WITH HIGH SPEED TO A SAFE EMERGENCY HANDLING - VIENNA - ST. PÖLTEN TUNNEL HIGH-SPEED LINE

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ABSTRACT

In December 2012, the Austrian Federal Railways (ÖBB) put the “Vienna - St. Pölten” high-speed railway line into operation. In total, 34.8 km of the 50 km long new twin-track line were built in tunnels. In other words, approx. 70 % of the line is located in tunnels. The longest of the eight tunnels is the Wienerwald tunnel with a length of 13.4 km. The whole line is designed for a maximum speed of 250 km/h and with maximum longitudinal gradients of 8 ‰.

The planning process (which started in 1990!) and the operation start-up procedure (which took place in 2011/12) of the new line was accompanied by a number of objectives. The main objective consisted in setting new standards in tunnel safety in terms of structural issues, technical solutions and operational procedures. The essential question to be addressed was how to effectively manage an emergency at the interface of human beings and innovative technical solutions.

Keywords: tunnel safety, emergency plan, evacuation, human behaviour, emergency exercises

1. INTRODUCTION

When the new “Unterinntal” and “Vienna - St. Pölten” high-speed railway lines were taken into operation in 2012, the Austrian rail tunnel network increased by approx.70 km. Up to the year 2024, more tunnels are expected to be constructed, bringing the total length of tunnel sections to approx. 300 km (including major tunnel projects like the 33 km long Koralm tunnel or the 27 km long Semmering base tunnel).

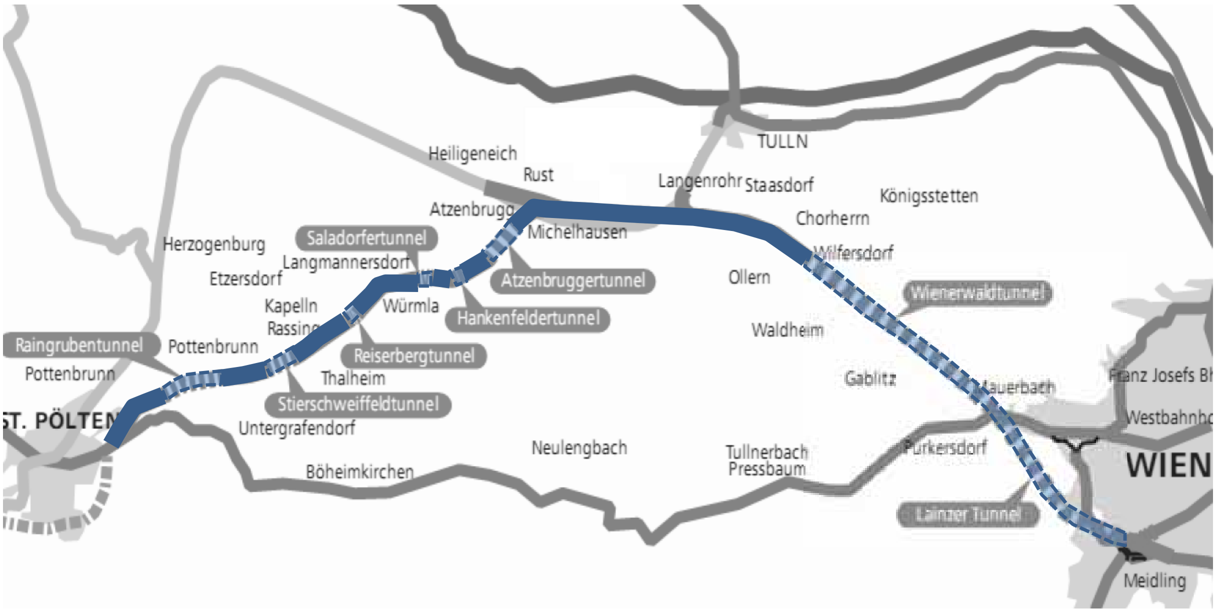

Figure 1: Scheme of the new Vienna - St. Pölten railway line

The new “Vienna - St. Pölten” railway line with a length of approx. 50 km for mixed traffic is an essential component of four-tracking the existing “Westbahn” railway line. The railway line branches off from the existing “Westbahn” line at the “Hadersdorf” junction (Vienna), runs underneath the “Wienerwald” in a 13.4 km long tunnel, subsequently passes through the southern “Tullnerfeld” area and the “Perschling” valley to the city of St. Pölten and joins the existing “Westbahn” line at the “Wagram” junction.

2. TUNNEL FACILITIES

2.1. Tunnel systems

The twin-track tubes of the new high-speed line have in total 32 vertical emergency exits, which lead directly to the surface. The shaft heights range from a minimum of 3 m to a maximum of 63 m. Shafts exceeding a height of 30 m are equipped with an emergency elevator. In the “Wienerwald” area, the tunnel system changes from a conventional twin-track tube to two single-track tubes. It features 22 cross passages at 500 m intervals, which lead to the adjacent tube. The Wienerwald tunnel was the first railway tunnel in Austria to be constructed with two single-track tubes.

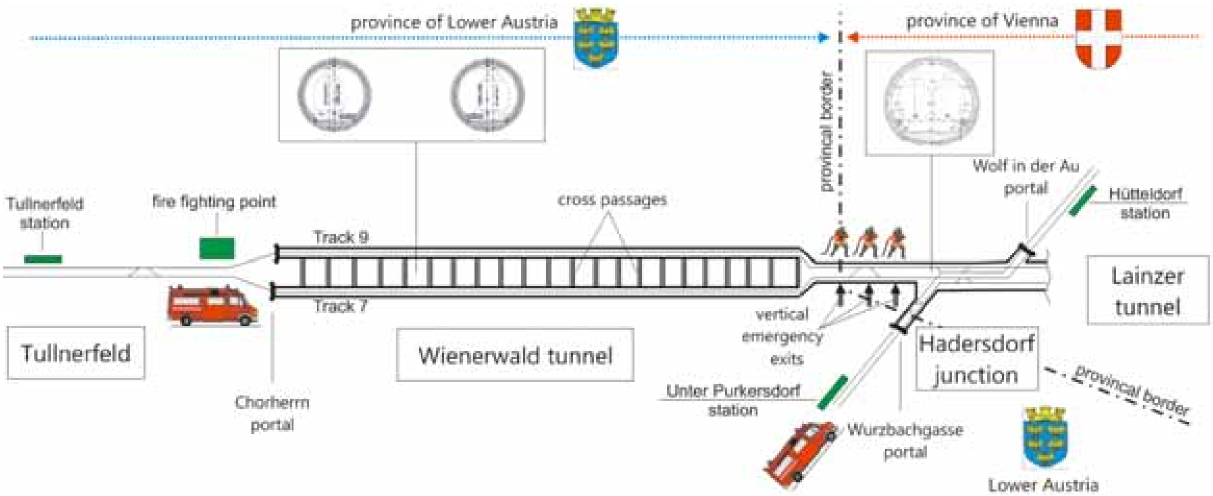

Figure 2: Change of tunnel system within the Wienerwald tunnel

2.2. Different concepts for assisted rescue

This change in tunnel system is mainly to be attributed to the different rescue strategies pursued by the fire brigades of the Austrian provinces of Vienna and Lower Austria. The professional Viennese fire brigade stressed its preference for the Wienerwald tunnel to be constructed with emergency exits, as this was in line with the municipal fire brigade’s intervention concept. The voluntary Lower Austrian fire brigade stated its preference for using its own rescue vehicles for interventions into the “Wienerwald” railway tunnel. The larger part of the tunnel (the two single-track tubes) is located in Lower Austria.

2.3. Rail tracks accessible by rubber-tired emergency vehicles

Following the design concept of the latest tunnel projects of the ÖBB, all tunnels of the new high-speed line are constructed with rail tracks which are accessible by rubber-tired vehicles and which allow fire brigades to proceed directly to the site of the emergency. Using their own vehicles and equipment inside the tunnel guarantees a safe emergency response and enables a significant gain in time, which is crucial when it comes to life or death of injured persons in the tunnel. The new line comprises a stretch of vehicle-accessible railway tracks, which is approx. 15 km in length and includes 3 turnouts (see Fig. 4).

Figure 3: Railway tunnel accessible for rubber-tired vehicles

2.4. Mechanical ventilation systems

Emergency ventilation facilities were installed in all cross passages and emergency exit shafts. In case of an emergency, these mechanical ventilation systems are taken into operation. To create a smoke-free environment, the air pressure is increased in the safe areas (emergency exit shafts, 2nd tube of the tunnel) but at the same time it builds up in front of the emergency doors. Under these emergency ventilation conditions, it is not only to be ensured that the doors have a fire resistance of at least 90 minutes and fulfill all the requirements defined for suction-pressure loads, leakage rates and opening direction (doors to open in the direction of the escape route) but it is also to be ensured that the force required to open the emergency exit doors will not exceed 100 Newton.

In addition to ventilation facilities in the cross passages and emergency exit shafts, the Wienerwald tunnel has furthermore been equipped with an emergency ventilation shaft which was positioned between the tracks before the two single-track tubes merge into the twin-track tube. In case of a fire near the single-track tube / twin-track tube interface, the ventilation shaft shall prevent smoke from entering the unaffected tubes (parallel adjacent tube or following twin-track tube).

2.5. Access to the safe area (evacuation)

Behind every emergency exit door in a tunnel, a lock is provided. This lock is equipped with another emergency exit door, which either leads to the adjacent tube (single-track) or to the emergency staircase (twin-track). In case of a tunnel fire, the safe area behind the lock is pressurized. This ensures smoke-free conditions in the safe area and keeps smoke from entering the lock, even if the doors are open.

For the emergency shafts, the area in front of the staircase was reviewed by the use of an evacuation simulation model. The evacuation model provided a detailed analysis both of the building structures and the organisational sequences involved in the evacuation of a passenger train in a tunnel. Using the model guaranteed an adequate design of the queuing space at the bottom of the staircase. It prevents escaping passengers from queuing back to the lock door.

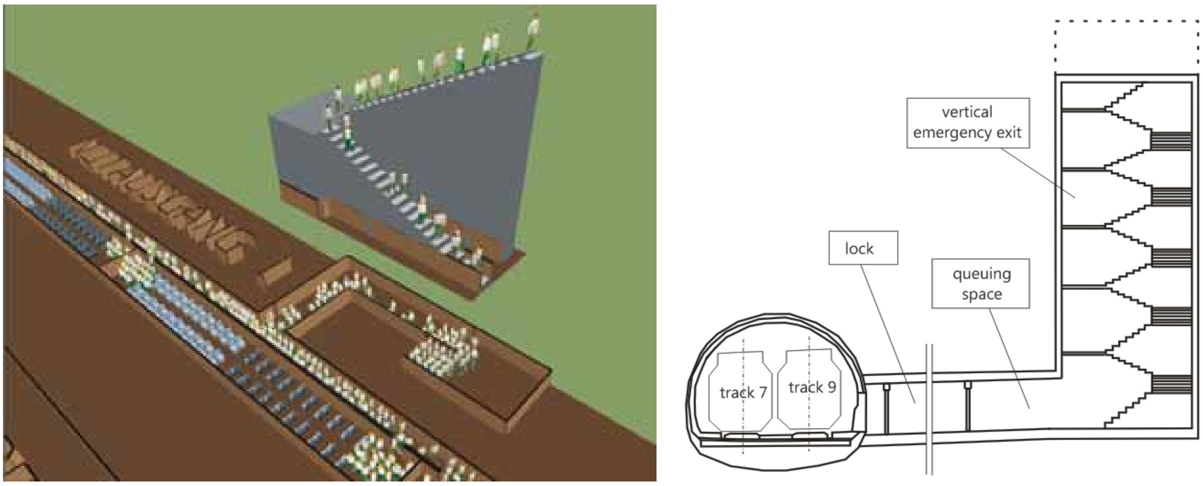

Figure 4: Evacuation simulation of vertical emergency exits

2.6. Catenary system

Prior to rescue teams entering the tunnel, a number of precisely defined requirements must be met. A vital requirement is that the catenary system must be grounded and disconnected from the power system. The complex tunnel system of the Wienerwald tunnel and the Lainzer tunnel (including 6 tunnel portals), requires a special solution to indicate whether this requirement is fulfilled. For fire brigades entering the tunnel, this information is either provided on control panels (including a key lock) or on display panels (only for notification). Control panels, which are installed at the portals, are not only equipped with a display system, which indicates the status of the catenary system, but are also equipped with a lock system to ensure that the catenary system cannot be reconnected. Only if the control panel shows "catenary system disconnected and grounded" (illuminated yellow arrows pointing towards each other), can the commanding officer of the fire brigade turn around the key in the lock. Subsequently a symbol signals "catenary system cannot be reconnected" (illuminated green lock). Now the commanding officer can remove the key from the control panel, which guarantees a safe emergency response for the fire fighters as long as he holds on to the key. The display panel cannot be operated by hand and only serves to provide information to forces approaching the vertical emergency exits. After the emergency response campaign, the commanding officer of the fire brigade returns the key to the commanding officer of the ÖBB.

The main advantage of the new disconnecting and signalling system is that time is gained in the process of visualisation and communication between the commanding officers. The new electrical system requires less communication in case of an emergency in the tunnel and replaces the old mechanical system used for grounding (earthing rods).

control panel - catenary system not disconnected and not grounded, and also not secured against reconnection

display panel - catenary system disconnected and grounded, but not secured against reconnection

display panel - catenary system disconnected and grounded, and secured against reconnection

Figure 5: System signalling the status of the catenary system

2.7. Interoperable train control system ETCS L2

In Austria, the declared goal is to continuously reduce the probability of train accidents. For this reason, the entire new railway line is equipped with the newest interoperable train control system called ETCS L2 (European Train Control System Level 2). The ETCS L2 has an on-board radio system allowing the on-board computer to communicate with the control centre. The train detection equipment sends the train's position to the control centre. The control centre, which receives information on the position of all trains on the line, allocates the new train movement authority to the train. To ensure safe railway operations, the on-board computer continuously determines the train's position and checks whether the current speed of the train corresponds to the distance travelled. In case of significant deviations from normal conditions, the train's speed is controlled automatically.

3. TUNNEL SAFETY DOCUMENTATION

Building the new railway line was an enormous constructional challenge. Putting it into operation led to many organisational challenges. One challenge was to bring together the different structures of the individual alarm control centres. Jurisdictional boundaries or interfaces in alerting procedures had to be clarified between all the parties involved like the ÖBB, the fire brigade, the police, the ambulance and the municipal disaster authorities. Emergency response plans and checklists were prepared in close consultation with the rescue services to support the respective officers-in-charge in case of an emergency.

All issues, which are relevant to the handling of an emergency in these tunnels, are collected in the "tunnel safety documentation", which focuses on tunnel-specific hazard analyses to determine the appropriate rescue concept. The crucial aspect is that people trying to escape from the site of an accident should be able to reach a safe area in an adequate period of time (evacuation). In addition, a tailored portfolio of tunnel safety measures should be available to the rescue forces to enable them to support the assisted rescue and the fire-fighting campaign. The tunnel safety documentation comprises detailed information on all physical tunnel structures as well as a manual for all operational actions for standardized emergency scenarios.

4. EMERGENCY EXERCISES

4.1. The Programme

Prior to taking a new tunnel into operation, the tunnel system must be checked by simulating rescue campaigns and performing fire drills. By establishing a systematically structured exercise programme, a new standard was set for new high-speed railway lines.

To implement the exercise programme, five different expert teams were formed, each consisting of members of the ÖBB, the district headquarters of the fire departments, the ambulance, the police and the relevant district authorities. The programme began with joint inspections to obtain the necessary site-, object- and system-related knowledge. Several training sessions followed focusing on different priorities, such as tunnel equipment, lines of communication, allocation of responsibilities, and cooperation of emergency services. Trainings focusing on operational tactics were only held after the team members had acquired the necessary system knowledge and had been briefed on the organisational framework conditions. The performance of emergency exercises followed the strategy of starting with simple rescue scenarios, gradually proceeding to more complex, multi-scale exercise scenarios involving various emergency services. After each exercise, debriefings were held. The experiences gained were documented in detail to be considered in subsequent exercises. The findings were furthermore recorded in the "tunnel safety documentation".

The completed training programme was as follows:

- 15 instruction courses [site-, object- and system-related knowledge]
- 11 emergency response exercises [tactical approach, safe handling of equipment]
- 3 staff exercises [communication, allocation of responsibilities]
- 4 disaster drills [cooperation between all parties involved]

The exercises were performed to meet the following objectives:

- Promote the motivation and cooperation of parties involved
- Gain confidence in the management of emergencies after the occurrence of an incident/accident
- Ensure a structured organisation of the exercise
- Ensure a smooth performance of the exercise
- Assess and document knowledge gained during the exercise

Figure 6: Simulation of a burning train (left) and a derailment with lost cargo (right)

4.2. Interesting findings identified during the exercises

One exercise took place at the transition zone from the twin-track tube to the two single-track tubes in the Wienerwald tunnel. The passengers were evacuated in the direction of the two single-track tubes. On the way to the emergency exit, the passengers stayed on the side of the escape walkway, on which they had left the train. They did not cross the tracks, although the emergency lighting ended on this side and continued on the opposite side of the emergency walkway. It seems that people leaving the scene of an incident or accident are afraid of crossing the tracks. It was furthermore observed that they waited in front of the emergency exit door and did not proceed into the lock area of the cross passage and into the adjacent tube.

In case of extensive smoke development in the tunnel, the colour of the escape lighting (which should indicate the route to the emergency exit) is similar to the colour of a fire. Due to this similarity in appearance, especially in a smoke-filled tunnel, the orange-yellow colour does not seem to be a good choice to mark the emergency exit in a tunnel and for psychological reasons it is hence considered to be changed to white.

Some of the exit signs were very dirty resulting in a reduced visibility in comparison to the concrete background. During maintenance works, special attention should thus be placed on cleaning the escape route signs at regular intervals.

With deep rescue shafts, walking up the emergency stairway to the surface, can be very challenging both physically and psychologically. This applies to all people walking up the staircase, but especially to elderly and impaired people. Numbering the steps to indicate the distance to the surface seems to be very important to evacuees, who long for certainty and psychological support.

Fire fighters and evacuees (some of them injured) met in the emergency staircase. Due to the width of the stairways (2 m) they could easily pass each other. But the acting performance of some of those participating in the exercise was so convincing that many of the fire fighters came to their rescue, helping “injured” and “exhausted” evacuees to a safe area at the surface, where they were looked after by the rescue services, instead of heading straight down to the tunnel to fight the fire.

At a different exercise scenario, a freight train derailed in the tunnel losing some of its cargo. The lost cargo consisting of tree trunks lay on one of the tracks. As the rail tracks could be accessed by rubber-tired vehicles, the obstacles on the tracks could be easily bypassed by the emergency vehicles. Rubber-tired vehicles were found to be more flexible than track-bound vehicles and thus proved to be advantageous under emergency conditions.

In addition rolling pallets, which are located at the emergency exits and at the fire-fighting points near the portals, were found to be very helpful, not only for the transport of equipment and the removal of lost cargo but also for assisted rescue operations (evacuation of people). Without this simple technical device, transport activities turned out to be very exhausting for the rescue services.

The exercises have shown that in case of an emergency, several voluntary fire brigades with several commanding officers are involved in the ensuing rescue campaign. A clear assignment of responsibilities (lines of communication, search for appropriate contact persons) is much more difficult, if there is more than one contact person for the different emergency services involved. The alarm and operation plan of the rescue forces must clearly identify and show the hierarchy of responsibilities among the different fire brigades.

Figure 7: Roller pallets (left) and numbering of staircase steps (right)

5. COMMISSIONING PROCESS

5.1. Timetable

It is only after all regulatory requirements have been met, that the required operating permit will be issued by the Federal Ministry for Transport, Innovation and Technology based on inspection documents and approval certificates. The timetable for the commissioning of the new Vienna - St. Pölten high speed line was as follows:

Table 1: Steps to obtain the operating permit for the Vienna – St. Pölten high-speed line

2009 - 2010	Completion of structural works
Mar. – Apr. 2012	Completion of infrastructure equipment installation
Apr. 2012	Acceptance tests in compliance with authority regulations
Mar. 2012	Acceptance tests and operation start-up of Tullnerfeld transformer substation
Mar. 2012	Completion of Tullnerfeld railway station
Apr. - May 2012	Start of courses for fire brigades (rescue services, police) to offer them the opportunity to familiarise themselves with the tunnel and the infrastructure equipment
Apr. - Aug. 2012	Start of test runs on the new railway line
Apr. - Sept. 2012	Staff exercises and training sessions for the fire brigades
Aug. 2012	Technical and functional acceptance test for operating speeds > 160 km/h
Sept. 2012	Trial runs gradually increasing the running speed from 160 km/h to 275 km/h (250 km/h plus 10%)
Sept. 2012	Performance tests for operating speeds > 250 km/h, verification of computation assumptions and theoretical computation results
Oct. 2012	Innovations and improvements for the rail traffic sector
Sept. - Nov. 2012	Operation start-up of the new train control system ETCS
Sept. - Nov. 2012	Final emergency exercises (large-scale disaster drills) involving all emergency services (fire brigade, rescue services, police, etc) as well as the authorities
Dec. 2012	Issuance of the operating permit by the Federal Ministry of Transport Innovation and Technology (BMVIT)
09. Dec. 2012	Opening of the new Vienna – St. Pölten high-speed railway line

5.2. Conclusion

When it comes to meeting the requirements to obtain the necessary operating permit, every large-scale railway infrastructure project needs intense cooperation between project management, signalling and control management, and emergency services. For that matter, the following aspects are of vital importance:

- For railway lines with many different tunnels, transparent harmonised guidelines for emergency services approaching the tunnel in case of an emergency (access by vehicle and on foot) are imperative.
- There is a strong need for standardised tunnel safety facilities and measures and for standardised operation management processes to ease the handling of emergencies.
- Emergency documents (emergency response plans, check lists, etc.) should be elaborated using a standardised structure and layout and should be delivered to all parties involved in due time.
- As an important part of the permitting process, the exercise programmes need to be systematically structured and scheduled (training sessions, complex multi-scale exercises).
- A proper and disciplined communication between key personnel is the most challenging task during an emergency. Exercises covering various realistic scenarios represent the most effective means to improve and optimise emergency communication.