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Ad hoc Multidisciplinary Group of Experts
on Safety in Tunnels (rail)

RECOMMENDATIONS OF THE MULTIDISCIPLINARY GROUP OF EXPERTS ON SAFETY IN TUNNELS (RAIL)

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CONTENTS

A. INTRODUCTION AND MANDATE

A.1 INTRODUCTION

In recent years the importance of safety in transportation tunnels has been dramatically emphasized by the accidents and fires in the Mont Blanc, Tauern and St. Gotthard road tunnels. In addition to the tragic loss of life the impact of the interruption in the use of these international routes was considerable. As a consequence, the UNECE Inland Transport Committee created an Ad hoc Multidisciplinary Group of Experts on Safety in Tunnels to consider and report on the issues, in the first place those pertinent to road tunnels. Their work was finalized in the report to the Inland Transport Committee published as TRANS/AC.7/9 dated 10 December 2001.

The Inland Transport Committee subsequently invited a further group of experts from the UNECE member countries to consider safety in railway tunnels. The International Union of Railways (Union Internationale de Chemin de Fer – UIC), an important non-governmental organization, was also included. The European Association for Railway Interoperability (AEIF), the joint representative body co-founded by UIC, UNIFE and UITP and mandated by the EU Commission to lay down the Technical Specifications for Interoperability (TSIs) bringing together representatives of the infrastructure managers, railway companies and industry, also participated in the work of the Group. Eurotunnel as the operator of the current longest tunnel in Europe was also invited to send a representative.

The Group began defining the area of its activity by asking members to indicate the scale of the problem in their country and if their Governments had rules or regulations or were likely to introduce new or revised rules or regulations to control safety in railway tunnels. The replies were published on the UNECE web site, http://www.unece.org/trans/main/tunnels/html.

The Group decided to limit its field of interest to tunnels longer than 1,000 m and up to 15,000 m. It noted that tunnels longer than 15,000 m may require further safety measures as may underwater tunnels, tunnels with road vehicle shuttle services and those typically having a rising gradient when leaving the tunnel. It also decided to limit its present work to heavy rail main lines, as likely to be found on international and interoperable routes. Underground or sub-surface stations and light rail or metro systems were not considered at this time.

Note was taken of the work already done by the UIC and its consultant. It has been published as UIC-Codex 779-9, Safety in Railway Tunnels in August 2003. In particular, the Working Group felt that the general principle set out in that document would be very suitable for its own deliberations. This principle sets out the preferred actions in order which can be summarized as:

1. Prevent accidents,
2. Mitigate the consequence of accidents,
3. Facilitate escape,
4. Facilitate rescue.

The Group also took note of the development of international railway routes and the impact that this might have on the safety of tunnels on the route. Specifically it noted the EC

Directive, 96/48/EC, on the interoperability of high-speed trains, which contains Essential Requirements for the safety of long tunnels.

It has also been noted that the European Parliament is considering a directive on safety on the European Community's railways including Common Safety Methods and Common Safety Targets – due for implementation in early 2006.

A. 2 MANDATE OF THE AD HOC MULTIDISCIPLINARY GROUP OF EXPERTS ON SAFETY IN TUNNELS (RAIL)

During its first session (27-28 June 2002), the Group adopted the following items as its mandate :

- To make an inventory of all long road and rail tunnels in the UNECE region on the basis of a reference length (e.g. 1,000 metres or longer) for rail*/road tunnels to be determined by the working group;

- To prepare a list of all serious fires and, if possible, major traffic accidents that have occurred in European tunnels in the last 40 years (if possible) indicating their causes (if known) and collect the most relevant findings for all these major accidents (if known);

- To obtain, if possible, information on safety provisions in tunnel management systems;

- To collect existing tunnel safety documentation (regulations, reports, recommendations, conclusions, etc.), within the European Union and relevant international organizations (UIC*, OSZhD*, CER*, ECMT, OTIF*, etc.) and draw up a list of ongoing work within these organizations;

- To prepare recommendations for improving safety in tunnels to be built in the future;

- To prepare in a coordinated manner, in the form of recommendations and/or proposals for amendments to existing legal instruments, minimum safety provisions for the operation, maintenance, repair, upgrading, rehabilitation and refurbishment of tunnels of various types and lengths, and traffic conditions in these tunnels particularly as regards: signals, rolling stock*/vehicles, dangerous goods, driver training, etc.;

- The above recommendations and/or amendments should, inter alia, minimize the risk of accidents in tunnels and maximize at the same time the economic efficiency of tunnel construction and operations.

It was proposed that the Multidisciplinary Group of Experts on Safety in Tunnels should be composed of representatives of SC.2 and WP.15 as well as relevant international governmental and non-governmental organizations and experts in tunnel matters appointed by the States members of the United Nations Economic Commission for Europe.

In responding to the mandate, the Group made an inventory of all long road and rail tunnels in the UNECE region. This may be found on the UNECE Transport Division Internet address: http://www.unece.org/trans/main/ac9/ac9inf1.html.

In addition, the Group has collected the available information from member countries about railway accidents in tunnels and associated injuries and fatalities. The evidence showed that very few, if any, accidents leading to major injury have occurred in railway tunnels over the last 30 years.

In addition the Group requested information on safety provisions in tunnel management systems and collected existing tunnel safety documentation (regulations, reports, recommendations, conclusions, etc.), from the member Governments, the European Union and relevant international organizations (UIC*, OSZhD*, CER*, ECMT, OTIF*, etc.) and made them available at the Internet address: http://www.unece.org/trans/main/ac9/ac9age.html.

After collecting and reviewing this documentation, the Group became aware that some member countries were far more advanced in regulating the safety provisions and setting up the safety requirements for railway tunnels than other countries of the UNECE. This finding had further strengthened the Group's conviction that a lack of internationally harmonized railway tunnel safety principles and measures should be brought to the attention of the Governments as it might have serious consequences for the safety of rail transport, users and transport operators. Aware of the strong necessity for developing commonly agreed recommendations with the aim of harmonizing safety principles across Europe, the Group has made an effort to offer to the member Governments a set of recommendations that might be instrumental in preventing the tunnel accidents and increasing the overall level of safety in rail tunnels.

The Group's recommendations for safety in new tunnels have been prepared in a coordinated manner and include safety measures related to the infrastructure, rolling stock and operations. These are aimed at minimizing the risk of accidents in tunnels and maximizing at the same time the economic efficiency of tunnel construction and operations and are presented in part C of this document.

The Group's has made recommendations for improving the safety of existing tunnels. These are aimed at minimizing the risk of accidents and are presented in part D of this document.

The Group has concluded with some standards for minimum safety measures, general recommendations, and several interoperability recommendations, which the Inland Transport Committee may wish to adopt.

B. GENERAL PRINCIPLES OF SAFETY IN RAILWAY TUNNELS

Introductory remarks

Comparisons can be drawn between road and rail tunnels based on various actual accidents or other worst-case scenarios but these are not appropriate since the operating systems are quite different. Railway trains are guided by the track. Trains' intervals are controlled by the signalling system in order to prevent collisions. Modern rolling stock is fire hardened. Frequently passenger services will be segregated from trains carrying hazardous materials. Train drivers and

other crew would normally be trained to ensure the safety of their trains and could be trained to lead any evacuation of a train in an incident.

These and other features mean that the actual risk arising from the use of a railway tunnel is much less than that of a road tunnel. This study has not been able to calculate the actual risk but it has been noted that there have been very few if any fatalities or even major injury accidents in heavy rail main line tunnels in the past 30 years.

The provision of fire and rescue services in any one country will depend on standards set out by national laws. In some countries this service will be delivered nationally or regionally where the organization can be trained and mobilized to deal with high-risk potentials such as a long railway tunnel. In other countries where the fire and rescue services are organized on a more local basis this level of training and mobilization can be more difficult to achieve.

Each country should therefore consider whether the level and type of rescue and fire-fighting facilities provided through the tunnel infrastructure and its equipment would be appropriate for use by the actual emergency response organization (ERO) for the area responsible for the tunnel.

System view

Cost effective safety in rail tunnels is the result of the optimum combination of infrastructure, rolling stock and operational measures. Infrastructure owners and train operators should have a comprehensive safety concept for all tunnels, new and existing, especially those longer than 1000 meters. This safety concept should contain the emergency plans of the operator and those parts of the plans of those public services ensuring cooperation with the operator in an emergency. The safety concept should demonstrate that the actual safety level for all persons (passengers, staff and contractors) meets the requirements set by state authorities.

Effectiveness

The objectives of the recommended safety measures are:

1. Prevention of accidents
2. Mitigation of the consequence of accidents
3. Facilitation of escape
4. Facilitation of rescue.

The order in which these are listed reflects their decreasing effectiveness, especially in the case of fire. Nevertheless, facilitation of escape and rescue is essential when an accident does occur.

Standards and Recommendations The Group's detailed advice given in Chapter C is given either as a "standard" or a "recommendation". "Standards" should be applied as a minimum requirement to any tunnel. Exceptions from any of the standard minimum safety measures could be allowed, provided that the desired safety level in the tunnel could be reached by a combination of other measures. "Recommendations" may be applied to particular tunnels according to the assessment of the risk involved. Application of "standards" supported or not by "recommendations" does not necessarily guarantee adequate or optimum safety in rail tunnels. The Group's advice should therefore be considered within the context of a coherent safety plan adapted to local conditions. Consideration needs to be given to the balance of costs for increasing safety in tunnels against the overall resources available to mitigate safety risks within the entire rail system.

Cost effectiveness Some of the safety measures proposed in Part C cannot provide a clear and unique recommendation, as their cost effectiveness varies in a wide range depending on local circumstances. Their effectiveness and adequacy may be quite different from one case to another. Therefore it is necessary for safety authorities to reach the desired safety levels in the most efficient way. The authorities will have to make decisions and select among the proposed measures according to the safety plan adapted to the local conditions.

Cross-border tunnels In specific cases, where tunnels connect two countries, all of the minimum safety recommendations or standards concerning the infrastructure, rolling stock and operational procedures should be consistently applied in both countries and harmonized among various network managers and train operators. Rescue and fire-fighting measures should be harmonized and coordinated between the responsible services of two countries, although they may be governed by different national practices.

In existing tunnels, measures requiring civil engineering modifications can generally only be applied at reasonable cost in the course of upgrading operations. Where the desired safety level in the existing tunnels cannot be reached by infrastructure improvements it may be achieved by a combination of rolling stock and operations measures.

The aim of the set of recommendations is to promote a harmonized safety level in Europe, taking into account the interoperability of infrastructure and rolling stock.

For this purpose, the Group has proposed minimum safety standards/recommendations that should ensure a harmonized minimum safety level in rail tunnels across Europe. The Group has

also proposed some interoperability rules, which if made binding would oblige railways to harmonize safety and incident response procedures.

C. SAFETY MEASURES FOR NEW TUNNELS

C.1 Prevention of accidents

Infrastructure measures

Recommendation C.1 01 Single-bore double-track /double-bore single-track tunnels

In the context of safety, both single-tube double-track and double-tube single-track tunnels have their advantages and disadvantages. Double-bore single-track tunnels might be safer as they avoid accidents caused by derailments obstructing the adjacent track and they provide the second tube as a possible safe haven. On the other hand, double-track tunnels have more space for possible rescue operations but they also have more space for smoke and fire to spread. For high-speed trains, single-bore double-track tunnels might be preferable and for mixed traffic, taking into account aerodynamics factors, a single-bore single-track might be more appropriate. The choice should be the result of a thorough evaluation of all parameters (such as, for example, length of the tunnel, type of traffic, etc.) related to safety as well as cost considerations.

Standard C.1 02 Speed monitoring and signalling system

As with all railways the signalling system is there to prevent one train colliding with another train by preventing it entering an occupied section or block. The system will also include interlocking to prevent derailment by wrongly set switches. It will include any train monitoring or protection system intended to prevent a train from passing a signal set at danger or exceeding a speed limit. The system should show the train identification code and location on the signaller's control panel. The system should be designed to avoid a train having to stop in the tunnel during normal service. All tunnels should be identified on the signaller's control panel.

Recommendation C.1 03 Tracking the status of the train before entering tunnels

Line side detectors of vehicle faults (hot box detectors, etc.) should be installed at a sufficient distance from the tunnel portal such that a defective train may be stopped by the signals before entering the tunnel in order to reduce the risk of an incident in the tunnel.

Recommendation C.1 04 Installation of switches and crossovers

Switches and crossovers in tunnels and on the immediate approach to tunnels should be avoided in order to avoid a derailed vehicle being thrown out of line and striking the tunnel. If crossings are essential, continuous guidance and support to the wheel should be provided in order to avoid obstacles as check rails.

Recommendation C.1 05 Monitoring of access to tunnels

Prevention of unauthorized access to tunnels should be a normal measure in respect of safety in tunnels.

Standard C.1 06 Regular inspection of tunnel condition

Regular, systematic and thorough inspection of the tunnel including its portals, emergency exits, rescue areas, access roads and technical buildings should be carried out in order to sustain its safety. This should include cleaning of any signs and regular clearing of any rubbish.

Rolling stock measures

Standard C.1 07 Fire protection measures

Construction and vehicle design measures should prevent the outbreak and spread of fire. The use of materials producing toxic substances and a large amount of smoke in the event of fire should also be avoided. Also, during the renovation and refurbishing of passenger train sets, the use of materials producing toxic substances and a large amount of smoke in the event of fire should be avoided.

See also the proposal for the new European regulation on fire resistance for railway passenger wagons (prEN 45545).

Recommendation C.1 08 On-board detectors

Various types of on-board detectors (heat, smoke, flame, etc.) may be installed on locomotives and rolling stock and might be more effective than those installed in tunnels. All alarms including their location shall be transmitted to the train crew who must be trained in the appropriate response.

It may not be absolutely necessary to install smoke and fire detection installations in passenger wagons, but passenger sleeping cars should have smoke and fire detection installations. Installation of fire and smoke detectors on locomotives and rolling stock is considered a preventive measure. Detectors are capable of early fire

and smoke detection and they could thus prevent the train with fire on board from entering into the tunnel.

Operational measures

Recommendation C.1 09 Regulations for operations

The scenario of a passenger train colliding with a freight train might be avoided if these trains are not allowed in a double track tunnel at the same time. This may not be feasible in all tunnels and is not recommended as a standard measure except for tunnels which are very long or have mixed passenger and freight trains with dangerous goods. Although effective as a preventive safety measure, total separation of traffic may not be necessary if an optimized timetable could prevent passenger and freight trains with dangerous goods from passing through a tunnel at the same time. Very frequent traffic through particular tunnels could be made safer by separation of operations of passenger and freight trains with dangerous goods into day and night. Reduced speed can also reduce the potential consequences.

Recommendation C.1 10 Regulation on the transport of dangerous goods

The transport of dangerous goods by rail is usually well regulated, e.g. packaging and labelling, to an extent that further restrictions would only be considered in a high-risk tunnel and if operating conditions permit. In practice only freight trains carrying dangerous goods in bulk might be segregated from passenger trains.

International freight is governed by the Règlement relatif au transports international des marchandises dangereuses par chemins de fer (RID). This is enforced in Europe by Directive 96/49/EC2.

A “consist”, a list for each journey of the type, hazard and quantities of the dangerous goods should be given to the driver with any instructions on to how to deal with accidents. The railway operator or driver must be able to pass this information to the fire brigade in the event of an incident. Common operational regulations for the transport of dangerous goods may also require more harmonized training and education of train drivers at the international level.

C.2 Mitigation of the consequence of accidents

Infrastructure measures

Standard C.2 01 Derailment containment measures

Derailment containment measures should be provided in all tunnels. The tunnel profile should be kept as free as possible from obstacles which might snag a derailed train.

Standard C.2 02 Fire protection requirements for structures

The need for structural fire protection and its type should be given careful consideration especially for those locations involved in any safe haven or rescue. The risk study should consider the likely fire size and its thermal impact on the type of structure involved (heat transfer, smoke leakage, structural damage, spalling, etc.) and the consequences of structural failure. Appropriate temperature development curves should be chosen for the testing of the materials involved. The standard temperature curve such as the ISO 834 Fire resistance tests – Elements of Building Construction – should be commonly used. Where high fire temperatures are possible, e.g. petrol fires, other test curves should be considered.

Recommendation C.2 03 Fire, smoke and gas detectors in the tunnel

The available technology cannot give reliable detection of fire on trains driving through a tunnel at normal speed. However, fire detectors are highly recommended for technical rooms to give an alarm of any threat to the essential safety equipment or to staff. Flammable gas detectors are recommended if there is a possibility of such gas collecting in the tunnel. Cables and equipment in the tunnel should be protected from the consequences of derailment or fire. Where possible, cable installations should be low smoke low fire type of installations.

Recommendation C.2 04 Fire extinguishing systems

The type of fire extinguishing systems, for technical rooms should be determined depending on the potential causes of fire. An effective fire suppression system in the main tunnel is not generally practical and is not recommended. Technical rooms, especially those containing safety critical equipment should be suitably protected.

Recommendation C.2 05 Smoke extraction systems/ventilation systems

The assessment of the air flow in a tunnel should consider tunnel and train aerodynamics, the fresh air supply (for physiological needs), the control of heat and smoke from a fire and the control of pollution (diesel). Ventilation design should take into account the associated risks and costs. Ventilation systems must be designed to keep emergency exits, cross passages and safety tunnels free of smoke.

Recommendation C.2 06 Track drainage system

Track drainage system of the appropriate dimensions is safety and environment protection measure. The system should be designed to remove ground water infiltrating through the lining, snow or rain brought into the tunnel by trains, spillage from bulk liquids in transit or fire-fighting water. It is suggested that there should also be a retention basin. This is not an essential measure for passenger only tunnels but is highly recommended for freight traffic, especially if dangerous goods are frequently transported. The retention basin could be used to retain polluted spillage or fire-fighting water for appropriate disposal without environmental damage. If this basin is enclosed, the risk of fire or explosion should be considered.

Rolling stock measures

Standard C.2 07 Train radio

This is highly recommended as a particularly effective device to provide communication between the operations centre and train crew.

Recommendation C.2 08 Derailment detectors for wagons

In some countries, on board derailment detectors are standard equipment on freight trains and are recommended for trains transporting dangerous liquids and other dangerous goods because of the higher consequences of a derailment when transporting dangerous goods through tunnels.

Standard C.2 09 Emergency brake neutralization and maintaining movement

All countries require passenger trains to be fitted with a passenger operated emergency brake. However for tunnels covered by these Recommendations, the driver should be able to override this emergency brake and drive the train into the open air.

Recommendation C.2 10 Onboard fire extinguishing equipment

For trains using long tunnels the installation of manually operated fire-extinguishing equipment is recommended on board passenger wagons.

Installation of automatic fire extinguishing systems in passenger cars might not be necessary but is recommended in passenger sleeping cars. Automatic or manually operated extinguishing systems are particularly important and recommended on traction units. Unmanned power units (push-pulled trains, multiple traction units, etc.) should have automatic fire extinguishing equipment installed.

Recommendation C.2 11 Central monitoring of air-conditioning

The purpose of central monitoring of air conditioning in an emergency is to limit the spread of fire and smoke in the carriages. It is recommended that air conditioning should be able to be switched off centrally and that the train crew/driver be able to operate it quickly.

Recommendation C.2 12 Ability to split trains

The ability to split a train is recommended in some specific situations. The decision to evacuate passengers by moving them into the unaffected part of a train, splitting this part, and pulling it out with a traction unit should be based on time calculation and quick evaluation of each particular emergency situation. Due to different coupling systems, decoupling of a passenger train may take too much time and thus endanger passengers and crew. For freight trains on fire, it is recommended to decouple those wagons able to move and not on fire, and pull them out of the tunnel.

Operational measures

Recommendation C.2 13 Driver response to incident on train

The train driver should have an instruction to assist him in making the decision as to where to stop the train after a defect (fire derailment) has been detected: before the tunnel, at an intervention point or to run through the tunnel to the exit.

Standard C.2 14 Take the train out of the tunnel

In case of fire on board a train passing through a tunnel, the first preference of the train driver should be to get the train out of the

tunnel and stop it in a good place for the self-evacuation of passengers and easier access by emergency and rescue services.

If the incident train is unable to run out of the tunnel, the driver should bring the incident train to a controlled stop at a known marker at a cross-passage or intervention point.

Standard C.2 15 Stop following or passing trains (out of the tunnel) in case of incident

In the event of an incident other trains should be stopped before they enter the tunnel. Trains in the tunnel should be allowed to continue and leave the tunnel but it may be necessary to restrict their speed in order to minimize any adverse aerodynamic effect on the incident train. The following trains already in the tunnel should be stopped as soon as possible in order to minimize any risk of them encountering any trailing smoke from the incident train.

C.3 Facilitation of escape

The rescue organizations in different countries may have a variety of approaches to rescue including self-rescue. It is recommended that procedures should be harmonized at the international level. Passengers should be informed in advance how to behave in case of accident or fire in the tunnel because train crew might not be available to assist them. It is recommended that all rail operators should develop and introduce appropriate methods for instruction of passengers on procedures in emergency situations. It is further recommended that these plans are discussed with fire brigades and other rescue services involved in rescue operations, as different standards may need to be applied to different networks (high-speed, freight, etc.). These plans should also be integrated in railway operators' operating procedures as well.

Infrastructure measures

Standard C.3 01 Escape walkway

Properly designed and indicated escape walkways are essential for easy and fast self-rescue. They should be planned and installed in the tunnel construction phase and should be provided on both sides of the double-track tunnels. The required height will depend on the specific tunnel situation. The escape walkways should be at least 700 millimetres wide and for preference 1,200 millimetres wide. In tunnels used exclusively for freight traffic escape routes might not be so necessary but are highly necessary in tunnels with passenger-only or mixed traffic.

Standard C.3 02 Handrails in tunnels

Tunnels should be equipped with handrails at an appropriate height above the walkway.

Standard C.3 03 Tunnel markings

Tunnels should be marked with standard signs (pictograms). Signs should be fixed in the tunnel to indicate the direction and distance to any safety feature such as: exits, cross passages, telephones, etc.

Signs should indicate the emergency equipment available to passengers and other potential users, such as:

Emergency telephone

The colours are the ones defined in the CEN norm of December 2000

Extinguisher

The pictogram is the one defined in ISO norm 6309

The other reference to pictograms could be found in the ISO 3864 – graphical symbols – safety colours and safety signs – Part 1. Safety signs in workplaces and public areas.

Emergency exits - The signs to indicate "Emergency exits" should conform to the pictograms proposed by the ISO 6309 standard or the CEN norm of December 2000. Its background colour is green. Examples are presented below:

It is also necessary to sign the two nearest exits on the sidewalls, at a height of 1-1.5 metres: Examples are presented below.

Standard C.3 04 Emergency tunnel lighting

Emergency tunnel lighting shall be installed on one or both sides of the tunnel, especially in tunnels used by passenger trains. Escape routes shall also be properly lit. Emergency lighting shall be reliable and operating under autonomous conditions, visible under smoke and other poor visibility conditions.

Recommendation C.3 05 Emergency telephones/communication means

It is recommended that emergency telephones should always be installed at the key points in tunnels – cross passages, on escape routes and shafts. Telephones should be able to function properly and work in the tunnel environment with a potentially high noise and poor light. It is recommended that they should be installed with a sound hood to avoid noise-affecting conversation. Emergency telephones should be linked to the emergency centre in the railway operations control centre. Emergency telephones should not be linked directly to fire or other rescue services. If the direct radio or GSM(R)[1] link between the train and the operations centre exists, installation of emergency telephones might not be necessary.

Recommendation C.3 06 Escape distances for passenger train tunnels

The distance between escape exits is different in practice from one country to another. It is recommended that a maximum distance between two safe places (portal of the tunnel, cross passage leading to another tunnel, emergency exit) be defined to enable easy and quick self-rescue. The exact distance varies depending on the local situation, operating parameters and the safety concept. In double-bore single-track tunnels and parallel safety tunnels, this distance should not exceed 500 metres. It is recommended to use cross passages between two parallel tubes rather than exits to the surface. Construction shafts and places close to the surface should be used for emergency exits.

The selection of vertical (C.3 07) or lateral (C.3 08) exits or parallel safety tunnel (C.3 10) for escape and rescue should be the subject of the study evaluating conditions of the specific tunnel.

Recommendation C.3 07 Vertical exits/access

It is recommended that vertical exits/access should be provided in single-bore tunnels. They may be feasible only if the tunnel lies near the surface It is recommended that vertical exits are equipped with proper lighting and communication means. Exits should be designed in such a way that smoke is prevented from spreading into the safe areas (air locks, pressurization). The deeper the shaft the less it is practical. A stair flight should not be higher than 6 metres between landings with a width of not less than 1,200 mm. Where the shaft is higher than 30 m, a fire-fighting lift might be installed for faster and easier access of fire brigades with their equipment or for the medical assistance services and evacuation of people with injuries and handicaps. Both stairways and lifts should

[1] GSM (R) gives priority to the train driver.

be pressurized and/or equipped to ensure a smoke free environment.

Recommendation C.3 08 Lateral exits/accesses

It is also recommended that lateral exits/access should be provided in single-bore tunnels. Preferably they should be located in the areas near the surface to limit their length as well as in places for easy exit and access by emergency services. The cross section of these exits should be determined on the basis of other safety elements but ideally their dimension should be 2.25 m x 2.25 m with a maximum length of about 150 metres. Lateral exits longer than 150 metres should be made accessible by road vehicles. The same installations that ensure a smoke-free, visible and otherwise safe environment in vertical exits should also be installed in lateral exits.

Recommendation C.3 09 Cross passages

Cross passages should be built to connect the main tunnel with safe places. It is recommended that they should be constructed between the tubes of double-tube single-track tunnels or a double-track tunnel and a safety tunnel. Cross passages should be lit and have means of communication and be designed to prevent spreading of smoke into safe areas. It is also recommended that, at the minimum, doors on exits to cross passages should be able to resist fire for 30 minutes and be able to resist the aerodynamic pressures found in the tunnel. It is further recommended that they should be easy to operate by hand or if heavy be motorized. In some cases where natural airflow does not exist, installing two doors (several metres apart) would ensure increased safety both by raising resistance to fire and by ensuring a pressurized environment.

Recommendation C.3 10 Parallel service and safety tunnel

The decision to construct a parallel service and safety tunnel for single tube tunnels should be based on an assessment of the geotechnical and operating conditions and cost-benefit considerations for each tunnel.

Possible benefits may include: pilot tunnel for the main tunnel (smaller, faster and safer to construct), advance knowledge of and chance to treat and improve the ground for the main tunnel, logistic opportunities in construction and service, cable and pipe runs clear of the railway, maintenance access to technical rooms at any time.

Rolling stock measures

Recommendation C.3 11 Escape equipment and design of coaches

It is recommended that passenger coaches (doors, windows, body shell) should incorporate emergency exits/accesses. These should be easily visible and instructions for their use should be clearly indicated to the passengers and rescue services (from both inside and outside the wagon). Future specifications of passenger coaches should incorporate aspects of easy escape design (hammer and easily breakable windows, easily removable doors, etc.). It is also recommended that the train crew is equipped with loudhailers to communicate with passengers in the event of evacuation) and hand lamps. These should be located in an easily accessible place). Measures related to security of passengers should not be in contradiction to safety measures for passengers.

Operational measures

Recommendation C.3 12 Emergency information for passengers

It is recommended that timely and straightforward emergency information should be provided to passengers as this represents an important part of escape and rescue. Different systems of emergency information provision are in use by different railways. It is, therefore, recommended that the content of emergency information in international transport takes into account all the possible difficulties in communicating with a variety of passengers and should not be contradictory between different rail operators. It is also recommended that this information should be presented in several languages and in a simple manner using pictograms as in air transport. The pictograms should be those as defined by the ISO norms 6309 and 3864 as well as the CEN norm of December 2000. It is suggested that passengers should be provided with written information (like on board airplanes) about the safety measures on board the train and in tunnels the train is passing through. Information should include only the basic instructions ("when instructed by the crew move to the next carriage", "do not leave train unless instructed by crew", "when leaving the train stay on the walkway and move in the direction indicated", "etc.").

Standard C.3 13 Training of railway staff

All railway staff responsible for infrastructure and operations and other staff should be trained. Training should be continuous and should correspond to their functions and responsibilities. It should enable staff to prevent and handle incidents in tunnels, verify an incident, report to the operations centre, make quick and accurate

decisions, provide first aid, initiate, carry on fire fighting and trigger self-rescue actions, etc. A normal safety measure requires the train crew to be trained to respond to medical emergencies by immediate care, planned stopping points and transfer to medical emergencies services. Functions of each staff in the case of incident should be specified beforehand.

Recommendations C3. 11 - (Escape equipment and design of coaches), C3. 12 - (Emergency information for passengers) and C3. 13 - (Training of railway staff) should be considered together as linked elements of a same safety concept.

C.4 Facilitation of rescue

Infrastructure measures

Recommendation C.4 01 Disconnection and earthing of traction current

The railway infrastructure/operating manager has the responsibility for the safe operation of the electric traction system including its disconnection in an emergency. It should be possible to safely disconnect the traction current, overhead lines or third rail, from suitable locations adjacent to the tunnel as well as remotely from the railway control room. This should be done by railway staff with the equipment and training following safe procedures that involve testing the conductor for absence of current and placing suitable earth bonds.[2]

Disconnection of the power supply can be done locally or remotely. Remote disconnection can be faster and safer. The disadvantage of local disconnection in an emergency is that it may have to be done by someone from the fire brigade if the railway staff cannot get to the site in a reasonable time.

In a situation when fire brigade or other rescue services have to carry out disconnection, it is recommended that clear and stringent rules and procedures, including training, should be introduced and respected. If the traction power supply cannot be disconnected remotely and if electrically competent railway personnel not able to attend rapidly it may be necessary to arrange for the emergency and rescue services to disconnect the power supply. In this case it is recommended that the switching interface is designed for simple operation and include a telephone for contact with the railway control room. The emergency rescue services must be trained on how to operate the disconnection apparatus and should not be allowed to reconnect the power.

[2] Care must be taken not to disconnect power too fast in order to prevent the stopping of trains in the tunnel.

Recommendation C.4 02 Road access to tunnel entrance and tunnel exit

It is recommended that road access should be provided for rescue services to portals and emergency exits of the tunnel. Access road should be drivable by normal vehicles of fire brigades, should have a solid surface and, be as close as reasonable to the entrance.

Recommendation C.4 03 Rescue areas at tunnel entrance or exits

Where possible, an area (ca. 500 m^2) with road access should be reserved for emergency services vehicles. Whether at one end or both, the layout and other details should be agreed with the emergency and rescue services. This information should be shown on the emergency plans. The recommendation is that these areas should be provided at both portals and at any emergency exits.

The surface of emergency services areas including the access roads and passing places should have a suitable all-weather surface able to support the vehicles likely to use it

If dual-mode (road-rail) vehicles are to be used in an emergency, a ramp suitable for mode changing should be installed adjacent to each portal.

Where possible, a helicopter landing area should be provided additional to the area provided for the emergency services.

Recommendation C.4 04 Road vehicle access to railway track

Modification of the railway track to make it suitable for road vehicles is only recommended if the use of road vehicles inside the tunnel is part of a comprehensive intervention and rescue concept based on the fire brigades plan.

Standard C.4 05 Water supply for fire fighting and rescue services

A fire-fighting water supply should be made available in all tunnels covered by these Recommendations. The tunnel designer should consult the fire brigade about the design of this water supply. The water supply system should be regularly tested and checked.

Recommendation C.4 06 Electrical supply for rescue services

The electricity power distribution system in the tunnel should be suitable for emergency/rescue services' equipment. Standard socket outlets with residual current circuit breakers should be

installed. All power outlets for rescue services should be regularly maintained and checked.

Standard C.4 07 Radio installation for rescue service

Radio continuity should be provided for the fire and rescue services linking fire fighters with their immediate command to ensure operational efficiency during an emergency. The system must be reliable and allow the rescue services to use their own communication equipment when needed.

Standard C.4 08 Reliability of electrical installations

Electrical equipment should be protected against damage; mechanical impact, heat or fire. The design of the distribution system should be able to tolerate unavoidable damage by energizing alternate links. The electrical supply should be reliable with key elements having 90 minutes backup, e.g. two independent supplies, standby generator, battery back-up.

Distinction must be made between electrical installations necessary during an emergency and those for normal use.

Recommendation C.4 09 TV monitoring

Closed circuit TV monitoring of the portals, access points and other critical points in the interior of the tunnel is recommended rather as a security measure than a safety measure.

Recommendation C.4 10 Provision of rescue equipment

It is most important that the fire brigade and rescue services and the medical emergency services are able to reach the access to the incident tunnel as quickly as possible consistent with safety bringing with them all the equipment provided for rescue in the tunnel.

Suitable breathing apparatus shall be provided based on the intended role in an emergency. Breathing equipment could be stored either at the nearest fire station or secured in the tunnel. It should be regularly checked and tested.

Given the specialist nature of storage, inspection and maintenance, it is recommended that the breathing apparatus should be stored by the fire service where it would be convenient for training. The standard breathing apparatus must have capacity to allow breathing for 30 minutes at the minimum, and its required endurance will depend in part on the distance between intervention shafts or

protected cross passages and in part on the activity or heat stress involved. It is recommended that the fire brigade not only regularly maintain breathing equipment but also practice with it in regular circumstances in order to accustom itself for use in tunnel accidents.

Recommendation C.4 11 Monitoring system

Generally, the normal monitoring of the tunnel systems and their operation in an emergency should be collocated with the railway control centre to enable full coordination of the response.

A very long heavily equipped tunnel could be better controlled from an equipment and railway control room adjacent to the tunnel.

In any case, the system must ensure full coordination between the railway control and the tunnel control.

Recommendation C.4 12 Rail (tunnel rescue train) and road/rail vehicles for rescue

The most important recommendation is that the fire brigade and other rescue services should get into the tunnel with their equipment as fast as possible, regardless of the type of vehicles used. In some places specialized rail vehicles are recommended as a part of the rescue concept. Rail/road vehicles for rescue are only recommended as a part of the comprehensive rescue equipment provided by the fire brigade. It is recommended that rescue trains be manned by the railway operator's staff and not fire brigade staff, who may not be familiar with the use of railway vehicles, equipment and special railway procedures. It is recommended that the fire brigade utilize either the road vehicles they use in their daily work or rail/road vehicles.

Operational measures

Standard C.4 13 Emergency and rescue plans

Preparation and regular maintenance of emergency and rescue plans is recommended as a standard safety measure. The laws governing emergency and rescue service deployment differ from one country to another. Although an emergency situation is directed by different services in different countries (United Kingdom – fire, police, medical service; France – "préfet", etc.) it is recommended that the response time of rescue and emergency services should be minimized. Any train incident in the tunnel might involve several organizations (train operator, tunnel operator, railway operations centre, fire brigade, rescue services,

police, medical services) and there is, therefore, the need to avoid confusion. It is recommended that emergency service planning shall be developed during the tunnel planning phase. If the safety concept and emergency services' intervention envisages separate plans or standard intervention strategies for railway operator and fire/rescue brigades, it is recommended that the several organizations not only prepare together and regularly review their plans but also exercise jointly in various scenario situations.

Each tunnel should have a unique name, numerical identifier and particular description for each end of the tunnel. All escape and exit doors shall also be identified uniquely. This identification should be used in all communications between railway operators and emergency and rescue services in order to minimize response time, avoid possible confusion and facilitate rescue.

Standard C.4 14 Exercises with rescue services (communication and coordination railway/rescue services)

There should be joint exercises based on tunnel accidents by rail operators and rescue services. Their objective is to ensure better cohesion, communication and coordination during a rescue operation. Exercise also maximizes the effectiveness of rescue services, reduces time delays for rescue operations under specific tunnel conditions and minimizes possible communication and coordination problems during the real accident.

Full-scale exercises are costly and difficult to organize (they may require closing down of the tunnel). However, occasional full-scale exercises, involving all rescue services, might need to be carried out in order to allow access for fire and other rescue services to familiarize themselves with tunnel and railway-specific conditions. In view of cost and operational consequences of full-scale exercises, whenever possible, it is recommended to have a "table-top" type of exercise, which, although it includes all relevant services, does not involve the actual entering of the tunnel and disruption of regular traffic. This type of exercise allows maximum flexibility in testing communications, contributes to stronger cohesion between railway personnel and rescue services and allows testing of various scenario cases.

Standard C.4 15 Information on transport of dangerous goods

Although not considered a specific tunnel safety measure, it is recommended that the information on transport of dangerous goods should be made available to the rescue and fire fighting services. The transport operating company should normally provide such information (train consist) to the network operator

before departure of the train carrying dangerous goods. The network operator should communicate this information to emergency and rescue services in case of an emergency or an accident. This information would allow emergency and rescue services to take appropriate measures in the event of an emergency, to select the appropriate emergency response and operation, and to reduce the risk for themselves. For safety purposes, an information system, in accordance with the RID regulations, defining relevant goods, is required at the international level and specific information must be passed quickly to the responsible operations' centre and rescue services. Although information about freight is already available through train numbers and freight information systems, it must be available within the required time and the degree of precision needed for fire and emergency services.

CONCLUSIONS

The advice given in this report is based on experience and best practice prevailing on railways in some member countries. For railway authorities that have not yet established standards corresponding to these, the above-mentioned standards could be considered as reference targets to be taken into account when railway tunnels' safety measures are being established.

If any of the above-mentioned standards for minimum safety levels in new tunnels could not be met, it is suggested to reach the desired safety level with another combination of standards and recommendations. These safety measures, standards and recommendations, should be recorded in the safety plan

D. RECOMMENDED SAFETY MEASURES FOR EXISTING TUNNELS

All countries should require their railway infrastructure and train operators to have and publish a comprehensive safety plan to ensure the health and safety of all persons (passengers, staff and contractors) using any tunnel covered by these Recommendations.

This safety plan should be supported by suitable analysis to show that the risk to passengers and staff has been reduced to as low as reasonably practicable.

A general demand to install all of the safety measures described for new tunnels in all existing tunnels may not be reasonable or appropriate. Therefore, existing tunnels should incorporate as many standard measures as is reasonably possible during any maintenance replacement actions. The infrastructure measures listed below are recommended for existing tunnels if they could be carried out, where possible, irrespective of the renewal and major structural modifications in existing tunnels, as they do not require structural or construction changes:

C.1 02 Speed monitoring and signalling system
C.1 03 Tracking the status of the train before entering tunnels
C.1 06 Regular inspection of tunnels
C.3 03 Tunnel markings
C.3 04 Emergency tunnel lighting
C.4 01 Disconnection and earthing of traction current
C.4 10 Provision of rescue equipment.

In each country the authority responsible for railway tunnel safety measures will have to determine the minimum safety standards for existing tunnels according to its own safety concept and plan and taking into account the cost/benefit effect of each measure. However, standard and recommended measures for rolling stock and operations for new tunnels listed in Chapter C should, whenever possible, be equally relevant when considering measures aimed at improving the safety level in the existing tunnels.

When establishing safety measures for existing tunnels, it is recommended that the priority should be given to rolling stock and operational measures, as they do not require structural changes in tunnels.

E. CONCLUSIONS

In conclusion, the Ad hoc Group of Multidisciplinary Group of Experts on Safety in Tunnels (rail) has prepared the following general recommendations for consideration by the UNECE Inland Transport Committee.

E.1 Risks and accidents

The Ad hoc Multidisciplinary Group of Experts on Safety in Tunnels (rail) has carried out a brief survey of the European railway system in tunnels, as to whether Governments have enacted laws or regulations specific to tunnel safety and obtained information where possible about accidents in tunnels.

The risk for passengers and train staff are less in rail tunnels than on the rest of the network because many of the causes of accidents are mostly not possible there (for example, collisions with objects, train shunting, etc.). The main causes of accidents in tunnels are derailments, collisions between trains and fires.

Based on submitted statistics from member Governments, the Group has noted the low occurrence of accidents in main line railway tunnels but equally noted the potential high consequences of hazardous events, especially fire.

E.2 General principles

The Group took into account the work done by various national bodies and by the UIC, in particular, the new UIC Leaflet on Safety in Railway Tunnels" (Leaflet 779-9 published in mid-2003).

The Group concluded that the objectives of the safety measures in railway tunnels are, by order of priority:

1. Prevention of accidents
2. Mitigation of the consequences of accidents
3. Facilitation of escape
4. Facilitation of rescue.

It has described and commented on approximately 50 safety measures in railway tunnels sorted in the above-mentioned categories. Among them, it distinguished

- 20 measures that are considered, by the Group, as minimal standards for all new tunnels
- other measures to be selected if they are in accordance with the safety plan of the specific tunnel, in order to reach the requested safety level at minimal costs.

The Group was of the opinion that if one of the minimal standard measures could not be realized at reasonable cost, it could be replaced by other measures providing the same level of safety.

The following recommendations apply to all railway tunnels; they can be reduced for tunnels shorter than 1 km and should be adapted or enhanced for very long tunnels over 15 km. Special tunnels might require special safety measures.

E.3 Standard and recommended safety measures for new tunnels

The following measures are considered as minimal safety standards for all new tunnels:

C.1 02	Speed monitoring and signalling system
C.1 06	Regular inspection of tunnel condition
C.1 07	Fire protection measures
C.2 01	Fire protection requirements for structures
C.2 06	Train radio
C.2 08	Emergency brake neutralization and maintaining movement
C.2 12	First aid equipment on board
C.2 13	Take the train out of the tunnel
C.2 14	Stop following or passing trains (out of the tunnel) in case of incident
C.3 01	Escape routes
C.3 03	Tunnel markings
C.3 04	Emergency tunnel lighting
C.3 13	Training of railway staff
C.4 05	Water supply for fire-fighting and rescue services
C.4 07	Radio installation for rescue service
C.4 08	Reliability of electrical installations
C.4 13	Emergency and rescue plans
C.4 14	Exercises with rescue services
C.4 15	Information on transport of dangerous goods.

Exceptions from any of the standard minimum safety measures could be allowed, provided that the desired safety level in the tunnel could be reached by a combination of other measures.

The minimum standard measures shall be completed by other measures such as described in chapter C, in order to reach the desired safety level. Their choice depends on traffic conditions and local circumstances. The complete set of safety measures for a tunnel is to be described and justified in the specific safety plan for this tunnel.

E.4 Recommendations for existing tunnels

There are a great many tunnels already in service. Many of them were built when safety considerations were less stringent than today. Obviously they cannot be adapted at reasonable cost to the dimensions suggested for new tunnels. But safety in railway tunnels does not depend only on structural measures - it can be enhanced also through rolling stock and operational measures.

Therefore, the Group recommends that safety plans for existing tunnels should be established, assessing their safety level and proposing to raise this level, if necessary, through measures that could be realized at reasonable costs. The Group expects these measures to be selected among the minimal standard measures for new tunnels, the first priority being given to non-structural measures.

E 5 Recommendations for interoperability rules

The aim of the Group is to promote a harmonized safety level in Europe, taking into account the interoperability of passengers, train crews and rolling stock. The Group, therefore, proposes that the following recommendations are examined, completed and transformed into binding rules for the European Union by the AEIF, the body in charge of writing Technical Specifications for the Interoperability:

C.1.02	Speed monitoring and signalling system
C.2.08	Emergency brake neutralization and maintaining movement
C.3.11	Escape equipment and design of coaches
C.3.12	Emergency information for passengers
C.3.13	Training of railway staff.

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