The AA Motoring Trust

March 2000

Tunnel Tests 2000
Safety of Road Tunnels in Europe

Background

In January 2000, AIT/FIA commissioned Deutsche Montan Technologie GmbH (DMT) to perform a second tunnel test. A total of 25 tunnels were to be examined in eight European countries. The AA was a leading partner in the project.

The aim of the test was to examine the standard of safety for drivers in tunnels. The results had to be displayed in an easy-to-understand form. This inspection was to be carried out within four weeks.

The situation

Compared to open roads and motorways, the risk of accidents in road tunnels is minor. Statistics show that fewer accidents happen in tunnels than on open roads. This is primarily due to the minimum effect of weather conditions, to speed limits, steady lighting conditions, as well as the low number of junctions/links in tunnels.

But, even small accidents are difficult to manage in tunnels, particularly rescue personnel (ambulance personnel, fire brigade, etc.) have very restricted access. Accidents resulting in fire can lead to a disaster – as recent events in Montblanc Tunnel and Tauern Tunnel demonstrated:

- Only restricted escape routes through the tunnel tubes; in extreme cases, there are only the two routes to the tunnel portals
- Restricted possibilities for the fire brigade to reach the seat of the fire
- Fumes in the tunnel (toxic, temperatures reaching up to around 1200 °C, dense soot) hinder the escape and rescue of the people in the tunnel as well as fire-fighting by the fire brigade.

Approach

For this project, a team of experts was brought together from the fields of fire protection, ventilation and tunnel construction.

The AIT/FIA member clubs in Europe selected 25 tunnels. The length of the tunnel and the importance of the tunnel for holiday traffic were the criteria for selection. The tunnels are spread over eight European countries, i.e. Austria, Switzerland, Italy, France, Great Britain, Spain, Belgium and Germany.

Checklist

DMT prepared a checklist that was reviewed together with the ADAC's traffic experts. The aim behind this checklist was to form an objective foundation for evaluating tunnel safety. It is based on the high standards for regulations governing road tunnels in Germany and Austria. The list contains the most important safety-related matters and is divided to the following main areas:

Apart from presenting the safety potential of a tunnel, this year's test aimed to record and evaluate the existing danger or risk potential. Based on similar inspections performed by DMT on behalf of Bundesanstalt für Straßenwesen [German Federal Institute for Roads and Traffic], the following parameters were taken into account:

- Traffic performance for each tunnel tube (product derived from the traffic volume and the tunnel length)
- Share of heavy goods vehicles
- Maximum gradient in the tunnel
- Type of traffic (one direction or both directions)
- Traffic situation (slow traffic /congestion every day or rarely)
- Vehicles carrying hazardous material

Based on the experience gained with the previous year's tunnel test, a data list was forwarded to operators in advance, containing all the most important technical parameters for a tunnel. This list, originally in prepared in German, was translated into English, French, Italian and Spanish.

Testing the tunnel on location

Between 21 Feb. 2000 and 11 March 2000, four experts from DMT drove though and inspected the 25 tunnels. Apart from the visual impression and random examination of safety installations (e.g. emergency call systems, hydrants, fire extinguishers), safety-relevant matters were discussed with the operators on site. Additional data, for example, special measures by the operator, revamping and modifications in the tunnel are largely listed in the presentation of the individual results, however, these were not taken into consideration for the evaluation of the tunnel.

Assessment

The protocols of the tunnel tests were analysed by Deutsche Montan Technologie GmbH and the results were compiled in table form (refer to appendix). Taking the maximum number of 1000 points achievable into account, the individual safety aspects were weighted. All the data was carefully examined and the data gathered by the four examiners was checked.

Results of the Tunnel Tests

In the total score for each Tunnel, the new elements of the checklist feature with varying importance attached. Fire ventilation and fire safety management count for about 40% of the total score. Escape routes, communication and the tunnel system/tunnel construction count for 30% of the total score.

For the rating of the safety potential the following grades were used:

Very good	90% or above of the total points available
Good	80% or above of the total points available
Acceptable	70% or above of the total points available
Poor	60% or above of the total points available
Very poor	less than 60% of the total points available

Evaluation of the individual tunnels produced the following table of ranking (from worst to best)

No	Country	Tunnel	Score	Rating
1	Spain	Alfonso XIII Tunnel	39%	very poor
2	Italy	Fornaci Tunnel	58%	very poor
3	Switzerland	San Salvatore Tunnel	63.5%	poor
4	Austria	Perjen Tunnel	64%	poor
5	GB	Tyne Tunnel	64%	poor
6	Switzerland	Isla Bella Tunnel	65.5%	poor
7	Switzerland	Crapteig Tunnel	66.5%	poor
8	France	Fourviere Tunnel	68%	poor
9	Belgium	Leopold II Tunnel	70.5%	acceptable
10	GB	Merseyside-Queensway Tunnel	71%	acceptable
11	Austria	Lermoos Tunnel	71%	acceptable
12	Italy	Giaglione Tunnel	72%	acceptable
13	Spain	Cadi Tunnel	72.5%	acceptable
14	Belgium	Craeybeckx Tunnel	73%	acceptable
15	Switzerland	Belchen Tunnel	74%	acceptable
16	Austria	Tauern Tunnel	74.5%	acceptable
17	France	L'Epine Tunnel	76.5%	acceptable
18	Austria	Schonberg Tunnel	80%	good
19	GB	Mersey Kingsway Tunnel	81%	good
20	Germany	Elbtunnel	82.5%	good
21	Spain	Vallvidrera Tunnel	82.5%	good
22	France	Charmoise Tunnel	82.5%	good
23	Germany	Tunnel Konighainer Berge	85%	good
24	Germany	Engelberg Tunnel	85.5%	good
25	Switzerland	Gubrist Tunnel	86%	good

No tunnel was rated "very good", 8 rated "good", 9 rated "acceptable", 6 rated "poor" and 2 rated "very poor".

The UK tunnel assessments

Tyne Tunnel in New Castle, Great Britain

+ Vehicles carrying hazardous material are well monitored and handled (registered in the safety post and escorted)
+ Very well prepared for crises and alarm situations
+ Very prompt and efficient breakdown service
+ Dedicated vehicles for initial fire-fighting operations
+ Tunnel certified according to ISO 9002 (quality management)

- Only one tube with traffic in both directions and without additional escape routes
- No lay-bys and no emergency lane
- Emergency walkways too high and can only be reached by fit people
- Emergency phones do not have sound-proof enclosures
- No automatic fire alarm system
- Risk for tunnel users in the event of fire resulting from the system with longitudinal ventilation (extraction of smoke from the area used by traffic) due to long ventilation sectors and oncoming traffic

<u>Remarks:</u>

- Construction of a second tunnel tube is planned

Mersey Queensway Tunnel in Liverpool, Great Britain

+ Access to heavy goods vehicles up to 3.5 t only, including vehicles carrying hazardous material
+ Additional escape routes leading outside
+ Very well prepared for crises and alarm situations
+ Dedicated personnel (tunnel police) always at hand and trained in fire and rescue matters
+ Very prompt and efficient breakdown service
+ Dedicated vehicles for initial fire-fighting operations

- No automatic fire alarm system
- No lay-bys and no emergency lane
- Emergency walkways too high and difficult to reach
- Emergency phones do not have sound-proof enclosures
- In the event of fire, the existing system for smoke extraction is detrimental, particularly due to oncoming traffic

Remarks:

- System for transmitting messages via car radio is currently being installed

Mersey Kingsway Tunnel in Liverpool, Great Britain

+ Two tubes with connecting passageways that are used as escape and emergency routes, as well as other escape routes leading outside
+ Lay-bys provided
+ Vehicles carrying hazardous material are well monitored and handled
+ Very well prepared for crises and alarm situations
+ Dedicated personnel (tunnel police) always at hand and trained in fire and rescue matters
+ Very prompt and efficient breakdown service
+ Dedicated vehicles for initial fire-fighting operations

- No automatic fire alarm system
- Emergency walkways are 1 m high and have railings and can hence only be reached by people who are fit
- Emergency phones do not have sound-proof enclosures

<u>Remarks:</u>

- System for transmitting messages via car radio is currently being installed
- Distance between escape routes will be reduced to 300 m by additional connecting passageways

Details of full assessments relevant to UK tunnels

The following statements sum up the main aspects examined where there is particular relevance to the UK tunnels:

Tunnel system

The width of the traffic lanes in most tunnels is sufficient ($\geq$ 3.25 m). Only the Alfonso XIII and Mersey Queensway tunnels have traffic lanes that are less than 3 m wide. In this context, heavy goods vehicles have basically no access to the Mersey Queensway Tunnel. Most tunnels have sufficiently wide emergency walkways on both sides. Only four tunnels (Fourvière, Alfonso XIII, Mersey Queensway and Kingsway) had emergency walkways that are less than 0.7 m wide. In the Leopold II Tunnel, the emergency walkways are fitted with a loose plastic cover which is not suitable for safe use of the emergency walkways (risk of injury!).

Traffic

There is no uniform mode of handling the transport of hazardous material through tunnels. In most tunnels, there are no restrictions for vehicles carrying hazardous material. Vehicles carrying hazardous material have basically no access to the Mersey Queensway Tunnel and the Leopold II Tunnel. Some tunnels do have restrictions for vehicles carrying hazardous material. These restrictions can involve restricting such vehicles to times of low traffic during the night (e.g. Elbtunnel), prohibiting the transport of particularly dangerous goods (Fourvière), or escorting vehicles with extremely hazardous material (e.g. Tauern, Tyne, Mersey Queensway and Kingsway tunnels).

With a view to traffic, only three tunnels were awarded a grade of "very good": Fourvière, L'Epine and Mersey Kingsway. Seven tunnels were found to be "very poor": Perjen, Schönberg, Lermoos, Isla Bella, Crapteig, Alfonso XIII and Craeybeckx.

Traffic Control

The majority of tunnels have traffic lights, both at the portals and in the tunnel, as well additional traffic management systems (e.g. variable message systems and signs). At some tunnels, information can be made available on time concerning detours/bypass in the event of congestion or disruption in operations (e.g. Elbtunnel, Königshainer Berge, Fourvière, Chamoise, L'Epine, Vallvidrera, Tyne as well as the Mersey Queensway and Kingsway tunnels).

Communication

The use of mobile phones is possible in almost all tunnels. The Giaglione and Tyne tunnels are the exceptions here, however, the technical equipment required for this is already installed in the Tyne Tunnel, but has not yet been approved for use by the operator for safety reasons.

Loudspeaker systems are available only in a few tunnels; in the Elbtunnel and Königshainer Berge Tunnel throughout, and in the Tauern, Cadi and Vallvidrera tunnels, at least in and around the lay-bys.

Communication is assessed as being "good" in four tunnels: Elbtunnel, Gubrist, Chamoise and Vallvidrera tunnels. Five tunnels were assessed as being "very poor": Alfonso XIII, Craeybeckx, Fornaci, Giaglione and Tyne.

Escape and rescue routes

On the whole, the escape and rescue routes were assessed as "very good" in two tunnels: Gubrist and Vallvidrera; seven other tunnels were awarded a grade of "good". A grade of "very poor" was primarily given to those tunnels with one tube where no additional escape routes were available (Tauern, Perjen, Lermoos, Isla Bella, Crapteig, Alfonso XIII and Tyne), however, this same grade was also given to tunnels with two tubes: Belchen, San Salvatore, Fourvière and Fornaci.

Fire

All tunnels have fire extinguishers that are properly serviced. The distance between fire extinguisher bays is usually 200 m or less. In British and Belgian tunnels, this is only 50m. In Giaglione, the fire extinguisher bays are 400 m apart.

Fire alarms are automatically triggered in most tunnels. The following tunnels do not have an automatic fire alarm system: Fourvière, Chamoise, L'Epine, Fornaci, Giaglione, Tyne, Mersey Queensway and Kingsway as well as Cadi.

Apart from the Alfonso XIII and Fornaci tunnels, all the other tunnels have pressurised water supply and hydrants throughout.

The distances to be covered by fire brigades range between 1 and 28 km. In most tunnels, it usually takes the fire brigade less than 15 minutes to arrive, and in some tunnels only 5 to 10 minutes. Only in the Alfonso XIII and Cadi does this take longer than 15 minutes.

The Elbtunnel, Mersey Tunnel and Tyne Tunnel each have their own dedicated fire brigade that is stationed at the tunnel portals and is responsible for initial rescue operations.

Most of the fire brigades have been specially trained and equipped for working in tunnels. For example, all the fire brigades have suitable equipment for rescuing injured passengers from vehicles, respiratory equipment and suitable fire-fighting equipment. Around half of the fire brigades are equipped with infrared cameras.

The precautionary measures in the event of fire are assessed as being "very good" in three tunnels: Crapteig, Engelberg and Elbtunnel. Twelve other tunnels were assessed as "good". The Alfonso XIII and Fornaci tunnels were seen to be "very poor".

Fire ventilation

In most cases, ventilation is activated according to a fixed programme, whilst the location of the seat of the fire is also taken into consideration.

In 16 tunnels, smoke can be extracted from the tunnel tubes. As a rule, the ventilators all have a sufficient performance capacity; in the Perjen and Crapteig tunnels, this capacity (<120 m^3/s) may be too low. Smoke extraction is particularly effective when the flaps that are usually located in the ceiling of the tunnel are opened fully near the seat of the fire and closed completely in the areas far from the fire. This is only fulfilled in the Tauern, Gubrist and Chamoise tunnels. In older tunnels, particularly, it is not possible to open or close the extraction flaps automatically; this is true for the Belchen, San Salvatore, Fourvière, Mersey Queensway and Kingsway tunnels.

Fire ventilation is assessed as "very good" in two tunnels: Gubrist and Leopold II. Five other tunnels are assessed as "good". Eight tunnels were seen to be "very poor": Perjen, Belchen, San Salvatore, Crapteig, L'Epine, Alfonso XIII, Fornaci and Mersey Queensway.

Crisis management / emergency organisation

In most tunnels, fire detection and fire alarms automatically trigger fire ventilation and closure of the tunnel. In some tunnels, the fire brigade is also immediately notified, in order to avoid false alarms, the safety post sometimes acts as an intermediary here.

Risk potential

As on open roads, the risk or danger potential in tunnels is influenced by a series of factors. In tunnels, these are primarily the volume of traffic, the number of heavy goods vehicles, the gradient of the tunnel, the type of traffic, the condition and handling of vehicles carrying hazardous material.

It is apparent and statistically proven in this context that the heavier the traffic the higher the probability of both accident and fire are in a tunnel.

Of the 25 tunnels inspected, 6 were assessed as having a high danger or risk potential: Tauern, Isla Bella, Crapteig, Alfonso XIII, Craeybeckx and Tyne. Ten tunnels have a medium and nine tunnels a low danger potential.

Apart from those tunnels that were assessed as "very poor" or "poor" anyway, the safety potential, particularly in the case of the Tauern Tunnel, seems to have room for improvement. Suitable measures are planned by operators (cf. section 6).

Recommendations by DMT for more safety in tunnels

Deutsche Montan Technologie GmbH formulated recommendations for the safe operation of road tunnels based on the experience gained during the tunnel test:

a) Short-term measures

- Traffic standstills (building site, congestion) in the tunnel must be avoided using suitable traffic management measures
- Vehicles carrying hazardous material must register in advance, they must be escorted and may only drive through the tunnel at a sufficient safety distance from other vehicles (simply banning the transport of hazardous material in tunnels is not the answer)
- Awareness among tunnel users concerning safety and behaviour must be improved in general, and special information concerning safety facilities (emergency phones, fire extinguishers, lay-bys, etc.) must be provided (task for the operator together with automobile clubs and driving schools)
- Communication must be improved; transmission of messages via car radio should be a standard facility, where standardised messages in several languages can be used for different situations (accident, closure, fire)
- Safety in the tunnel must undergo scrupulous testing by independent experts
- Emergency calls in the tunnel should not be made via mobile phones, but using the emergency phones provided

- Drivers must be forced to adhere to a sufficient safety distance and a reasonable speed

- Traffic lights and signs must be automatically activated, particularly in the case of breakdowns, accidents and closures. Switching to red, resulting in cars lining up, when possible, in front of the portals. Tunnel users must be informed of the reasons for closing the tunnel!

b) Medium-term measures (within 2 to 4 years)

- Ventilation systems must be checked and brought up to meet with today's standard for ventilation and fire ventilation
- Equipment and training for fire brigades must be optimised
- Synchronised plans for alarms and emergency operations must be prepared for all tunnels
- Escape chambers or rescue rooms must be set up in all long tunnels and use must be made of possibilities for creating additional escape routes
- Lay-bys / emergency lanes must be set up in all tunnels
- Internationally valid pictograms should be agreed to for certain situations (e.g. accident, fire, maintenance/construction work)

c) Long-term measures (10 years)

- Escape and rescue route must be created (e.g. by building a 2nd tube)
- Special safety precautions for tunnels with traffic in both directions

