

New regulations for safe tunnel operation with focus on the European Directive of 2004

Nuevas normativas para la operación segura de túneles, con énfasis en la Directiva Europea del 2004

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ABSTRACT

Safety in tunnels plays a key role for an efficient tunnel management system. In the last years new trends for this subject were developed based on international initiatives and European research projects.

For providing an integrated view of tunnel safety management systems the major objectives, basic elements and structures were defined in this presentation. As a result integrated safety for tunnels must take into account not only infrastructure but also operation, users and vehicles.

In this context, the European Directive on the minimum set of safety requirements as a new regulation implies the standardization of the institutional, organizational and operational aspects of tunnel safety management systems across the member states of EU.

RESUMEN

La seguridad en túneles, es uno de los aspectos más importantes dentro de un sistema eficiente de gestión de túneles. Durante los últimos años han aparecido nuevas tendencias en esta temática, a partir de iniciativas internacionales y proyectos de investigación europeos.

Con el propósito de proveer una visión integrada de los sistemas de gestión de seguridad en túneles, en este trabajo se presentan los objetivos principales y la estructura y elementos básicos de dichos sistemas. Esta integración debe considerar no sólo aspectos de la infraestructura de túneles, sino también su operación, usuarios y vehículos.

En este contexto, las directivas europeas que definen nuevas regulaciones para los requerimientos mínimos de seguridad implican en consecuencia la estandarización de los aspectos institucionales, organizacionales y operacionales de los sistemas de gestión de seguridad en túneles, para todos los estados miembros de la Unión Europea.

1. INTRODUCTION

Road tunnel safety is a subject of growing interest since the last years, thanks to that risk awareness that was raised by the different incidents. The numerous initiatives, which have taken place at the national European and international levels, have led to new regulatory developments. Many countries agree on the fact that there is a need for a framework in which all relevant aspects of tunnel safety, such as regulations, technical and operational safety measures, safety assessment, tunnel use, operating experiences and safety management, are taken into account in an holistic way. All these activities focus on the same goal to make sure that a tunnel is safe.

2. INTERNATIONAL AND EUROPEAN FUNDED ACTIVITIES

In the past regulations concerning tunnel safety were mostly dealing with infrastructure. The first international regulation with a holistic approach was published by the UN ECE. A multidisciplinary group of experts on road tunnel safety (with members of PIARC and ITA) was launched 2000 in Geneva and published 2001 the final report of UN ECE which includes recommendations on all aspects of road tunnel safety: user, operation, infrastructure and vehicles. This report was approved by all member countries and is being taken into account in the European agreements managed by UN ECE , e.g. for road signing, characteristic of the E-roads, transport of dangerous goods.

After the fire incidents of 1999 in the Mont Blanc and Tauern tunnel safety in tunnels was a topic of the European Commission and the starting point for the Directive on minimum safety requirements for tunnels in the Trans-European Network. This legislative document 2004/ 54/EC entered into force on 29 April 2004 and has to be transposed into national legislation within two years.

In comparison with the final report of UN ECE the EU Directive is compulsory to all 25 member states and regulates a complete safety management system. Beside prescriptive requirements for infrastructure, operation and users several levels of responsibilities and procedures for different stages including the planning and operating phase are provided.

The European Directive applies to new and existing tunnels longer than 500 m and aims a harmonised level of safety for all relevant tunnels. Concerning existing tunnels the implementation of detailed solutions is sometimes not possible or at least very expensive and for this reason for various particular risk relevant influence parameter for a specific tunnel also the use of a risk analysis is required.

Also PIARC (the World Road Association) is an international forum for analysis and discussion of the issues related to road tunnel safety, identifying, developing and disseminating best tunnel safety management practice and giving better access to international information with regard to tunnel safety. One of the themes in the strategy of PIARC is the improvement of safety assessments, mechanisms, design and procedures consistent with efficient and effective operations that meet road user acceptance. One of the goals is to improve the safe and efficient use of the road system, taking into account road structures such as tunnels, including the movement of people and goods on the road network, while effectively managing the risks associated with road transport operations and the natural environment.

The PIARC Working group No. 2. 'Management of tunnel safety' of Technical Committee 3.3 on Road Tunnel Operation aims to provide safer tunnels by:

- The development of an integrated approach of road tunnel safety. This includes a holistic approach, a survey of prescriptive versus performance-based criteria, and a choice of measures for new and in-service tunnels.
- Studying the application of risk analysis. This will cover the principles and use as well as a survey of methodical elements of risk analysis, a short presentation of selected methodologies (including case studies), and an overview of experience and practical application of risk analysis methods in diverse countries.
- To promote and follow-up use of OECD/PIARC QRA and DSM software for the transport of dangerous goods. This includes the promotion, assistance in distribution, advise on support and training, follow-up of use and improvements, advise on policy implications.
- The responsibilities in tunnel safety management (definition of responsibilities, tasks, competences, organisation, relations between bodies, procedures to verify the safety of tunnels)
- The development of tools for safety management (safety documentation, collection and assessment of incident data, safety inspections)

Five subgroups were initiated in Lyon in September 2004 in order to realise these aims.

Sub group 1	Integrated approach for road tunnel safety
Sub group 2	Risk analysis
Sub group 3	Promote and follow-up use of OECD/PIARC QRA and DSM models
Sub group 4	Responsibilities in tunnel safety management
Sub group 5	Tools for tunnel safety management

3. OBJECTIVES OF TUNNEL SAFETY

A basic prerequisite for providing an integrated view of the tunnel safety is to define its major objectives and outline its basic elements and structure.

A major step forward to meet these requirements has been reached due to the international work of PIARC (report on fire and smoke control in road tunnels of 1999), UN ECE (report of the group of experts on road tunnel safety of 2001) and European Union (Directive on Minimum Safety Requirements for Tunnels in the Trans-European Road Network). The European Directive 2004/54/EC is today the major legislative guideline to be issued at such a huge level.

These international works agree on the definition of following basic objectives:

1. Prevent critical events that may endanger human life, the environment and tunnel installations
2. Reduce the consequences of accidents, such as fires by creating the prerequisites for:
 - people involved in the incident to rescue themselves;
 - road users to intervene immediately to prevent greater consequences;
 - ensuring efficient action by emergency services;
 - protecting the environment; and

- limiting material damage.

Prevention is of course of primary importance, but unfortunately it is not possible to prevent all incidents. In case of an accident or fire, the most effective response is self-rescue of users inside the tunnel. The experience of past large fire incidents shows that an intervention of the fire brigade is ineffective after e.g. ten minutes or emergency services cannot reach the fire place in such a short time.

4. REQUIREMENTS OF THE EUROPEAN DIRECTIVE 2004/54/EC

The European Directive on minimum safety requirements for tunnels provides several levels of responsibilities, safety measures regarding the infrastructure, operation and users, a risk analysis and procedures for the different planning stages of tunnels.

4.1 Responsibilities in tunnel Safety management

The EU Directive regulates the responsibilities in the tunnel safety management and designates the following actors involved within the tunnel safety management:

- Administrative Authority

shall ensure that all aspects of safety of a tunnel are assured and shall assess their compliance with the requirements of the Directive both for tunnels in the designing stage, before opening for the public traffic and existing tunnels. Several tasks are defined in detail e.g. that regular inspections are carried out by the inspection entity.

- Tunnel Manager

is responsible for the management of a tunnel in the design, construction and operating stage. The Tunnel Manager nominates with the prior approval of the Administrative Authority one Safety Officer for each tunnel, who can be a member of the tunnel staff or the emergency services.

- Safety Officer

shall coordinate all preventive and safeguard measures to ensure the safety of users and operational staff.. He is responsible for assessing the effectiveness of the tunnel safety measures and ensures the coordination of the tunnel manager and the emergency services with respect to the emergency response planning.

- Inspection Entity

is established by each Member state in order to perform evaluations tests and inspections by or on behalf of the Administrative Authority on the technical and operational conditions of the tunnel.

- Emergency services

including police services, fire brigades and rescue teams, intervene in the event of an incident.

4.2 Risk analysis

The European Directive requires a minimum safety level for new and existing tunnels and provides various parameters for a systematic consideration of all aspects of the safety system. For tunnels with special characteristics regarding the

mentioned parameters additional safety measures should be proven to reduce the risk in the tunnel by the use of a well-defined risk analysis methodology. The member states are required to find out a well defined method. The type of risk reduction measures is entirely up to each member state to determine. The risk analysis shall take into consideration possible accidents, which clearly affect the safety of road users in tunnels and which might occur during the operating stage and the nature and magnitude of their possible consequences.

4.3 Safety Measures

The EU Directive requires a set of safety measures which mainly deals with infrastructure and operation, additional provisions relating to the tunnel users, e.g. information campaigns are included. The proposed safety measures shall be implemented at a minimum in order to ensure a minimum level of safety in all relevant tunnels.

4.3.1 Infrastructure measures

The projected traffic volume is the main criteria for deciding to build a single or a twin-tube tunnel. If the traffic volume will exceed 10 000 vehicles per day per lane a twin-tube tunnel with unidirectional traffic shall be in place.

Concerning the tunnel geometry issues, the EU Directive emphasizes the importance of the cross-sectional geometry and horizontal and vertical alignment of a tunnel and its access roads. It is clearly stated that for new tunnels the longitudinal gradient should not exceed 5% while for already existing tunnels that their gradient exceeds 3% additional risk reduction measures should be enforced. Furthermore, if the width of the slow lane is less than 3,5 m then additional risk reduction measures should also be applied.

The design of the tunnel should include emergency exits which are defined as
 direct exits from the tunnel to the outside,
 cross connection between tunnel tubes,
 exits to an emergency gallery,
 shelters with an escape route separate from the tunnel tube.

For new tunnels, emergency exits shall be constructed in case the expected traffic volume per lane exceeds 2000 vehicles. In addition, for existing tunnels longer than 1000 m with a traffic volume higher than 2000 vehicles/lane/hour, the construction of emergency exits shall be evaluated. Anyhow, the distance between two emergency exits should not exceed 500 m.

The escape routes shall be protected against smoke and heat. Furthermore, the construction of shelters without an exit to an escape route shall be avoided. Any tunnel shall also be provided with emergency lanes or emergency walkways for use by the tunnel users in case of a breakdown or an accident. This provision can be omitted in case that it is not practically or technically infeasible and the tunnel is unidirectional and equipped with a tunnel closure system under these circumstances.

Other design considerations involve the establishment of access inside the tunnel for emergency services i.e. cross-sections every 1500 m for twin-tubes tunnels in order to provide access to emergency services.

In particular, lay-bys shall be constructed every 1000 m for new bi-directional tunnels, which are longer than 1500 m, and the expected traffic volume exceeds 2000 vehicle per lane (in the absence of emergency lanes).

In addition, each lay-by that is constructed shall be provided with an emergency station.

If hazardous materials are allowed through the tunnel, then it shall be provided with drainage of flammable and toxic liquids.

The electromechanical specifications addressed by the EU Directive involve the power supply, the tunnel lighting and ventilation systems.

In particular, it is stipulated for tunnels to be equipped with emergency power supply for the operation of the tunnel equipment utilized for evacuation.

Furthermore, it is implied that the tunnel shall be provided with

Safety lighting in order to allow the users to evacuate the tunnel in case of an emergency situation and, evacuation lighting i.e. evacuation marker lights that guide tunnel users to emergency exits.

The perspectives for designing, constructing, and operating a ventilation system are:

the control of pollutants emitted by road vehicles and

the control of smoke and heat in the event of fire.

The EU Directive implies that any tunnel that is longer than 1000 m and the respective traffic volume exceeds 2000 vehicles per lane shall be equipped with a mechanical ventilation system. transverse or semi transverse ventilation is preferred to longitudinal ventilation for bi-directional and congested unidirectional tunnels. In these cases a longitudinal ventilation system is only allowed if an analysis shows acceptable risks or specific measures are taken. For tunnels with bi-directional traffic with a control centre and transverse and/or semi transverse ventilation, longer than 3000 m and having traffic volume exceeding 2000 vehicles per lane, smoke extraction dampers and monitored longitudinal air velocity shall be installed.

For any new tunnel emergency stations shall be placed at the portals and inside the tunnel with a maximum distance of 150 m. The corresponding distance for the existing tunnels is 250 m. The minimum equipment requirements of an emergency stations includes an emergency telephone and two fire extinguishers. It is mandatory for a tunnel to be provided with a water supply. Hydrants shall be placed at the portals and inside the tunnel at a maximum distance of 250 m from each other.

The communication system specifications refer to the establishment of communication between the tunnel manager and the tunnel users in emergency situations. In particular, the following communication considerations shall be covered: Radio re-broadcasting equipment for emergency services use, and installation of loudspeakers within shelter facilities in order to achieve provision of information to the evacuees.

4.3.2 Operational measures

According to the EU Directive, the tunnels should be provided with the essential operating means that ensure the safety of the traffic flow inside the tunnel. In

addition, proper traffic arrangements should be applied when maintenance works are performed. These arrangements refer to the traffic inside and nearby the tunnel.

Traffic management plans should be developed covering the procedures of closing the tunnel in case of an emergency situation. The tunnel closure should be performed with the activation of tunnel closure specific equipment (e.g. traffic signals, loudspeakers, variable message signs, and barriers placed every 1000 m for tunnels longer than 3000 m and having traffic volume exceeding 2000 vehicles per lane).

5. TOOLS FOR THE SAFETY MANAGEMENT

The European Directive stipulates tools for safety tunnel management to ensure a constantly safety throughout the life of a tunnel. For this purpose general demands are defined for safety documentation, collection and analysis of incident data and safety inspections of tunnels

The tunnel manager shall provide a safety documentation for the three different stages of a tunnel project: The design stage, the commissioning stage before opening the tunnel for public traffic and the operation stage. The safety documentation shall contain all safety-relevant information about the respective tunnel.

Following content of a safety documentation is defined in the European Directive:

- a precise description of the tunnel e.g. the geometry, emergency facilities
- traffic situation e.g. characteristic traffic data, portion of heavy goods vehicles , traffic regulation
- transport of dangerous goods
- safety organization and emergency response e.g. emergency response plan, coordination with the emergency services
- feedback of experience e.g. documentation on safety exercises carried out, implementation of findings from exercises

Collection and analysis of incidents are essential for the risk assessment of a tunnel and for the improvement of safety measures. The EU-Directive requires a report when a significant incident or accident occurs in a tunnel by the tunnel manager and every two years an information about the frequency and causes of significant incidents by the member states. Significant incident which have to be reported are incidents, accident or fires in tunnels which clearly affect the safety of road users in tunnels.

The collected data allow in particular, evaluating the frequency and the causes of significant incidents or accidents and provide information on the actual role and effectiveness of safety facilities and measures and on users behaviour.

Safety inspections of tunnels is another tool of safety management which is required by the European Directive. At least every 6 years periodic inspections are mandatory to make sure that the tunnel meets the safety requirements. The inspections shall be carried out by the inspection entity, which have to be independent from the tunnel manager. The administrative authority may execute the inspection entity or transmit it to a private entity.

Considering a possible change of relevant parameters of tunnel safety, e.g. traffic density, status of safety equipment, the safety level of in service tunnel must be regularly assessed in order to

- secure the tunnel management team on its organisation and safety measures applied
- check that the initial safety level has not decreased regarding possible new conditions of operation

A detailed content of a report of safety inspection is not defined in the European Directive but it could be included in following topics:

- infrastructure and systems
- safety documentation and existing procedures
- tunnel management (organisation, training and quality assurance).

6. CONCLUSIONS

Various international initiatives to improve safety in tunnels including recommendations and regulations for new and existing tunnels applied new trends in tunnel management systems. An order to look for an integrated approach for road tunnel safety all aspects for tunnel safety are taken into account in a holistic way. Besides the implementation of safety measures regarding relevant guidelines and standards, the application of risk-based approaches in the process of tunnel safety management recently gained on importance.

The European Directive 2004/54/EC satisfies these trends and provides the implementation of safety measures regarding infrastructure, operation and tunnel user but otherwise the use of a risk analysis considering the particular risk relevant influence parameter for a specific tunnel. Several levels of responsibilities and a regulatory system complete the safety management system of a tunnel regarding the EU-Directive.