Fire Fighting Operations in Modern Road Tunnels: An Australasian Perspective

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ABSRACT

Modern road tunnels in Australia and New Zealand are typically provided with a range of life safety systems including Fixed Fire Fighting Systems (FFFS). These systems are installed for a number of reasons including incident mitigation and to support the means of egress in the event of an emergency such as a fire. An increased focus of modern road tunnel design, which is in part driven by a performance based approach, is the specific consideration of fire fighting operations and fire brigade needs as part of the holistic design process. FFFS, and in particular deluge systems, are now common practice across Australasia and are typically installed in long tunnels. The provision of deluge systems in particular, are recognised and accepted by the fire brigades as one of the key fire life safety systems to support fire brigade intervention in the event of fire [1].

There is much discussion and consideration within the literature that deals with fire fighting operations in underground infrastructure including road tunnels [2, 3, 4]. However, there is very little discussion, if any, that deals with the provision of FFFS and the ever increasing complexity of modern road tunnel design and their systems. This paper discusses the recent increase in road tunnel infrastructure in Australia and New Zealand, the lessons learnt and findings being applied to tunnels from a fire fighting perspective.

KEYWORDS: Fire Fighting Operations, Fixed Fire Fighting Systems, Incident Management Planning, Emergency Services, Fire Brigade Intervention

AUSTRALIAN AND NEW ZEALAND ROAD TUNNELS

Australia is following international trends in road and rail traffic management for major cities by including tunnels as part of the overall traffic management plan. Nowhere is this more apparent than in Brisbane, the capital city of Queensland. Only a few years ago, Brisbane had very few tunnels of any significance. On 15 March 2010, Australia's largest road tunnel, the 4.8 km "Clem7", opened to traffic in Brisbane. This milestone for tunnelling in Australia was eclipsed on 24 June 2012 when Brisbane's 5.3 km Airport Link Tunnel opened for traffic. Brisbane's third major road tunnel, the 4.6 km "Legacy Way" is currently under construction and scheduled for opening in mid-2015.

New Zealand has a long history of road tunnels and is now following Australia's lead with a number of road tunnel projects recently completed with more currently being designed and under consideration. Prior to 2009, there had not been any major road tunnels constructed in New Zealand for over 30 years. In Auckland, New Zealand's largest city, there are now two major road tunnels operating, a third due for completion and the Waterview Connection Project, which comprises of 2.5 km of twin bored tunnels is currently under construction. At just over 14m in diameter, the Waterview tunnel boring machine will be the 10th biggest ever built globally, and will create Australasia's largest ever tunnel. In Wellington, the existing Terrace and Mt Victoria tunnels have recently undergone safety upgrades including the provision of deluge systems.

TUNNEL DESIGN GUIDANCE

New Zealand does not have any specific tunnel design guidance and has historically looked to Australia and further overseas for support with design and operational considerations. In 2001 the Australasian Fire and Emergency Services Authorities Council (AFAC), of which the NZFS is a member, produced the 'Fire Safety Guidelines for Road Tunnels' [1]. The AFAC guidelines were seen as a response from the Australian Fire Brigades to ensure their involvement within the design of tunnels and to assist Fire Brigades in providing comment to developers regarding fire and life safety matters. In 2011 the Australian Standard AS 4825 Tunnel Fire Safety [5] was published to standardise and reduce the inconsistency of tunnel design throughout Australia. Whilst not a mandatory document in New Zealand, AS 4825 has some recognition through the Austroads association of which the New Zealand Transport Agency (NZTA) is a member. The Austroads Guidance to Road Tunnels [6] identifies that the basis for its guidance is that contained within AS 4825.

An increased focus of modern road tunnel design, which is in part driven by a performance based approach, is the specific consideration of fire fighting operations as part of the holistic design process. This is recognised in various standards and is defined in AS 4825 to include:

> ***Fire Brigade Intervention***
> *All fire agency activities from time of notification up to departure from the incident site and includes **all fire brigade operations**.*
>
> ***Fire Brigade Operations***
> *All firefighter activities **from time of arrival** at an incident including set-up, search and rescue, fire attack extinguishment and other activities **up to time of departure** from the incident site.*

The Australian Standard goes on to state that;

> *"An integral part of the fire safety strategy of a tunnel is the intervention of the emergency services **to carry out search and rescue and firefighting activities**"*

The above statement is consistent with other internationally recognised standards and tunnel design guidance such as that of PIARC [8] and NFPA 502 [9]. FFFS are now common practice in both new tunnel design and also existing tunnel retrofits and are typically installed in long tunnels in both Australia and New Zealand. Long Tunnels are defined as those **longer than 120m by AS 4825**. The provision of FFFS and Deluge systems in particular, are recognised and accepted by Fire Brigades as one of the key fire life safety systems to support Fire Brigade Intervention in the event of fire. To meet this intended design guidance and ensure that the necessary needs and functional requirements of the Fire Brigades is met, both for the initial tunnel design and over the tunnels operational lifetime, it is necessary for both designers and fire brigade representatives to have an understanding of fire brigade operations in tunnels.

FIRE FIGHTING GUIDANCE

Most of the available literature regarding fire fighting operations is road tunnels focuses of the difficulties associated with undertaking fire fighting and rescue operations underground with particular emphasis on the **limitations of the use of breathing apparatus** within the underground environment. However, there is limited discussion available regarding fire fighting operations in tunnels equipped with FFFS and other systems now commonly found in modern road tunnels that can have a significant influence on the evolution of fire fighting and rescue operations. This gap is evident even within recent research such as the SP Report [3] which states that;

> *For tunnels with fixed fire suppression systems, more research is necessary for the development of effective fire fighting operations. Based on the findings from the research, **desirable operations should be developed and proposed.***

These following sections describe the authors experience and findings from fire fighting operations undertaken within many of Australasia's tunnels including real fire events and the many field exercises and that been undertaken and have included the operation and interaction with FFFS.

Fixed Fire Fighting Systems

FFFS are strongly supported as one of the main means to control fire size and support fire fighting intervention in road tunnels. However, the experience of fire fighting operations in tunnels provided with FFFS and in particular deluge systems, which are now common place in Australasia, require their impact on both fire fighting and rescue operations to be specifically considered.

A recent fire event within the Clem 7 tunnel identified some of the problems associated with the provision and operation of deluge systems as identified by comments made by one of the authors in response to the investigation into the operational response:

> *"The deluge was so thick that the crew almost ran into the car in question"*
>
> *"The force and noise of the deluge made it impossible to use radio communications"*

The above problems have also been observed within the many emergency field exercises that are regularly conducted within tunnels containing deluge systems. Without experience it has been found that both members of the public and the emergency services have in many situations tried to enter the operating FFFS zones **without appreciating the complete loss of visibility and high noise associated with this environment**. Experience of this environment suggests a comparison to 'white out' conditions which can quickly lead to disorientation, particularly if there is no fire hose to follow back out of the zones.

a)  b) 

Figure 1 a) View inside a vehicle within the operating deluge zone and b) Fire fighters advancing towards multiple vehicles obscured by deluge spray Source?

Common practice for tunnel management and the operation of FFFS is for the systems to be designed and operated on the basis of **manual operator activation with automatic back up** in the event that the operator does not respond to alarms. This practice is reliant on the presence of a dedicated operator who is trained in the correct use and operation of these systems. The ability of trained operators to rapidly deploy FFFS has been shown to be a major contributor to the effectiveness and ability of FFFS to control fire growth and prevent fires from spreading [10]. However, the need to operate these systems at the earliest opportunity also places some reliance on the operator's prior knowledge of the incident that has occurred within the FFFS zone and requires effective communication of this incident to the fire brigades on arrival so that an appropriate intervention strategy can be put in place prior to commencing fire fighting operations. **In particular, communication between fire brigades and tunnel operators is essential to enable a decision to be made whether to send emergency services into the FFFS zone or to shut down the FFFS first**. However, experience to date suggests that initiating effective communications between responding fire fighters and tunnel operators is not necessarily occurring to the extent necessary to allow both parties to understand each other's current and proposed actions. In summary the following observations are provided to support additional considerations which need to be made with regards to the operation of FFFS:

- **Loss of visibility**

The loss of visibility for fire fighters, tunnel operators and those caught within the operating FFFS means that it is difficult to understand what is going on. The loss of visibility is significant as it can be difficult to establish the nature of the incident and its evolution over time. If a fire occurs immediately, it has been observed that it may not be readily possible **to identify how many vehicles or occupants may be involved.** This can be particularly problematic as the presence of dangerous goods vehicles directly involved or local to fires may not be obvious. This is also true as to the problem of determining whether occupants remain trapped and require immediate rescue from vehicles or if occupants have simply chosen to remain within their vehicles.
NUMBER OF CCTV IN CLEM 7:

- **Water water everywhere**

So much water means that other design considerations, such as the drainage system and FFFS runoff become important factors. Contaminated fire fighting water runoff and the impact on fire fighting operations needs to be considered particularly during extended operations. Fire fighters also need to appreciate what this will look like inside the tunnel. Can a river of water be expected along the side of the tunnel during FFFS operation or should this be captured entirely in the operating zone? It may not be practicable to capture all of the FFFS run off within the operating zones, so the question of what is acceptable needs to be established and then understood by responding brigades. If not, confusion as to the failure of drainage systems and safety of contaminated run off may cause problems and potentially incur delays to fire fighters reaching and operating in the areas affected.
WATER DISCHARE RATE:
SUMP CAPACITY

- **If fire fighters go into the deluge system they get soaked**

Fire fighting in wet clothing can be hazardous as the ability of fire fighters clothing to provide protection from the thermal effects of fires and contamination is reduced, to the extent that prolonged fire fighting operations in saturated clothing can become dangerous. As such fire fighters cannot normally operate inside the operating deluge zone so procedures and an understanding of this environment needs to be developed. This may include appointing different tasks to different fire fighters and ensuring that sufficient resources are available so that fire fighters can rotate and swap tasks if their clothing becomes saturated.

- **Turning on and off FFFS**

Turning FFFS off is typically necessary to provide final control and suppression of the fire. To enable a decision to be made to turn off a FFFS system and risk fire flare up or allow fires to grow, fire fighters require knowledge and confidence in the system operation to ensure that they don't turn of the systems prematurely. FFFS are usually **zoned**, typically in 25-30m long zones with multiple zones operating at any one time. The firefighting water supplies including hydrant systems are typically also supplied from combined mains, which should be designed to enable sufficient firefighting resources to be established and put in place before the FFFS system is shut down. It is then recommended that the **FFFS be shut down one zone at a time** based on knowledge of the location of the incident and resources positioned to enable water sprays to be positioned over the location of the fire prior to and during system shut down. This type of procedure whilst taking into account information and understanding of the fire size, will dictate whether water can be put onto the seat of the fire whilst the FFFS system is still operating or if it needs to be turned off first. It then becomes a risk informed decision as to whether it is better to leave the FFFS system operational in an attempt to extinguish the fire, rather than risk turning it off and allowing the fire to regain hold. Appropriate control and knowledge of operation of the FFFS then becomes essential for both the tunnel operators and fire fighters to understand. Who will operate the system in these circumstances, system design to prevent over complication will then form an essential part of the upfront FFFS design.
IDENTIFY FIRE SOURCE – SET UP HANDLINES – RECONISANCE – SHUT DOWN NON ESSENTIAL ZONES ASAP – SHUT DOWN INCIDENT ZONE ASAP

- **Visibility through FFFS and ventilation operation**

Fire fighters should be aware of the differences that can evolve as a result of ventilation conditions inside the tunnel, not only with respect to smoke but also with its effect on visibility inside the FFFS zone. It has been observed that the ventilation rate can either help with visibility or hinder it depending on its operation. The complication of smoke being released inside the deluge zone is also another factor that can significantly affect the visibility conditions internal to the FFFS zones.
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- **Correct FFFS system operation**

The size and capacity of the FFFS system is important as it is not always easy to correctly identify and operate the correct zone. This has been observed from both an operator and fire fighters perspective. During a trial within a 300m long tunnel containing a deluge system, fire fighters took five attempts to operate the correct deluge zone from a remote fire panel, even though they could see from one end to the other, including the incident location. This 'trial and error' approach indicates the difficulty of fire fighters remotely and locally choosing the right zone from either a local or remote fire panel and brings into question the over complication and provision of multiple FFFS control points. This leads to a number of design considerations including;

  - That it is considered preferable to have tunnel operators oversee FFFS, aided by appropriately located CCTV systems,
  - It is necessary to provide appropriate FFFS zone identification, including signage and markings internal to the tunnel and on the systems components, i.e. deluge vales and manual release valves,
  - The design of the system should include the capacity to provide extra zone operation/areas coverage. This way additional zones can be activated without having to close of a zone first which can be important for incidents occurring at the edge of zone boundaries.

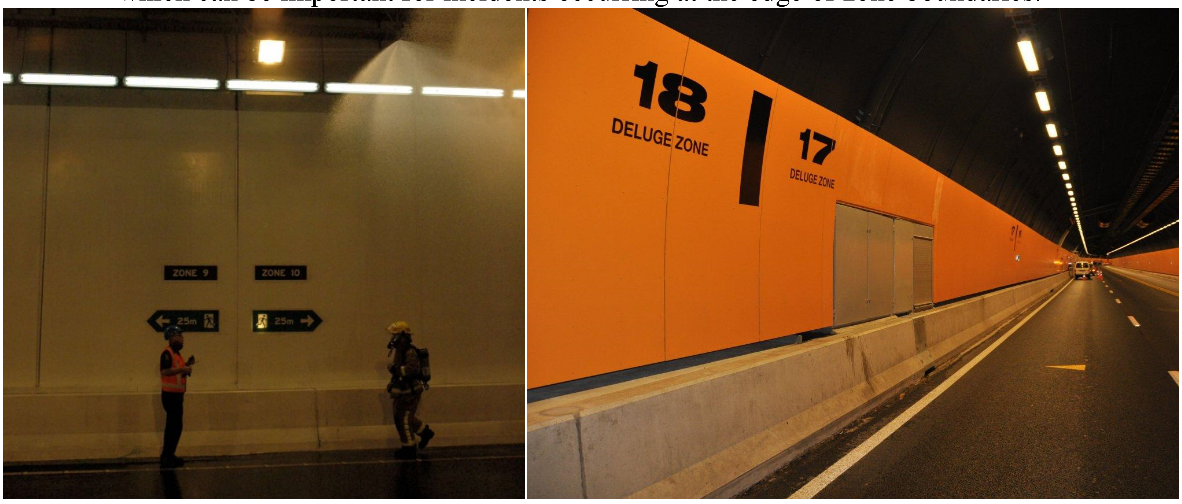

Figure 2 Examples of FFFS zone markings used in New Zealand's tunnels

- **FFFS training and familiarisation**

It is important to undertake acceptance testing and commissioning of all tunnels safety systems, with a particular emphasis on FFFS to allow tunnel operators to practice and understand factors associated with their operation. For example, the accuracy of correct zone identification and operation through a CCTV system needs to be appreciated as well as the time taken between 'pressing a button and water dropping' can be considerable. Fire fighters should be involved in these opportunities to help them understand system operation and system characteristics and their individual idiosyncrasies.

- **Fire fighting water supplies**

It is standard practice in Australasia to design fire fighting water supplies to include for 1 hour supply for the FFFS system and 4 hours supply to the hydrant system including allowance for redundancy in supply. Taking into account the necessary operating flow and pressures requirements dictated by relevant standards can result in significant on site water storage capacity and street main supplies. Other considerations including the capacity of drainage systems, need to allow for both FFFS and other fire fighting operations that may further release water into the tunnels drainage system. Typically it will be unnecessary to design for hydrant and FFFS operation at the same time, especially at full flow and pressure. However there will be times when operation of the two systems overlap which needs to be catered for. These considerations extend not only to the design of the these systems but also other system design capacities including drainage sump design where in-tunnel water flows and external events such as rain need to be considered to prevent exceeding their design capacity. An understanding of fire fighting operations and the development of appropriate fire fighting tactics taking into account FFFS operation, can in some cases lead to the most appropriate design development of drainage system elements and ensure that these systems do cater for incident scenarios whilst at the same time not be over specified.

Smoke control and ventilation systems

Of major importance is the impact of smoke control, ventilation system control and their operation with respect to fire fighting operations. Smoke control in the event of a tunnel fire is essential to allow fire fighters to make entry to tunnels and effect fire fighting and rescue operations. Typical tunnel ventilation systems including transverse and longitudinal ventilation systems are operationally very different systems for fire brigades to operate with.

Longitudinally ventilated systems are generally considered preferable due to their ability to prevent back layering and provide a clear path to the location of the incident in fresh air. These systems are usually simplistic in operation and also conceptually for fire brigades to understand. However, depending on system specifics their availability and use under all possible conditions such as during times of traffic congestion, may not be possible. Also depending on the specifics of the system design, these systems may have different modes of operation requiring an understanding of their impact on smoke and FFFS interaction. For example, if smoke is allowed to stratify during the evacuation period, operating the ventilation system for smoke clearance to allow safe fighting operations may be necessary. However, changing the ventilation conditions may drastically alter conditions within the tunnel. Such changes need to be understood by both tunnel operators and fire brigades so that they do not interpret these changes as failures of the ventilation systems. Figure 3 below shows the impact of operating jet fans on a stratified smoke layer and the disruption of the smoke layer.

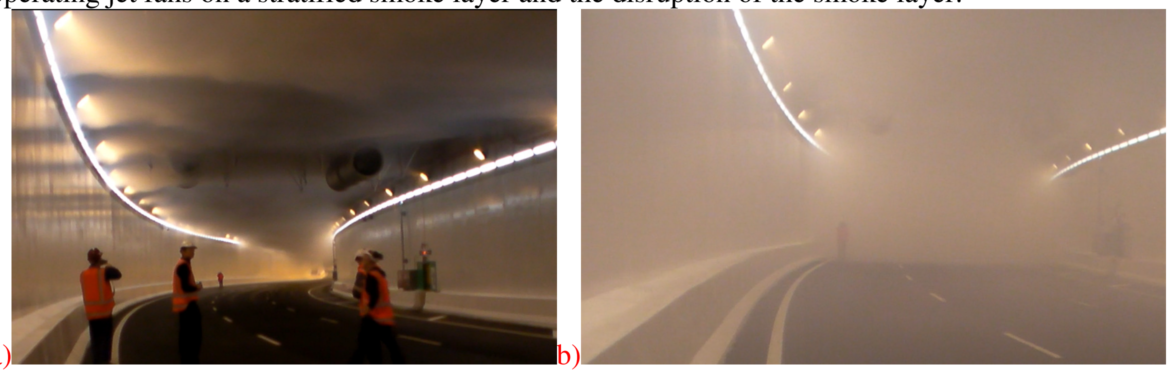
a) b)

Figure 3 a)Back layering of smoke occurring prior to operation of the ventilation system and b) seconds later, the effects of a de-stratified smoke layer with a 'smoke front' or 'smoke plug' seen advancing towards the fire location as the jet fans ramp up.

Emergency access to the incident location in a longitudinally ventilated tunnel goes hand in hand with the direction of traffic with contraflow options normally unavailable. Different to longitudinal ventilation, transverse systems utilising point type extraction sometimes allow greater flexibility in access direction, but may require fire fighting operations to take place underneath the smoke layer inside the ventilation zone. Complicating both of these smoke control and fire fighting principles arises when the impact of FFFS system is also taken into account. Upon FFFS operation a stratified smoke layer will be destroyed, mixing with the water spray which in some situations may appear as a solid wall of water spray and smoke. Depending on the type of ventilation system they may help push the smoke through the water spray whilst being cooled, or may simply create a solid wall of smoke.

The operation of different types of ventilation systems and knowledge of fire fighting intervention also becomes important when appreciating the impact of operating the wrong zone versus delays in operating these systems and direction of operation. It is well known that the more simplistic a system, the higher the chance of it operating successfully. Further, adding complexity through multiple complex control points and via interaction of tunnel control systems and fire system control adds additional points of failure. Introducing an untrained fire fighter to the mix with the ability to turn on, turn off and reverse ventilation systems can present a recipe for disaster.

a) b)

Figure 4 a) A 'wall of smoke' on the edge of a ventilation zone during the Burnley Tunnel fire incident and b) deluge operation within the Clem Jones Tunnel (CLEM7)tunnel.

Fire systems controls

Tunnel fire systems are becoming ever more complicated, necessitating the need for the systems to be operated by trained tunnel operators rather than relying on the first arriving fire brigade personal to operator systems remote from the fire scene. The authors have observed the conflict between the traditional building approach and that required to be employed within tunnels when it comes to fire system design and consideration of operational control and over sight of these systems. It is standard practice in building design for fire systems to be automatic in operation with local manual control provided at the fire alarm panel, typically located at the main entrance of the building. In tunnels however, it is often necessary for the tunnel operators, who are often located in a remote location to the tunnel, to have full system control. Tunnels share similarities in some sense to major process facilities in that 'the process', i.e. vehicles flowing through the tunnel, is overseen by operators who can identify the onset or early stages of an incident and if they have sufficient training and experience, can operate safety systems to retain control or shut down the process in a safe manner and to prevent escalation of the incident. For tunnels it is necessary to understand these principles and apply them to the fire system design and fire brigade Standard Operational Procedures (SOP's).

Long tunnels with zoned FFFS and detection systems can lead to the identification of some hundreds of detection and deluge zones. Providing local control at multiple remote fire panels has been observed to provide an unnecessary level of complication to the system design and importantly a level of system complexity that is simply too difficult for a fire fighter who is not trained and familiar with the tunnels systems, to understand. Furthermore, with multiple points of control and the ability to isolate both tunnel operators and fire fighters from the systems operation, it is important that both the systems designers, tunnel operators and fire brigades fully understand the implication of making design decisions regarding system provision and functionality. Where a tunnel is overseen by dedicated operator's, fire fighters need to be in a position to be able to trust and rely on operator oversight and appreciate that they are not necessarily best placed to operate fire safety systems as they would in a normal building. Once this concept is understood by all parties, the burden of training and system operation can be placed upon the operators who are best placed to operate these systems. This however requires confidence in each other's ability to perform these tasks which can only be gained through experience including emergency field exercises and heavily relies on appropriate communications.

The operation of ventilation systems as with FFFS should be ideally left to the tunnel operators who should have a fundamental understanding of the systems operation and impact of system interference either deliberately or unintentionally. Direct contact between the parties is then necessary so that any misunderstanding and system operation needs can be clearly understood and the impact of operating or shutting down a system can be communicated between parties.

Communications

Communications between the various emergency services and between the emergency services and tunnel operators is critical to a successful incident outcome. This is particularly important where the command and control aspects of the incident and system operation are fundamentally interlinked, yet controlled by different parties. It is therefore necessary to provide multiple means of communication, both internal to the tunnel and external to allow the emergency services to communicate with each other and with the tunnel operators. Systems typically utilized include;

- leaky feeder coaxial cables – to allow radio communications throughout the tunnels and their ancillary spaces
- Motorist Emergency Telephones (MET) and maintenance phones (hardwired and Internet Protocol phones) located throughout tunnel spaces to provide redundant and multiple communication paths
- Personnel Announcement (PA) systems to allow tunnel operators and the emergency services to communicate and broadcast messages to the general tunnel population

The design of these systems requires consideration of the tunnel environment as again it has been observed that applying systems typically in building design within the tunnel environment can lead to problems in use. PA systems for example need to be configured specific to the tunnel and be controllable, including system design to allow operators to differentiate between tunnel bores and locations. If the design of PA systems is not undertaken taking into account the tunnel characteristics, then speech intelligibility can be poor leading to confusion and difficulties interpreting safety message and instructions. These issues become compounded with the operation of FFFS which can be very noisy as well as normal and emergency vehicle operations. Experience to date in tunnels has identified that PA systems may need to be isolated at the earliest opportunity, irrespective of whether evacuation has been completed or not due to these systems hampering communications between emergency responders working inside and outside the tunnel. Operating PA systems and fire alarms may be a contradiction to what occurs in normal buildings where fire brigades leave such system in operation until they are confident that occupants have evacuated the building and to prevent reoccupation. Another important consideration to the design and operation of communication systems in tunnels includes provision such as handsets and ear pieces to aid the use of equipment in high noise environments. The provision of multiple systems may also be necessary to ensure that communication between parties is available and maintained throughout the incident. For example, it may be necessary to provide more than one means of communication at the main staging points, i.e. two phones with individual dial in/extension numbers as communications between tunnel operators and other parts of the tunnel may be necessary at the same time by various parties.

Time to intervention and rescue

The authors have identified that designers and other stakeholders in tunnels tend to underestimate the time it may take for fire fighters to set up and establish operations. This is particularly relevant to situations considering both short and long travel times from fire stations where perceptions can lead to an underestimation of other time components once arrival on scene has occurred. Two recent independent emergency exercises in Australia and New Zealand have indicated that it might take 30 minutes or longer before fire fighters are ready to enter the tunnel and reach trapped people inside the operating deluge zone. The involvement of hazardous goods may increase this time significantly.

OPERATIONAL PLANNING

As part of the design and as soon as practicable, designers need to involve fire brigade representatives with the design development of the tunnel. This involvement and collaboration works both ways with the designer in a position to provide help and support into the development of operational plans and the fire brigade supporting the design to effectively integrate fire brigade resourcing and capability. Operational plans need to be developed and improved throughout the design and life of the tunnel including commissioning, acceptance testing and regular exercises.

Local relevance

The impact of local knowledge and the experience of the fire fighters who will actually likely respond to incidents in the tunnel under consideration cannot be underestimated. The Johnstone's Hill tunnel 35km north of Auckland for example, is located within the first response area of a rural fire district which includes a first response by a rural volunteer fire force. The tunnel is also very close to a well-supported composite fire station comprising a mix of volunteers and career fire fighters. The time of day of any incident occurring within the tunnel can therefore expect varying responses from a range of fire brigade staff and equipment.

TRAINING AND EMEREGNCY FIELD EXERCISES

The AFAC guidelines recognised the importance of emergency exercises and need to undertake them at regular and frequent intervals. The guidelines identify that they are necessary to test both the individual parts of Incident Management Plans (IMP) and also that major exercises are required to test the integration of the IMP's into the emergency services response procedures. AS 4825 requires that, amongst other things, emergency drills and exercises are undertaken as part of a suite of incident mitigation measures. The standard recommends that exercises should be conducted with the emergency services as part of the pre-incident planning function and be undertaken prior to the tunnel opening. It also identifies that emergency management planning should be 'tested' by the application of both desktop and field exercises, at least every two years. None of these documents are considered mandatory application in New Zealand but are recognised as relevant by the Austroads association. Prior to the publication of AS 4825, the Austroads Guide to Road Tunnels [6] identified that the basis for its guidance would be that contained within the AS 4825 standard. As well as identifying the requirements for emergency exercises from the then draft AS 4825, Part 3 of the Austroads guidance [7] goes on to recognise the importance of desktop and major emergency field exercises in the role of training tunnel operations staff.

FFFS OPERATIONAL PROCEDURES

There are a large number of factors that must be considered when developing emergency response plans for tunnel incidents. The general geometry of the tunnel (twin bore/single bore, bi-directional or unidirectional traffic flow, ventilation systems and availability of FFFS) will play a major role in determining the strategic and tactical options available to emergency responders. For reasons such as these, it is essential that each tunnel complex has its own specific operational plans that take into account the large number of variables encountered.

There are however generic principles that can be applied to most tunnel situations. One of the most important considerations is to gather mission critical information BEFORE committing crews and emergency vehicles into the tunnel. The understanding of generic SOP's from a designer's perspective can also be useful in testing the procedures against the design provisions during early concept designs and throughout the various design stages to ensure that the procedures remain applicable to the evolution of the design. For the purposes of providing some guidance and establishing a set of basic operational tactics that can be applied to tunnels provided with FFFS the following information provides a starting point.

Tunnel fire fighting can be extremely resource intensive and the internal environment can be unforgiving of any attack that is attempted without prior consideration of the most advantageous direction of approach. Traffic congestion is a critical factor in determining the most effective approach route. It is therefore essential that fire and emergency crews liaise with tunnel operators to gather essential information prior to entering the tunnel. Best practice is to keep the initial response into the tunnel to a minimum to allow for an accurate initial size up before committing additional resources. Once an accurate assessment is made of the resource requirements, the staged appliances can be rapidly directed to the most advantageous locations.

1. BEFORE committing crews and appliances into the tunnel it is essential to contact the tunnel control centre and establish the following initial Mission Critical Information:
    a. Type of incident (RTC, Entrapments, Hazmat, Fire)
    b. Exact location
    c. Number of vehicles and people involved or threatened
    d. Internal conditions (fire, smoke, traffic congestion)
    e. Evacuation in progress?
    f. What fixed installations are in operation? – Are they being effective?
    g. BEST ACCESS for emergency vehicles (TCP initiated to support flushing of tunnel and clear access to emergency vehicles). Is there traffic downstream of the fire/ is there traffic congestion inside of the tunnel
    h. Incident commander to confirm incident visually via CCTV or through communication with officers visually confirming scene in tunnel.
2. Establish water supplies and ensure that tunnel operators are aware of proposed tactics
3. Make entry to the incident tube (via the non-incident tube in twin bore tunnels) and establish hoses at FFFS operating boundary
4. Establish that incident tunnel is clear of occupants or that if any remain they are in clear air under operating ventilation system
5. Close down non-essential systems including alarms
6. When sufficient crews are available and in tunnel, where multiple FFFS zones are operating shut down one zone and advance to next zone boundary
    a. Shut down zones via tunnel operators or manually if required
    b. Ensure that it is possible to re-establish operation of the FFFS
7. Shut down FFFS whilst providing cover spray to incident vehicle
8. Assess incident and establish
    a. need to undertake casualty extrication
    b. removal/aid occupants from FFFS zones to safe area
    c. continued operation of ventilation system

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