EMERGENCY EXERCISES IN AUSTRIAN RAILWAY TUNNELS

[1]Sommerlechner C., [2]Valo R., [3]Neumann C.

[1] ÖBB Betrieb AG, Austria
[2] Railway Operations Expert, Austria
[3] ILF Consulting Engineers, Austria

ABSTRACT

Emergency exercises are an important part of safety concepts for railway tunnels. This report presents time sequences and experiences acquired when performing emergency exercises in three railway tunnels.
Additional conclusions could be drawn when conducting unannounced emergency exercises with passenger trains transporting pupils.
In the course of these exercises, a new rescue concept involving a ballastless track system inside the tunnel, which is accessible to road vehicles was tested, which revealed advantages as well as disadvantages.
All these exercises confirmed the necessity and the importance of emergency exercises, with the lessons learned being beneficial to railway companies and design offices alike, as they offer valuable information for the improvement of tunnel safety.
Key words: tunnel safety, emergency exercises, railway safety

1. INTRODUCTION

In line with national and international guidelines established for Austrian railway tunnels, a wide range of safety measures has been developed for both the construction of new tunnels and the retrofitting of existing tunnels.
Thanks to very high safety standards in general, very few railway accidents occur and as a result, staff members are hardly ever challenged to cope with scenarios of this type. In the endeavour to verify the efficiency of safety measures, conclusions are often drawn by analogy resorting to other traffic and transport areas (e.g. road tunnels).
It is in the light of these facts that the ÖBB Betrieb AG is stepping up its emergency exercise efforts, simulating scenarios which are as close to reality as possible to be able to gain insights and learn lessons for the further development of tunnel safety concepts.

2. REQUIREMENTS STIPULATED IN RAILWAY OPERATION REGULATIONS

Emergency management manuals not only define requirements regarding systematic measures (search for causes, advanced professional training, technical measures) which come into play following an incident, but also stipulate requirements regarding the frequency and scale of emergency exercises. These requirements shall not just be applicable to the tunnel area, but shall be applicable to the entire line section.
In this context, a differentiation is made between the following types of emergency exercises:

Exercise	Emergency and alarm exercises of fire brigades and rescue organisations, which are planned and executed in conjunction with the railway operator.
Emergency training	In every monitoring sector of a train operations centre, an emergency training is performed once a year involving the entire equipment available as well as all necessary actions. This training shall be designed not to affect normal railway operation.
Practice alarm	Practice alarms are exercises without previous notification or information of the parties intended to participate. For the duration of the practice alarm, the emergency response is coordinated with the commanders of the individual rescue organisations. For every tunnel exceeding 1 km in length, a practice alarm shall be carried out at least once every three years.

The responsibilities regarding preparation, implementation, performance evaluation and feedback are clearly defined.

For the entire monitoring area of the operation control centres there is a standardized emergency folder, which stipulates the organisational and operational standards for the existing infrastructure.

For every railway tunnel exceeding 1500 m in length, a tunnel safety plan exists, which describes all safety-relevant building structures and equipment components and which contains all necessary orientation plans and schematic drawings.

3. LINES OF COMMUNICATION AND ALLOCATION OF RESPONSIBILITIES IN CASE OF AN EMERGENCY

Figure 1 shows the key communication lines in case of an emergency in a railway tunnel.

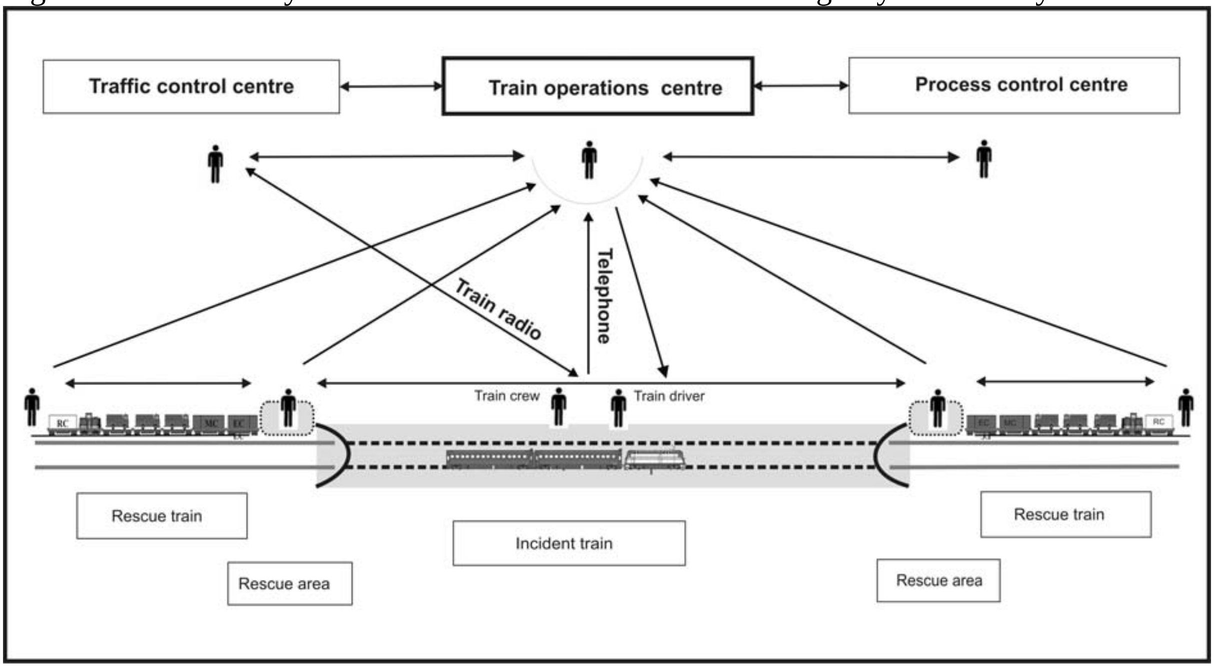

Figure 1: Communication scheme for railway tunnel (rescue concept involving rescue train)

In case of an emergency, different tasks are assigned to the individual parties involved. Table 1 lists the main tasks to be performed.

Table 1: Parties involved and allocation of responsibilities in case of an emergency

Train driver Train crew	Search for causes, internal communication, emergency call to traffic control centre (train radio) or train operations centre (telephone), switching on of tunnel lights, information of passengers, elimination of potential hazards (e.g. fire fighting), decision for self-rescue, instructions for and support of self-rescue
Traffic control centre	Forwarding of emergency calls to train operations centre, support of train operations centre, diversion of train traffic
Train operations centre	Switching on of tunnel lights, alerting of rescue organisations and internal rescue teams, driving trains out of tunnel, stopping of all train traffic, preparation for earthing of overhead lines, communication via emergency telephone, emergency coordinator of railway company (up to arrival of standby emergency coordinator)
Process control centre	Earthing of overhead lines, indication of overhead line status, activation of special light switching cycles, monitoring of electrical equipment (e.g. ventilation) and of switching operations in case of a power supply failure
Emergency coordination at rescue area (portal)	Communication between fire brigade, rescue team, police force and railway company, management of rescue works, coordination with other rescue organisations at second portal and at rescue train
Emergency coordination at rescue train	Assisted-rescue operations following the instructions and in coordination with the emergency coordinator at the portal

With a tunnel envisioning a rescue concept without rescue train, there is no need for an emergency coordination of the rescue train. For every tunnel, the tasks are specified in consultation with the rescue organisations, and they tend to deviate only slightly from the specifications listed above.

4. REPORTS OF EMERGENCY EXERCISES

In order to acquire new and unbiased insights in the course of emergency exercises, new paths were pursued in the last three years in preparation of these exercises.
It was the declared objective of these exercises to check tunnel safety concepts in a more realistic way than under desktop conditions and to identify weak points in organisational measures.
Subsequently three exercises shall be highlighted out of a multitude of emergency exercises conducted in the last few years, which differ considerably regarding their rescue concepts.

4.1. Exercise No. 1 – derailment of freight train with emission of hazardous substance

During this exercise, the train driver transmitted the following radio message “Practice alarm. This is the driver of the Exercise No. 1 train. I am standing inside the tunnel at km xy and the train was stopped automatically as a result of an emergency breaking. I will check the situation.”
Five minutes later the train driver sent another message “Practice alarm. Coach No. 10 is derailed. There is a leakage”.

The persons responsible for the voluntary rescue organisations had given their consent to a practice alarm outside their normal working hours yet without knowledge of the exact point in time. The train driver and the staff members of the railway company had not been informed in advance.

Table 2: Tunnel Data Exercise No. 1

Tunnel length	Approx. 5 km
Emergency exits	None
Rescue concept Rescue organisations	Fire brigades at the portals and rescue train with rail wagon for the transport of road-bound rescue vehicles; Rescue train is in the station closest to the portal
Meeting point of emergency coordinators	At a pre-defined portal; There are no designated premises, as rescue organisations have rescue vehicles with adequate communication equipment

The following list shall indicate critical points in time:

- 5 min	First radio message of train driver to traffic control centre, forwarding of message to train operations centre
- 3 min	Tunnel lighting switched on by train driver
Time 0	Emergency call of train driver to traffic control centre, forwarding to train operations centre
+ 2-5 min	Alerting of voluntary fire brigade and of police force by train operations centre
+ 9 min	Switching off and earthing of overhead line by process control centre
+ 11 min	Information on train location and freight from train driver to traffic control centre, forwarding to train operations centre
+ 22 min	Arrival of voluntary fire brigade at portal and at rescue train
+ 30 min	Emergency coordinator of Austrian Federal Railways (ÖBB) on scene, arrival of rescue team and police force at portal, slight delay in contact making
+ 30-45 min	Arrival of approx. 20 vehicles at rescue train site and at portal
+ 55 min	Arrival of rescue train at portal
approx. 1.3 h	Arrival of rescue train at scene of accident

Figure 2: Train operations centre /
rescue train with rail wagon for transport of road-bound rescue vehicles

Important lessons learned from Exercise No. 1:

- The operation control points of the railway company responded efficiently to the sequence of events envisaged in the alarm plans.
- The emergency shutdown and the earthing of the overhead line shall be tested in the course of exercises (the normal shutdown procedure shall not be applied).
- The process of contacting the individual emergency coordinators was a little long winded and calls for an easier identification of the emergency coordinators and for a better definition of the meeting point.
- The communication between the fire brigade and the train operations centre (emergency coordinator of the railway company in the initial phase) is to be improved.
- The staff members of the railway company in the rescue train wore respiratory equipment as well as the same protective equipment as the fire brigade and could not be told apart; a different outfit shall be envisioned.
- The loading and launching of the rescue train took quite some time as one had to wait on the arrival of vehicles and crews as well as on the loading of additional equipment for the management of hazardous materials. This time period is definitely to be reduced.

4.2. Exercise No. 2 – derailment of passenger train

During this exercise, the train driver transmitted the following radio message “Practice alarm. The Exercise No. 2 train is derailed, bring all trains to a halt“.

The commanders of all rescue organisations had previously been informed of this exercise. One of the coaches carried extras sporting various injuries. Yet the train driver and the staff members of the railway company had not been notified in advance.

Table 3: Tunnel Data Exercise No. 2

Tunnel length	Approx. 1.1 km
Emergency exits	Rescue tunnel accessible to vehicles
Rescue concept Rescue organisations	Fire brigades at the portals entering tunnel on a carriageway granting road vehicles access to the tunnel; Use of rescue adit located in the middle of the tunnel
Meeting point of emergency coordinators	At a pre-defined portal; There are no designated premises, as rescue organisations have rescue vehicles with adequate communication equipment

The following list shall indicate critical points in time:

Time 0	Emergency call of train driver to traffic control centre, forwarding of message to train operations centre
+ 4 min	Stopping of train traffic Switching off and earthing of overhead line through separate push button by train operations centre
+ 5-10 min	Alerting of voluntary fire brigade and of police force by train operations centre
+ 8 min	Siren alarm of voluntary fire brigade
+ 15 min	Emergency coordinator of fire brigade makes contact with train operations centre by use of emergency telephone at portal
+ 26 min	Train operations centre grants road vehicles access to the tunnel
+ 36 min	First persons injured are brought to a “safe area”

Figure 3: Emergency coordination at portal / fire-fighting vehicles inside tunnel

Important lessons learned from Exercise No. 2:

- The alerting and arrival of the fire brigade was accomplished in a very short period of time. A shorter period of time seems to be unrealistic if faced with a real incident.
- The time which elapsed until the road vehicles were granted access to the tunnel could further be reduced by additional training.
- For efficient rescue efforts, it ought to be determined which vehicles will in fact be needed inside the tunnel (limited availability of space).

4.3. Exercise No. 3 – traction unit of passenger train on fire

During this exercise, the train driver transmitted the following radio message "Practice alarm. This is the driver of the Exercise No. 3 train. There is smoke emerging from my engine. There is no way of bringing the train to a halt in front of the tunnel. I try to make it through the tunnel." Then the train came to a standstill with a full service breaking. The train driver was assumed to be unconscious.

The passenger train carried classes with approximately 55 pupils. The pupils' parents were asked whether their children would be allowed to take part in a disaster control exercise and the respective permissions were granted in writing.

To avert any possible harm, psychosociologists were asked to accompany these adolescents, and no fire or smoke effects were brought into play.

In order to eliminate any potential danger, all trains were barred from entering the tunnel during the exercise.

The regional managements of the voluntary rescue organisations were informed of unannounced practice alarms. As this practice alarm was staged around mid morning on a week day, the rescue operations did not take part in this exercise. The train driver, the chief conductor and the staff members of the railway company were not informed in advance.

Table 4: Tunnel Data Exercise No. 3

Tunnel length	Approx. 5 km
Emergency exits	Rescue tunnel
Rescue concept Rescue organisations	Fire brigades at the portals and rescue train; Rescue train parked in the train operations centre at a distance of a few 100 m to the portal, the railway company maintains its own stand-by rescue team for the rescue train
Meeting point of emergency coordinators	In the area of the train operations centre; Premises with communication equipment as well as equipment for railway company's rescue team are available

The following list shall indicate critical points in time:

Time 0	Emergency call of train driver to traffic control centre, forwarding of message to train operations centre Train comes to a halt inside the tunnel
+ 2 min	Tunnel lighting activated by train operations centre Alerting of fire brigade
+ 2-5 min	Chief conductor tries to reach train driver via train telephone Chief conductor gets off the train and checks the traction unit
+ 6-12 min	Chief conductor advises passengers of practice alarm using loudspeaker system Chief conductor informs traffic control centre of situation on-board using radio system Passengers are requested to get off the train and walk towards the rear end of the tunnel (shorter distance according to escapeway signs)
+ 12-15 min	Passengers get off the train and follow the escapeway Chief conductor informs train control centre of self-rescue campaign Guidance of passengers through clear and confident instructions
+ 15-18 min	Chief conductor verifies whether all passenger have left the train (including toilets) Chief conductor informs traffic control centre
+ 18 min	Emergency coordinator of railway company arrives at emergency communications centre
+ 25 min	Rescue train is ready for departure
+ 36 min	Chief conductor uses emergency telephone at the portal to inform train operations centre that all passengers have been evacuated from the tunnel

Figure 4: Self-rescue inside tunnel / Rescue train

Important lessons learned from Exercise No. 3:

- The chief conductor responded in a fast, efficient and professional manner. When giving instructions to passengers trying to escape the tunnel, problems occurred when indicating the escape direction, but the assertive response met with a positive perception.
- After approx. 15 minutes all travellers had left the relevant train section and after approx. 30 minutes all travellers had walked the 300 m to the portal.
- The rescue train with the company's own fire brigade team was available at short notice.
- The train operations centre reacted without hesitation and completed the tasks listed in the alarm plans one by one. The communication with passengers inside the tunnel (emergency telephone), fire brigade and traffic control centre was found to be very time consuming.

5. COMPARISON OF SEQUENCE OF EVENTS

The three example exercises presented above are not quite suited to provide a representative overview of a possible time sequence in case of an incident or accident. But many of the exercises performed in Austrian railway tunnels reflect a similar picture.

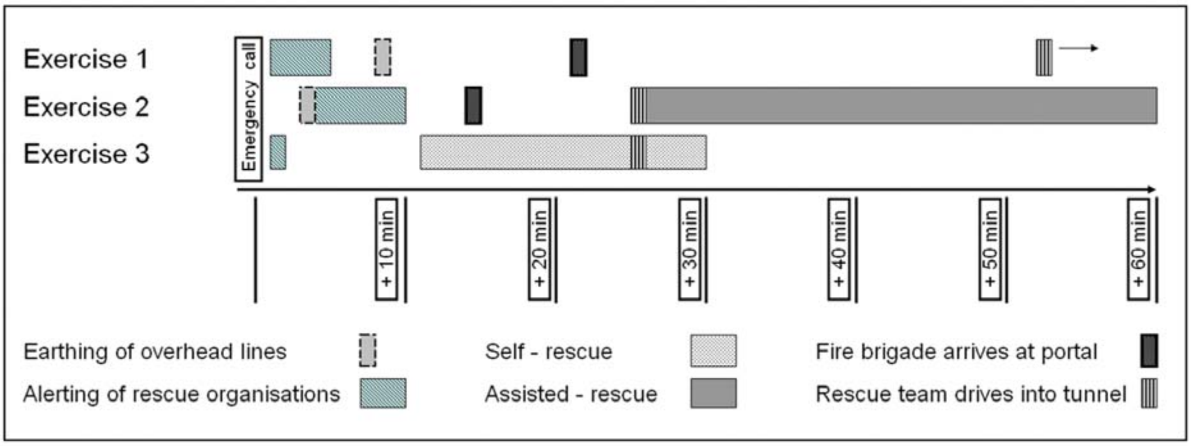

Figure 5: Time Sequence Exercise No. 1 – Exercise No. 3

From the time-sequence point of view, the following conclusions may be drawn based upon the elapsed time periods and the practical experiences made during the exercises, whereby "Time 0" represents the moment at which the train has come to a standstill and an emergency call is received at the train operations centre:

- Within 10 minutes an alert is issued to the rescue organisations, the trains leave the tunnel and the overhead line is earthed
- The instruction advising passengers to perform a self-rescue is given, once the situation inside the train has been clarified, the train staff has communicated with the traffic control centre and the passengers have been informed on repeated occasions. This sequence may realistically be assumed to take 10 minutes (in case of an acute hazard exposure, a self-initiated rescue effort is likely to get underway).
- After 20 - 30 minutes the first vehicles of the rescue forces arrive either at the portal or at the rescue train.
- After 30 - 60 minutes a rescue train is ready to drive into the tunnel.

6. EXPERIENCES GAINED WITH THE NEW RESCUE CONCEPT ”RAILWAY TUNNELS ACCESSIBLE TO ROAD VEHICLES OF RESCUE ORGANISATIONS”

In several new railway tunnels, a new rescue concept has been realised in the last few years, which requires a track which is accessible to road vehicles.
This concept necessitates the following provisions regarding both structure and equipment:

- Access to track area via portal area
- Technical access control in the form of barriers, gates, etc. (permission granted by train operations centre upon shutdown of railway operation and earthing of overhead line)
- Ballastless track system between portal area and portal accessible to road vehicles
- Tunnel accessible to road vehicles over its entire width:
  - Adaptation of noise control elements along slab track
  - Retrofitting of sideways (cable trough covers suited for traffic loads)
  - Surface between tracks accessible to road vehicles

Figure 6: Access area near portal / Accessibility of tunnel by road vehicles

This new system has the following advantages and disadvantages:

- Chances of reducing rescue times inside the tunnel, due to less interaction between railway company and fire brigade
- More flexible use of additional vehicles in case of an emergency
- Reduced dependence on especially trained drivers for rail/road vehicles or on qualified train drivers (respiratory equipment)
- Reduction in permanent costs for emergency stand-by services of railway company
- Use of familiar equipment and vehicles
- In case of smoke emission, additional hazards involved, due to vehicles not being track bound
- More time required for reversing or turning around of vehicles
- Fire brigades enter the tunnel in the absence of skilled railway personnel
- Higher investment costs due to adaptation of permanent way and installation of concrete cable troughs suited for traffic loads
- Safety system of railway company not suited for monitoring of road vehicles
- Hazard of facilities being damaged by road vehicles even in the event of emergency exercises

The experiences gained from the exercises in these tunnels and the feedback received from the relevant rescue organisations and the staff members of the railway company show that this new safety concept literally paves the way for a very fast rescue operation inside the tunnel. It offers the opportunity of additional rescue vehicles entering the tunnel, but it also holds the risk of all kinds of vehicles entering the tunnel - whether they are needed or not.

The turning around of two-axle vehicles in a twin-track tunnel did not take a lot of time. But it remains to be tested whether the rescue concept stands the test of time under reduced visibility conditions due to smoke emission.

7. CONCLUSIONS

Emergency exercises are inevitable to check the efficiency of rescue concepts, emergency concepts, and technical facilities.
Emergency exercises involving rescue organisations are an essential component of the safety concept when it comes to verifying operational and organisational sequences as well as communication lines on a regular basis under hands-on conditions.

7.1. Lessons learned with a view to design

- Emergency exercises reveal additional requirements made on both building structures and equipment components. In this context, special consideration is to be given to the experience gained with respect to user acceptance and error tolerance.
- Emergency exercises confirm the necessity of both the structural and the technical facilities.
- With railway tunnels the interaction of railway companies and rescue organisations is of special importance. This stands in contrast to other emergencies involving rescue organisations, where the emergency response can be planned more independently. These aspects and the knowledge of the parties involved in case of an emergency are already to be taken into account in the design stage.

7.2. Lessons learned with a view to operation

- An efficient communication between the staff members of the railway company and the rescue organisations is the essential precondition for a fast assisted-rescue campaign. Apart from functioning technical facilities, it is decisive that every emergency coordinator (railway company, rescue organisations) is prepared to act on his own initiative without waiting for his counterpart to contact him.
- The train personnel play a key role in detecting and identifying an emergency scenario, in informing the railway passengers, and in launching a self-rescue campaign. An adequate training and sensitization of the railway personnel regarding these issues is thus of great significance to enable the train crew to consult and support the passengers during their self-rescue effort.
- In the initial phase, the traffic operations centre turns into an emergency coordination centre for the railway company as well as into a centre meeting communication and railway operation needs. Staff members working under these conditions are already quite busy and in order to successfully perform their tasks, the safety concept will have to be simple and the main tasks need to be visible at a glance.