TS 00008.3:1.0

Standard

Fire Life Safety

Part 3: Tunnels

Issue date: 30 October 2024

Effective date: 30 October 2024

Disclaimer

This document has been prepared by Transport for NSW (TfNSW) specifically for its own use and is also available for use by NSW public transport agencies for transport assets.

Any third parties considering use of this document should obtain their own independent professional advice about the appropriateness of using this document and the accuracy of its contents. TfNSW disclaims all responsibility and liability arising whether directly or indirectly out of or in connection with the contents or use of this document.

TfNSW makes no warranty or representation in relation to the accuracy, currency or adequacy of this document or that the document is fit for purpose.

The inclusion of any third party material in this document, does not represent an endorsement by TfNSW of any third party product or service.

For queries regarding this document, please email Transport for NSW Asset Management Branch at standards@transport.nsw.gov.au or visit www.transport.nsw.gov.au

Document information

Owner:	Director Interchanges and Buildings Asset Management Planning, Integration and Passenger
Mode:	Multimodal
Discipline:	Interchanges and buildings

Document history

Revision	Effective date	Summary of changes
1.0	30 October 2024	First issue as TS 00008.3

Preface

This standard is a first issue.

This document forms part of the TS 00008 series of documents related to fire life safety.

The intended outcome of this document is to set the minimum mode specific fire life safety requirements for the design of new and existing tunnels.

This document defines the minimum fire life safety requirements for tunnels.

This document should be read in conjunction with TS 00008.1 and TS 00008.2.

Table of contents

1 Scope

This document sets out the minimum fire safety measures and fire engineering process to be applied to tunnels and the equipment and services rooms that are ancillary to the tunnels which include:

- rail tunnels
- road tunnels
- pedestrian and bicycle tunnels
- services tunnels.

This document aims to:

- reiterate the proactive, asset management-based approach to manage fire risks implemented by TfNSW
- improve the efficiency of stakeholder review processes by using acceptable standards of fire safety analysis and design
- set out the minimum requirements for fire safety measures and the fire engineering process, including stakeholder consultation.

This document covers the following:

- specific principles applicable to fire safety measure selection and design in tunnels
- minimum requirements for selected fire safety measures to protect occupants and allow for their safe evacuation in the event of an emergency
- minimum design requirements for tunnel firefighting systems and fire engineering design and review processes.

This document does not cover the following:

- fire safety risks within an office building, which is covered by the BCA
- bushfire risk, which is subject to separate assessments by a competent bushfire practitioner
- non fire safety risks that are part of a tunnel
- fire safety within construction sites which is to be managed by the site safety management plan.

2 Application

This document applies to all tunnels, including but not limited to rail, road, pedestrian, bicycle and services tunnels throughout the asset life cycle including planning, design, construction, operation, maintenance, refurbishment and disposal.

This document should be read in conjunction with TS 00008.1 for all types of tunnels. The BCA and TS 00008.2 apply where tunnels interface with a train station in relation to fire safety measures.

This document applies to Technically Assured Organisations (TAOs), service providers and TfNSW personnel involved in the following:

- assessment of fire safety risks
- development of performance solutions
- development of asset fire life safety strategies
- development of fire systems design.

This document is intended for use by:

- roles responsible for the overall project development, stakeholder consultation and technical assurance
- fire safety engineers who are responsible for the development of the fire engineering process and performance solutions
- fire protection engineers who are responsible for the development of specific fire systems designs for tunnel fire systems
- Asset Steward – operate and maintain who are responsible for the ongoing asset management of the tunnels fire safety measures.

This document can also apply to asset managers, project managers, technical managers, tunnel operators and designers of any discipline as it provides guidance in understanding fire safety risk and applying fire safety measures towards the whole-of-life of assets.

3 Referenced documents

The following documents are cited in the text. For dated references, only the cited edition applies. For undated references, the latest edition of the referenced document applies.

Australian standards

AS 1170.4 *Structural design actions – Part 4: Earthquake actions in Australia*

AS 1530.4 *Methods for fire tests on building materials, components and structures – Part 4: Fire-resistance tests for elements of construction.*

AS 1670.1 *Fire detection, warning, control and intercom systems – System design, installation, and commissioning – Part 1: Fire*

AS 1670.4 *Fire detection, warning, control and intercom systems – System design, installation, and commissioning – Part 4: Emergency warning and intercom systems*

AS 2118.1 *Automatic fire sprinkler systems – Part 1: General systems*

AS 2118.3 *Automatic fire sprinkler systems – Part 3: Deluge systems*

AS 2419.1 *Fire hydrant installations – Part 1: System design, installation and commissioning*

AS 2444 *Portable fire extinguishers and fire blankets – Selection and location*

AS 4214 *Gaseous fire-extinguishing systems*

AS 4825 *Tunnel fire safety*

AS 5637.1 *Determination of fire hazard properties – Part 1: Wall and ceiling linings*

AS 60529 *Degrees of protection provided by enclosures (IP Code)*

AS/NZS 2293 (all parts) *Emergency lighting and exit signs for buildings*

AS/NZS 3000 *Electrical installations "Wiring Rules"*

AS/NZS 3013 *Electrical installations – Classification of the fire and mechanical performance of wiring system elements*

AS/NZS IEC 60812 *Failure modes and effects analysis (FMEA and FMECA)*

Transport for NSW standards

TS 00008.1 *Fire Life Safety – Part 1: Principles*

TS 00008.2 *Fire Life Safety – Part 2: Stations*

TS 00014 *Risk Assessment for Transport of Dangerous Goods through Tunnels*

TS 01722 (ESC 340) *Tunnels*

TS 03996 (T HR RS 17010 ST) *Passenger Rolling Stock Fire Safety*

TS 03998 (T LR RS 17010 ST) *Light Rail Vehicle Fire Safety*

TS 04936 (T HR SS 80003 ST) *Infrastructure Emergency Lighting*

TS 04981 *System Safety Standard for New or Altered Assets*

TS 04982 (T MU MD 20002 ST) *Risk Criteria for Use by Organisations Providing Engineering Services*

TS 04985 (T MU MD 20003 GU) *Quantified Safety Risk Assessment*

Other referenced documents

National Fire Protection Association (USA), NFPA 502, *Standard for Road Tunnels, Bridges, and Other Limited Access Highways*

The Australian Building Codes Board, *National Construction Code,* Volume 1

Work Health and Safety Act 2011 (NSW)

4 Terms, definitions and abbreviations

The following terms, definitions and abbreviations apply in this document:

Asset Custodian the TfNSW Division accountable for the end to end life cycle management and performance of assets (including asset condition, risk and reporting) on behalf of the asset owner to achieve agreed customer and community outcomes.

Asset Steward – delivery the entity responsible for:

- procuring assets from investment decision to commissioning
- delivering the benefits
- translating requirements from the client and managing delivery outcomes
- selecting the most appropriate supplier/s to meet project objectives.

Asset Steward – operate or maintain the entity responsible for the day to day operations and maintenance of assets once commissioned. May be a part of the Asset Custodian division or a separate entity. Operator and maintainer of the assets might be separate entities.

BCA *Building Code of Australia* (NCC Volume 1)

EEC emergency equipment cabinet

FEEP fire brigade emergency equipment point

fire safety measures includes items of equipment, forms of construction or fire safety strategies that are provided to promote the safety of people in the event of a fire

FRL fire resistance level

MEEP motorist emergency equipment point

RABT-ZTV Richtlinien fur Ausstattung und den Betrieb von Strassentunneln – a series of fire curves developed to represent the fire growth rates in the rail and road tunnel environment

SCADA supervisory control and data acquisition

- **SFAIRP** so far as is reasonably practicable

TfNSW Transport for NSW

5 General requirements for existing tunnels

This document shall be applied in accordance with TS 00008.1 for existing tunnels and applies in full for new tunnels.

6 Design requirements and principles in tunnel environments

The design of all fire safety measures and fire safety engineering process shall minimise the harmful effects of fire in tunnels and ancillary rooms. All fire safety measures and associated fire safety systems required to operate in fire mode in tunnels shall be designed and installed to ensure the safety of tunnel occupants and responding emergency services, and to protect tunnels for the entire lifecycle of the asset.

The design of tunnel fire safety systems shall assess the failure of fire systems on other tunnel infrastructure elements. Failure mode and effects analysis shall be done in accordance with AS/NZS IEC 60812 and impacts minimised SFAIRP to the tunnel occupants and responding emergency services. Failure mode and effects analysis shall be done in consultation with stakeholders which shall also include responding emergency services as needed for strategies effecting emergency response. Design changes and or fire engineering process changes that alter the emergency response strategy shall be consulted with emergency services. Evidence of consultation shall include consultation documents for subsequent design changes after initial brigade consultation to demonstrate suitability with brigade operational response.

Proposed design solutions shall incorporate access requirements for repair and maintenance personnel, vehicles and equipment required to carry out works on fire safety systems and include allowances for traffic management and possessions where required for ongoing repair and servicing of equipment.

The key control equipment used for controlling the installed fire safety systems and testing shall be installed in locations that enable repair, maintenance and testing activities to be carried out without the need to shut down tunnels or other activities that would affect normal operations of tunnels. Where access to key control equipment cannot be achieved, alternate design approaches shall be identified and evaluated in consultation with the Asset Steward – operate or maintain (if known), Asset Steward – delivery and Asset Custodian.

6.1 Fire brigade access and response

The design of tunnels shall allow for the movement of fire brigade personnel and vehicles where applicable within tunnels. Strategies shall be developed and documented through a consultation process with the respective agencies whose jurisdiction a tunnel is located within.

Tunnels shall include the following features as a minimum:

- Egress passages to provide safe egress from tunnels and access for emergency services during an incident.
- Access and egress widths to facilitate emergency and rescue operations.
- Full coverage for the NSW Public Safety Network to support emergency services communications during an incident.
- Full coverage of emergency phones.
- Full coverage of mobile phone network with a minimum of 90 minutes back up within tunnels to facilitate fire brigade mobile phone usage for relay of sensitive information.
- Detailed block diagrams outlining the location of fire safety services and approach direction to incidents. These block diagrams shall be provided in fire control rooms and at the ground level entry to each of the fire exits.

6.2 Minimisation of the impact of incidents

Tunnels fire safety systems and measures shall be designed so that the impact of fire incidents within tunnels or tunnels adjoining tunnel structures is limited during the ongoing tunnel operations. Placement of safety equipment shall allow for effective use and ease of operation in an emergency and to prevent or limit damage to the equipment in the event of a fire emergency.

Processes shall be in place during the operations phase of the tunnels to limit impacts to tunnel operation, permitting return to service in a safe, practicable and acceptable timeframe by the Asset Steward – operate or maintain.

6.3 Fire safety measures

The design of tunnel fire safety measures shall be appropriate to the following tunnel characteristics:

- length of a tunnel
- width
- height
- geographic location
- gradient
- usage of a tunnel with respect to expected rolling stock for rail, vehicle usage for roads, expected pedestrian and bicycle traffic for pedestrian and bicycle tunnels and services installed for services tunnels, including future services uptake if known at the time.

The fire safety measures include:

- fire resistance
- fire separation
- fire detection and alarm systems
- automatic and manual fire suppression systems
- fire hydrant systems
- fire extinguishers
- emergency warning and intercommunication systems
- ventilation and smoke management system
- emergency lighting and exit signage
- communication systems including public address and fire phones used in emergency scenarios
- closed-circuit television (CCTV)
- all power supplies, control systems and cabling associated with the above systems
- emergency egress passages
- track access ladders
- track trolleys
- flame traps.

Fire safety systems shall be designed to operate for a minimum time as outlined in the respective Australian standards, unless more stringent requirements are specified by the fire engineering report or the following sections of this document.

Local failure of components in the vicinity of fire shall not cause a fire safety system to operate below its design performance requirement. All support devices for heavy equipment suspended within tunnels shall be capable of maintaining its support function for not less than two hours at 450°C. Seismic restraints for fire safety equipment shall be in accordance with AS 1170.4.

All wall and ceiling linings installed in tunnels and any ancillary rooms shall have a group number 1 rating determined in accordance with AS 5637.1.

Additional fire safety measures specific for rail, road, pedestrian and bicycle, and services tunnels are in Sections9 to12.

6.4 Interface with other systems

Where services are required to operate in emergency mode, they shall be interfaced with tunnel fire safety systems to enhance the safety of occupants. This includes communication systems, electrical systems and mechanical ventilation systems.

Refer to TS 01722 for interface of mechanical and electrical systems with fire safety systems.

6.4.1 Emergency lighting

Tunnel emergency lighting shall be provided in accordance with TS 04936 and AS/NZS 2293 (all parts).

Emergency lighting should use an addressable control system readily programmable to facilitate modifications, maintenance and test facilities. The emergency lighting systems shall be integrated with the operating control system to allow remote testing, control, and monitoring.

Illuminated exit and directional exit signage shall be installed so that it is clearly visible to all occupants in a tunnel, indicating a clear path to an exit.

6.5 Egress analysis

AS 4825 contains guidance for safe egress with respect to tunnels. All tunnels shall be designed to have paths of travel to enable safe egress which can be achieved by satisfying the provisions of AS 4825.

The fire engineering process, where used to justify increased distance between exits used for egress, shall be in consultation with the fire brigade. The design shall facilitate the safe evacuation of occupants and facilitate fire brigade intervention. The fire engineering report shall be accompanied by a detailed analysis of local fire brigade response capabilities and operational expertise.

7 Fire engineering process

The fire engineering process shall be developed in accordance with TS 00008.1 noting that specific planning legislation for tunnel projects is different to other aspects of the built environment. Fire engineering to assess non-compliances to this standard through the fire engineering process shall:

- assess the impact of fire system failures on other tunnel structures and services
- demonstrate that consequences from the failure of fire safety measures are reduced SFAIRP.

Performance solutions shall ensure that any modifications to part of a fire safety system, outside of an entire base structure upgrade, are clearly articulated in the facilities annual fire safety certificate.

7.1 Applicable areas

The fire engineering process in this document shall apply to:

- tunnels and associated operations, including plant and equipment rooms, and dive structures
- areas used as emergency egress paths from, and assembly areas for, tunnels
- areas used as emergency access paths to tunnels
- areas outside tunnels where fire safety measures are shared or integrated with those for a tunnel.

7.2 Risk assessment parameters

The risk assessment process for tunnels shall take into account all reasonable fire safety measures that have the potential to reduce the fire safety risk including the minimum scenarios nominated in Section 9 to 12 for that type of tunnel. This shall form part of the overall safety assurance argument for the tunnel fire safety measures.

Where a fire safety measure is determined as not reasonably practicable to be adopted tunnel's asset fire safety strategy shall include a justification for not being implemented. The determination shall be based on the *Work Health and Safety Act 2011*, published guidance from the Office of National Rail Safety Regulator (ONRSR) for rail tunnels and TS 04982 for other tunnels. The assessment shall take into account the following:

- the likelihood of the hazard
- the consequence of the hazard
- knowledge about the hazard or risk and ways of eliminating or minimising the risk
- availability and suitability of ways to eliminate or minimise the risk.

If cost is used as the basis for discounting a control, it shall be relative to the potential safety benefit.

When performing the analysis, the fire engineer, Asset Steward – delivery and Asset Steward – operate or maintain (if known) shall consider the following, as a minimum:

- areas outside of TfNSW owned tunnels, where a fire could create a hazard, such as the spread of heat or smoke, to tunnels
- number and proximity of fire stations in and around the site

- travel time to the location of the emergency
- capabilities of the available equipment at the fire stations
- availability of emergency services personnel.

  Note: The availability of personnel will depend on the local arrangements with the fire brigade, for example whether the personnel are permanent, on-call or volunteer.

The availability of personnel shall be confirmed with the relevant emergency services agencies within their jurisdiction, for example Fire and Rescue NSW (FRNSW), Rural Fire Service (RFS) and the accredited specialist rail rescue unit.

7.3 Balance of benefits

A fire safety measure may be discounted as not reasonably practicable if the fire safety benefit is outweighed by the overall safety benefit when considered in the context of all safety risks as part of an integrated safety argument in accordance with TS 04981.

If cost is used as the basis for discounting a control it shall be relative to the potential safety benefit. This cost-benefit analysis does not always need to be quantified where the outcome is overwhelmingly obvious. Records shall be kept of all determinations that a control has been discounted with reasons and be available for review. Costs shall include whole-of-life costs.

A quantitative cost-benefit analysis is insufficient as the sole justification that a design is safe with respect to fire risk. Fire safety shall take into account the following and find a reasonable balance of benefits:

- the duty of care of all stakeholders
- community expectations
- legislative requirements
- political risk appetite
- quantitative risk assessment
- local and international precedence
- the requirements of key stakeholders.

Each step of the fire risk assessment shall be documented in a tunnel's fire safety hazard log for audit purpose and provide a transparent record of the assumptions made and fire safety measures that have been discounted. The fire safety hazard log shall form part of an overall project hazard log.

Estimations of the overall fire safety risk for an asset shall use the risk criteria and matrix described in TS 04982.

TS 04985 provides information on carrying out quantitative safety risk analysis.

7.4 Hazard identification and scenario generation

The fire engineering process shall address the selection and use of the proposed fire safety measures within tunnel environments. The fire engineering process shall apply the minimum hazard scenarios in Section 7.4.1 in addition to the mode specific tunnel minimum scenarios in Sections 9 to 12. These scenarios shall be assessed and developed as part of the fire safety strategy and the safety assurance argument.

7.4.1 Minimum scenarios

The fire safety engineer and fire protection design engineer shall feed into the project safety assurance argument and risk assessment process in regard to the selection and use of proposed fire safety measures within the tunnel environment. The fire engineering risk assessment process and fire safety measures design for tunnels shall, at a minimum, address the minimum scenarios identified within each specific tunnel against the risk posed to the safety of a tunnel occupants and responding emergency services, and a tunnel's structure. When assessing the risks the following consequences shall be considered where applicable:

- injury or fatality from:
    - heat or smoke from a fire to occupants and maintenance staff evacuating a tunnel or cross passage from the burning materials in a tunnel, installed equipment, or structure
    - structures in a tunnel failing due to heat from a fire
    - falling objects and services due to failure of supports in a fire
- operational interruption due to:
    - cessation of movements during a fire incident
    - prevention of commuter access during a fire incident
    - delayed return to operations due to post fire clean-up or loss of operationally critical assets or elements
    - injury caused to staff
- asset damage:
    - to transport infrastructure from heat and smoke
    - to transport infrastructure from firefighting water
    - to tunnel infrastructure and services
    - to structural elements and waterproofing elements within underground tunnels within an incident tunnel and adjoining tunnels

- environmental damage due to:
    - pollution from smoke generated by the fire
    - pollution from contaminated firefighting water.

All fire safety hazards shall be recorded in a hazard log in accordance with TS 04981.

7.4.2 Risk criteria

For all scenarios, including extreme event scenarios, the fire safety measures design shall demonstrate that the risk are reduced in SFAIRP through the following:

- all reasonably practicable fire safety measures have been adopted to minimise the safety risks from fire
- risk has been reduced to at least a tolerable level when assessed against the risk matrix in TS 04982 the risk identification process shall incorporate TfNSW's organisational hazard register.

8 Dangerous goods in tunnels

Refer to TS 00014 for details on the risk assessment of dangerous goods being transported through tunnels. The passage of dangerous goods shall require the assessment of the fire safety measures within a tunnel. The risk assessment shall incorporate:

- fire safety measures
- installed systems and processes for sourcing and communicating information about dangerous goods manifests to the fire brigade in the event of an emergency
- a review of local fire brigade capabilities to respond to incidents which shall be documented in a detailed report noting the consultation and assessment of capabilities including brigade response times and staffing arrangements of the station with regards to whether they are retained or permanent fire fighters
- the risk to community and surrounding infrastructure in accordance with TS 04982.

Fire life safety studies for dangerous goods risk assessments shall also take into account the risks associated with the response to the event. Examples of risks during the response to dangerous goods events include:

- ventilation systems propagating toxic gases
- contaminated water
- water reactive chemicals for which extinguishment with water would be inappropriate.

Spills of dangerous goods and hazardous materials can cause toxic gases to be released into tunnel environments. Such risk shall be assessed as part of the dangerous goods assessment.

Tunnel services shall prevent the spread of toxic gases and prevent the propagation of the gases throughout tunnels.

The spread of contaminated water as a result of the extinguishment of fires or the spill of dangerous goods and hazardous materials shall be prevented. Refer to section 10.4.3 for suppression requirements of tunnel drainage systems. The design and operation of fire safety measures and tunnel services shall take into account the fire brigade's emergency response, which generally involves large volumes of water.

9 Rail tunnels

Rail tunnels fire safety systems shall be designed, built, operated and maintained to:

- provide a practicable level of safety for rail occupants and users that is consistent with the intent of AS 4825
- ensure acceptable levels of fire safety are achieved for train crews, rail passengers, other rail staff and contractors, the public and emergency services personnel
- ensure the safety of people outside a tunnel or at connecting stations or buildings
- minimise the impact of fire on rail infrastructure including tunnels, stations, other buildings associated with the tunnel operations, rolling stock and on the continuity of operations of railway operators.

9.1 Minimum scenarios

The rail tunnel network is an operating environment and consequently the fire engineering process shall consider the following operational and management controls to ensure effective emergency response:

- emergency services and the accredited specialist rail rescue unit capability
- incident management plans and procedures (including communication protocols)
- management of train movements
- staff training.

The scenarios in Table 1 are the minimum scenarios that shall be assessed as part of the fire engineering process to determine the appropriate tunnel fire safety measures. Table 1 outlines the specific primary scenario requirements that shall be adopted when designing new rail tunnels and alterations to existing rail tunnels based off the potential hazards to occupants in Section 7.4.1.

Table 1 – Primary fire scenarios in rail tunnels

Primary scenarios	Potential cause
Passenger rolling stock fire within the tunnel – including rooftops, under floors and within passenger cars	• Electrical faults from rolling stock traction, low voltage systems, air conditioning or other onboard systems • Overheated brakes • Airborne rubbish lodged in traction • Arson • Materials brought onto the rolling stock • Derailment or collision
Infrastructure fire involving systems equipment, electrical cable insulation, rubbish or maintenance equipment	• Electrical faults in equipment such as lighting, tunnel HV, switchboards, distribution boards, tunnel ventilation systems, drainage pumps, maintenance vehicles • Accumulation of debris and other combustible materials within tunnels and ancillary areas • Matches, lighters or cigarettes from tunnel occupants, unauthorised occupants or arson • Maintenance hot works, track grinding, machinery and associated rail infrastructure machinery
Cross passage fire involving systems equipment, electrical cable insulation, rubbish or maintenance equipment	• Electrical faults in equipment such as lighting, switchboards, distribution boards, drainage pumps • Matches, lighters or cigarettes from tunnel occupants, unauthorised occupants or arson • Maintenance hot works
Track maintenance or inspection vehicle fire	• Electrical faults from traction, low voltage systems or air conditioning • Overheated brakes • Maintenance hot works, track grinding • Derailments collisions
Freight train fire (for heavy rail only)	• Electrical faults in locomotives • Diesel fuel system faults • Overheated brakes, seized wheel bearings on rolling stock • Fire starting in payload • Derailments collisions
Heritage (steam) train fire (for heavy rail only)	• Steam engines, furnace faults in locomotive • Electrical faults from, low voltage system, air conditioning or other on-board systems • Overheated brakes • Arson • Derailments, collisions

The maximum and minimum design fire size for rolling stock within a tunnel shall be in accordance with TS 03996 for heavy rail vehicles and TS 03998 for light rail vehicles. Lower

peak heat release rates for rolling stock complying with newer standards shall only be used where it is the only type of rolling stock running within the tunnel. Where the tunnel is shared among different rolling stock then the peak heat release rate shall be based on the most onerous rolling stock using the tunnel at the time of design.

9.2 Fire resistance

The separation of adjoining tunnel structures, emergency egress cross passages and functional areas shall achieve a minimum FRL of:

- 120/120/120 for load-bearing elements and walls separating functional areas such as equipment rooms and emergency egress cross passages
- – /120/120 for non-load bearing elements and walls separating functional areas such as equipment rooms and emergency egress cross passages
- – /120/30 for emergency egress cross passage doorways.

Dive structures, any structures directly exposed to train fires in a tunnel and cavern spaces that support a building shall achieve a minimum FRL of:

- 240/240/240 for load bearing elements
- – /240/240 for non-load bearing elements
- – /240/30 for doorways in the bounding walls of the dive structure.

Service connections between the bounding construction of fire separated areas shall be fire sealed to the required FRL in the preceding bullet list. Testing for fire resistance shall be in accordance with AS 1530.4.

9.3 Fire detection and occupant warning systems

Fire detection and occupant warning systems shall be designed and installed in accordance with AS 1670.1.

If a fire detection and warning system is not proposed to be provided through the fire engineering process, signage within a heavy rail tunnel shall be provided so that train location can be determined with sufficient accuracy for the driver to communicate with tunnel operator. This is to enable the driver to advise their location so the smoke exhaust system can be manually activated to facilitate safe egress from that location. This does not apply to metro rail tunnels, where train control systems can locate their position in the tunnel.

Equipment rooms within tunnels shall be provided with a fire detection system in accordance with AS 1670.1 to provide alert to the operating control system.

9.4 Automatic fire suppression systems

The provision of automatic fire suppression systems in rail tunnels shall be determined by the fire engineering process.

Critical equipment rooms shall have an automatic fire suppression system for asset protection and to control the size of the fire to prevent fire spread. Suppression systems shall be in accordance with AS 2118.1 for wet fire sprinkler systems and AS 4214 for gas suppression systems. Design and selection of the type of suppression systems shall be based on the criticality of assets being protected within equipment rooms. Suppression systems shall be centrally monitored.

9.5 Fire hydrant systems

Fire hydrant systems in rail tunnels shall be a charged wet system, designed and installed in accordance with AS 2419.1.

The fire hydrant system shall, at a minimum, be capable of delivering the pressure and flow for three fire hydrant outlets to flow simultaneously.

9.5.1 Fire hydrant mains

Fire hydrant mains in tunnels shall be designed to meet the following criteria:

- single track tunnels shall have a single fire hydrant main installed
- two single track tunnels that run parallel to each other and contain cross connection passages shall have a single fire hydrant main installed in each tunnel
- dual track single tunnels shall have two fire hydrant mains installed on opposite sides of tunnels.

9.5.2 Ring mains

Tunnel fire hydrant systems shall provide a continuous ring main between adjacent tunnels, subject to approval of the relevant water authority, such that if one section of the ring main fails, coverage is not lost to the fire hydrant outlets within the tunnels.

The systems hydrant ring main pipes, hydrant valves and isolation valves shall not encroach into the egress path or the kinematic envelop of the train.

9.5.3 Isolation Valves

Monitored isolation valves and isolation sections shall be provided on the fire hydrant ring main to allow the isolation of sections under failure or for maintenance purposes, while maintaining full functionality of the remainder of the ring main.

Monitored isolation valves shall be:

- fitted at locations and heights that are readily accessible for operation and maintenance
- provided at intervals not greater than 120 m
- strapped and padlocked in the open position
- capable of transmitting to the fire panel, and SCADA system if provided, the open/close status of the isolating valves.

9.5.4 Fire hydrant outlets

Dual fire hydrant outlets shall be provided within 4 m of cross passage doorways, on the cross passage side, with intermediate fire hydrant outlets at intervals not greater than 60 m.

Each fire hydrant outlet shall be provided with compliant hose coupling and a blank cap attached to the valve body by a suitable metal chain.

9.5.5 Fire brigade booster assemblies

Fire brigade booster assemblies shall be provided at ground level of stations for fire brigade vehicles to connect to and boost the tunnel fire hydrant system. Additional fire brigade booster connections shall be provided at the adjacent station to maximise the availability of the system. For tunnels not connected to a station, the location of the boosters shall be determined in consultation with the fire brigade.

Each separate tunnel fire hydrant system shall be provided with its own booster inlet, labelled with a single boost pressure required to achieve the performance requirements at all points of the system. The fire brigade booster location and connections shall be subject to fire brigade consultation.

9.5.6 Electrical isolation

Electrical isolation joints shall be installed in the fire hydrant mains at intervals not greater than 300 m, to reduce the corrosion effect of stray traction currents and transfer potentials along tunnels.

9.6 Portable fire extinguishers

Portable fire extinguishers shall be provided within 4 m of each cross passage doorway, on the cross passage side, and within each room that opens into a rail tunnel. The selection of type of extinguishers and their location shall be in accordance with AS 2444. Fire extinguishers shall be positioned to enable easy access for emergency use and maintenance by trained staff.

9.7 Tunnel smoke management systems

Tunnel smoke management strategies shall be determined by the fire engineering process. Smoke management strategies shall be designed to maintain tenable conditions in rail tunnels to facilitate occupant evacuation and fire brigade intervention.

Where a smoke management system is provided, the design of the smoke management system shall be in accordance with TS 01722 and the fire engineering process.

9.8 Occupant egress and fire brigade access

Egress provisions from rail tunnels shall be provided in accordance with this standard and in consultation with the fire brigade. The egress provisions shall include provisions for persons with a disability and provide a strategy for their evacuation. Refuge areas should be provided in accordance with the egress strategy for the tunnel.

Where emergency egress cross passages are provided, they shall:

- be free of smoke ingress from tunnel fires
- be provided at intervals not greater than 240 m
- have a minimum clear width of 1500 mm
- have a minimum clear height of 2100 mm.

The access doorways to the emergency egress passages shall:

- have a minimum clear width of 1000 mm
- have a minimum clear height of 2100 mm
- be operable through a sliding movement
- be designed to operate under all tunnel ventilation system operating conditions and be capable of being opened with a force of less than 110 N.

Occupant egress from rail tunnels shall be consistent with fire brigade intervention plans to aid fire brigade access and the safe evacuation of occupants.

Track trolleys shall be provided at underground station portals to facilitate access for emergency services during an emergency. The placement of the track trolleys shall be in consultation with the relevant emergency services agencies.

Track access ladders or stairs from the track to the platform shall be provided at stations to enable occupants to egress onto the station platform in the event of an emergency from a train stuck in a tunnel.

Elevated walkways shall be provided in accordance with TS 01722 to facilitate occupant evacuation and emergency and rescue operations, unless it can be demonstrated that all

passengers regardless of mobility status are able to safely evacuate a train in a timely manner in the event of a fire incident to a place of safe refuge from either end of the train.

10 Road tunnels

Road tunnels fire safety systems shall:

- provide a practicable level of safety for road occupants and users that is consistent with the intent of AS 4825
- facilitate access for emergency services personnel during an incident in accordance with the requirements established by the project's fire safety engineering process and this standard
- limit the impact of any incidents within tunnels and adjacent tunnels on tunnel assets, tunnel operation and maintenance including in-ground services, adjacent infrastructure, buildings, the surrounding road network, public transport operations and surrounding built environment
- provide systems and measures which minimise the time taken to return to service after a fire incident.

10.1 Minimum scenarios

Fire scenarios shall be assessed considering occupant life safety with regards to:

- fire size of 50 MW for a design fire scenario
- fire growth rate in NFPA 502 (2017 is the preferred method for critical velocity)
- fire spread.

The scenarios in Table 2 are the minimum scenarios that shall be assessed as part of the fire engineering process to determine the appropriate tunnel fire safety measures. Table 2 outline the specific primary scenario requirements that shall be adopted when designing new road tunnels and alterations to existing road tunnels based off the potential hazards to occupants in in Section 7.4.1.

Table 2 – Primary fire scenarios in road tunnels

Primary scenarios	Potential cause
Light vehicle fire incidents	• Mechanical or electrical vehicle failures leading to a fire • Failure of vehicle propulsion systems • Accidents, collisions or impacts resulting in fuel leaks or ignition sources • Occupant use of open flames or smoke within tunnels • Vandalism or arson • Inadequate incident responses
Heavy vehicle fire incidents	• Mechanical or electrical vehicle failures leading to a fire • Failure of vehicle propulsion systems • Accidents, collisions or impacts resulting in fuel leaks or ignition sources • Occupant use of open flames or smoke within tunnels • Fuel spills from trucks • Overheated brakes, seized wheel bearings on heavy vehicles • Improper transportation of hazardous materials or unsecured cargo in payloads • Vandalism or arson • Inadequate incident responses
Infrastructure fire involving systems equipment, electrical cable insulation, rubbish, maintenance equipment	• Electrical fault in equipment such as lighting, power supplies, switchboards, distribution boards, tunnel ventilation systems, drainage pumps, maintenance vehicles • Maintenance hot works, road line marking machinery and associated road infrastructure machinery • Spontaneous combustion of improperly handled or stored materials • Accumulation of debris and other combustible materials within tunnels and maintenance areas • Matches, lighters, cigarettes from tunnel occupants, unauthorised occupants in secured areas or arson • Malfunctions, inadequate maintenance of tunnel fire safety systems • Sump areas fire incidents with spills and ignition of materials • Drainage area fires due to fuel spill
Cross passage fire involving systems equipment, electrical cable insulation, rubbish or maintenance equipment	• Electrical faults in equipment such as lighting, switchboards, distribution boards, drainage pumps • Matches, lighters, cigarettes from tunnel occupants, unauthorised occupants or arson • Accumulation of debris and other combustible materials within the cross passages • Maintenance hot works
Reduced visibility from external sources	• Smoke from external bushfires

Fires originating from the transportation of dangerous goods shall be assessed in accordance with TS 00014.

10.2 Fire resistance

10.2.1 Tunnel structure

Road tunnels and separation of adjoining carriageways, including associated structures, shafts, cross passages, adits, equipment rooms, plant storage rooms, underpass structures, linings and ground support elements and structures shall achieve a minimum FRL of:

- 240/240/240 for load-bearing walls
- 240/ – / – for load bearing elements and overhead structures
- – /240/240 for non-load bearing elements.

Any tunnel structure that may be affected by a road tunnel fire and as a consequence may result in collapse or operational failure of a building, structure, major road or rail infrastructure, tunnel or utility services shall achieve a minimum FRL of 120/120/120.

The concrete used in the construction of the carriageway structure shall prevent spalling when exposed to the RABT-ZTV (road) fire curve.

10.2.2 Fire separation

The separation of adjoining carriageways, emergency egress passages and functional areas shall achieve a minimum FRL of:

- 240/240/240 for load-bearing elements and walls separating functional areas such as equipment rooms, emergency egress passages and carriageways
- – /240/240 for non-load bearing elements and walls separating functional areas such as equipment rooms, emergency egress passages and carriageways
- – /240/ – for tunnel ventilation dampers in ventilation tunnels that link tunnel carriageways
- – /120/120 for emergency egress cross passage doorways where there are no refuge areas within the emergency egress cross passage
- – /240/240 for emergency egress cross passage doorways where there are refuge areas within the emergency egress cross passage
- – /240/240 for single doorway egress between carriageways (that is, where there is no cross passage)
- – /240/240 for longitudinal emergency egress passageway doorways.

Service connections between the bounding construction of a tunnel shall be fire sealed to the required FRL in the preceding bullet list. Testing for fire resistance shall be in accordance with AS 1530.4.

Vehicle cross passages shall have fire doors or shutters to achieve equivalence to FRL – /240/240 between tunnel carriageways.

10.3 Fire detection and occupant warning system

The provision of a fire detection and warning systems in road tunnels shall be determined by the fire engineering process.

Where provided, fire detection systems shall be designed in accordance with AS 1670.1, except the spacing of detection devices. The spacing of fire detectors within the carriageway and emergency egress passages shall be determined by the fire engineering process. Thermal detection systems, where specified, shall have adjustable set points as an absolute temperature and as rate of rise temperatures.

Equipment rooms within tunnels shall be provided with smoke detection systems in accordance with AS 1670.1 and occupant warning systems in accordance with AS 1670.4.

The detection system zones shall align with the suppression system zones where suppression systems are provided. Additional detection system zones should be provided at tunnel entry and exit areas including tunnel approach and exit structures, and in locally enlarged areas such as caverns, merge and diverge areas, and breakdown bays. Detection systems shall be designed and installed so that:

- activation of fire detection zones initiates the timing cycle for the automatic activation of the corresponding suppression zones
- activation of heat or smoke detectors initiates a fire alarm condition and transmit signals to the main fire control panel
- activation of fire detection or suppression systems activates emergency warning systems and smoke hazard management systems.

The main fire indicator panel for the detection and warning systems shall be provided in the tunnel control room.

10.4 Automatic fire suppression systems

The provision of automatic suppression systems in road tunnels shall be determined by the fire engineering process. The design and selection of type of suppression systems shall be based on criticality of the asset being protected and be analysed using a fire engineered solution.

Suppression systems shall be centrally monitored from the main fire control panel with an automatic call out service to local fire brigades upon activation. Where local fire brigades are not

staffed by permanent fire brigade officers, consultation shall be carried out with the fire brigade for appropriate signalling of panels.

10.4.1 Deluge systems

Deluge systems are the preferred form of suppression in road tunnels. Deluge systems, where provided, shall extend throughout the carriageways including maintenance bays, breakdown bays, mergers, diverges and shoulders. The design of deluge systems shall be in accordance with AS 2118.3.

Deluge system designs shall:

- have a minimum design density of 10 mm per minute
- have a deluge design zone length of 30 m minimum for carriageways of three lanes or less
- be designed and commissioned so that upon activation by an operator, the minimum deluge design density can be applied over a 60 m length of carriageway operating, including most hydraulically disadvantaged and largest deluge zone.

The deluge system shall:

- allow for manual operation of the system to override the automatic functions when initiated by the automatic fire alarm signal
- be capable of being remotely operated from the tunnel main fire control centre.

10.4.2 Water mist systems

Water mist systems may be considered as an alternative to deluge suppression systems provided they represent the same or better levels of safety provided by a deluge system. The type of water mist system shall be fit for purpose. The design and installation of water mists system shall as a minimum:

- Be based upon the volume of a tunnel and area of operation of each zone. Nozzles shall be of open type interface with linear heat detection as per manufacturer’s recommendations to increase the efficiency of application of water mist systems to the affected areas.
- Ensure that the placement of nozzles does not exceed the maximum operating area of the nozzle as recommended by the manufacturer and noting any interference to spray patterns from surrounding tunnel services and structural elements.
- Have pumps and tanks designed to accommodate sustained flow rates and pressure requirements of systems for a duration of not less than that specified by the fire safety systems design with additional capacity incorporating a factor of safety.

10.4.3 Foam suppression systems

Foam suppression systems shall be provided for tunnel drainage sumps that are located within tunnels. Foam suppression systems shall:

- have a gas detection system that automatically activates the foam extinguishing agent on detection of lower explosive limit of flammable gases
- be centrally monitored for activation of the foam pump, gas detection system through the tunnel fire control centre
- have a manual activation button through tunnel fire systems main panels.

10.5 Fire hydrant systems

Fire hydrant systems in road tunnels shall be a charged wet system. The system shall be designed and installed in accordance with AS 2419.1 requirements.

10.5.1 Fire hydrant outlets

Fire hydrant outlets in road tunnels shall be provided with dual head hydrants, be within 4 m of cross passage doorways and at intervals not greater than 60 m.

Where emergency egress cross passages exceed 30 m in length or 10 m in vertical elevation, an additional hydrant landing valve shall be provided at each end of the cross passage.

Each fire hydrant outlet shall be provided with a complaint hose coupling and a blank cap attached to the valve body by a suitable metal chain.

10.5.2 Fire brigade booster assemblies

Fire brigade booster assemblies shall be provided for fire brigade vehicles to connect to and boost the tunnel fire hydrant system. Fire brigade booster locations shall be designed in consultation with the fire brigade. Booster locations shall comply with AS 2419.1 and have space for a minimum of one fire brigade appliance to park adjacent to the booster to use it. Physical barriers shall be provided to allow safe fire brigade access where booster assemblies and hydrant outlets are located at portals.

Booster points for hydrant systems shall be provided in accordance with type of system, hydraulic requirements, the requirements of fire brigade and relevant local council requirements. Hydrant system shall be labelled noting required boost pressure to achieve the performance requirements at all points of the system.

10.5.3 Isolation valves

Monitored isolation valves and isolation sections shall be provided on the fire hydrant ring main to allow the isolation of sections under failure or for maintenance purposes, while maintaining full functionality of the remainder of the ring main.

Monitored isolation valves shall be:

- fitted at locations and heights that are readily accessible for operation and maintenance
- provided at intervals not greater than 120 m
- strapped and padlocked in the open position
- capable of transmitting to the fire panel, and SCADA system if provided, the open/close status of the isolating valves.

The provision of motorised isolation valves shall be in consultation with fire brigade to ensure it meets their operational needs.

10.6 Water supplies

Deluge, hydrant and foam suppression systems shall be provided with a dual water supply. The dual water supply shall have effective capacity to satisfy the following simultaneously:

- operation of the largest combined deluge zones in the hydraulically most disadvantaged zone of a tunnel for a 60 m length for a minimum of two hours
- operation of three single hydrant outlets simultaneously for a minimum of four hours
- operation of draining sump foam suppression systems for a minimum of one hour.

10.7 Portable fire extinguishers

Portable fire extinguishers shall be provided within the carriageway, MEEPs and any staff offices or control rooms attached to tunnels including electrical switch rooms and plant rooms. The selection of type of extinguishers and their location shall be in accordance with AS 2444. Extinguishers shall be positioned to enable easy access for emergency use and maintenance by trained personnel.

10.8 Tunnel smoke management systems

Tunnel smoke management strategies shall be determined by the fire engineering process. Smoke management strategies shall be designed to maintain tenable conditions in road tunnels to facilitate occupant evacuation and fire brigade intervention.

Where a smoke management system is provided, the design of the smoke management system shall be in accordance with TS 01722 and the fire engineering design process.

10.9 Emergency equipment cabinets

EECs that are provided throughout road tunnels are not considered dedicated fire safety systems, however, they may be incorporated into the fire safety strategy for road tunnels.

10.9.1 Fire brigade emergency equipment points

FEEPs shall be located adjacent to each emergency egress door. Each FEEP shall contain, at a minimum, the following:

- one double headed fire hydrant
- one fire hose reel of 60 m in length
- two spare single phase 240 V power outlets
- one fire phone for emergency purposes.

Each FEEP shall be positioned in an EEC. Where an EEC contains a FEEP, the EEC shall:

- have all electronic and electrical equipment within the enclosure rated to IP65 in accordance with AS 60529 to withstand conditions in a tunnel during cleaning operations
- be mounted with the face of the EEC flush with the wall panels surface where installed within wall panels.

10.9.2 Motorist emergency equipment points

Where MEEPs are provided, they shall contain one 4.5 kg dry chemical type fire extinguisher in accordance with AS 2444.

10.10 Flame traps

Flame traps shall be provided throughout road tunnels to prevent the spread of fire caused by flammable liquids. The design and selection of type of flame trap shall be based on analysis by a hydraulic engineer.

10.11 Occupant egress and fire brigade access

Egress provisions from road tunnels shall be determined by the fire engineering process in consultation with the fire brigade. The egress provisions shall include provisions for persons with a disability and provide a strategy for their evacuation.

Emergency egress cross passages shall be provided at intervals not greater than 120 m. Longitudinal emergency egress passages shall not exceed 240 m.

Emergency egress passages shall:

- be free of smoke ingress from tunnel fires
- have a minimum clear width of 1500 mm
- have a minimum clear height of 2100 mm

Access doorways to the emergency egress passages shall:

- be adequately protected from vehicle impact
- have a minimum clear width of 1000 mm
- have a minimum clear height of 2100 mm
- be operable through a sliding movement
- be designed to operate under all tunnel ventilation system operating conditions and be capable of being opened with a force of less than 110 N.

Emergency egress to open space, as defined in the BCA, shall be provided at each tunnel portal.

Fire brigade access cross passages shall be provided such that the maximum distance from the firefighting access point within the non-incident tunnel to an incident in an adjoining tunnel does not exceed 240 m when approaching from the upstream side in the incident tunnel.

11 Pedestrian and bicycle tunnels

Pedestrian and bicycle tunnels fire safety systems shall be designed, built, operated and maintained to:

- ensure the safety of occupants using a tunnel and occupants of any adjoining structures
- minimise the impact of fire on tunnel infrastructure and any adjoining structures.

11.1 Tunnels adjoining buildings

The tunnels fire safety strategy shall address occupant entrapment and fire separation. The strategy shall address fire spread from a fire within a building affecting the tunnel and the spread of fire from the tunnel to the building.

The provision of fire safety systems in the canopy areas adjoining the pedestrian and bicycle tunnel shall be determined by the fire engineering process.

11.1.1 Fire separation

Fire separation measures between pedestrian and bicycle tunnels and the adjoining buildings should be designed to allow for free passage of evacuating occupants to a place of relative safety.

11.2 Minimum scenarios

Table 3 covers the minimum scenarios that shall be assessed as part of the fire engineering process to determine the appropriate tunnel fire safety measures. Table 3 outlines the specific primary scenario requirements that shall be adopted when designing new pedestrian and bicycle tunnels or where there is a change in use of an existing tunnel based off the potential hazards to occupants in Section 7.4.1.

Table 3 – Primary fire scenarios in pedestrian and bicycle tunnels

Primary scenarios	Potential cause
Infrastructure fire involving systems equipment, electrical cable insulation, rubbish, maintenance equipment	• Electrical fault in equipment such as lighting, switchboards / distribution boards, tunnel ventilation systems, drainage pumps • Combustible materials stored in a tunnel • Arson or vandalism
Ignition of combustible materials	• Improper storage of combustible materials in a tunnel • Improper disposal of cigarettes • Unsupervised or unauthorised activities involves open flames or heat sources • Insufficient fire safety measures • Arson or vandalism
Fire incidents of electric micro mobility vehicles	• Mechanical or electrical vehicle failure leading to a fire • Arson or vandalism

11.3 Fire resistance

Tunnel structure and functional areas shall achieve a minimum FRL of:

- 120/120/120 for load bearing elements
- – /120/120 for non-load bearing elements
- – /120/30 for doorways in the bounding walls of a tunnel's structure

Service connections between the bounding construction of a tunnel shall be fire sealed to the required FRL in the preceding bullet list. Testing for fire resistance shall be in accordance with AS 1530.4.

11.4 Fire detection and warning system

The provision of a fire detection and warning system in the pedestrian and bicycle tunnel shall be determined by the fire engineering process.

Where a smoke detection and alarm system is provided, it shall be designed and installed in accordance with the requirements of AS 1670.1. The smoke detection system shall activate the occupant warning system.

11.5 Automatic fire suppression systems

The provision of an automatic fire suppression system in the pedestrian and bicycle tunnel shall be determined by the fire engineering process.

Where an automatic fire suppression system is provided, it shall be designed and installed in accordance with the requirements of AS 2118.1.

11.6 Fire hydrant systems

The provision of a fire hydrant system in the pedestrian and bicycle tunnel shall be determined by the fire engineering process and in consultation with the fire brigade.

11.7 Portable fire extinguishers

Portable fire extinguishers shall be provided in pedestrian and bicycle tunnels. Portable fire extinguishers shall:

- be appropriate to the type of services installed in a tunnel in accordance with AS 2444
- be provided within 4m of tunnel entry/exits
- be provided with accompanying projected fire extinguisher signage provided at right angles to the location of the enable identification upon approach
- be fitted within vandal proof enclosures.

11.8 Tunnel ventilation

A smoke management strategy shall be determined by the fire engineering process. The smoke management strategy shall be designed to maintain tenable conditions in the pedestrian and bicycle tunnel to facilitate occupant evacuation and fire brigade intervention. Refer to TS 01722 for design of tunnel smoke hazard management system requirements.

11.9 Occupant egress

Egress provisions from pedestrian/bicycle tunnels shall be determined by the fire engineering process. The egress provisions shall include provisions for persons with a disability and provide a strategy for their evacuation.

Emergency egress points shall be provided at intervals not greater than 60 m unless demonstrated through the fire engineering process that safe egress of occupants is facilitated without the use of emergency egress points.

12 Services tunnels

Services tunnel fire safety systems shall be designed, built, operated and maintained to:

- ensure the safety of occupants using a tunnel and occupants of any adjoining structures
- minimise the impact of fire on tunnel infrastructure and any adjoining structures.

12.1 Minimum scenarios

Table 4 covers the minimum scenarios that shall be assessed as part of the fire engineering process to determine the appropriate tunnel fire safety measures. Table 4 outlines the specific fire scenario requirements that shall be adopted when designing new services tunnels or where there is a change in use of an existing tunnel based off the potential hazards to occupants in Section 7.4.1.

Table 4 – Primary fire scenario in services tunnels

Primary scenario	Potential cause
Infrastructure fire involving systems equipment, electrical cable insulation, rubbish, maintenance equipment	• Electrical faults in equipment such as lighting, power supplies, switchboards, distribution boards, tunnel ventilation systems, drainage pumps, maintenance vehicles • Maintenance hot works • Accumulation of debris and other combustible materials within tunnels and maintenance areas. • Matches, lighters, cigarettes from tunnel occupants, unauthorised occupants or arson

12.2 Fire resistance

Tunnel structures and functional areas shall achieve a minimum FRL of:

- 120/120/120 for load bearing elements
- – /120/120 for non-load bearing elements
- – /120/30 for doorways in the bounding walls of a tunnel’s structure.

Service connections between the bounding construction of a tunnel shall be fire sealed to the required FRL in the preceding bullet list. Testing for fire resistance shall be in accordance with AS 1530.4.

12.3 Fire detection and warning systems

Fire detection and warning systems shall be provided to alert occupants, staff and fire brigade of a fire emergency in services tunnels. The design and selection of type of fire detection device will be based on the fire engineering process.

12.4 Portable fire extinguishers

Portable fire extinguishers shall be provided in services tunnels. Portable fire extinguishers shall:

- be appropriate to the type of services installed in a tunnel in accordance with AS 2444.
- be mounted horizontally so that fire extinguishers do not impede occupant egress
- be provided within 4 m of tunnel entries and exit and at 30 m intervals
- be provided with accompanying projected fire extinguisher signage provided at right angles to the location of the enable identification upon approach.

12.5 Tunnel ventilation

Tunnel ventilation shall be provided in accordance with the TS 01722.

In the event of the activation of the fire detection, the operation of a tunnel's ventilation systems shall be determined by the fire engineering process.

12.6 Occupant egress

Egress provisions from services tunnels shall be determined by the fire engineering process. There shall be a minimum of two entry/exit points from the tunnel. A minimum unobstructed width of 850 mm shall be provided to services tunnels to facilitate the safe egress of services tunnel occupants.