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INLAND TRANSPORT COMMITTEE

Ad hoc Meeting of the Multidisciplinary
Group of Experts on Safety in Tunnels (rail)
(Second session, 25-26 November 2002,
agenda item 2)

QUESTIONNAIRE ON SAFETY IN RAILWAY TUNNELS

Annexes A and B

Transmitted by the Government of Norway

Note: Annexes A and B reproduced in this Informal document were transmitted in conjunction with the reply to the questionnaire by the Government of Norway and should be considered together with the document **TRANS/AC.9/2002/9**.

Annex 1

In Norway, there are about 700 railway tunnels with a total length of 285 km. This corresponds to about 6.5% of the total railway network. Ten tunnels are longer than 5 km and another 12 tunnels are longer than 2 km.

Table 1: Tunnels longer than 2 km

Section	**Tunnel name**	**Length Im]**
0270 (Etterstad) - Gardermoen	Romeriksporten	14 580
1420 (Asker) - Drammen	Lieråsen	10 723
2311 Haugastøl - Myrdal	Finse	10 *589*
2130 (Kristiansand) - Egersund	Kvineshei	9 *065*
2130 (Kristiansand) - Egersund	Hegebostad	8 474
2330 (Voss) - Dale	Trollkona	8 043
2340 (Dale) - Bergen	Ulriken	7 670
2340 (Dale) - Bergen	Hananipa	6 096
2130 (Kristiansand) - Egersund	Gyland	*5* 717
2311 Haugastol - Myrdal	Gravehalsen	*5* 311
2330 (Voss) - Dale	Kvålsåsen	4 923
1400 (Oslo S) - Lysaker	Oslotunnelen	3 632
2330 (Voss) - Dale	Hernes	3 336
2130 (Kristiansand) - Egersund	Tronås	3 178
2130 (Kristiansand) - Egersund	Sira	3 107
1130 (Stavne) - (Leangen)	Tyholt	2 760
2311 Haugastøl - Myrdal	Gråskallen	2 710
1310 (Steinkjer) - Grong	Medjå	2 549
1680 (Hønefoss) - Nesbyen	Haversting	2 300
2340 (Dale) - Bergen	Arnanipa	2 190
2130 (Kristiansand) - Egersund	Drangsdal	2 163
1350 (Fauske) - Bodø	Svarthammeren	2 075

There have not been any fatal accidents in any railway tunnel the last 50 years. In the table below all accidents since 1976 are listed.

Derailments in tunnels

Since 1976, there have been nine occurrences of derailments in tunnels resulting in one personal injury.

Table 2: Derailments in Norwegian railway tunnels since 1975

Date	Train	Tunnel	Description/cause
30.10.78	Work train	v/ Fokstua	Rock fall
13.02.80	Passenger train	Bjellum	Rail defect
12.09.81	Passenger train	Reinunga	Rock fall
18.09.86	Freight train	Sagfiat	Rock fall
18.09.87	Passenger train	Hesjevik	Rock fall
17.08.89	Work train	Ulsberg	Error in train/unknown
30.05.90	Goods train	Nordalstnl.	Error in train/unknown
3 0.06.90	Engine	Myrdal st.	While switching
13.12.90	Passenger train	Lunnan	Rock fall, one person injured
30.09.99	Passenger train	Gjerstad	Rock fall
06.10.02	Passenger train	Oslo S	Track work

Collisions in tunnels

Since 1976, there have not been any collisions in any railway tunnel. The last collision in a tunnel happened in 1962 in the Bekkelagstunnel between a suburban train and a work train. Three people were injured in the collision.

Fires in tunnels

There have been 13 fires in tunnels, where 8 started in trains. None of the fires caused any personal injuries.

Table 3: Fires in Norwegian railway tunnels since 1975

Date	**Train** type	**Tunnel**	**Description**
25.08.78	Motor coach	Lieråsen	Heavy smoke production due to fire in ventilation canal. Train exited tunnel, and fire was put out.
30.09.80	-	Oslotunnelen	Fire in cables. Fire department summoned. Big consequence for traffic.
04.01.82	Motor coach	Oslotunnelen	Fire department summoned to put out fire at underground station. The fire started in door opener.
17.04.86	Motor coach	Oslotunnelen	The fire started in tunnel, but the train continued to next station where the fire was put out.
31.05.86	Motor coach	Oslotunnelen	Arcing in train caused a small fire. The fire was put out with a fire extinguisher.
15.05.87	Motor coach	Oslotunnelen	Fire in motor.
16.08.89	Pass.train	Lieråsen	Fire in engine. Put out before fire department arrived.
12.01.95	Motor coach	Lieråsen	Smoke emission detected when train exited tunnel. Passengers evacuated at the station.
25.12.95	-	Oslotunnelen	Explosion in transformer station at central station gave off smoke. Station area evacuated.
01.01.96	-	Oslotunnelen	Fire in electrical equipment at underground station.
16.12.99	-	Lieråsen	Fire caused by welding.
05.10.01	-	Lieråsen	Fire in battery room inside the tunnel.
09.08.02	Freight train	Oslotunnelen	Fire in engine. Station area evacuated.

Annex 2

Substructure
Regulations for new lines
Tunnels – safety requirements

1 INTRODUCTION

These regulations cover safety measures for railway tunnels. The requirements are minimum requirements and special conditions may necessitate supplementary measures. Such conditions may be, for example, station areas inside tunnels, sag-curves or where the tunnel is to be used frequently for the transportation of large quantities of dangerous goods. The requirements apply to new tunnels only.

All measurements given are from top of rail unless stated otherwise.

Assessment of tunnel safety measures is to begin at the feasibility study stage.

2 TUNNEL DESIGN

When new tunnels are planned, these are to be based on the tunnel profiles in Appendix la.

3 TUNNEL CLASSIFICATION

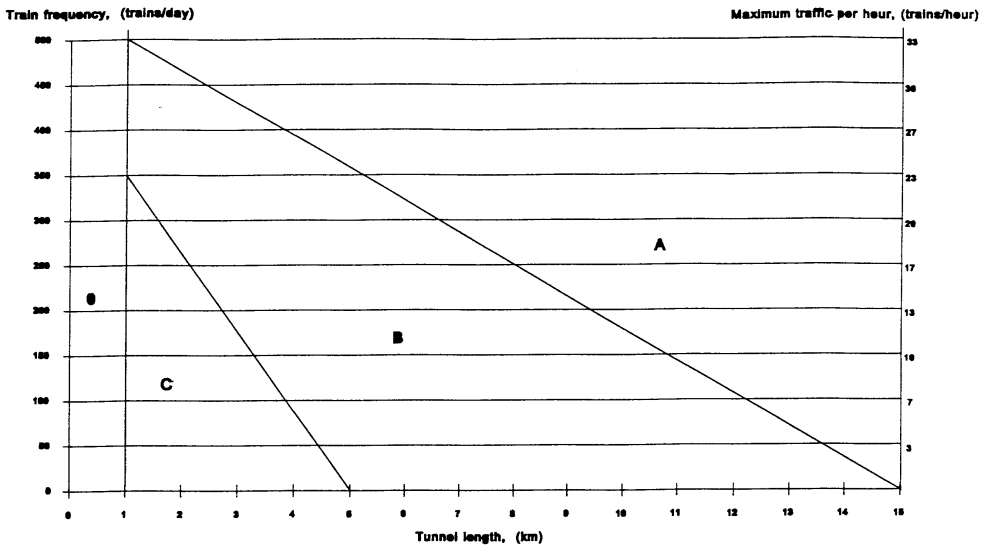


Figure 12.1 Tunnel classification

The train frequency per day (24 hours) and the maximum traffic per hour are plotted on the graph in Figure 12.1 and the tunnel is classified by the strictest class.

Tunnel length is defined as the total length measured between the tunnel mouths. Where it is possible to enter the tunnel via a cross-cut, tunnel length is defined as the greatest distance between the mouth of the cross-cut and one of the tunnel mouths. Where tunnel length is to be measured from the mouth of the cross-cut, the cross-cut must meet the following requirements:

- it must be equipped as an escape route and a means of access
- it must be reached by an access road available for emergency staff at all times (for tunnels where an access road is inappropriate due to the distance from emergency services, a helicopter landing pad may be provided instead).

A one-track railway tunnel with station inside the tunnel shall be classified one class higher than indicated by length and traffic.

4 SAFETY MEASURES

Table 12.1 shows the minimum safety requirements for the different classes of tunnel. The appropriate supplementary measures which should be assessed are given in Table 12.3. Other measures which may be considered are discussed in the report "Safety guidelines for railway tunnels".

Table 12.1 Minimum safety requirements for different classes of tunnel

Minimum safety requirement	**Tunnel class**		
	A	**B**	**C**
Derailment indicators before entrance to double-track tunnels and tunnels where tracks cross, also inside tunnel beside points/loops and in connection with other main entrance signals inside tunnel	x	x	x
Escape routes via cross-cuts from tunnelling or, where appropriate, specially laid shafts	x	x	
External access to tunnel mouths and exits of cross-cuts used as escape routes	x	x	
Fire extinguishers in equipment rooms	x	x	x
Handrails (one side)	x	x	
Walkway	x	x	x
Emergency lighting	x	x	x
Signs showing direction and distance to nearest emergency exit	x	x	x
Emergency telephones	x	x	x
Communication between train and CTC-central/emergency services	x	x	x
Overhead line earthing rods in tunnel mouths on electrified lines	x	x	x
Power outlets for lighting and rescue equipment	x	x	x
Fire protection for flammable insulation materials	x	x	x
Ban on storage of highly flammable materials	x	x	x
Emergency plans	x	x	

Table 12.2 Appropriate supplementary measures

Appropriate supplementary measure	Tunnel class		
	A	B	C
Ventilation system	x	x	
Extension of cross-cut to allow room for motonsed vehicles	x		
Helicopter landing pads	x	x	
Guard rails	x	x	x
Rail vehicles for evacuation	x	x	
	x	x	x

4.1 Specific minimum requirements - type, amount and location

4.1.1 Derailment indicators

Derailment indicators are to be installed for tunnels in classes A, B and C:

- before all double-track tunnels or before double-track stretches with many tunnels
- before tunnels with passing loops
- where the tunnel contains points/loops
- in connection with other home signals inside tunnel

Derailment indicators are to be fitted on each track in connection with the main entrance signals. The method is described in regulations JD 551 “Signals - construction regulations”.

4.1.2 Escape routes via cross-cuts

In tunnels in classes A and B, cross-cuts from the tunnelling are to be fitted out as escape routes where appropriate. Where necessary or where appropriate, the use of specially laid shafts as escape routes should be assessed.

Design of cross-cuts used as escape routes:

- For especially steep cross-cuts, steps against one wall should be considered.
- Where used as an escape route, the dimensions of the cross-cut should be at least 2.5 x 2.5m.
- Cross-cuts should have an exit gate allowing the entrance and exit of emergency vehicles. In addition, the gate is to contain a door which can be opened from the inside without a key or from the outside with a key. The door must open outwards and the opening should be at least 0.90 x 2.0 m.
- It must be possible to switch on the lighting in the cross-cut from the CTC-central, at the entrance to the cross-cut from the tunnel and at the cross-cut exit.
- The lighting must be no dimmer than 0.2 lux 20 cm above walkway level. For emergency lighting, see Section 4.1.7.
- The same minimum safety requirements as for the tunnel (communications, guard rails, signs etc.) also apply to the cross-cut when used as an escape route.

4.1.3 Access to tunnel mouths

For tunnels in classes A and B, where practically/financially feasible, access must be provided to the tunnel mouths for emergency crews. This access is to be usable throughout the year.

Where this is not possible, alternative solutions may be assessed, e.g. a helicopter landing pad, see Section 4.2.3.

4.1.4 Fire extinguishers in equipment rooms

In tunnels in classes A, B and C, fire extinguishers are to be placed in equipment rooms.

4.1.5 Handrail

All tunnels in classes A and B are to be fitted with a handrail along one side - the same side as the escape route and the emergency lighting.

The handrail is to be fitted at a height of approximately 90 cm above walkway level (approximately 70 cm above top of rail) and 5 – 10 cm away from the tunnel wall.

The handrail is to be made from material which does not conduct electricity. The handrail is to be painted white.

4.1.6 Walkway

In all tunnels, the distance between the wall and a stationary train must be at least 1.5 m and the available height 2.20 m. Signals and equipment installations are to protrude no more than 0.5 m from the tunnel wall and such narrow sections are to extend for no more than 2 metres. A guiding system (handrail) is to be installed in these areas to lead those escaping around the hazard, see Figure 12.2.

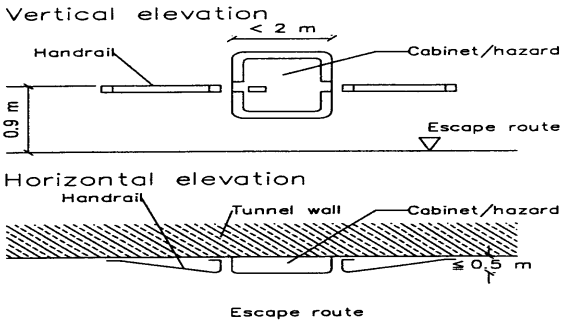


Figure 12.2 Example of guiding system around hazard

Escape walkways are to be constructed on the same side of the tunnel as the handrail. Ballast for the walkway is to be filled in to a horizontal level in line with the top of the sleeper, extending to the tunnel wall/top of cable duct cover.

The cable duct should be situated sufficiently far out from the wall that it can form part of the walkway. The distance from the centre of the cable duct to the tunnel wall should be approximately 70 cm.

4.1.7 Emergency lighting

Emergency lighting is to be installed in all tunnels in classes A, B and C. In emergencies the tunnel emergency lighting is to function as a guide.

Normally the emergency lighting is to be switched off. In emergencies it must be possible to switch on the lighting from the railway control centre, at the tunnel mouths and at emergency

telephone points. During tunnel maintenance work or inspections, the emergency lighting should be included as part of the lighting.

The lighting must be no dimmer than 0.2 lux at top of rail level at any point on the walkway.

The emergency lighting is to be installed on the same side of the tunnel as the escape route and at a height of 2.0 - 2.5 m above top of rail.

Emergency lighting is to be fitted beside signs showing the way to the nearest exit and beside emergency telephones. The lighting points may be integrated with the signs. For signs, see Section 4.1.8.

The emergency lighting is to be connected to a battery system which takes over automatically if the power supply is cut. The battery system must be able to ensure lighting for at least 2 hours.

In areas where emergency lighting cables run outside the duct, they must be made from flame-retardant materials.

Also see regulations JD 546 “Tunnel lighting regulations”.

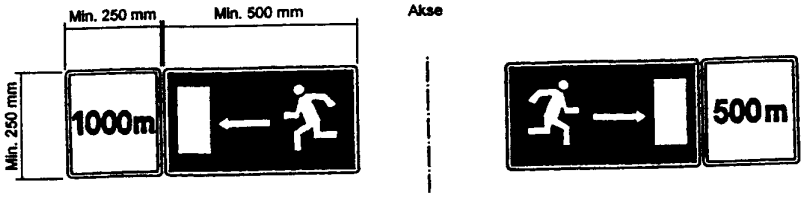
4.1.8 Signs

Signs showing the direction and distance of the two nearest exits must be fitted in all tunnels in classes A, B and C.

Signs showing the direction and distance of exits are to be fitted at emergency lighting points or be integrated with the emergency lighting.

The signs are to be fitted at least every 100 m. They may be transparent or directly lit by the emergency lighting.

The signs are to be at least 250 x 500 mm in size. Signs with lettering are to be at least 250 x 250 mm in size, with letters at least 100 mm high. The distance to the exit is to be rounded off to the nearest 100 m. Figure 12.4 gives an example of sign design.



The signs are to be white on a blue background, so conforming to international standards for informative signs. Signs may not contain the colours green, red or amber, due to the risk that they may be confused with signals.

4.1.9 Emergency telephones

Tunnels in classes A, B and C are to be fitted with emergency telephones every 600 m. In double-track tunnels telephones are to be installed on both sides, while in single-track tunnels they should be installed on the same side as the escape route. Signs showing the direction of the nearest emergency telephone are to be installed in conjunction with the signs for escape routes. For the location of signs, see Section 4.1.8. The telephones are to be situated in a cabinet or box. Telephone cabinets are to contain their location on the line in tenths of a kilometre.

4.1.10 Communications

For tunnels in classes A, B and C, it must be possible to operate train radio, mobile telephones and any radio systems used by the emergency services.

Radio connections must be able to withstand the effects of an accident. Cables running outside the duct are to be of flame-retardant material.

Damage at one point must not cause reduced communication over a stretch longer than 100 m.

4.1.11 Overhead line earthing rods for tunnel mouths

On electrified stretches, tunnels in classes A, B and C are to be fitted with overhead line earthing rods for each track at both mouths of the tunnel.

4.1.12 Power outlets

Tunnels in classes A, B and C are to contain power outlets for lighting equipment and rescue equipment, located beside the emergency telephones.

The power points are to have a voltage of 220 - 230 V.

4.1.13 Fire protection for flammable insulation materials

The following demands shall be satisfied:

- The constructions shall not take an active part in a fire on a train, not spread a fire and not burn after the fire in the train has stopped.
- Constructions shall not contribute to extra smoke emission while the fire is proceeding and must not produce poisonous gas.

Use of insulation made of foamed polyethylene or similar flammable material is to be protected against fire as followed:

- Approved fire protection is min. 70 mm spray concrete with reinforcing steel and without fibre of steel.
- Maximum allowed unprotected foamed polyethylene in tunnels shall be in accordance with table 12.4

Table 12.4 Maximum allowed unprotected foamed polyethylene in tunnels

Length / Type of tunnel	<500 m	500 — 5000 m		> 5000 m	
		Max. area of an unprotected stretch	Min. distance between the stretch	Max. area of an unprotected stretch	Min. distance between the stretch
Tunnel with low flow of traffic[1]	No demand for fire protection	50 m^2	100 m	50m^2	200 m
Tunnel with high flow of traffic[1]	No demand for fire protection	Everything shall be fire protected		Everything shall be fire protected	

1) The limit between high and low flow of traffic is 30 trains per day and night for single track and 80 trains per day and night for double track tunnels.

- All unprotected insulation is to be of flame-retardant material.
- In tunnels with home signal all insulation shall be skal fire protected in the area where the trains stop for the signal, i.e. a section of 300 m in front of the home signal no matter what length the tunnel is nor the flow of traffic.
- In tunnels with a length <500 m insulation made of foamed polyethylene shall not be used in longer connected parts.
- In tunnels with a low flow of traffic longer than 500 m unprotected stretches of up to 50 m can be allowed from the tunnel outlet with a maximum area of the stretch of 150 m^2.
- For unprotected stretches the distance to the next stretch must be as shown in table 12.3.

Table 12.3 Distance between unprotected stretches in tunnel outlet and remaining tunnel

Area of stretches (m^2)	Length between the stretches (m)
100	150
150	180

4.1.14 Ban on storage of highly flammable materials

It is forbidden to store highly flammable materials such as class A liquids and class B liquids in all tunnels in classes A, B or C.

4.1.15 Emergency plans

An emergency plan is to be drawn up for tunnels in classes A and B and for stretches of line containing many tunnels. In addition, tunnel equipment is to be specified in emergency plans for all stretches containing tunnels.

The emergency plan is to include the following as minimum requirements:

- a description of the available resources and equipment and the location of equipment;
- categorization of emergencies by severity;
- description of duties and organization of resources in emergencies of varying severity;
- telephone numbers for the fire brigade, police, health services and internal emergency services.

For the design of emergency plans, see also Railway security services - Assistance services (Document No. 427).

The emergency plan is to be approved by the units concerned.

Work on the emergency plan is to commence during the planning phase of the project, such that the optimum solution is chosen with regard to the design of the tunnel and the choice of safety measures with regard to emergencies.

4.2 Appropriate supplementary measures - type, amount and location

4.2.1 Ventilation system

Use of a ventilation system is to be considered for tunnels in classes A and B. The need for ventilation is to be evaluated on the basis of the location of the tunnel, its incline, length and other safety measures.

When installing a ventilation system, the aim should be controlled ventilation which will send any smoke in the most appropriate direction.

4.2.2 Extension of cross-cut to allow room for motorized vehicles

In view of evacuation, the extension of cross-cuts to allow room for motorized vehicles may be assessed for tunnels in class A. The need for such an extension is to be evaluated on the basis of the tunnel’s location, length and other safety measures.

4.2.3 Helicopter landing pad

For tunnels in classes A and B, where access to the tunnel mouths is considered insufficient, a helicopter landing pad beside all tunnel mouths may be an alternative solution where practically/financially feasible.

Landing pads are to be at least 15 m in diameter.

4.2.4 Guard-rails

Guard-rails are to be assessed for tunnels in classes A, B and C.

The guard-rails are to be fitted throughout the tunnel or possibly at the entrance sections of the tunnel and at points inside the tunnel.

For installing guard-rails see regulations JD 530 “Superstructure - technical design regulations”.

4.2.5 Rail vehicles for evacuation

Rail vehicles should be available for evacuation from tunnels in classes A and B. Vehicle design and location and available equipment carried are to be included in the emergency plan for the tunnel.

5 DESIGN

All equipment installed in tunnels is to be designed for the aerodynamic loads which may be created by passing trains.

6 MAINTENANCE OF EQUIPMENT

Maintenance, testing and inspections are to ensure conformance with the standards and levels of safety for the tunnel.

A plan is to be drawn up for periodic maintenance of all equipment fitted in the tunnel. The maintenance procedures are to take into account the type of environment in which the equipment is used and the manufacturers’ recommendations. Defects or faults discovered during this periodic maintenance are to be reported and defects corrected as quickly as possible.

In the event of major faults in safety equipment, the responsible body is to be notified immediately and corrective action taken. The cause of major faults is to be investigated with the aim of avoiding similar faults in the future, either by altering procedures or by raising the technical standards for the equipment.

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