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# *Tunnel safety: where we are now*




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***10 Why this publication?***

***The tragic mishaps in the Mont Blanc and Tauern road tunnels and in the funicular tunnel in Kaprun touched off intense discussions on tunnel safety. After the initial hectic reactions, cooler heads prevailed and all parties went over to a productive, broadly based consideration of the tunnel safety problem. Roughly five years after this series of mishaps, we can state that not only have standards been updated (Ref 1), research done and documented, and existing tunnels inspected (Ref 2), but that there have been significant changes in constructing new tunnels as well as in refurbishing old ones.***

***This report will summarise the current state of safety technology as regards tunnels designed for human transport.***

***20 Tunnel events since 2000***

***The tunnel events mentioned below are not a comprehensive list of all the tunnel accidents of recent years. They are merely included as indicators of where the main tunnel safety problems lie, particularly with regard to road tunnels.***

***21 Rail tunnel accidents***

- ***11 November 2000: A funicular train burned in a tunnel on the way from Kaprun, Austria, up to the Kitzsteinhorn. There were 155 fatalities and only 12 survivors. Investigations showed the fire to have started in an electrical heater in the engine driver´s compartment at the back of the train, which was not manned.***

***22 Road tunnel accidents***

- ***6 August 2001: A fire following an automobile collision in the Gleinalm Tunnel in Austria cost five persons their lives.***
- ***24 October 2001: Two lorries collided in the Gotthard Road Tunnel (Switzerland), triggering an inferno in which eleven persons died.***
- ***4 April 2002: Two lorries involved in a rear-end collision in the Baregg Motorway Tunnel (Switzerland) completely crushed an automobile between them. The accident claimed as victim the woman at the wheel of the crushed vehicle.***
- ***12 April 2004: Again in the Baregg Tunnel (Switzerland), an automobile driver rear-ended a motorcycle without braking. The motorcycle rider died.***
- ***15 September 2004: In Austria´s Ofenauer Tunnel, a lorry crossed into the oncoming lane and collided with an automobile. The tunnel´s second tube was closed for repairs at the time.***
- ***21 October 2004: Inattention on the part of a lorry driver led to a chain collision in the Oberdollen Tunnel (Germany). Five persons were briefly hospitalised with slight injuries.***

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- *12 November 2004: A tractor-trailer combination drove into the side wall in the Horberg Tunnel (Switzerland) and overturned. The driver was seriously under the influence of alcohol at the time.*

*It is not astonishing that the road tunnel accidents, some of which were followed by fires, were caused by inattentive drivers, or those impaired in their ability or by freight not allowed in tunnels. This fact clearly demonstrates that the principle risk in road tunnels is the human element: the driver – a risk that can never be excluded, no matter how extensive, or expensive, the safety measures.*

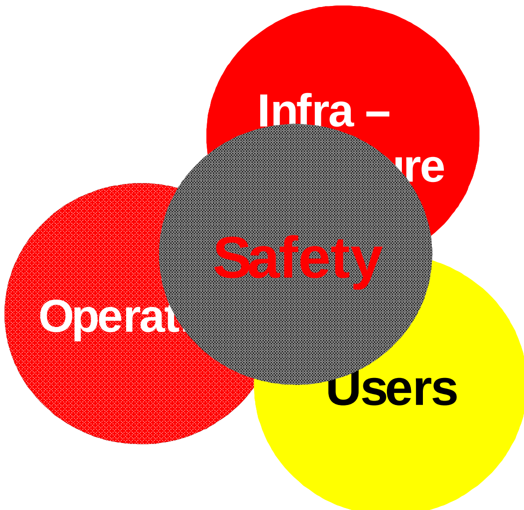
*Fig. 1: Chain collision in Germany's Oberdollen Tunnel*

## *30 The basics of tunnel safety*

*For any tunnel, the level of safety – or conversely, the level of risk – is the result of several different factors. The design of the tunnel itself, and the safety equipment installed – in other words, the overall infrastructure – exert a decisive influence.Just as important are tunnel operations: traffic routing, monitoring, the traffic density, the safety and rescue concepts, as well as the mix between lorry and automobile traffic. The third major component is the user: this includes the type and condition of the vehicles, as well as the drivers themselves.It is particularly this "user component" that clearly distinguishes rail and road tunnels.*

## *31 Infrastructure*

*In traditional tunnels, the structure and infrastructure – the tunnel's plan, gradient, cross section and interior finish – were always a "given": these were defined, and the other elements that contributed to overall safety were handled in the best way possible.*




*More recent tunnels and tunnel projects, however, demonstrate a line of thought that is clearly different. Attempts are being made – and indeed, these must be pursued with great energy – to plan for and implement together the three factors illustrated in Fig 2: for these are in fact all inter-*

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*Fig 2: The factors of safety* ***manner***

***related and interdependent. Only in this will it be possible to improve tunnel safety.***

***It is also important to mention that the structure and infrastructure of many already completed tunnels have been modified to comply with new standards or the heightened need for safety, though this often demands considerable financial and engineering resources.***

***32 Operation***

***Safe tunnel operation, as noted above, depends on the infrastructure (single or double-tube, for example), the traffic density and mix (lorry-to-automobile traffic), emergency access and the available emergency and rescue personnel.***

***At present, considerable sums are being invested in traffic monitoring systems that allow incidents to be recognised and suitable measures initiated. As to fire protection, discussion is still ongoing as to the weighting that should be given to technical systems such as fire extinguishing equipment, as opposed to organisational measures such as monitoring, safety equipment and rescue teams. In both of these areas of fire protection – technical and organisational – costs are a decisive factor. It is in any event vital for there to be a functioning information system, a well thought-out and tested emergency and rescue concept, as well as clear cut responsibilities.***
***Another very important operation principle for tunnels is: Traffic or construction!***

***33 Tunnel users***

***The tunnel users as the main risk factor constitutes the difference between rail and road tunnels users.***

***The vehicle condition and driver behaviour of rail-tunnel users are "known", and individual differences are very small. The tunnel transport of road vehicles by rail is an exception, however. Pre-loading checks of the vehicles' condition and of the goods they are carrying differ greatly with regard to thoroughness. A tragic example of this is the poor monitoring that failed to discover the defective lorry that nearly caused a catastrophe in the Channel Tunnel in 1996.***

***In contrast, the behaviour of road tunnel users – mainly that of the drivers – is unknown and difficult to predict. These persons may be influenced quite strongly by their physical or psychological condition, their fears, their uncertainties or work stress as they drive through the tunnel. Further, the condition of their vehicles is unknown, and no reasonable amount of effort would make it knowable; the same applies to the goods transported.***

***When there is an emergency inside a tunnel, the operators and rescue personnel sent in to take care of the situation are not able to rely on a "public" that has been drilled and trained. In such a case, the "average" driver or passenger is hopelessly beyond any ability to react usefully –and yet, the success of any plans for self-rescue depend on the behaviour of the tunnel users.***

***As this short presentation of the three main factors of tunnel safety clearly shows, any improvement in the level of safety is only possible when all safety-relevant aspects are considered in a coordinated fashion and integrated into the project during the concept phase.***

***Refurbishing existing tunnels is difficult. While considerable investment may be necessary to update and improve the ventilation system in road tunnels (Mont Blanc, Gotthard…),in rail tunnels, the options for installing such modifications are even more starkly limited. Often, the***

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*engineering situation does not allow any notable design or systems improvements. One common improvement is to equip existing rail tunnels with (emergency) lighting, and handrails, to provide those trying to escape a certain sense of security. However, we may be justified in regarding such provisions with a certain amount of scepticism. Just how effective will handrails be – in a long tunnel?*

### *40 The current state of technology*

*The following material is partly based on international standards, guidelines and ordinances, and partly on the author's on-site observations and experience.*

### *41 Rail tunnels*

*Rail tunnel safety is the topic of a draft guideline (Ref 6) under study by the UIC (Union internationale des chemins de fer – International Union of Railways). In addition, a standard has been issued on rail tunnel planning, the SIA 197/1 (Ref 1).*

### *411 Infrastructure*

*The single most important safety feature in designing long rail tunnels is the avoidance of two or more tracks in the same tunnel: this excludes either parallel or opposing traffic. In a well planned and smoothly functioning emergency concept, the tunnel not affected by the event plays the role of an escape route or refuge. This, of course, is predicated upon planning in cross passages which, on the one hand, will permit easy access from one tunnel to the other but, on the other hand, must provide a tight, smoke-proof seal between the tunnels. There is no real consensus as to the maximum desirable distance between these cross passages/escape routes. SIA Standard 197/1, published in 2004, prescribes a maximum spacing of 500 m (Chapter 8.8.4.3). This means an escape time of 6–8 minutes under favourable conditions. This is clearly too long. In this writer's opinion, cross passages should be spaced no more than 250–300 m apart, for escape times of 3–4 minutes.*

*Rail tunnels should be designed with a walkway along their side at least 1.2 m wide and with 2.2 m vertical clearance. A handrail might be built in as well.*

*As concerns rail operations, an absolute minimum of switches should be installed inside the tunnels, due to the increased risk of derailment that they entail. The entrance to any emergency stopping place inside the tunnel should not be carried out by means of a switch. In the case of the newer, longer tunnels (>20 km),*

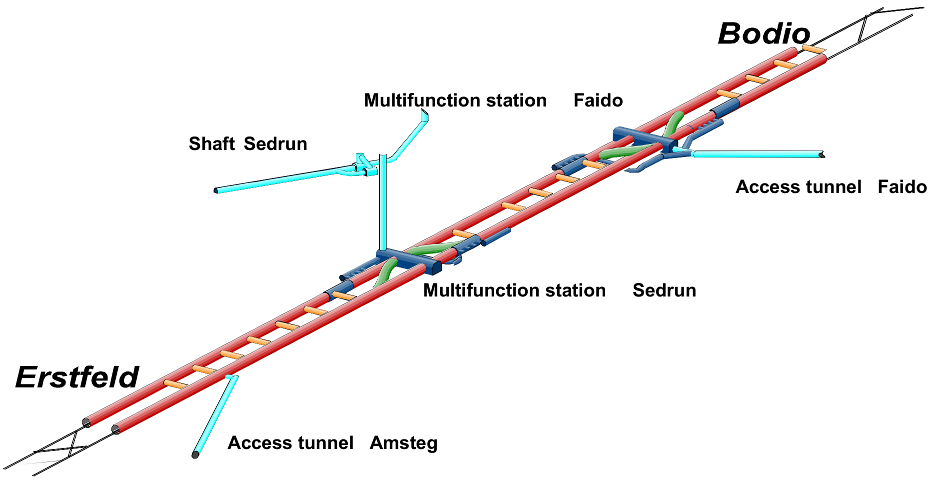


*Fig 3: Design of the Gotthard Base Tunnel*

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these emergency stopping points are used to divide the tunnel overall into single "tunnel segments" (see Fig 3). These emergency stopping places (Fig 4) must be easily accessible for rescue personnel, and permit egress for tunnel users. In addition, they must be equipped with safe places as well as fire fighting and rescue equipment. These emergency stopping places must be at least as long as the longest passenger train, and equipped with controllable smoke extraction and ventilation equipment. The emergency stopping places must also be provided with first-aid equipment and materials.

Supply and communication lines must be planned and installed so that they will function under almost any conditions: fire, heat, water, physical damage. During an event, communications to or with the beleaguered tunnel users could be a decisive factor. The Gotthard Base Tunnel can be used as an example: with a few exceptions such as the spacing of cross passages (~325 m), its safety features may be considered as representing the current state of technology.

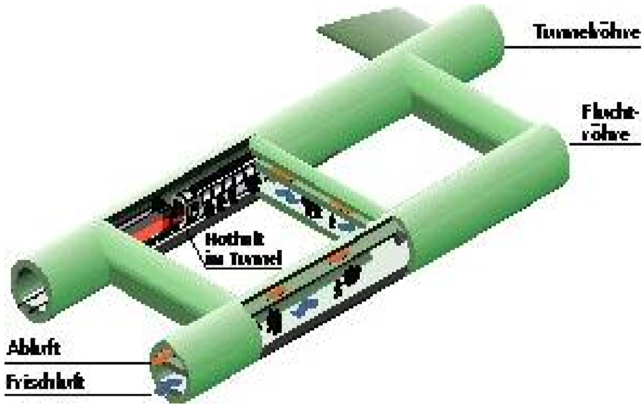


Fig 4: Emergency station in the Gotthard Base Tunnel

412 Operation

The operational concepts for rail tunnels are based on different factors. During normal operations, timetables must to be arranged to exclude the presence of passenger trains in the same tunnel segment as trains carrying hazardous goods. It is even better to completely avoid having passenger and freight trains in the tunnel at the same time. In the single-tube, double-track Zimmerberg Base Tunnel, timetables are arranged to avoid passenger and freight trains meeting each other. Where single-tube, double-track installations are long enough to pose the risk of an entire passenger train having to come to a standstill inside the tunnel, monitoring equipment must be installed. The same applies to single-track tunnels whose length is sufficient for several trains to be in the tunnel simultaneously, or in the same tunnel segment (ie between emergency stopping points).

Trains not in conformance with these rules must not be allowed to enter the tunnel.
That means that the tunnel approaches, at least, must be equipped with the proper monitoring equipment, such as axle counters, hot box detectors and derailment detectors. It is also desirable to have closed-circuit monitoring of important train components before tunnel entry.

Trains having technical problems but are already in the tunnel, must be got out of the tunnel, or to the nearest emergency stopping point, as soon as possible.

Here, too, various sorts of detection and monitoring systems inside the tunnel will be necessary to identify and locate such trains. These detectors should be located inside the tunnel as well. Another method that shows promise is monitoring of the CO content of the air in the tunnel: in this way, small fires in the trains can be detected. This method is only effective, however, where the tunnel is not used by locomotives with combustion engines.

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*413 Users*

***So that trains will still be able to move despite damage, the rolling stock used must demonstrate sufficient movement capability. According to UIC Guideline 779-9 (Ref 8), the rolling stock used should be able to continue running as long as possible in the event of fire, but no less than 15 minutes. For passenger trains, it is also very important for the emergency brake activation to be neutralised while the train is in the tunnel, and for this to be replaced by means of communication among the train crew. However, we will not enter here into the basic discussion on the subject of whether emergency brakes should be used at all. To ensure that trains are capable – purely from the point of view of the necessary traction – of exiting the tunnel, or at least of reaching the nearest emergency stopping place, the locomotives must be provided with active fire protection and extinguishing. Further, care should be taken to minimise the fire load attributable to the materials or lubricants used in the rolling stock. Such materials do not only include flammable materials, but also those that smoulder or generate smoke.***

***Train crews, too – particularly in passenger trains – making long or frequent tunnel traverses must fulfil higher training and performance requirements. They should be well trained in handling frightened passengers in emergency situations, and these skills should be kept current through periodic refresher training. Good communication and language skills are necessary, too.***
***Written materials being available in the trains should make passengers aware of correct behaviour in the event of an unusual event, as is the norm in air travel.***

*42 Road tunnels*

***In mid-2004, the European Union put into effect a directive (Ref 8, Fig 5) applying to road tunnels either in operation, under construction, or being planned, and longer than 500 m. Member states are to incorporate this directive into their own laws before 30 April 2006. Renovation or refurbishment work in all tunnels must be completed by 30 April 2014. In switzerland, an SIA standard has been issued on road tunnel planning (Ref 9).***

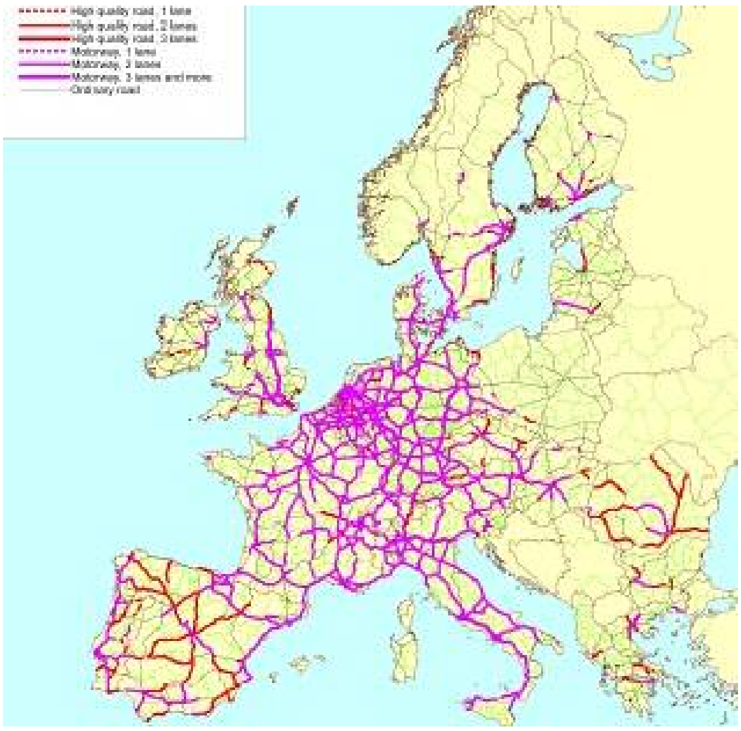

***Fig 5: Trans-European road network***

*421 Infrastructure*

***As the traffic mix of lorry and automobile traffic in tunnels can be regulated only with great difficulty if at all, road tunnels are to be double-tube, and the directions of the traffic thus separated. The two***

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***traffic tubes are to be connected by cross passages spaced no further than 300m apart, so that the second tube can be used as a safe place and escape route in the event of an emergency. If a double-tube tunnel is not feasible for engineering or finanzial reasons, it must be provided with a rescue or safety tunnel, as is the case with many of the newer tunnels today. These must be dimensioned to allow access for rescue vehicles. The newer, longer road tunnels will use a concept similar to that used for rail tunnels: the overall length is divided into segments that include switchovers at the two portals and in the middle of the tunnel (see Fig 6).***

***Absolute requirements for road tunnels include lay-bys provided with fire fighting and communication equipment, walkways on at least one side of the tube(s), emergency lighting, escape route signage with indications of direction and distance, and powerful ventilation systems that can be regulated and controlled at least manually.***

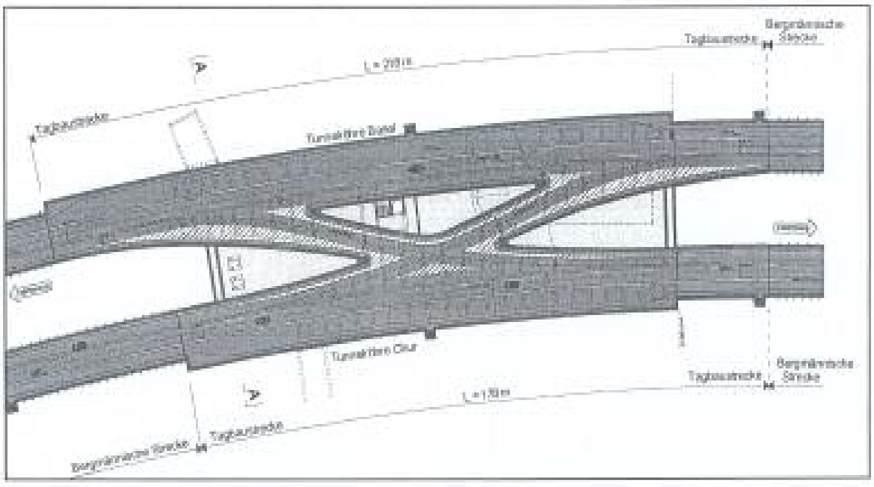

***Fig. 6: Switchover in the Uetliberg Road Tunnel***

***Road tunnels must also be equipped with the appropriate equipment for detection and monitoring: this should include sensors for temperature, visibility, $CO_2$ and smoke, as well as closed-circuit video cameras.***

***As to the installation of deluge or sprinkler systems for fire control, opinions clearly diverge as to their cost effectiveness. Despite high costs, this writer favours the installation of active extinguishing equipment in road tunnels. Late 2003 marked the opening of the twin-tube Markusbierg Tunnel in Luxembourg, currently considered one of the most advanced. In addition to multiple monitoring systems with digital image evaluation, the tunnel is also equipped with a foam fire fighting system.***

### *422 Operation*

***In road tunnels, operation and monitoring requires considerably more resources than in rail tunnels. Traffic is not according to a timetable, and neither the density nor the mix can be controlled to any great extent. Though the measures taken to "dose" transport traffic in the Gotthard Road Tunnel have been partially successful, they do not offer any fundamental solution to the basic problems associated with mixed lorry/automobile traffic.***

***Road tunnel operation depends heavily on traffic control and monitoring, as well as on well prepared and tested emergency and rescue plans comprising all important parameters and resources. According to the EU directive on road tunnels (Ref 8), tunnels greater than 3000 m in length and average traffic densities above 2000 vehicles per lane per day must have a control centre. On alpine roads, this writer suggests integrating shorter tunnels into the overall traffic control and monitoring system. It would be possible to monitor and operate several tunnels from one control centre.***

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Monitoring and control prior to tunnel entry brings considerable benefit, as it can be used to prevent traffic jams inside the tunnel, or to prevent vehicles from entering where a blockage has occurred.

423 Users

In road tunnels, it is the users – ie the drivers and their vehicles – which are theprime and virtually only risk factor; one which is very difficult to reckon with (Ref 3–5). It is simply not possible to determine or constantly monitor these drivers´ degree of training and driving ability – or indeed, capability.

It is difficult to give prior information on tunnel use before these users traverse the tunnel, or information on the events they may encounter. Drivers usually assume that ˝nothing is going to happen anyway˝. Their risk perception does not reflect the facts, as any comparison between road and rail traffic will make clear (Fig 7, source KKV 1997).

No initiatives in this direction have shown any notable success to date, which is regrettable considering what could be accomplished: compare the ˝Instructions in the event of an emergency˝ (see Appendix) distributed to drivers using the Channel Tunnel.

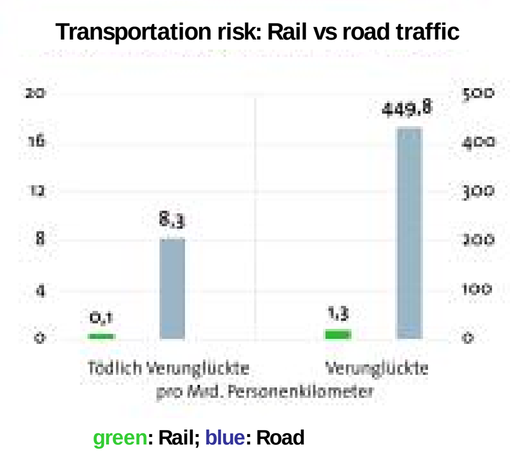


Fig 7: Road and road: a comparison of risk

Actually, private individuals at the wheels of their vehicles are clearly the exception in the transport sector. Unlike train drivers or pilots, who are regularly given refresher training and checked, these persons are left to their own devices after a single test.
In the event of an emergency, highly trained first-response personnel, in sufficient number, are necessary to counter the ignorance or negligence of the average driver.

50 Tunnel classification and evaluation

Taken together, the parameters chosen for use in classifying or evaluating tunnels should give a good idea of its "safety status˝. We will not attempt to list them all here, but only those most important – and equally important – for road and rail tunnels:

- tunnel length
- number of tubes
- traffic density
- traffic mix
- topography of access roads or rail lines

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*51 Rail tunnels*

***The length classification used for rail tunnels are based on the maximum length of a passenger train, and on the maximum agreed escape route spacing (300– 500 m). Tunnels up to 500 m in length (somewhat more than one train-length) may be regarded as an open stretch of track, and are not a safety concern.***

***The greatest difficulties are with tunnels ranging from 500 m to around 3 km in length. For these tunnels, most railroad companies use the concept "Drive the train out of the tunnel!" It is thus difficult to determine which safety and escape features the tunnel needs. The catalogue of equipment and measures also depends heavily on local conditions and the selected rescue concept.***

***All new tunnels over 3 km in length, no matter what rescue concept is used, should be equipped with safety features such as escape routes to the outside (where possible), escape routes to safe places, and detection and monitoring equipment.***

***Any detailed safety evaluation of a rail tunnel should include the following parameters:***

- ***safety concept***
- ***number of tracks per tube***
- ***number of switching areas***
- ***train frequency***
- ***traffic share of freight, hazardous goods***
- ***number of trains simultaneously in the tunnel***
- ***maximum speed of passenger trains***
- ***average and maximum numbers of persons on board***
- ***detection and monitoring equipment***
- ***self-rescue provisions (escape routes, lighting etc)***
- ***facilitated rescue provisions (rescue team access, reaction time, resources etc)***
- ***loss history***

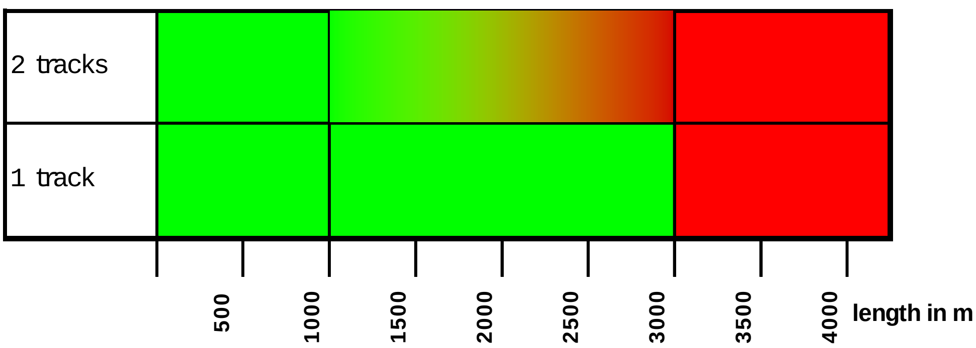


*Fig. 8: Rail tunnel classifications*

*The urgency of such safety measures is represented graphically in Fig 8 above. In the transitional area from green (no major measures necessary) to red (for single-tube, two-track tunnels, structural and organisational safety measures mandatory), the evaluation depends on other concerns.*

### *52 Road tunnels*

*In classifying road tunnels, the tunnel length and traffic density are usually used for a first approximation. Road tunnels less than 3 km long and with less than 2000 vehicles per lane and day need not be designed as double-tube structures, and need not have an onsite control centre (Fig 9: yellow). Tunnels with traffic densities of over 10,000 vehicles per lane and day must always be built as double tubes (red), according to EU directive. Independent of traffic density, tunnels longer than 3 km must be monitored by a control centre. Here too, as with rail tunnels, there is a transitional area in which additional parameters must be considered in deciding on the tunnel design, safety equipment and procedures.*

*For tunnels longer than 1 km, lay-bys equipped with fire fighting and communication equipment are obligatory.*

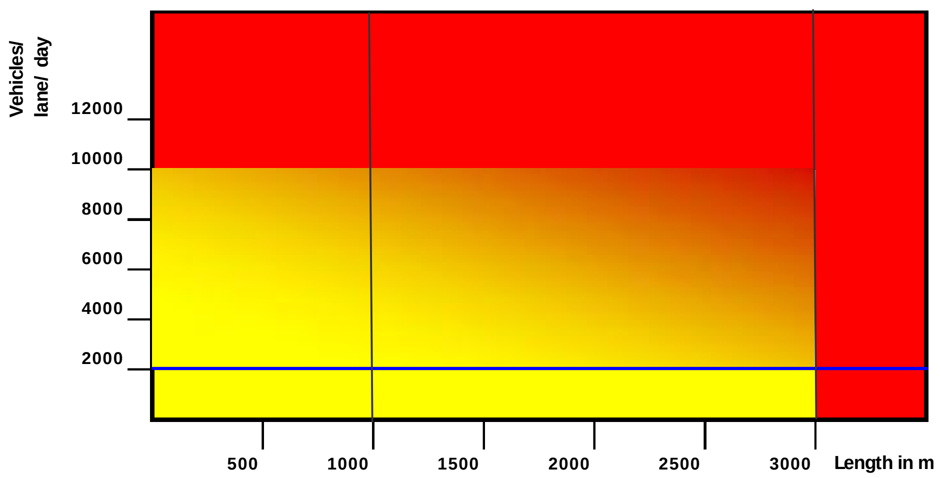


*Fig 9: Road tunnel classifications (see text)*

*Any detailed safety evaluation of a road tunnel should include the following parameters:*

- *tunnel length*
- *number of tubes including escape tubes*
- *number of lanes per tube*
- *average traffic density per lane*
- *two-way or one-way traffic*
- *traffic mix (lorry/automobile traffic)*
- *gradient and length of the tunnel approach*
- *Wintern weather conditions*
- *control centre(s)*

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- *operation plan, traffic plan*
- *traffic jams during normal operations*
- *design safety features (lay-bys, escape routes, rescue tubes etc)*
- *safety equipment (fire fighting, ventilation etc)*
- *emergency planning*
- *readiness and response time of emergency resources*
- *loss history*

*A software tool has been available for some time now to produce a first, approximate risk evaluation for road tunnels. This tool has now been updated. In the current version, a distinction is made between tunnels older than five years and newer tunnels, as a comprehensive consideration of safety has only found its way into tunnel and construction in recent years.*

## *60 Examples of modern tunnels*

### *61 Rail tunnels*

*The two rail tunnels currently under construction in Switzerland, at the Gotthard range and on the Lötschberg, can both be classified as representing the state of technology.A detailed description is superfluous here: refer to the following two links :* www.alptransit.ch und www.blsalptransit

### 62 Road tunnels

#### *621 Markusbierg Tunnel, Luxembourg*

*This tunnel, opened in the third quarter of 2003, is one of Europe´s best-equipped road tunnels; see above and Ref 10.*

#### *622 Uetliberg tunnel, Switzerland*

*The Uetliberg tunnel, currently under construction on Zurich´s west tangential road, is a very modern and safe design: see Fig 5 or* www.uetlibergtunnel.ch/ *for more information.*

#### *623 Plabutsch Tunnel, Austria*

*The very high traffic density (up to 36,000 vehicles per day on two lanes with opposing traffic) prompted the construction of a second tube, opened in mid-2004. The two tubes were provided with 17 cross passages: 13 for pedestrians and four large enough for road vehicles. Their spacing, at 450 m, must be considered as rather far apart. Closed circuit TV monitoring and smoke detection has been installed over the full length of both tubes.*

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### 624 A8 bypass tunnel, Lungern, Switzerland

*See Fig 10.*
*An important element in ensuring tunnel safety is the safety tunnel, which was included in the project at a late date. This safety tunnel runs parallel to the main tube and about 20 m from it. Cross passage spacing is 300 m. The main purpose of this safety tunnel is to enable tunnel users to effect a self-rescue in case of an event.*

*In addition, the main tunnel features four double-sided lay-bys, as well as SOS and hydrant niches every 150 m. Ventilation is along the length of the tunnel from both ends, with exhaust in the middle. The ventilation control room and the operations centre are at the north portal; a second operations building is located at the south portal. In addition to ventilation and lighting, electromechanical equipment includes traffic control, signage and communications equipment as well as the customary measuring and monitoring systems.*


*Fig 10: A8 bypass tunnel, Lungern*

*The most important aid allowing independent operation is the closed circuit video system which monitors the complete tunnel and the portal areas. The canton´s operations and traffic control system for the A8 relays all data and reports on unusual occurrences to the police centre and road maintenance depot in Sarnen.*
*See* http://www.a8-ow.ch/lungern/projektbeschrieb.html

### 625 A8 bypass tunnel, Giswil, Switzerland

*This project, too, was complemented at a late phase by the addition of a parallel safety tunnel. It is located on the uphill side of the main tunnel, and about 20 m from it. Cross passage spacing is 300 m. The safety tunnel has an inside diameter of about 3.8 m. Its main purpose is to provide an avenue of self-rescue for tunnel users and access to rescue forces.*
*http://www.a8-w.ch/giswil/projektbeschrieb.html*


*Fig 11: A8 bypass tunnel, Giswil*

*Zurich, 07 February 2005, M. P. Müller*

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*70 Appendix*

*71 "Well meant" advice for drivers in tunnels*

***The text presented below has been found in the internet, concerning the „ideal" behaviour of the car driver in a tunnel. All this information is well meant, but it is questionable if all these details will be kept in mind by car drivers.***

## Normal conditions

- *Check fuel reserves well before entering the tunnel.*
- *Tune the radio to the traffic information frequency.*
- *Switch headlights onto low beam and the ventilation to interior circulation.*
- *Be prepared for the rapid transition in lighting intensity when entering or leaving the tunnel.*
- *Before entering and while traversing the tunnel, observe all illuminated signage and other instructions and warnings. Drive at a speed close to the speed limit and maintain a two-second separation (at least!) to other vehicles.*

## Traffic jam

- *Switch on your warning blinkers and come to a stop as far to the right as possible.*
- *If possible, pull into a lay-in, or stop in the break-down lane.*
- *Exit your vehicle cautiously on the right and walk to the next niche with an emergency telephone.*
- *Where possible, make emergency calls using the SOS telephone instead of a mobile phone.*

## Breakdown

- *Switch on your warning blinkers and come to a stop as far to the right as possible.*
- *If possible, pull into a lay-in, or stop in the break-down lane.*
- *Exit your vehicle cautiously on the right and walk to the next niche with an emergency telephone. Where possible, make emergency calls using the SOS telephone instead of a mobile phone.*

## Smoke or fire

- *Check that your ventilation is not taking in outside air.*
- *Drive cautiously on.*
- *When it is not possible to drive further, stop you vehicle as far to the right as possible.*
- *Shut off the engine.*
- *Do not take the keys out of the ignition.*
- *Leave your vehicle (taking your papers with you, if readily accessible). Go away from the location of the fire to the next safe place or to the portal.*

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## 72 Safety instructions for the Vereina rail tunnel (vehicle transport)

*1. Give an alarm with your mobile telephone: No 117.*

*2. Actuate the SOS emergency alarm (at the ends of the rail car).*

*3. Tune your radio to one of the following stations and listen for any safety information.*
*Radio DRS 1*

*95.2 MHZ*

*Radio Grischa*
*99.7 MHZ*

*Radio Rumantsch*
*89.4 MHZ*

*4. Follow the instructions given by the train crew:*

*5. Fire extinguishers are located at the head and the end of the train*

## 73 Safety instructions for the Channel Tunnel (vehicle transport)

Follow the instructions of the Chef de Train.

In the event of an evacuation, follow the Chef de Train to the exit.


You will evacuate into the service tunnel, (running parallel to the one you are in).

The smoke hoods are located in the

Fitting instructions are

Pull the smoke hood over your head and

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compartments at each end of the Club Car.

on the package.

breathe normally. Do not remove the smoke hood until you are inside the service tunnel.

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### 742 Figures

Abb. 1: Internet page, Hamburger Anzeiger
Abb. 3: With courtesy of Alptransit AG, Schweiz
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Abb. 5: Internet page Europäische Union
Abb. 6: Internet page Uetlibertunnel.ch
Abb. 7: KfV 1999, Deutschland
Abb. 10: Internet page, A8-OW.ch
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