



## Memorandum

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**HBKBQE Subject: Tunnel Definition and General Design Criteria**

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### Introduction

The purpose of this document is to describe and define the design criteria related to ventilation, lighting and life safety for a potential covered highway that is fully enclosed. The information below is to be used as a reference that provides an outline of the current industry standards and codes that are adopted on all enclosed public highway structures in the US for existing and new build projects. It does not represent all of the technical studies required to design and construct a tunnel nor is it intended to specifically address any proposed design or proposed project.

### Definition of a Tunnel

The Federal Highway Administration defines a Road Tunnel as:

*“an enclosed roadway for motor vehicle traffic with vehicle access limited to portals, regardless of type of structure or method of construction, that requires, based on the owner’s determination, special design considerations that may include lighting, ventilation, fire protection systems, and emergency egress capacity. The term “tunnel” does not include bridges or culverts inspected under the National Bridge Inspection Standards.”*

*Federal Code of Regulation – CFR 650.107 (tunnels)*

It is important to note that this definition does not include a minimum or maximum length.

### Design Considerations

Design standards for highway tunnels are developed through the American Association of State Highway and Transportation Officials (AASHTO) Technical Committee for Tunnels (T-20). The Technical Committee for Tunnels focuses primarily on best practices surrounding materials, maintenance and structural requirements as well as fire suppression, ventilation and safety requirements. AASHTO has identified the following standards for enclosed structures:

## ***Fire Emergencies – NFPA 502 – Standard for Road Tunnel, Bridges and Other Limited Access Highways***

NFPA 502 is the standard used for the design of emergency ventilation systems and other life safety systems in road tunnels or enclosed highways and this has well established precedent. The first version of this document was released in 1972 under the reference NFPA 502-T, in 1981 the reference was revised to NFPA 502 and new versions of the standard are released approximately every 3 years (a complete history of document development is outlined at the beginning of the document). The document is an approved American National Standard and at the time of writing this is the standard applied by all transportation entities.. In addition, FDNY uses NFPA 502 as its minimum requirements. The document is not applicable to parking garages, bus terminals, truck terminals, or other structures where vehicles are stored, repaired, maintained or parked. Other standards/requirements would apply to those types of structures.

The standard breaks the requirements for the minimum fire protection and fire life safety requirements based on tunnel length. Five Categories are identified:

- Category X for tunnels less than 300 ft in length
- Category A for tunnels between 300 ft and 800 ft in length
- Category B for tunnels between 800 ft and 1000 ft in length
- Category C for tunnels between 1000 ft and 3280 ft in length
- Category D for tunnels longer than 3280 ft in length

An excerpt of the requirements is included in Annex A of this document for reference. The requirements of the analysis become progressively more stringent as the tunnel's length becomes longer.

### ***Construction Methodology and Separation***

The type of construction methodology (cut & cover tunnel, bored tunnel, etc.) is irrelevant to the final design requirements and does not impact the requirements defined in Annex A or other applicable standards. The types of vehicles using the tunnel also does not impact the applicable standards or requirements detailed under the category of protection but, will impact other facets of the design such as the maximum design fire size.

A relatively small separation or opening in the roof structure would not impact the requirements from the perspective of tunnel design requirements or analysis. Only when the distance between portals would provide passengers and other tunnels users with an indefinite point of safety from smoke and other hazards could any kind of 'separation' warrant the possible review of the tunnel category as defined in NFPA 502. However, this distance would need to be in the order of 20 to 30 feet at a minimum and would require significant analysis for confirmation that smoke (for example) is not transferred from one tunnel to the other.

## Annex A – Fire Protection/Ventilation

Fire Protection Systems	Category Tunnel Requirements				
	X	A	B	C	D
	Less than 300 ft	Between 300 ft & 800 ft	Between 800ft & 1000 ft	Between 1000ft & 3280 ft	Greater than 3280ft
<b>Engineering Analysis</b>	Mandatory	Mandatory	Mandatory	Mandatory	Mandatory
<b>Fire Protection of Structural Elements <sup>a</sup></b>	Mandatory	Mandatory	Mandatory	Mandatory	Mandatory
<b>Fire Detection</b>					
Detection, identification, and location of fire in tunnel	-	-	Mandatory	Mandatory	Mandatory
Manual fire alarm boxes	-	-	Mandatory	Mandatory	Mandatory
CCTV systems <sup>b</sup>	-	-	Conditionally Mandatory	Conditionally Mandatory	Conditionally Mandatory
Automatic fire detection systems <sup>b</sup>	-	-	Conditionally Mandatory	Conditionally Mandatory	Conditionally Mandatory
Fire alarm control panel	-	-	Mandatory	Mandatory	Mandatory
<b>Emergency Communications Systems <sup>c</sup></b>	Conditionally Mandatory	Conditionally Mandatory	Conditionally Mandatory	Conditionally Mandatory	Conditionally Mandatory
<b>Traffic Control</b>					
Stop traffic approaching tunnel portal	Mandatory	Mandatory	Mandatory	Mandatory	Mandatory
Stop traffic from entering tunnel's direct approaches	-	-	Mandatory	Mandatory	Mandatory
<b>Fire Protection</b>					
Fire apparatus <sup>d</sup>	-	-	-	-	-
Fire standpipe	-	Mandatory	Mandatory	Mandatory	Mandatory
Water supply	-	Mandatory	Mandatory	Mandatory	Mandatory
Fire department connections	-	Mandatory	Mandatory	Mandatory	Mandatory
Hose connection	-	Mandatory	Mandatory	Mandatory	Mandatory
Fire pumps <sup>e</sup>	-	Conditionally Mandatory	Conditionally Mandatory	Conditionally Mandatory	Conditionally Mandatory
Portable fire extinguishers	-	-	Mandatory	Mandatory	Mandatory
Fixed water-based fire-fighting system <sup>f</sup>	-	-	-	Conditionally Mandatory	Conditionally Mandatory
Emergency ventilation system <sup>g</sup>	-	-	Conditionally Mandatory	Conditionally Mandatory	Mandatory

Tunnel drainage system <sup>h</sup>	-	Conditionally Mandatory	Mandatory	Mandatory	Mandatory
Hydrocarbon detector <sup>h</sup>	-	Conditionally Mandatory	Mandatory	Mandatory	Mandatory
Flammable and combustible environmental hazards <sup>i</sup>	-	-	Conditionally Mandatory	Conditionally Mandatory	Conditionally Mandatory
<b>Means of Egress</b>					
Emergency egress	-	-	Mandatory	Mandatory	Mandatory
Exit identification	-	-	Mandatory	Mandatory	Mandatory
Tenable environment	-	-	Mandatory	Mandatory	Mandatory
Emergency exit doors	-	-	Mandatory	Mandatory	Mandatory
Emergency exits (includes cross-passageways) <sup>j</sup>	-	-	Mandatory	Mandatory	Mandatory
<b>Electrical Systems <sup>k</sup></b>					
General	-	Conditionally Mandatory	Mandatory	Mandatory	Mandatory
Emergency power	-	Conditionally Mandatory	Mandatory	Mandatory	Mandatory
Emergency lighting	-	Conditionally Mandatory	Mandatory	Mandatory	Mandatory
Exit signs	-	Conditionally Mandatory	Mandatory	Mandatory	Mandatory
Security plan	-		Mandatory	Mandatory	Mandatory
<b>Emergency Response Plan</b>					
Emergency response plan	Mandatory	Mandatory	Mandatory	Mandatory	Mandatory

### NFPA 502 References:

- <sup>a</sup> Determination of requirements in accordance with Section 7.3.
- <sup>b</sup> Determination of requirements in accordance with Section 7.4.
- <sup>c</sup> Determination of requirements in accordance with Sections 4.5 and 7.5.
- <sup>d</sup> Not mandatory to be at tunnel; however, they must be near to minimize response time.
- <sup>e</sup> If required, must follow Section 10.5.
- <sup>f</sup> If installed, must follow Section 7.10 and Chapter 9.
- <sup>g</sup> Section 11.1 allows engineering analysis to determine requirements.
- <sup>h</sup> If required, must follow Section 7.12.
- <sup>l</sup> Determination of requirements in accordance with 7.16.2.
- <sup>j</sup> Emergency exit spacing must be supported by an egress analysis in accordance with 7.16.6.
- <sup>k</sup> If required, must follow Chapter 12.