to a place of safety.

Fires originating within sealed equipment enclosures that comply with the requirements of Section 5.2.1 (c) are not classified as developing fires for the purposes of this clause.

10.2.2 Freight locomotive

Freight locomotives that operate through tunnels greater than 100 m in length shall be fitted with an appropriate number of self-rescue devices such that, in the event that the crew of a freight locomotive is required to evacuate from the locomotive through a smoke-filled tunnel, they are provided with equipment to reduce the hazard posed by the smoke during evacuation.

Commentary C10.2.1

Early fire detection enables the locomotive to continue operating for a short period following system activation. This provides the crew with the opportunity to move the train to a safe stopping location, such as beyond a tunnel.

10.3 Deemed to satisfy provisions

10.3.1 Locomotives

EN 50553 specifies functional and technical requirements for passenger trains, including locomotive-hauled configurations, to ensure that, in the event of a fire on board, the train retains sufficient running capability to reach a designated safe stopping location.

The performance requirements of clause 10.2 shall be deemed to be satisfied by:

(a) compliance with EN 50553:2012 to show that the locomotive coupled to passenger vehicles maintains sufficient operational capability to reach a designated safe stopping location under realistic fire conditions. This includes protection of essential systems such as traction, braking, communication and fire detection.

(b) implementation of fire protection measures for all components critical to train movement and control, including traction converters, braking systems and energy management systems. These components shall be located, shielded or rated to withstand fire for the duration required to reach a place of safety.

10.3.2 Freight locomotive

The performance requirements of Clause 10.2.2 shall be deemed to be satisfied if:

(a) Each driver's cab of freight locomotives, which operate through tunnels greater than 100m in length, shall be fitted with self-rescue devices that are compliant with the requirements of EN 403:2004.

(b) The number of self-rescue devices provided in each cab shall not be less than the number of train crew who will occupy that cab in normal service operations.

(c) The type of self-rescue equipment provided shall provide smoke protection for not less than the expected egress period in the tunnel systems in which the locomotive will operate.

10.3.3 HFS and ESS locomotive

In addition to Section 10.3.1 and Section 10.3.2 of the general deemed-to-satisfy provisions, the following shall be used to demonstrate compliance for locomotives and freight locomotives with HFS or ESS systems:

(a) Compliance with EN 50553:2012, ensuring the freight locomotive maintains operational capability for a sufficient duration to reach a designated safe stopping location in the event of a fire.

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

(c) 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 locomotive functionality.

(d) 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

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). Release types shall be classified in accordance with IEC 60079-10-1:2020.

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

(f) Primary release: Occasional or periodic; must be avoided by design.

(g) Secondary release – Through designated vent lines, typically triggered by overpressure or overtemperature. Manufacturers must provide expected rates based on component design.

(h) 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:

(i) prevent gas accumulation in enclosed spaces;

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

(k) 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 ISO 834-1:1999 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 Maintenance, modification, refurbishment and operational change

12.1 General

Maintenance, modification, refurbishment or changes in operational conditions are not to 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.

12.2 Performance requirements locomotive & freight rolling stock

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; or

(b) not reduced below the deemed to satisfy requirements specified in this document.

If the maintenance, modification or refurbishment of rolling stock 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 specified in Section 2 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:

(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, such as from freight to passenger operation.

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

12.3 Deemed to satisfy provisions

12.3.1 Locomotives & Freight Rolling Stock

12.3.1.1 Maintenance

The requirements of Clause 12.2 relating to maintenance are deemed to be satisfied by implementing all of the following where applicable:

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

Maintenance procedures shall include periodic battery cell health checks to identify defective or degraded cells, thereby reducing the likelihood of thermal events or system damage during service operation.

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

Component replacement shall be 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 Section 12.3.2.

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

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

(a) 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.

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

(c) Materials relying on specific layering for fire resistance (e.g. seat trim, flooring, insulation layers) shall undergo periodic inspections. If degradation is identified, rectification works shall be undertaken.

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

Fire Protection System Maintenance:

Fire protection systems shall be maintained in accordance with the requirements of AS 5062:2022.

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

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

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

Self-rescue devices provided shall be maintained in accordance with manufacturer instructions and applicable regulatory requirements.

Self-rescue devices shall be inspected periodically, tested functionally (where applicable) and replaced prior to expiry.

A process shall be established to reassess the specification of self-rescue devices where tunnel length, ventilation profile or egress duration changes.

The number of self-rescue devices shall be reviewed whenever crew configurations change, ensuring sufficiency for normal operation.

12.3.1.2 Modification and refurbishment

The requirements of Clause 12.2 in relation to modification and refurbishment may 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 with 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), then it is acceptable to replace it with another equivalent-type component or material that is:

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

  (ii) certified to EN 45545-2 HL requirements set by the operation category that is relevant for where the rolling stock will operate.

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

  (iii) certified to EN 45545-2:2020 HL requirements set by the operation category that is relevant for where the rolling stock will operate.

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

NOTE:

EN 45545-2 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.

12.3.1.3 Operational changes - locomotive

The requirements of Clause 12.2 regarding operational change shall be deemed to be satisfied by demonstrating the following:

Where a freight locomotive is proposed to be used for passenger operations, the locomotive shall be assessed for compliance with the fire safety requirements applicable to locomotive, as defined in this document.

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.

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

(a) fire detection and suppression adequacy;

(b) self-rescue device suitability and duration;

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

(d) 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
5.16	Train protection system failure
5.17	Poor cab vision
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)

Hazard number	Hazard
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)
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)
5.53.1.2	Human error
5.45.1.15	Being overcome by fire products (Unable to reach exit safely - Unable to successfully evacuate)
5.53.1.3	Invalid test procedures
5.53.1.9	Incorrect analysis methods (Design error)

Bibliography (Informative)

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

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- AS/NZS 1715, Selection, use and maintenance of respiratory protective equipment AS/NZS ISO 45001, Occupational health and safety management systems – Requirements with guidance for use
- IEC 61881, Railway applications – Rolling stock – Capacitors for power electronics
- IEC 62619, 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 62660 series, Secondary lithium-ion cells for the propulsion of electric road vehicles
- BS EN IEC 63341-1:2023 [Under development], Railway applications – Rolling stock – Fire protection – Part 1: General requirements
- BS IEC 63341-2 [Under development], Hydrogen safety – Fire protection design guidance for onboard systems
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- ISO 19880-1, Gaseous hydrogen – Refueling stations – Part 1: General requirements
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- Commission Regulation No 1302/2014, Technical specification for interoperability relating to the rolling stock – locomotives and passenger rolling stock
- ASTM E2061, Standard guide for fire hazard assessment of rail transportation vehicles
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- NFPA 130, Standard for fixed guideway transit and passenger rail systems
- NFPA 497, Recommended practice for the classification of flammable liquids, gases or vapors and of hazardous (classified) locations for electrical installations in chemical process areas
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