Tunnel fires: Are tunnels safe?

Pedro Soria García-Ramos
ITSEMAP Servicios Tecnológicos MAPFRE

A notable growth in the volume of subterranean transport has been brought about by the development of metropolitan areas of large cities, stretches of high velocity railroad and motorway networks, together with improvements in the efficiency of drilling techniques.

Without any doubt this has meant an increase in transport quality, both with regard to travelling times and with regard to transport safety.

Despite this, events such as that which occurred in the Mont Blanc tunnel on March 24, 1999, or in the funicular railway in Austria make the consequences which may arise from a tunnel fire clear.

Loss of profits is also a factor in fires of a certain degree, not only with respect to the company operating the tunnel itself, but also those which are subsidiary to or dependent on the functioning of the tunnel (hotel and catering trade, transport, etc.)

What happened to the Eurotunnel in 1996 is a good example of this; the fire meant a cease of activity for various months, in addition to the impact on public opinion with regard is to its confidence in tunnel safety.

THE PARTICULAR CHARACTERISTICS OF TUNNEL FIRE HAZARDS

Tunnel fire hazards have the following particular characteristics, which in turn may be specific to a certain use:

Combustible materials

Until now the combustion of a light vehicle in the tunnel has not been the cause of a catastrophe. Despite this however, the transport of hazardous goods is a critical element in highway and inter-urban railroad tunnels.

In the case of railroad passenger transport, great efforts are being made with respect to the combustibility of materials (electrical, structural and covering material insulation), measuring behaviour on small-scale samples derived from life scale tests in working conditions.

Confinement

The interior of a tunnel is a confined space which restricts not only the evacuation of heat, smoke and combustion gases, but also hinders access for fire fighting and for rescue of personnel.

As an example, data are given for fires in relevant tunnels in the last few years:

Place	Date	Type of tunnel	Victims
Baku (Azerbayan)	1995	Metropolitan	270
Mont Blanc (France-Italy)	1999	Highway	26
Kitzsteinhorn(Austria)	2000	High mountain funicular	159

Physical evacuation conditions

In addition to the problem of large evacuation distances there are others such as:

- Poor illumination conditions, either due to its absence in the design or due to the presence of smoke produced by the fire.
- Deficient conditions in the ground in the case of railroad tunnels.
- In addition to this, in the case of metropolitan railroad tunnels, it should be added that they have to be evacuated in an environment which has not been designed for this (absence of platform).

Emergency management

In general the people affected by a fire are not part of the organisation managing the tunnel, it is therefore difficult to achieve the required levels of awareness, training and information in those using the infrastructure.

As a consequence of this, a common characteristic in all large accidents is a lack of efficient two-way communication between the point where the fire has occurred and the emergency control centre, if this exists.

TUNNEL FIRE HAZARD MANAGEMENT TRENDS

The experience which has been obtained, and legislative initiatives developed by those countries most directly affected by these types of catastrophes, are leading to the assessment and implementation of measures in various areas with the aim of preventing these types of accidents.

Naturally the requirements and trends are more demanding in newly constructed tunnels than in tunnels which are already in operation.

Risk assessment

Assessment of the risk consists of estimating its frequency and the number of victims expected resulting from an accident of this type with regard to the technical measures which are foreseen or possible - in such a way that it is possible to reach conclusions both with respect to the suitability of the measures and with respect to the «acceptability» of the risk.

A key tool in this assessment is the application of numeric fluid dynamics calculations (CFD, abbreviation for **computational fluid dynamics)** which allow the space-time harmful variables which are a consequence of a fire (temperature, smoke concentration and toxic gases, etc.) to be assessed.

Hazardous goods

A measure which has already been implemented is the restriction of movement of these types of vehicles during peak traffic conditions. In addition to this, assessment is also made of this hazard compared to the use of alternative routes in order to determine the need to use these.

Finally, it is also necessary to adapt the tunnels, so that, through gradients in the paving and suitable drainage networks, the severity of a possible catastrophe may be limited.

Construction of rolling stock (metropolitan railroads)

With regard to this point it is important to use materials for construction, coverings and services which provide low fire loads, low combustibility and low gas or smoke production. However the materials which have been put together to form the train may lack test programmes on a real life scale, also due to the high repercussion on the cost of development and construction of rolling stock and due to uncertainties concerning the growth of a fire in real conditions which are at times not foreseeable (baggage, various degrees of vandalism, etc.)

Some companies are implementing fire-extinguishing systems for the passenger and driver cars so that fires in these areas can be controlled at source.

Means are also being developed which will allow, as far as possible, the safe and rapid exit of people from the passenger cars to the tunnel (practical ladders).

Evacuation routes

The layout of evacuation routes, together with the maintenance of suitable conditions in these during a fire, constitutes one of the keys to success in the case of fire in the tunnel. This however may involve large investments in infrastructure and installations and their later maintenance.

The resources included in this section are:

- Tunnel evacuation exits at «reasonable» intervals; depending on the type of construction these may be directly to the exterior or to another tunnel (the experience of the use of «refuges» has meant that these are no longer being considered a solution in this respect).
- Ventilation, using currents of air in such a way that the heat, smoke and combustion gases flow in the opposite direction to the evacuation.
- Emergency illumination and signposting, this last may be fixed or variable, in such a way that the evacuation may be directed as is it is carried out.
- In the case of railroad tunnels use is also made of concrete supports or lateral passages in order to resolve the additional difficulty which would be caused by the sleepers.

Emergency management

Once the incident has occurred, the management of the emergency is the last card left to be played in order to fully take advantage of the technical resources previously mentioned.

In order to successfully manage this, although this may be relative, work is being carried out on:

- **Resources for the detection of incidents and communication with the emergency point.**

Rapid detection of incidents allows a rapid response using resources appropriate to the incident. Therefore, in highway tunnels, in addition to the traditional roadside SOS telephones (highways) or train to land telephones (railroad), use is being made of intelligent video incident detection systems, whilst on railways there is a trend towards the use of early fire detection systems both inside and outside the train (traction and tunnel).

- **Response procedures**

Experience has shown that improvisation is an ally of catastrophes, which is why much work is done drawing up response protocols which consider not only the characteristics of incidents but also circumstantial aspects (timetable with relation to occupation, existing ventilation conditions, status of the incident with respect to exits and ventilation, availability of company employees, etc.)

The use of computer applications is made absolutely necessary by the complexity of possible circumstances and the volume of information which must be dealt with.

FINAL CONSIDERATIONS

The repercussions which catastrophic accidents occurring in tunnels and their circumstances have in the media often mean that the «perceived» risk takes precedent over the «real» risk.

Experience has however shown that, in overall terms, underground rail transport has a better safety record than any type of road transport, whilst road tunnels may be considered to be as safe as «open sky» roads, if not safer.

With respect to current safety levels, costs associated with the reduction of potential victims mean that investments in improvements are justified from the «social risk» point of view. ■