Fire Safety Engineering in Road Tunnels

AS4825:2011 – Some thoughts

Nigel Casey

Tunnel Technology, Motorways

Motorway

Existing Concessions

Courtesy – RMS, Major Projects 2023

Motorway

…plus motorways managed by RMS (TfNSW)

Courtesy – RMS, Major Projects 2023

Motorway

…plus projects in delivery and procurement

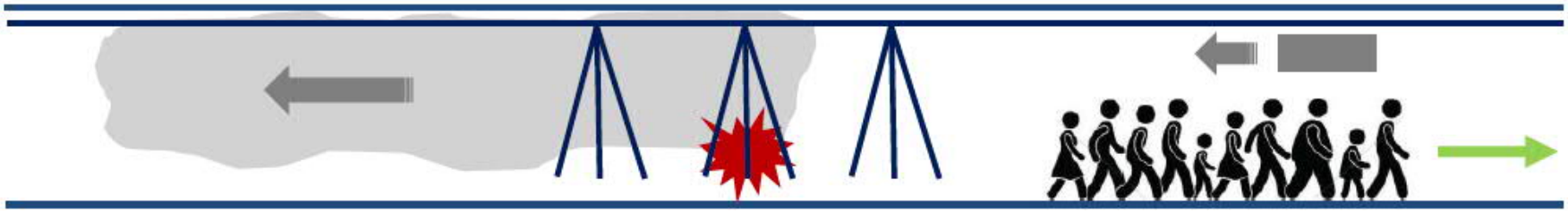
Courtesy – RMS, Major Projects 2023

Motorway

…plus future projects

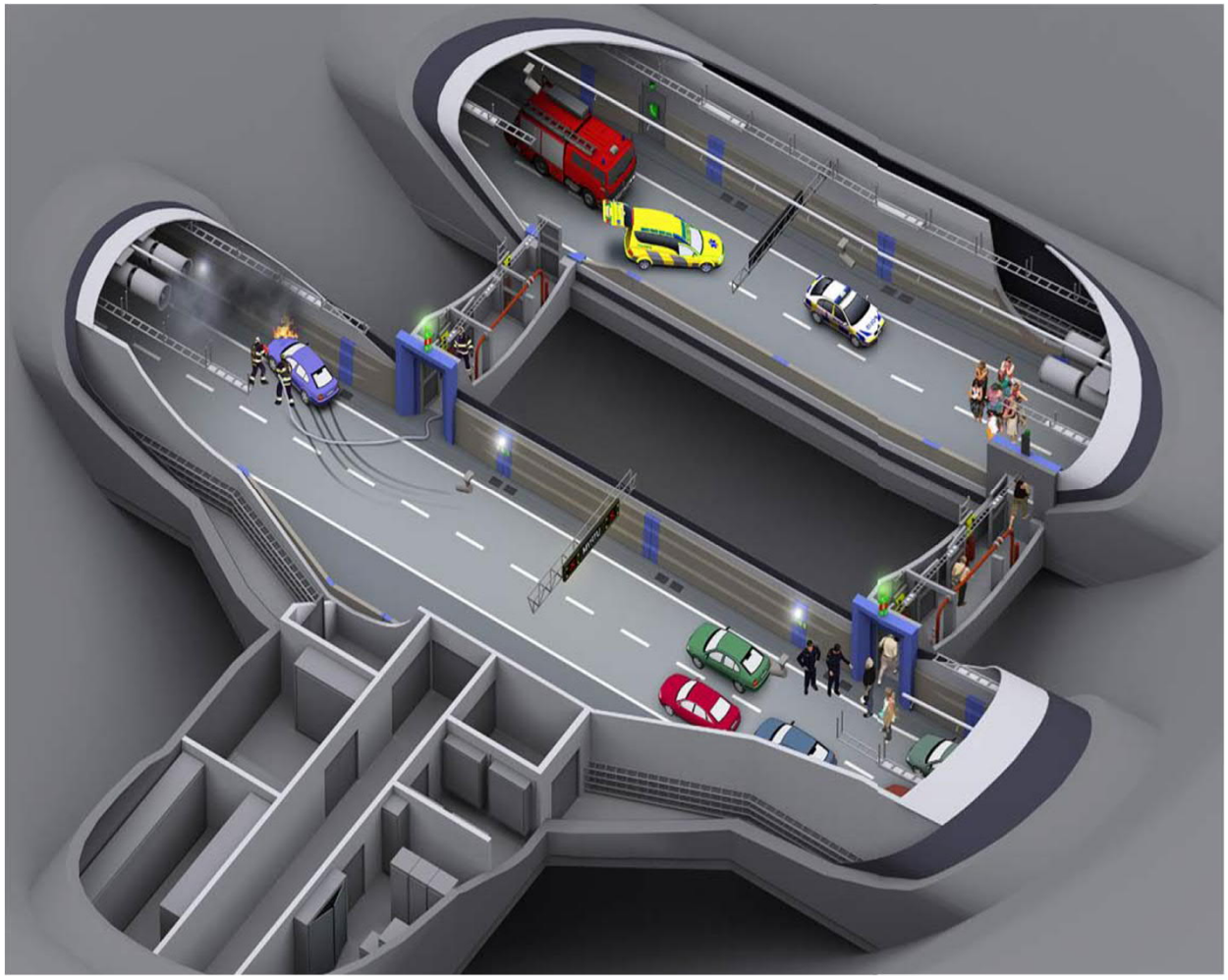
Courtesy – RMS, Major Projects 2023

Fire Safety Concept



Courtesy – Stephen Grubits & Associates

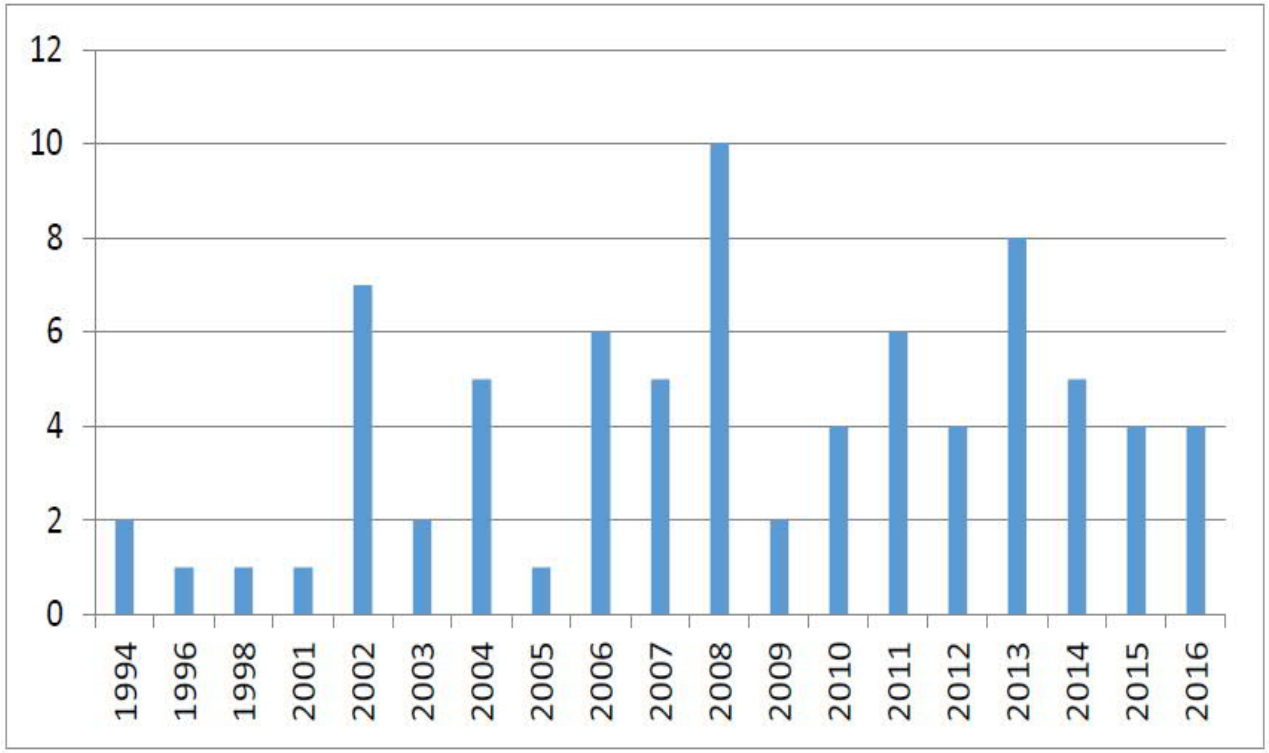
Emergency Response



Courtesy – Trafikverket

Fire Incidents in Major Australian Road Tunnels

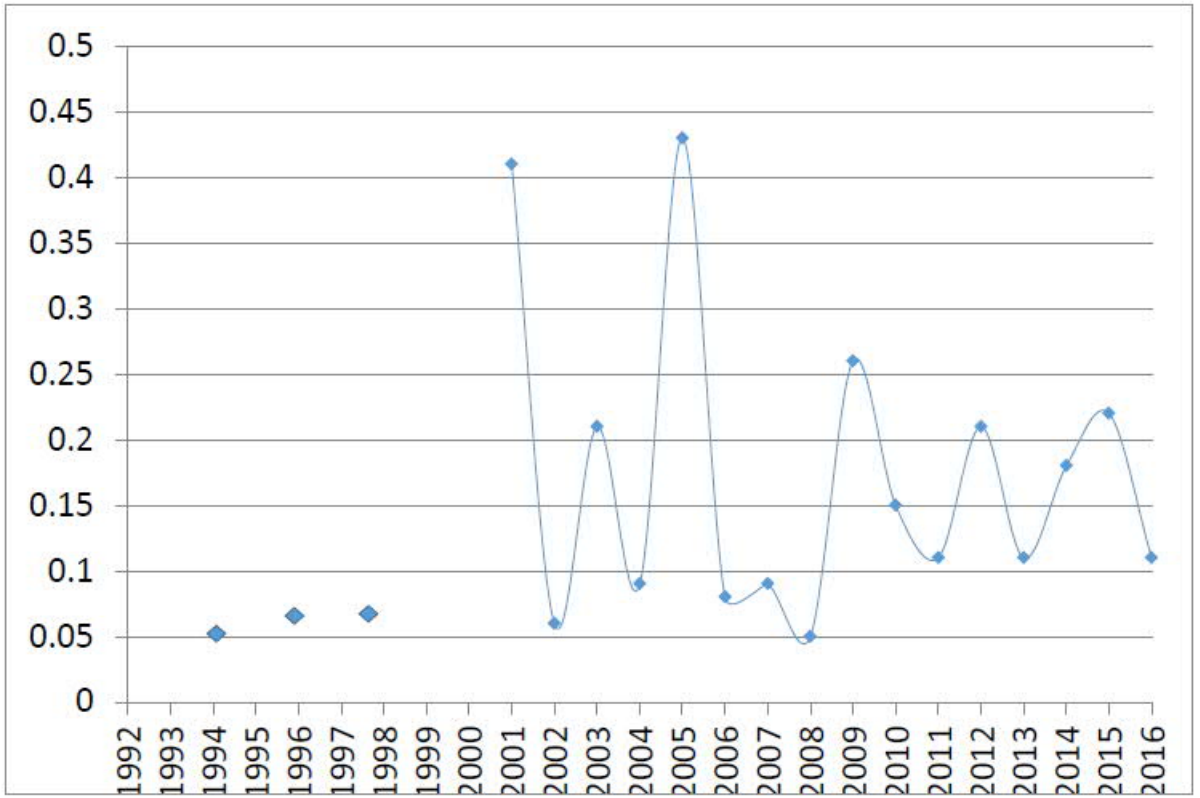
Historical data (1992 – 2016)



Casey, International Symposium on Tunnel Safety and Security, 2018

Fire Incidents in Major Australian Road Tunnels

Annual vehicle kilometres travelled (billions) for each fire incident



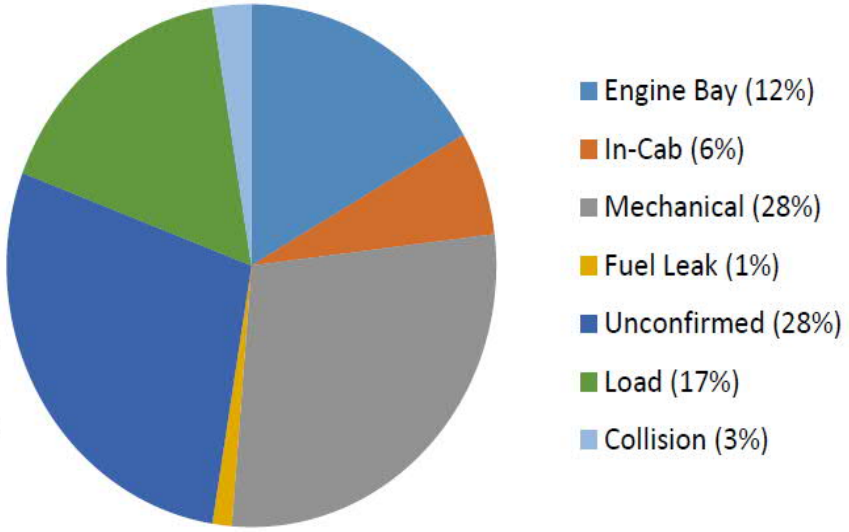
Casey, International Symposium on Tunnel Safety and Security, 2018

Fire Incidents in Major Australian Road Tunnels

Historical data can provide a guide to future frequency (and source) of fire incidents

No. of Fires	78
Vehicle Kilometres Travelled (VKT)	10,338,000,000
Fire Frequency	1 fire / 132million VKT
Fire Frequency	8 fires / billion VKT

Vehicle	Passenger Car	Light Duty Vehicle	Heavy Vehicle	Multiple Vehicle
No. of fires	41	14	20	1
Percentage of total	53.9%	18.4%	26.3%	1.3%



Casey, International Symposium on Tunnel Safety and Security, 2018

Fire Incidents in Major Australian Road Tunnels

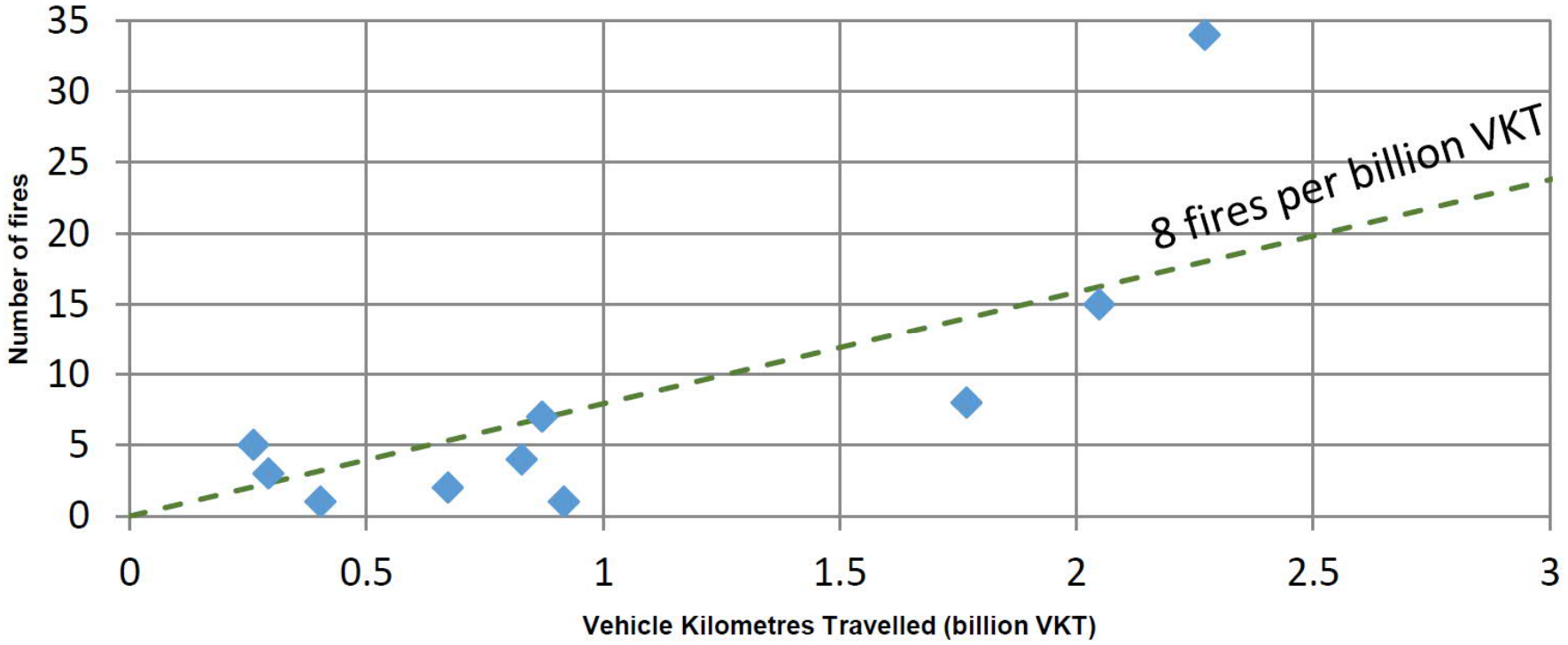
Historical data can provide a guide to future frequency (and size) of fire incidents

Fire Severity Category	Approx. Fire PHRR	Non-HV (73.7%)	HV (26.3%)
1	0 - 1MW	33 (41.2%)	12 (15%)
2	1 – 5 MW	25 (31.2%)	1 (1.3%)
3	5 – 20 MW	1 (1.3%)	7 (8.8%)
4	20- 50 MW	-	1 (1.3%)
5	>50 MW	-	-

Casey, International Symposium on Tunnel Safety and Security, 2018

Fire Incidents in Major Australian Road Tunnels

Tunnels do not have the same frequency of fire incident…..



Casey, International Symposium on Tunnel Safety and Security, 2018

AS4825 Tunnel Fire Safety

The Committee

The following are represented on Committee FP-023:

- AUSTROADS
- Australasian Fire and Emergency Service Authorities Council
- Australian Automobile Association
- Australian Tunnel Operators Group
- CSIRO Manufacturing and Materials Technology
- Engineers Australia
- Fire Protection Association Australia
- Main Roads Department, Queensland
- Main Roads Western Australia
- Society of Fire Safety
- RailCorp
- Risk Management Institution of Australasia
- Roads and Traffic Authority of NSW

AS4825 Tunnel Fire Safety

Acceptance Criteria

PREFACE

This Standard was prepared by Standards Australia Committee FP-023, Tunnel Fire Safety.

Whilst a number of existing overseas Standards and guidance documents were considered by the committee during the preparation of this first edition of the Standard, the document is not based upon any other Standard.

The committee decided that the most appropriate format for the Standard is to facilitate the current Australian practice of adopting a performance-based approach to fire safety in tunnels. Such an approach is reliant on fire safety engineering methodologies similar to those described in the *International Fire safety engineering Guidelines* which is extensively used in Australia for performance-based design for fire safety in buildings.

The Standard is intended to provide a generic framework for establishing the fire safety systems that are required in road, rail or bus tunnels to provide an acceptable level of safety in case of fire. This Standard is intended to guide professional fire safety engineers in the development of a fire safety strategy, the design and documentation of fire safety systems for tunnels.

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IFEG

This document has been produced through a collaborative venture between the following organizations (the collaborators):

- National Research Council of Canada (NRC)
- International Code Council (ICC), United States of America
- Department of Building and Housing, New Zealand (DBH)
- Australian Building Codes Board (ABCB)

The following organizations endorse the Australian parts of this document as describing an appropriate process for design and approval of fire safety in buildings by competent practitioners:

- The Australian members of the Australasian Fire Authorities Council (AFAC)
- Australian Institute of Building Surveyors (AIBS)
- The Institution of Engineers Australia (IEAust) Society of Fire Safety

The Insurance Council of Australia (ICA) supports the aims of this document.

The following organizations endorse the New Zealand parts of this document as describing an appropriate process for design and approval of fire safety in buildings by competent practitioners:

- The Institution of Professional Engineers New Zealand Inc (IPENZ)
- The New Zealand Fire Service (NZFS)

The document is published by the Australian Building Codes Board.

IFEG, ABCB

AS4825 Tunnel Fire Safety

Acceptance Criteria

FOREWORD

The design and implementation of fire safety measures and a management system for a tunnel will be influenced by the varying needs and operational requirements pertinent to the tunnel's use. Factors such as traffic volume, nature of vehicles, length of tunnel, and traffic conditions, all influence the risk and hence the level of safety within tunnels. Thus, fire safety measures that may be adequate to provide an acceptable level of risk under one set of operating conditions, may not be adequate under a different set of circumstances. Therefore, it is not possible to provide a prescriptive list of fire safety measures suitable for tunnels that, at first glance, are similar in specific characteristics (e.g. length).

The acceptability of a specific tunnel design is a matter for all the stakeholders, which include authorities having a regulatory function, in addition to the tunnel's owner and operator.

Fire safety engineering is an iterative process consisting of the evaluation of an initial concept design and a series of design assumptions that are tested through an analysis process. If the analysis reveals that the acceptance criteria are not met, then the concept design is modified until an acceptable outcome is obtained. The design assumptions used in the analysis then needs to be implemented in both the design and the built works to arrive at a tunnel with an acceptable level of safety.

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Acceptance Criteria

3.4.2 Documentation

The following set of documentation is suggested as a basis for the fire safety design documentation. Where the fire safety engineer has not prepared the following documents, the fire safety engineer should review the document for consistency with the fire safety strategy and design assumptions:

(a) *Fire engineering brief (FEB)* The FEB is an essential part of the fire engineering process, which defines the scope of work for the fire engineering analysis. Its purpose is to set down the basis, as agreed by the relevant stakeholders, on which the fire safety analysis will be undertaken.

Areas for consideration during the FEB stage include the following:

(i) Fire safety objectives.

(ii) Occupant characteristics.

(iii) Trial concept design.

(iv) Preliminary technical assessment.

(v) Acceptance criteria.

(vi) Assessment methods.

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Objectives

How do we link objectives and acceptance criteria?

2.3 DESIGN CONSIDERATIONS

2.3.1 Objective

The aim of any tunnel design is to provide an adequate level of fire safety for the tunnel occupants, firefighters, and maintenance and other emergency services personnel. Fire safety objectives include the following:

(a) Safety of occupants (reduce fire risk to acceptable level).

(b) Facilitation effective emergency services intervention.

(c) Protection of adjoining property and third parties.

Other objectives may include the following:

(i) Minimization of interruption to tunnel operations.

(ii) Minimization of property damage.

(iii) Minimization of fire incidents.

(iv) Minimization of the adverse impact of fires on the environment.

(v) Minimization of capital and life cycle costs.

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Assessment Methods / Acceptance Criteria

Typical Assessment Methods / items that we assess

- Probabilistic Comparative Assessment
  - Comparison of NSW Scope of Work & Technical Criteria vs NFPA502 vs PIARC (World Road Association)
  - Are we safer than in other jurisdictions?
  - Does NFPA502 and PIARC contemplate this complexity?

- Deterministic Egress Assessment
  - Is RSET less than ASET?
  - If we are achieving critical velocity and traffic flow is greater than 20kph?

- What is the Fire Brigade Intervention time?

- Disability Access (and Egress)

- BCA (NCC) Assessment

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Assessment Methods / Acceptance Criteria

Project Specific Issues

- Tenability in Cut & Cover areas (higher tunnel clearance)
- Fire safety performance of sprayed concrete (spalling)
- Emergency Longitudinal Egress Passages (extra long)
- System to System responses particularly at tunnel to tunnel interfaces
- Operational Response to an Incident (extent of closure)

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Maybe a different process?

Can our road tunnel fire safety requirements be re-aligned to:

Deemed-to-satisfy

areas where we’re doing business-as-usual

a detailed Trial Concept Design produced by the Principal

Trial Concept Design supported by fire safety performance of existing tunnels

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Acceptance Criteria – how safe is safe enough?

….and…

Alternative Solutions

areas where we’re doing something new or different

this would be focus of fire safety assessment on each project

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Existing Tunnels

1.1 SCOPE

This Standard provides guidelines for fire safety in new road, rail and bus tunnels. It covers uni-directional and bi-directional tunnels of various lengths meeting the limitations outlined in Clause 1.3.

This Standard can be applied to tunnels involving vehicles with no drivers such as driverless trains, although special additional considerations may apply. For rail and bus tunnels, this Standard addresses the tunnel/station interface. This Standard addresses tunnels used to carry both passengers and freight, and the combustible materials and goods carried by those vehicles.

This Standard is not specifically intended for existing tunnels; however, the general principles may be applied to the upgrade of existing tunnels to improve fire safety. In the case of modification works to a tunnel, the modification should be treated as building a new tunnel for interpretation of this Standard. The existing constraints however, may limit the choice of fire safety measures that can be implemented. Such constraints may result in the fire safety measures not being able to fully satisfy the objective contained in this Standard.

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Dangerous Goods

1.3 LIMITATIONS OF STANDARD

This Standard does not apply to the following types of tunnels:

(a) Tunnels that do not meet the definition of a tunnel in Clause 1.6.

(b) Funicular tunnels.

(c) Service tunnels.

(d) Pedestrian or bicycle tunnels.

(e) Railway and bus stations.

(f) Tunnels for vehicles with no persons onboard.

This Standard does not cover transportation of dangerous goods through tunnels.

NOTE: Transportation of dangerous goods usually involves a comprehensive risk assessment as to the optimum transportation route and other safety considerations. If dangerous goods or bulk fuels are to be transported through a tunnel, consideration should be given to any additional fire safety measures or precautions required to that are given in this Standard.

This Standard does not address fire safety during construction.

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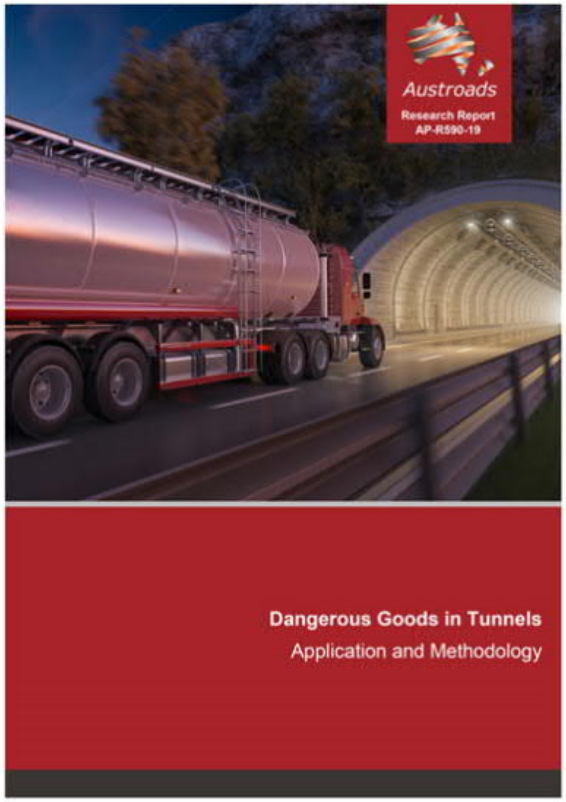
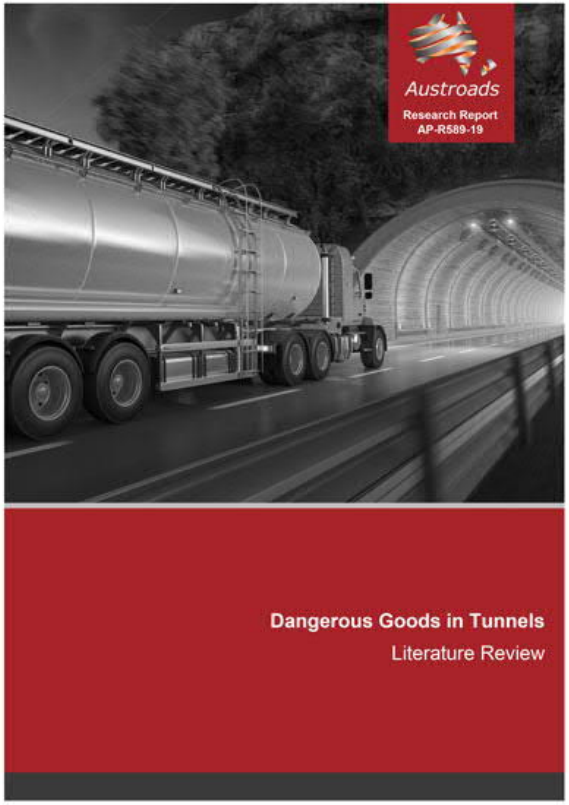
Dangerous Goods





Webinar – see Austroads Website

AS4825 Tunnel Fire Safety

Referenced Australian Standards

1.5 REFERENCED DOCUMENTS

The following documents are referred to in this Standard:

AS	
1530	Methods for fire tests on building materials, components and structures
1530.4	Part 4: Fire-resistance test of elements of construction
1603	Automatic fire detection and alarm systems
1603.5	Part 5: Manual call points
1603.7	Part 7: Optical beam smoke detectors
1603.8	Part 8: Multi-point aspirated smoke detectors
1668	The use of ventilation and airconditioning in buildings
1668.1	Part 1: Fire and smoke control in multi-compartment buildings
1670	Fire detection, warning, control and intercom systems—System design, installation and commissioning
1670.1	Part 1: Fire
1670.4	Part 4: Sound systems and intercom systems for emergency purposes
1851	Maintenance of fire protection systems and equipment
1905	Components for the protection of openings in fire-resistant walls
1905.1	Part 1: Fire-resistant doorsets
2118	Automatic fire sprinkler systems
2118.1	Part 1: General systems
2118.3	Part 3: Deluge
2293	Emergency escape lighting and exit signs for buildings
2293.1	Part 1: System design, installation and operation

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Roles & Responsibilities

3.2.7 Fire safety engineer

The role of the fire safety engineer is to develop the fire safety design and demonstrate the adequate performance of that design to the satisfaction of the Principal.

NOTE: A fire safety engineer is a person appropriately qualified to the satisfaction of the stakeholders to undertake fire safety engineering tasks.

3.2.8 Tunnel operator

The tunnel operator (for the purposes of tunnel fire safety) manages and is responsible for the tunnel fire safety systems, including their maintenance, and incident response.

3.2.9 Fire authority

The fire authority provides input to the fire engineering process in relation to its statutory role of the fire authority. This input may include—

(a) protection of persons, property and the environment from fire and hazardous materials emergencies;

(b) management of emergencies; and

(c) provision of an advisory service and undertaking of other activities, to promote tunnel fire safety and operational requirements.

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Credible Scenarios

6.3.2 Scenario development

The hazards identified above should be developed into credible fire scenarios in conjunction with appropriate stakeholders.

All credible fire scenarios should be screened and grouped into one of the following three groups:

(a) *Design fire scenarios* General fire events for which all fire protection systems in the tunnel are expected to operate to achieve an outcome acceptable to the stakeholders.

(b) *High challenge design fire scenarios* Fire events with unusual characteristics such as extra high fire growth rates or particular system failures. (These would constitute sensitivity tests in analysis.) These scenarios should not result in an outcome that is considered catastrophic.

(c) *Extreme events* Fire events beyond the worst credible that are not for design or analysis.

(iv) Minimization of the adverse impact of fires on the environment.

(v) Minimization of capital and life cycle costs.

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Trial Concept Design

1.4 TUNNEL CLASSIFICATION

Tunnel classification is provided for the purpose of establishing the preliminary fire safety measures for tunnels with different design characteristics for the purposes of an initial concept design.

Tunnels are classified according to four criteria:

(a) Tunnel length:

(i) *Long tunnel (L)* Where the length is greater than 120 m in the case of road and bus tunnels and 250 m in the case of rail tunnel.

(ii) *Short tunnel (S)* Where the length is less than the long tunnels.

(b) Traffic condition—Road tunnel only:

(i) *High traffic (HT)* Where there is a high volume of traffic or high likelihood of congested traffic.

(ii) *Low traffic (LT)* Where there is a low volume of or low likelihood of congested traffic.

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Australia (AS 4825): Trial Concept Design

Classification/requirements determined by:

1.4 TUNNEL CLASSIFICATION

Tunnel classification is provided for the purpose of establishing the preliminary fire safety measures for tunnels with different design characteristics for the purposes of an initial concept design.

Tunnels are classified according to four criteria:

(a) Tunnel length:

(i) *Long tunnel (L)* Where the length is greater than 120 m in the case of road and bus tunnels and 250 m in the case of rail tunnel.

(ii) *Short tunnel (S)* Where the length is less than the long tunnels.

(b) Traffic condition—Road tunnel only:

(i) *High traffic (HT)* Where there is a high volume of traffic or high likelihood of congested traffic.

(ii) *Low traffic (LT)* Where there is a low volume of or low likelihood of congested traffic.

(c) Direction of traffic:

(i) Uni-directional (U). (See Clause 1.6.)

(ii) Bi-directional (B). (See Clause 1.6.)

TABLE 4.1

TCD FOR ROAD TUNNEL

Fire safety measure		High traffic tunnel		Low traffic tunnel (without intersection)	
		S	L	S	L
1	**Traffic direction**				
(a)	Uni-directional	✓	✓	✓	✓
(b)	Bi-directional	S	X	S	X
2	**Fire detection system**				
(a)	Automatic detection system	S	✓	S	✓
(b)	BGA (break glass alarm)	S	S	S	S
(c)	Door monitoring	N	✓	N	✓
3	**Fire alarm system**				
(a)	Warning signs	✓	✓	S	✓
(b)	Audible sounders	S	S	S	S
(c)	PA—Pre-recorded	S	✓	S	✓
(d)	PA—Live directed	S	✓	N	S
(e)	Radio rebroadcast	S	✓	N	S
(f)	Variable message (informative)	S	✓	N	S
4	**Video surveillance**				
(a)	Intermittent monitoring	S	X	N	S
(b)	Continuous monitoring	S	✓	N	S
(c)	Incident detection	S	✓	N	S
5	**Communication**				
(a)	Motorist emergency phone	✓	✓	✓	✓
(b)	Fire service phone	N	✓	N	✓
(c)	Emergency services radio (GRN, operator)	N	✓	N	✓
(d)	RRB	N	✓	N	✓

AS 4825: TRIAL CONCEPT DESIGN FOR ROAD TUNNEL

Tunnel Categorisation

Safety Requirements are stipulated based on tunnel characteristics, typically:

Tunnel Length (450m)

Traffic Throughput (low)

The following countries have specific characterisations and requirements:

USA – National Fire Protection Agency (NFPA) 502 Standard (2017)

Norway – Norwegian Public Roads Authority (NPRA) Road Tunnels Handbook (2014)

UK – Design of Road Tunnels – BD 78/99 (1999)

France – CETU: Safety Measures in New Road Tunnels (2000)

Europe – Minimum Safety Requirements for Tunnels (2004)

Australia (AS 4825): Typical Requirements

Classification: Long Tunnel, Low Traffic

FIRE SAFETY

- Portal egress
- Fire-isolated exit
- Portable Extinguisher
- Hose Reels
- Hydrants at portals
- Internal hydrants
- Booster facility
- Water supply
- Deluge system
- Fire compartmentation
- Fire protection of structural elements

MECHANICAL AND ELECTRICAL

- Passage/stair pressurisation
- Natural Ventilation
- Dual Power supply and UPS for essential services
- Flame Traps (for drainage)

OPERATION AND TRAFFIC CONTROL

- Portal entry signals
- TMCS
- Control Room
- Operator Response Plan
- Plan for emergency services
- Illuminated exit signs
- Strobe lights
- Warning signs
- Incident access door ID
- Emergency lighting

MONITORING AND COMMUNICATIONS

- Automatic fire detection
- Motorist emergency and fire service phones
- Emergency services radio
- Door monitoring
- PA – Pre-recorded
- Radio Re-broadcast

USA (NFPA 502): Mandatory Requirements

Classification/requirements determined by graph and table:

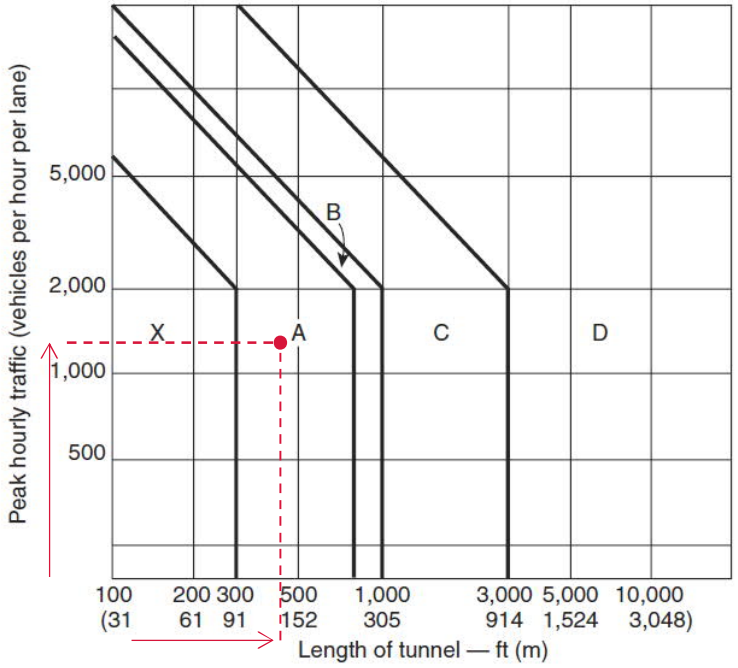

FIGURE A.7.2 Urban and Rural Tunnel Categories.

Table A.7.2 Minimum Road Tunnel Fire Protection Reference Guide

Fire Protection Systems	NFPA 502 Sections	Road Tunnel Categories: X [See 7.2(1).]	A [See 7.2(2).]	B [See 7.2(3).]	C [See 7.2(4).]	D [See 7.2(5).]
Engineering Analysis						
Engineering analysis	4.3.1	MR	MR	MR	MR	MR
Fire Protection of Structural Elements[a]						
Fire protection of structural elements	7.3	MR	MR	MR	MR	MR
Fire Detection						
Detection, identification, and location of fire in tunnel	7.4	—	—	MR	MR	MR
Manual fire alarm boxes	7.4.6	—	—	MR	MR	MR
CCTV systems[b]	7.4.3	—	—	CMR	CMR	CMR
Automatic fire detection systems[b]	7.4.7	—	—	CMR	CMR	CMR
Fire alarm control panel	7.4.8	—	—	MR	MR	MR
Emergency Communications Systems[c]						
Emergency communications systems	4.5/7.5	CMR	CMR	CMR	CMR	CMR
Traffic Control						
Stop traffic approaching tunnel portal	7.6.1	MR	MR	MR	MR	MR
Stop traffic from entering tunnel's direct approaches	7.6.2	—	—	MR	MR	MR
Fire Protection						
Fire apparatus[d]	7.7	—	—	—	—	—
Fire standpipe	7.8/10.1	—	MR	MR	MR	MR
Water supply	7.8/10.2	—	MR	MR	MR	MR
Fire department connections	10.3	—	MR	MR	MR	MR
Hose connections	10.4	—	MR	MR	MR	MR
Fire pumps[e]	10.5	—	CMR	CMR	CMR	CMR
Portable fire extinguishers	7.9	—	—	MR	MR	MR
Fixed water-based fire-fighting systems[f]	7.10/9.0	—	—	—	CMR	CMR
Emergency ventilation system[g]	7.11/11.0	—	—	CMR	CMR	MR
Tunnel drainage system[h]	7.12	—	CMR	MR	MR	MR
Hydrocarbon detection[h]	7.12.7	—	CMR	MR	MR	MR
Flammable and combustible environmental hazards[i]	7.15	—	—	CMR	CMR	CMR
Means of Egress						
Emergency egress	7.16.1.1	—	—	MR	MR	MR
Exit identification	7.16.1.2	—	—	MR	MR	MR
Tenable environment	7.16.2	—	—	MR	MR	MR
Walking surface	7.16.4	—	—	MR	MR	MR
Emergency exit doors	7.16.5	—	—	MR	MR	MR
Emergency exits (includes cross-passageways)[j]	7.16.6	—	—	MR	MR	MR
Electrical Systems[k]						
General	12.1	—	CMR	MR	MR	MR
Emergency power	12.4	—	CMR	MR	MR	MR
Emergency lighting	12.6	—	CMR	MR	MR	MR
Exit signs	12.6.8	—	CMR	MR	MR	MR
Security plan	12.7	—	CMR	MR	MR	MR
Emergency Response Plan						
Emergency response plan	13.3	MR	MR	MR	MR	MR

MR: Mandatory requirement (3.3.37). CMR: Conditionally mandatory requirement (3.3.37.1).

NFPA 502: Minimum road tunnel fire protection guide

USA (NFPA 502): Mandatory Requirements

Classification: Category A

FIRE SAFETY

- Portal egress
- Fire-isolated exit
- Portable Extinguisher
- Hose Reels
- Hydrants at portals
- Internal hydrants
- Booster facility
- Water supply
- Deluge system
- Fire compartmentation
- Fire protection of structural elements

MECHANICAL AND ELECTRICAL

- Passage/stair pressurisation
- Natural Ventilation
- Dual Power supply and UPS for essential services
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- Motorist emergency and fire service phones
- Emergency services radio
- Door monitoring
- PA – Pre-recorded
- Radio Re-broadcast

Norway (Road Tunnel Handbook): Requirements

Classification/requirements determined by graph and table:

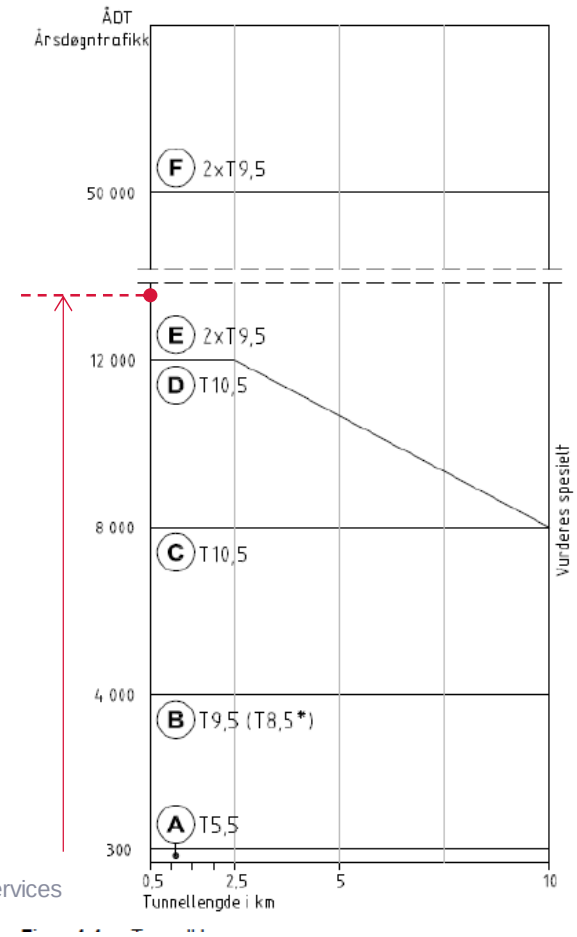


Table 6.1 Safety equipment in tunnels

EQUIPMENT	TUNNEL CATEGORY						NOTES
● Obligatory Ⓣ Evaluated	A	B	C	D	E	F	
Emergency lay-bys		●	●	●	●	●	See Ch. 4 "Geometric design"
Turning points		●	●	●			
Escape possibility by foot					●	●	Interconnections every 250 m
Power supply, lighting and ventilation	See Chapter 10 "Technical equipment						
Emergency power supply		●	●	●	●	●	Lighting in the event of power failure See Sections 602.201 and 1003.6
Emergency exit lighting			Ⓣ	●	●	●	Approx. every 62.5 m.See Sec. 602.202
Emergency Exit sign					●	●	Also obligatory in other categories if the tunnel is constructed with alternative emergency exits,e.g.interconnections. See Sections 602.203
Emergency telephone		●	●	●	●	●	Category B: Approx. every 500 m[1)] C: Approx. every 375 m[1)] D: Approx. every 250 m (both sides)[1)] E: Approx. every 500 m[1)] F: Approx. every 250 m[1)]
Fire extinguishers	Ⓣ	●	●	●	●	●	Category B: Approx. every 250 m[1) 2)] C, D: Approx. every 125 m[1) 2)] E: Approx. every 125 m[1)] F: Approx. every 62,5 m[1)]
Water for fire extinguishing		●	●	●	●	●	Alternative solutions in Section 602.206
Flashing red stop signal		●	●	●	●	●	See Section 602.207
Remote controlled barriers		Ⓣ	Ⓣ	Ⓣ	Ⓣ	●	Evaluated on basis of expected frequency of use. See Section 602.208
Changeable signs		Ⓣ	Ⓣ	Ⓣ	Ⓣ	Ⓣ	See Section 602.209 and 603
Lane signals					Ⓣ	Ⓣ	See Section 602.209
CCTV surveillance					Ⓣ	Ⓣ	See Section 602.210 and 603

Road Tunnel Handbook: Classification for <500m tunnel is the level below

Norway (Road Tunnel Handbook): Requirements

Classification: Category D

FIRE SAFETY

- Portal egress
- Fire-isolated exit
- Portable Extinguisher
- Hose Reels
- Hydrants at portals
- Internal hydrants
- Booster facility
- Water supply
- Deluge system
- Fire compartmentation
- Fire protection of structural elements

OPERATION AND TRAFFIC CONTROL

- Portal entry signals
- TMCS
- Control Room
- Operator Response Plan
- Plan for emergency services
- Illuminated exit signs
- Strobe lights
- Warning signs
- Incident access door ID
- Emergency lighting
- Emergency Lay-bys
- Turning Points
- Height control barrier
- Remote controlled barrier
- Changeable Signs

MECHANICAL AND ELECTRICAL

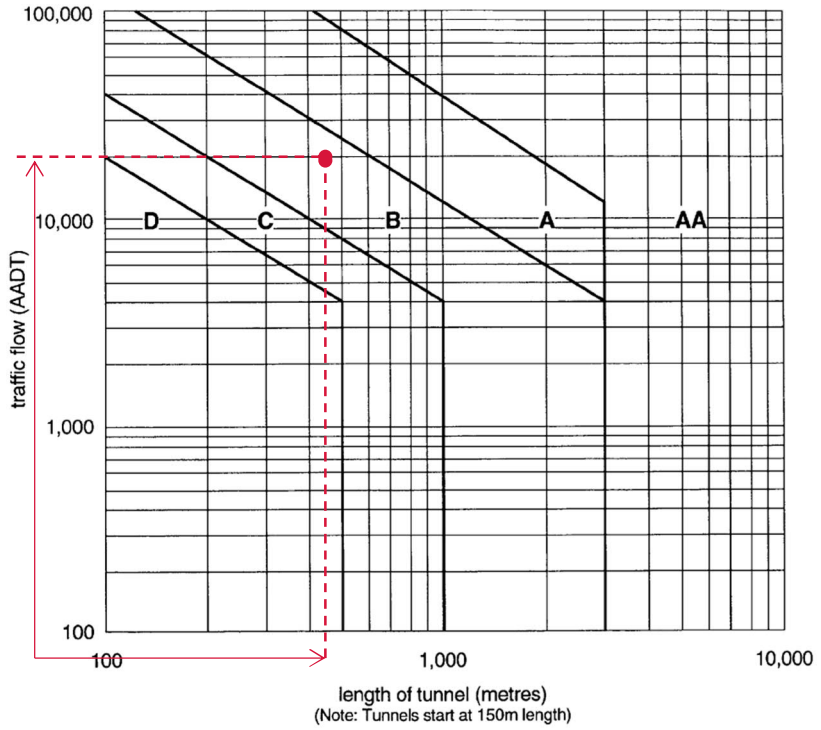
- Passage/stair pressurisation
- Natural Ventilation
- Dual Power supply and UPS for essential services
- Flame Traps (for drainage)
- Adequate ventilation to meet critical velocity

MONITORING AND COMMUNICATIONS

- Automatic fire detection
- Motorist emergency and fire service phones
- Emergency services radio
- Door monitoring
- PA – Pre-recorded
- Radio Re-broadcast

UK (BD 78/99): Mandatory Requirements

Classification/requirements determined by graph and table:



Determination of Tunnel Category

SAFETY AND FIRE PREVENTION EQUIPMENT		TUNNEL CATEGORY				
		AA	A	B	C	D
Communication and Alarm Equipment	Emergency Telephones	●	●	●	●	*
	Radio Rebroadcasting System	●	○	○	○	
	Traffic Loops	●	○	○	○	○
	CCTV	●	○	○	○	○
Fire Extinguishing Equipment	Hand Held Fire Extinguishers	●	●	●	○	
	Pressurised Fire Hydrants	●	●	●	●	○
	Fire Hose Reels	●	○	○	○	
Signs and Rescue Equipment	Emergency Exit Signs	●	●	●	○	○
	Lane Control and Tunnel Closure Signs/Signals	●	●	●	●	○
Other Provisions and Equipment	Emergency Stopping Lane	●	●	●		
	Emergency Walkway	●	●	●	●	○
	Escape Doors	●	○	○		
	Turning Bays	○				
	Ventilation for Smoke Control	●	●	●	○	○

● Normal provision

○ Requirements to be determined by TDSCG

* Provision determined by local requirements

See Figure 3.1 for tunnel category.

BD 78/99: Basic Safety Provisions for Tunnel Categories

UK (BD 78/99): Mandatory Requirements

Classification: Category B

FIRE SAFETY

- Portal egress
- Fire-isolated exit
- Portable Extinguisher
- Hose Reels
- Hydrants at portals
- Internal hydrants
- Booster facility
- Water supply
- Deluge system
- Fire compartmentation
- Fire protection of structural elements

OPERATION AND TRAFFIC CONTROL

- Portal entry signals
- TMCS
- Control Room
- Operator Response Plan
- Plan for emergency services
- Illuminated exit signs
- Strobe lights
- Warning signs
- Incident access door ID
- Emergency lighting
- Lane Control Signals
- Em. Stopping Lane
- Em. Walkway
- Escape Doors

MECHANICAL AND ELECTRICAL

- Passage/stair pressurisation
- Natural Ventilation
- Dual Power supply and UPS for essential services
- Flame Traps (for drainage)
- Adequate ventilation to meet critical velocity

MONITORING AND COMMUNICATIONS

- Automatic fire detection
- Motorist emergency and fire service phones
- Emergency services radio
- Door monitoring
- PA – Pre-recorded
- Radio Re-broadcast
- CCTV

France (CETU): Provisions

Classification/requirements determined by:

In the remainder of this document a number of terms are used with the special meanings defined below.

Light traffic tunnel : the tunnel in which the envisaged traffic in each direction ten years after it has been placed in service is less than both an annual average of 2 000 vehicles per day and 400 vehicles at peak times (30th heaviest hour in the year). When assessing these criteria heavy goods vehicles are to be counted as five vehicles.

Urban tunnel : a tunnel located within an urban unit of more than 20 000 inhabitants as defined by the INSEE (see 1990 general population census - Composition of urban units by communes) and fulfilling at least one of the following conditions:

- envisaged traffic in one direction more than 1 000 vehicles per traffic lane at daily peak times ten years after commissioning,
- risk of traffic backing up into a tunnel because of the existence of a crossroads at grade a short distance away from a tunnel exit, or any other arrangement of a permanent nature (route through a heavily built-up area, etc.),
- the existence in the tunnel of exchangers, arrangements for pedestrians, for bicycles, for common or public transport, etc.

Tunnels located within urban units of less than 20 000 inhabitants in which there is a risk of frequent congestion shall also be regarded as urban tunnels.

Non-urban tunnel : a tunnel which does not meet the conditions requiring it to be regarded as an urban tunnel.

Table 1 : URBAN TUNNELS WITH TWO ONE-WAY TUBES OF GAUGE > 3.50 m

URBAN 2 TUBES		300 m	500 m	800 m	1000 m	1500 m
CIVIL ENGINEERING ARRANGEMENTS						
EXCESS WIDTH / WALKWAYS	§ 2.1	Additional width or access by EV required or not depending upon access routes - compuls				
EMERGENCY ROUTES	§ 2.2			Compulsory every 200 m (closer together in tubes with more than 3 lan		
if depth < 15 m	§ 2.2.1			Direct communication with the exterior compuls		
others possib. if depth >= 15 m	§ 2.2.2	Communication between tubes if there is room for an air lock, safety tunnel or shelte				
ARRANGEMENTS FOR EV in the tunnel	§ 2.3.1	-	-	-	Communication between tubes	
at ends	§ 2.3.2	In front of each entrance, parking space on the right hand side and possibility fo				
EMERGENCY RECESSES	§ 2.4				Every 200 m on the right hand si	
FIRE RECESSES	§ 2.5			Preferably separate from the safety recesses, every 200 m		
HELIPAD	§ 2.6	-	-	-	-	-
PREVENTION OF SMOKE RECYCLING	§ 2.7	Steps to be taken to avoid smoke from passing from one tube to the other, prefera				
LAY-BYS	§ 2.8	-	-	-	Every 800 m if the numbe	
SAFETY EQUIPMENT						
ELECTRICITY SUPPLY	§ 3.1		Sockets in emergency recesses + uninterruptible supply + uninterruptible p			
ORDINARY VENTILATION	§ 3.2.1			CO concentration < 150 ppm and K < 9.10^{-3} m^{-1} in the event of ar		
SMOKE EXTRACTION VENTILATION	§ 3.2.2			Compulsory		
- LONGITUDINAL general case	§ 3.2.2.a	Accepted			Accepted only with massive extraction ev	
with appropriate operation/equipment		Accepted		Accepted only with massive ex		
- (SEMI-) TRANSVERSE	§ 3.2.2.b			Accepted		
control of air flow		-	-	-	-	If pos
LIGHTING / MARKER LIGHTS	§ 3.3			Emergency lighting + marker lights every 10 m on each side		

CETU: Summary Tables of Provisions

France (CETU): Provisions

Classification: Urban Tunnel 2 Tubes

FIRE SAFETY

- Portal egress
- Fire-isolated exit
- Portable Extinguisher (2 per em. recess)
- Hose Reels
- Hydrants at portals
- Internal hydrants (every 200m)
- Booster facility
- Water supply
- Deluge system
- Fire compartmentation
- Fire protection of structural elements

MECHANICAL AND ELECTRICAL

- Passage/stair pressurisation
- Natural Ventilation
- Dual Power supply and UPS for essential services
- Flame Traps (for drainage)
- Adequate ventilation to meet critical velocity

OPERATION AND TRAFFIC CONTROL

- Portal entry signals
- TMCS
- Control Room
- Operator Response Plan
- Plan for emergency services
- Illuminated exit signs
- Strobe lights
- Warning signs
- Incident access door ID
- Emergency lighting
- Lane Control Signals
- Em. Stopping Lane
- Em. Walkway
- Em. Recesses (200m)
- Fire recesses (200m)
- Em. Veh Parking at portal

MONITORING AND COMMUNICATIONS

- Automatic fire detection
- Motorist emergency and fire service phones
- Emergency services radio
- Door monitoring
- PA – Pre-recorded
- Radio Re-broadcast
- Communication between tubes in air lock room
- Ventilation monitoring
- Incident detection

Europe (EU Min. Safety Requirements for Tunnels)

Classification/requirements determined by:

● mandatory for all tunnels ❍ not mandatory
* mandatory with exceptions ◉ recommended

SUMMARY OF MINIMUM REQUIREMENTS			Traffic ≤ 2 000 veh. per lane		Traffic > 2 000 vehicles per lane			Additional conditions for implementation to be mandatory, or comments
			500-1 000 m	>1 000 m	500-1 000 m	1 000-3 000 m	>3 000 m	
Structural Measures	2 tubes or more	§2.1						Mandatory where a 15-year forecast shows that traffic > 10 000 veh./lane.
	Gradients ≤ 5 %	§2.2	*	*	*	*	*	Mandatory unless not geographically possible.
	Emergency walkways	§2.3.1 §2.3.2	*	*	*	*	*	Mandatory where there is no emergency lane, unless the condition in §2.3.1 is respected. In existing tunnels where there is neither an emergency lane, nor an emergency walkway additional / reinforced measures shall be taken.
	Emergency exits at least every 500 m	§2.3.3 - §2.3.9	❍	❍	*	*	*	Implementation of emergency exits in existing tunnels to be evaluated case-by-case.
	Cross-connections for emergency services at least every 1 500 m	§2.4.1	❍	❍ / ●	❍	❍ / ●	●	Mandatory in twin-tube tunnels longer than 1 500 m.
	Crossing of the central reserve outside each portal	§2.4.2	●	●	●	●	●	Mandatory outside twin- or multi-tube tunnels wherever geographically possible.
	Lay-bys at least every 1 000 m	§2.5	❍	❍	❍	❍ / ●	❍ / ●	Mandatory in new bi-directional tunnels >1 500 m without emergency lanes. In existing bi-directional tunnels >1 500 m: depending on analysis. For both new and existing tunnels, depending on extra usable tunnel width.
	Drainage for flammable and toxic liquids	§2.6	*	*	*	*	*	Mandatory where transport of dangerous goods is allowed.
	Fire resistance of structures	§2.7	●	●	●	●	●	Mandatory where a local collapse can have catastrophic consequences.

EU Minimum Safety Requirements Summary

Europe (EU Min. Safety Requirements for Tunnels)

Classification: Urban Tunnel 2 Tubes

FIRE SAFETY

- Portal egress
- Fire-isolated exit
- Portable Extinguisher
- Hose Reels
- Hydrants at portals
- Internal hydrants (every 250m)
- Booster facility
- Water supply
- Deluge system
- Fire compartmentation
- Fire protection of structural elements

OPERATION AND TRAFFIC CONTROL

- Portal entry signals
- TMCS
- Control Room
- Operator Response Plan
- Plan for emergency services
- Illuminated exit signs
- Strobe lights
- Warning signs
- Incident access door ID
- Emergency lighting
- Em. Station (150m)
- Crossing of Central Reserve @ Portals

MECHANICAL AND ELECTRICAL

- Passage/stair pressurisation
- Natural Ventilation
- Dual Power supply and UPS for essential services
- Flame Traps (for drainage) for dangerous goods veh.
- Adequate ventilation to meet critical velocity

MONITORING AND COMMUNICATIONS

- Automatic fire detection
- Motorist emergency and fire service phones
- Emergency services radio
- Door monitoring
- PA – Pre-recorded
- Radio Re-broadcast
- Loudspeakers in shelters
- Incident detection

AS4825 Tunnel Fire Safety: Trial Concept Design

Consideration

- Why is our base position (TCD) more onerous?
- Is the fire safety process set up to remove items from the TCD?
- Does this extra cost affect the assessment of viability of road tunnel projects?
- Does this mean that projects may move away from tunnels as a solution, when it may be the most efficient overall solution?

> As it not possible to prescribe either the fire safety measures or the analysis required, the Standard has been written as an 'informative' document providing guidance to competent designers to undertake a performance-based design for fire safety. Further, the information presented permits a systematic consideration of a fire safety strategy with fire safety measures that can form the input into the fire safety engineering analysis to demonstrate to stakeholders that an acceptable level of safety can be achieved by the design.

AS4825, Tunnel Fire Safety

Fire Safety Engineering in Road Tunnels

AS4825:2011 – Some thoughts

Nigel Casey

Tunnel Technology, Motorways