FIRE RESPONSE MANAGEMENT

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ABSTRACT

This paper presents a discussion of the question of emergency response activities arising from a fire in a tunnel. It is based on the work of FIT Work Package 4 (WP4) and the author has attempted to summarise some of the topics that have been discussed in the working sessions and are being developed in the report of the group.
The objective of WP4 is "the definition of best practices for tunnel authorities and fire emergency services on prevention and training, accident management and fire emergency operations."

1. INTRODUCTION

When a new tunnel construction is proposed a safety philosophy should be established, risk analyses performed, the operation of the system defined and emergency response plans developed. The designer will attempt to provide systems that will allow notification of an incident, its location and equipment to control smoke. Ideally, this will be carried out in very close collaboration with the tunnel authorities and emergency services so that there is agreement on all aspects of safety.
When the tunnel is operational the input of the designer will be embodied in procedures and plans which can be readily understood and executed by the operator in order to allow the emergency services to undertake their rescue work safely. However, many years of operation may pass before a serious incident occurs and when it does the procedures must ensure that the equipment works to the capacity expected and the operators and emergency services take te correct actions. Hence, maintenance, testing, fire tests and drills need to be carried out on a regular basis so that there is no need for original thought from the participants during the incident.
One of the challenges facing the working group is that of relatively limited representation and so the proposed guidelines may be rather specific to the experience of the participants. Hence best practice guidelines will tend to address a given set of experiences from which we have to draw out the fundamental features and perhaps provide examples of their application.
The members of FIT WP4 have defined the need to structure its guidelines in a way that shows the complexity of tunnel safety and the interrelated nature of the elements needed to ensure a high and balanced level of safety. The major elements are:

- The parties involved - the tunnel operator, emergency services and tunnel users;
- The different phases which should be considered, namely (1) before a fire, (2) during a fire and (3) after a fire;
- The safety factors for each phase and each involved party.

What happens when a fire occurs in a tunnel? Other members of the FIT network have defined "design fires" which the tunnel designer will consider in the provision of ventilation equipment. Such fires will be large and grow rapidly, perhaps a time of about ten minutes, so the response to such an incident must be rapid and require little thought on the part of the operator. The response of the emergency services must also be quick, but it is likely that the fire will be fully developed by the time they arrive.
The tunnel users will in all probability be unfamiliar with their environment and with the technical features available in the tunnel. It may be in their best interests to take action with regard to self-rescue prior to the arrival of the emergency services. This may depend on their prior education with regard to tunnel safety. It also raises the question "what does the operator want the users to do in an emergency" and how is this to be communicated.
The emergency services face an unpredictable situation on their arrival at the fire site. An understanding of the tunnel details and the knowledge of tunnel operational possibilities are required to take control of the situation and begin the rescue operation with maximum safety. The complexity of this interface cannot be underestimated, with a need to interpret possibly incomplete information in a situation that may change rapidly and to deal with human behavioural problems.
The purpose of WP4 is to define these responses in the context of these different categories and so determine the best practices that should be adopted to ensure a high level of safety.
Response management will vary depending on many factors; existing road tunnels with low traffic volumes and limited technical equipment, for example, will require a different approach to an urban metro tunnel or a rail tunnel passing through several different countries.

2. DESIGN PHASE

During the design phase the tunnel operator must address the question of safety and set out an appropriate framework, such as the appointment of a Safety Manager who is responsible for the co-operation with the emergency services as well as acting as a safety controller within the tunnel operator organisation.
Close co-operation should be built up between the tunnel operator and the emergency services, bearing in mind that each end of the tunnel may be under a different jurisdiction or a different country, and require the involvement of several groups. Their joint aim to prevent accidents occurring or when an accident does occur, to manage the rescue of tunnel users efficiently and minimise consequences. There should develop a mutual understanding between the emergency services and the tunnel operator concerning their different roles.
In the design phase the emergency authorities may act as advisers to the tunnel operator concerning the design of the tunnel and should develop the functionality of technical systems. Analysing different accident scenarios and rescue strategies may bring to light functional requirements which result in changes to the design.

3. SAFETY FACTORS BEFORE A FIRE

It is self-evident that the safety factors taken 'before a fire' represent the greatest work in response management. Without this work it would not be possible to rely upon a smoothly operating procedure to optimise the level of safety during a tunnel fire.

There are three principal objectives:

- Prevention of the occurrence of an incident
- Prevention of an incident developing into a serious accident
- Preparedness to manage a serious fire in order to reduce its consequences

3.1 The role of the tunnel operator

The tunnel operator's safety attitude has to start at the highest levels of management and this attitude has to permeate to all levels in the organisation. The responsibilities and levels of authority for different functions in the organisation need to be defined and the appointment of a Safety Manager to supervise all safety aspects related to tunnel operation helps to define these levels and to ensure a proper focus.

There should only be one single control room for supervision and control of traffic and technical systems. This avoids conflicting actions on the part of the operator. Qualifications should be defined for traffic operator staff ensuring they are properly trained to react in a rational manner in accident situations. Their attitude should be proactive in order to take appropriate actions to prevent an accident from happening.

The tunnel operator needs to define strategies that need to be in place as a basis for the formulation of preventive maintenance activities, exercises and test activities affecting traffic. With regard to maintenance, there needs to be a balance between preventive and corrective maintenance taking into consideration safety aspects and traffic management. The frequency of education and exercises programs for operators and whether they are theoretical or practical exercises need to be defined. Ventilation and evacuation strategies need to be implemented to make it possible for tunnel users to self evacuate and to create an environment making it possible for emergency services to perform a safe rescue effort.

The development of these strategies will be aided by a risk analysis to determine the probability of an event occurring and the consequences of the event, perhaps compared with other similar tunnels and relevant open roads in surrounding regions in order to decide the risk acceptance level. This will show whether risks are such that improvements are necessary, where improvements will be evaluated after cost-benefit analyses and acceptable risks where no improvements are necessary. The risk analysis should be reviewed and improvements made in the light o operational experience and study of actual accidents. Risk reduction evaluations might be performed to determine the advantages different operational approaches. For example, in a road tunnel this might mean lowering the maximum speed allowed, introduction of restrictions for hazardous goods transports and obtaining rules for minimum distances between vehicles and forbidding overtaking.

This work will result in the development of procedures for tunnel operation that define both normal and emergency operation of traffic or technical equipment. Procedures for testing safety technical systems on a regular basis will be defined. Such tests minimise the probability for degraded functionality in an accident situation. Procedures for communication of information during an incident will also assist the tunnel operator, giving guidance on who to inform.

Maintenance procedures regulate how to perform maintenance operations from the initial stage where the work is identified up to the documentation of the work. The procedures are to be regarded as a description of the different stages to be taken to ensure that all aspects including e.g. safety and quality are followed. These would include, or reference, rules for the performance of maintenance works e.g. what safety considerations are required and what safety training is dictated for the maintenance staff.

A Maintenance Management System will provide an overview of the maintenance activities and the status of safety related equipment. The system makes it possible in a simple manner to plan the maintenance activities, to get a statistic overview of technical systems faults for safety related functions and also making it possible to decide on system changes. Clearly, a maintenance programme is needed for the planning and co-ordination of maintenance and service activities.
There should also be an education plan for all staff dealing with safety, including maintenance contractor's staff. The education of newly employed staff and time intervals for refresher courses should be defined. Similarly, an exercise plan should define traffic operator's regular exercises. The exercises would focus on the prevention and handling of incidents and seldom-used procedures.
The above elements do not represent a set of static documents. As experience grows or new technologies are introduced the plans and procedures will change and develop. Quality Assurance reviews are an opportunity to examine safety related events and technical systems faults, evaluate them in order to identify improvements in organisation, procedures and technique. This would include the evaluation of education programs and exercises, verifying and refining the quality of the education. The Quality System should also examine, perhaps on a yearly basis, the operation of the tunnel, including technique, procedures, organisation, etc in order to detect safety risks and identify appropriate actions.

3.2 The Role of the Emergency services

From the design stage of a new tunnel and throughout the life of an operating tunnel there should be frequent and organised dialogue between the tunnel operator and the emergency services. This should cover all aspects related to safety such as accidents that have occurred, changes in technical systems affecting the emergency strategies, education and exercises. From these dialogues a common understanding between emergency services and the tunnel operator should grow. When different rescue organisations (from different organisations or from two countries) are involved special attention needs to be paid to decisions concerning who is in charge and different organisation structures and culture.
The strategies adopted by the emergency services will recognise that an incident could rapidly escalate into an accident and that fast response is necessary. Tunnel rescue strategies should be planned, tested and implemented in the emergency organisation. The rescue strategy should be co-ordinated with the tunnel operator interventions so that ventilation, traffic or train control, deactivation of live rail's etc. Another important consideration may be how to enter a particular tunnel in a safe way. A communication strategy is essential in tunnels realizing that communication in tunnels often has, for technical reasons, some limitations compared to outside.
Access times for the emergency services can be analysed from different perspectives, including the location of the accident, turnout from the rescue station, turnout from another place or if relevant with reserve rescue forces when the normal forces are occupied. The conditions within the tunnel, and the exposure limits should be identified and reviewed regularly in order that proper precautions can be taken by rescue staff in a fire situation.
A contingency plan should be implemented that for predefined events, indicates the initial responses, emergency numbering system etc. Specific rescue effort plans should exist based on the contingency plan. Also a common information/media plan should be agreed upon between the emergency services and the tunnel operator. This will include information activities to media with the aim of keeping tunnel users and media focused on safety aspects. The plan should also define the information responsibilities during and after an accident specifically what information the tunnel operator can communicate.

As for the tunnel operator, an education plan should be implemented for all rescue staff, reflecting both the education of newly employed staff and refresher courses. The education should not only reflect the actions to be taken by different categories of rescue forces but also knowledge of the tunnel construction, the technical systems functionality, limitations in communication and similar factors.
Likewise, an exercise plan should be developed for the emergency service. These exercises can help to train new staff in communication or the use of technical systems like fire hydrants. A common exercise plan between the emergency services and the tunnel operator staff is especially important. Common exercises can be either theoretical or practical full-scale exercises. Theoretical exercises have the opportunity for the participants to learn and understand the different roles and activities for all involved actors in an accident situation.
The handling of a tunnel fire exposes the rescue forces to environmental conditions that are different to those on open land. The need for specific tunnel rescue facilities or equipment should be analysed and if found favourable from an efficient and safe rescue point of view it should be incorporated in the emergency services normal rescue facilities.
In case of an accident an efficient and clear alarm for resources is essential. When emergency services from different organisations or from two countries are involved special attention needs to be paid to the advantages of a computer based alarm system ensuring that all involved parties get the same information. Such a system eliminates the risk for misunderstandings due to two different languages and speeds up the response time.
The emergency services and the tunnel operator should perform common functional tests regularly to demonstrate the technical functionality as well as the staff's ability to handle the equipment e.g. communication radios. Reliable, efficient and fast communication possibilities for the rescue staff internally in the tunnel and externally with the rescue centres are also essential.
With regard to Quality Assurance, the tunnel operator and the emergency services should, separately and together, perform common and frequent evaluations of safety-related events and risk trends and evaluate the results and findings of common exercises. These should be aimed at identifying and implementing the necessary actions to improve safety.

3.3 The role of the User

The tunnel user is potentially the least informed actor in a tunnel fire emergency. The environment is unfamiliar and they may not be acquainted with safety equipment or procedures. There may also be language and similar communication difficulties. The difference between road and rail tunnels becomes sharper. In road tunnels the user has more control over the causes of accidents and is perhaps less uniform in response – some may self-evacuate, others may stay in their vehicles.
Safety strategies which define how road tunnel users should behave during an accident should be developed by the tunnel operator. A dialogue between representatives from the users (e.g. a commuter association) and the tunnel operator should be organised in order to collect drivers' comments and proposals on, for example, signage during restrictions and thereby improving the user effectiveness of safety behaviour. Motorist- and Transport Associations should be active in order to improve driver's tunnel behaviour. Both the tunnel operator and the emergency services should influence the Associations to be active concerning tunnel safety.

The tunnel operator should draw up an information plan in order to influence drivers' behaviour. The plan should comprise activities directed to media, users and relevant organisations. This would provide a training and education function for drivers, providing information on signage, technical equipment and how to behave in different situations. This can also be distributed through information leaflets from the tunnel operator to the users.
Facilities should be provided in the tunnel such as emergency telephones, help buttons and fire extinguishers. User interventions in an accident situation should follow the tunnel operator's orders from public address system, radio system or according to emergency signs and guidelines of appropriate behaviour stated in e.g. information leaflets.
In their regular Quality Assurance review, the tunnel operator and the emergency services should follow-up and take necessary corrective actions caused by user's attitude and behavior.

4. DURING A FIRE

If the prevention measures arising from the above safety plans and procedures fail to prevent a fire in the tunnel, then the objective is to manage the fire in an efficient and co-ordinated manner in order to minimise the consequences for involved tunnel users, the tunnel structure and the environment.

4.1 Role of the Tunnel Operator

In the initial stage of an accident situation the tunnel operator should perform the activities defined by the operational procedures as quickly as possible. In a fire situation these would include:

- Notification of rescue resources according to operational procedures.
- Support to emergency services comprising information of e.g. course of event, creation of access passages and possible change of operational mode technical systems.
- Activate internal information according to communication plan.
- Handle the external information to media and public according to the common information/media plan.
- Other tunnel operator interventions depend on the specific tunnels installed technical systems. Interventions could be:
- Activate necessary traffic- or train-control restrictions.
- Activate fire ventilation scenario.
- Give information and orders to users by using e.g. the public address system or the radio system on how to act e.g. evacuate the tunnel.

4.2 Role of the Emergency services

Here again the operational plan developed in conjunction with the tunnel operator should be followed, with actions taken which are appropriate for the particular emergency. The rescue forces should be able to communicate at least with their own control centre during the incident to get the information about the cause of event. They should also be able to communicate between the inside of the tunnel and their control centre.

Co-ordinated interventions should always be performed according to the rescue plans at least with regard to the number of resources for the initial rescue phase. The intervention should also follow the plans concerning how and in which way to enter the tunnel, how to organise the rescue vehicle disposition both inside the tunnel and for resources waiting outside the tunnel.

4.3 Role of the Users

Users should have the capability of calling for help through emergency telephones, help buttons or by making mobile calls to the alarm centre. Fire extinguishers may be available for the tunnel user to deal with a small fire and stop it from developing into a big one. There should also be facilities for the tunnel users to follow the emergency signs and evacuate to safe place without assistance from rescue forces.
User interventions will vary depending on the nature of the transport system.

5. SAFETY FACTORS AFTER A FIRE

After a fire it is necessary to:

- To examine possible damage to the construction.
- Bring the tunnel back to safe operation. (If there is a degraded functionality by using emergency procedures).
- Find out what can be learnt from the fire case and introduce improvements where necessary in organisation, procedures, technique etc.

5.1 Role of the Tunnel Operator

The tunnel operator should be aware that his staff involved in the handling of the accident might have undergone considerable stress and require assistance in recovering from this.
After fire damage the tunnel structure and technical systems should be carefully investigated and checked to ensure that they are functioning in an acceptable manner.
An internal evaluation of the handling of the accident should be performed. The evaluation should comprise a description of what happened , how long did the situation last, possible deviations from procedures and as a conclusion the identification of necessary improvements which should be implemented as soon as possible.

5.2 Role of the Emergency services

An internal evaluation of the rescue should be performed for all involved emergency services, as for the tunnel operator evaluation. When the internal evaluations have been made a common evaluation should be performed between the tunnel operator and the emergency services. The evaluation should comprise the identification of necessary actions in order to improve safety and identified safety improvements should be implemented as soon as possible.
The results of the common evaluation should be communicated to the public about accident reasons, consequences and evaluation conclusions.

5.3 Role of the Users

The common evaluation of fire accidents and the information and lessons learned should be communicated to users and user-organisations to continue the educative process.

6. ACKNOWLEGDEMENTS

The author greatly appreciates the help of his colleagues on the FIT WP4 working group, namely Mrs. Ulle Eilersen, and Messrs. Manny Gaugain, Eddy Verbesselt, Gernot Beer, Gabriel Santos, Christophe Kauer, Anders Bergqvist, Leif Vincentsen, Johan van Dessel and Berndt Thamm