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Guidelines for the officer-in-charge for fighting fires in road tunnels immediately following a report

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Inhoud

Why these guidelines

The stability of road tunnels in the Netherlands is not guaranteed in the event of extreme fires (with very high fire capacities (approximately 200 megawatts and more) resulting from fires in the cargo of trucks and tankers). The non-guaranteed fire resistance of the concrete of (national road) tunnels (hereinafter referred to as 'problems with concrete') means that the constructive stability of a road tunnel is jeopardised more quickly (see: Parliamentary letter about reduced fire resistance of concrete). This stability should be 60 and 120 minutes respectively for land and underwater tunnels, but it has been found that it can only be 22 and 45 minutes respectively in the case of extreme fires, because concrete spalls faster than expected. As a result of this non-guaranteed fire resistance, the reinforcement is exposed (more quickly).

This problem concerns at least the following four tunnels: 2nd Coentunnel (Amsterdam), Koning Willem Alexandertunnel (Maastricht), Ketheltunnel (Schiedam) and the Salland-Twentetunnel (Nijverdal). Partly on the advice of the Safety Officer for Road Tunnels, the tunnel managers have made short-term operational arrangements per tunnel with the competent authority and the Safety Region in the municipality concerned.

The reduced fire resistance also has consequences for the investigation by the officer-in-charge *immediately after the report* ("will the first fire brigade unit enter the tunnel or not?") and for the decision to deploy ("will the first fire brigade unit enter the incident tube or not?").

The Knowledge Platform for Tunnel Safety (KPT)[1] asked Nils Rosmuller, lecturer in Energy and Transport Safety at the IFV, to think about the possibilities for fire fighting in such tunnels. In consultation with Brandweer Nederland (Organisation of Dutch fire services), Rijkswaterstaat and the IFV Brandweeracademie (Dutch National Fire Service Academy) (we refer to this as Discussion Table 4[2]), resources for officers-in-charge have been developed. This document presents the tools that have been developed (decision diagram and operational capability table) as well as the process of their creation. Discussion Table 3 of the KPT[3] has contributed ideas about the section on 'concrete spalling' in the development of the decision diagram.

[1] In the so-called "Pact of Houten", four subjects have been identified in relation to the problems with concrete in tunnels. These topics will be developed in separate discussion tables. This present document with a tool for officers-in-charge was the subject of Discussion Table 4.

[2] The following people took part in Discussion Table 4: Ron Beij (Amsterdam Amstelland Fire Service), Addy Burger (Utrecht Safety Region), Hans Godding (Limburg-Zuid Safety Region), Adriaan ter Huurne (Twente Safety Region), Rob Terpstra (Brabant Zuidoost Safety Region), Marcel Valk (Utrecht Safety Region) and Hylke Visser (Rijkswaterstaat). Nils Rosmuller (IFV) coordinated the discussion table.

[3] 'Research' is the theme of Discussion Table 3, which consists of experts in the field of concrete technology, tunnel construction, fire safety and emergency response, and focuses on identifying knowledge gaps regarding the 'problems with concrete'.

Purpose and target group

The decision diagram and the operational capability tables are intended for the officer- in-charge of the fire service. They offer him or her an initial perspective on how to act in the event of fires in 'the average' Dutch road tunnel. Interviews with officers-in-charge and officers from the fire service have shown that the tools that have been developed (decision diagram and operational capability tables) are also of value for fires in 'regular' road tunnels (tunnels without 'problems with concrete'). In fact, the tools can be used for all road tunnels and 'problems with concrete' are only a specification in the decision diagram.

Please note that these are generic action perspectives. Each road tunnel has its own specific aspects that will influence the incident response. That is why an Emergency Response Plan (CBP, prepared by the tunnel manager) and an Incident Response Plan (IBP, prepared by the Safety Region) are mandatory for each road tunnel. They must be aligned with each other. The decision diagram and operational capability tables included in this document are useful when drawing up these Emergency and Incident Response Plans. However, they are not intended for use on other infrastructures such as railway tunnels and car parks.

Finally, innovations in vehicle development, such as the use of different fuels, may lead to an update of this document. In this document, we have not made a distinction between fire fighting options for different fuels such as petrol, diesel, electricity, LNG or hydrogen.

1 Description of key terms

Various terms used in this publication are defined below:

Concrete spalling: the crushing/crumbling/loosening of concrete parts (several centimetres and larger) of the tunnel wall or ceiling as a result of a fire in the tunnel and its high temperature (see Figure 3).
Concrete problems: tunnel where it is known that the fire resistance is not guaranteed during the legal requirement of 60 minutes (land tunnel) or 120 minutes (underwater tunnel) in case of an extreme fire (200 MW).
Downwind of the accident: The area from the crashed vehicle further into the tunnel, in the direction of the tunnel traffic.
Emergency: serious accident, fire or suspicion thereof, release of hazardous substances, dangerous or suspected (Rarwv (Regulation on additional rules for road tunnel safety) Art. 6, section 4). In this document specifically referred to as 'fire'.
Emergency services information panel: facility located near the entrance (> 150 metres away) of a tunnel. It allows the detailed image shown by the camera system to the (coordinating) Road Traffic Controller (c)WVL in the Traffic Control Centre to be displayed to the emergency services. The emergency services information panel is also equipped with an intercom, enabling voice contact with the (c)WVL.
Escalation: spread of vehicle fire to other vehicles or cargo/goods which substantially increases the size and intensity of the fire.
Escape door (intermediate door): opening between the tunnel tubes intended to enable road users to escape from the incident tube.
Immediately after report: the first 15 to 30 minutes after a report of a fire incident in the tunnel. In this acute phase, it is essential to build up an initial understanding of the incident that is as adequate as possible. This is not only essential for the safety of those who arrive first, that of other road users and that of the environment, but also to give the further control of the incident a 'flying' start.
Incident tube: The tunnel tube in which the incident occurs.
Reinforcement: the iron bars that transfer the tensile stresses in the tunnel wall.
(Road) tunnel: the whole of (several) tunnel tubes, installation spaces and (if present) a central tunnel channel within the enclosed part of the road, being longer than 250 metres.
Support tube: a (neighbouring) tube that is closed off to traffic at the time of an emergency so that the emergency services can be provided with a safe attack route and working environment in the event of an emergency.
Furthermore, in specific situations, this tube can also be used as an escape tube (Salland-Twentetunnel at Nijverdal).
Upwind of the accident: The area from the crashed vehicle back into the tunnel, against the direction of the tunnel traffic.
Vehicle fire: the burning of a road vehicle, possibly with a load, ranging from a passenger vehicle, van, bus or lorry to a tanker with flammable liquids/gases.

2 Combatting tunnel fires in the Netherlands

Road tunnels in the Netherlands are quite similar. They usually have two traffic tubes (one per direction of travel) connected by doors, passages or a central tunnel channel. These connections (intermediate doors) are no more than 100 metres apart. In general, there is a well-functioning longitudinal ventilation system which provides a good view of the fire from upwind and 'blows away' heat and toxic combustion products in the (downwind and congestion-free) direction of traffic.

Combatting tunnel fires in the Netherlands is uniformed to a considerable degree during the first minutes after a (fire) report (Flohr, Rosmuller and Koebrugge, 2016). Therefore, we can speak of a regular working method in fighting fires in (road) tunnels that applies to the tunnel situation described above.[4]

The control room receives a report of a vehicle fire in a tunnel. The control room sends out a dispatch message after which a water tender (TS) is dispatched. The regular procedure is as follows:

1. The TS drives to the entrance of the **support** tube and is provided with images from the incident tube by the emergency services information panel outside the tunnel.
2. Next, the fire brigade enters the support tunnel in the same direction as the traffic.
3. The fire brigade enters the **incident tube** for an initial reconnaissance on the instructions of the Traffic Control Centre and using the breakthrough possibility via the upwind escape door nearest to the burning vehicle.
4. A reconnaissance is carried out from the support tube to answer the following questions: What is burning? Is there a possibility of the fire spreading? Are their assumptions correct?

Therefore, there are at least three locations relevant for the fire brigade in case of a vehicle fire in a tunnel, namely (in order of possible deployment) (see also Annex 1):

1. the **location outside the tunnel** (at the emergency services information panel),
2. the marshalling area in the **support tube** and
3. the incident location in the **incident tube.**

[4] Exceptions are when 1) the doors are located further apart (e.g. 250 m) and 2) when there is a traffic jam downwind.

The dilemma for officers-in-charge due to the problems with concrete

In the case of a fire in a tunnel, the officer-in-charge is confronted with an exceptional emergency. He/she will have little experience of it and will probably be less familiar with the (tunnel) environment. There are also certain risks to their own personnel. Because of the 'problems with concrete', the officer-in-charge is faced with an additional uncertainty, namely the non-guaranteed stability of the tunnel. At that moment, the officer-in-charge lacks a tool to reduce that uncertainty and/or to make a proper assessment of it.

Although the officer-in-charge has of course his own professionalism to reach a well-considered decision, he currently lacks a tool to reduce that uncertainty and/or to make a good assessment of the uncertainty mentioned. Because experience with tunnel fires is limited and knowledge transfer is crucial, such a tool must be simple: quick to understand and apply and as much in line with the normal way of acting as possible.

The greatest simplification of a (complex) deployment decision in the case of a tunnel fire is obtained by reducing the number of variables in such a fire and by adhering to the quadrant model for fighting building fires of the Dutch National Fire Service Academy.
Based on this, the Werkgroep Brandbestrijding Wegtunnels Haaglanden created a classification which can be applied to fire fighting in tunnels.

There are two crucial factors that guide the deployment decision in broad terms, namely the size of the fire (small/large) and whether the tunnel ventilation is working (yes/no).
Plotted against each other, the size of the fire and the functioning of the tunnel ventilation give four quadrants. Each of the quadrants specifies the preferred course of action.

Table 2.1 Quadrant model for fighting tunnel fires

		Tunnel ventilation	
		Working	**Not working**
Fire	Small (< 50 MW)	offensive interior attack (deployment in incident tube from support tube)	offensive interior attack (deployment in incident tube from support tube)
	Large (> 50 MW)	offensive exterior attack (deployment from outside tunnel mouth of incident tube) defensive interior attack (deployment from support tube)	defensive exterior attack (action from outside tunnel, preventing spread to surroundings)

Only the officer-in-charge (in consultation with the duty officer) will always determine the deployment tactics based on his own professionalism, experience and familiarity with the location, and on the equipment, the incident, etc. This context also has an effect on the performance of the incident officers, something that the officer-in-charge will take into account in his/her decision/action perspective (consider the maximum (acceptable) deployment time, the type of protection, and so on). The decision diagram presented here is a tool that can assist in this and does not prescribe the decision in any way. It can also be used within the framework of training in the regions and can be added to the IFV training course for officers-in-charge.

3 Tool 1 for the officer-in-charge: decision diagram

In reality, more factors than those presented above in the quadrant model will play a role in the officer-in-charge's deployment decision. Some of those additional factors are included below (without wanting to increase the complexity, but to approximate reality a little better) in the decision diagram developed for the officer-in-charge. The two additional variables included are: the possibility of escalation and whether or not there is concrete spalling.

In Discussion Table 4, we worked on a simple decision diagram for the officer-in- charge to assist him/her in their fire fighting decisions. The questions below can be answered using this diagram:

- Should the first arriving unit of the fire brigade enter the support tube/ incident tube of the tunnel or not?
- Should the first arriving unit of the fire brigade be deployed in the incident tube or should the deployment decision be reassessed? This reassessment must be carried out outside the tunnel, i.e. not in the support tube.

The key question that the decision diagram can assist the officer-in-charge with is: "When is it still safe to enter the tunnel (both the support and incident tubes) in case of fire?"

To answer this question as an officer-in-charge, a decision diagram has been developed in the form of four questions. The answers to these questions can be obtained from information from the Traffic Control Centre, the emergency services information panel and from the officer-in-charge's own reconnaissance data. When drawing up the diagram, the order in which the information becomes available to the officer-in-charge was taken as the starting point.

1. What is burning?

This concerns the size of the fire. With a 'small' fire (maximum 50 megawatt (MW): a few passenger cars, delivery van, engine fire, lorry cabin fire) the fire resistance of the concrete in the incident tube is not at stake. In case of such a (vehicle) fire, reconnaissance can take place in the incident tube by approaching through the support tube. With sufficient operational capability (see Chapter 4), such a fire can normally be extinguished by the deployment of one water tender in an offensive interior attack.

In the case of a 'major' fire (more than 50 MW: bus/touring car, cargo fire of a lorry, tanker with flammable liquids/gas), the collapse of the tunnel cannot be excluded in advance. In the event of a fire including cargo, the advice is: remain outside the tunnel, explore the tunnel from the outside via the emergency services information panel, and reconsider the options (outside the tunnel).

If, in the case of a cargo fire, the tunnel ventilation is working, no escalation is possible and if no concrete spalling or reinforcement is visible, the officer-in-charge may consider a deployment in the incident tube.

2. Is the tunnel ventilation working?
If the tunnel ventilation in the incident tube is working, there will be a clear view of the fire and of the concrete.[5] The officer-in-charge will therefore know what is burning and the fire service will be able to approach the fire fairly well and investigate further: are there any victims? Are any other vehicles involved? Are there any possibilities of escalation?

There are ways to achieve safe deployment in the incident tube. If the ventilation is not working, there is no view of the fire, nor of the escalation possibilities or of possible concrete spalling and the exposure of the reinforcement. No responsible deployment is possible in the tunnel (not in the incident tube, nor in the support tube). Examine the tunnel from outside and reconsider the (deployment) possibilities.

3. Are there any escalation possibilities?
Escalation possibilities should include the possibility that the vehicle fire could (quickly) develop into a large multi-vehicle fire or a (very) large fire (100-200 MW - 1000-1300oC). Examples of this are a) large numbers of vehicles such as passenger cars, vans or buses which are parked (downwind) close to each other (within metres) and which become caught in the fire, b) a lorry carrying pallets, empty beer crates, car tyres, and so forth, or c) a tanker lorry carrying flammable liquids. If there is a large fire, this means that the concrete may be affected or become affected, which means that tunnel stability is not guaranteed. If the fire is limited to a single vehicle, it depends on the condition of the concrete whether it is safe to deploy fire fighters in the incident tube.

4. Is there any concrete spalling or is the reinforcement visible?
This fourth question refers to the reason for the development of the tools mentioned (the problems with concrete) but is just as important for regular tunnels. If the concrete is intact and the tunnel ventilation is working, it is reasonable to deploy in the incident tube. If the concrete has started to spall (this can be seen and heard), the reinforcement is exposed (see Figure 3 in Annex 1) or if both are present, then it is unsafe to deploy in the incident tube because the stability of the tunnel is not guaranteed. In that case, investigate from outside the tunnel and reconsider the (deployment) options. (Tunnel) debris of concrete on the road surface is also an indication of concrete spalling (see Figure 3 in Annex 1).

Answering the four questions will lead to one of the two[6] action perspectives recommended below, which follow from going through the decision tree:

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[5] The fire in the Heinenoordtunnel has shown that in the case of a lorry fire involving both the cabin and the fuel tank, where the ventilation is working and where there are no escalation factors, a
deployment in the incident tube is relatively safe.

[6] For the sake of simplicity (which is necessary), only two possibilities for action have been identified here for the officer-in-charge. A limitation of the options is in fact desirable for exceptional and
unknown situations, where there may be great dynamic risks to personnel and where the experience of the officer-in-charge will be limited.

> A fire service deployment in the incident tube. This is possible in the case of 'small' fires and is always primarily aimed at fighting the fire unless there is a possibility of the fire escalating: then, if necessary, rescue operations could also be carried out immediately.
> A (re)assessment of the deployment, which is made outside the tunnel. The reassessment itself, the question on which it focuses and the possible outcome are dependent on so many aspects that they have not been developed.

In the case of a deployment aimed at fighting a fire in the incident tube, the officer-in- charge determines the required cooling capacity (see Chapter 4). A deployment in the incident tube is undertaken if sufficient cooling capacity is available or can be built up and on the assumption that the deployment can actually be completed (successfully) and will lead to the fire being extinguished.

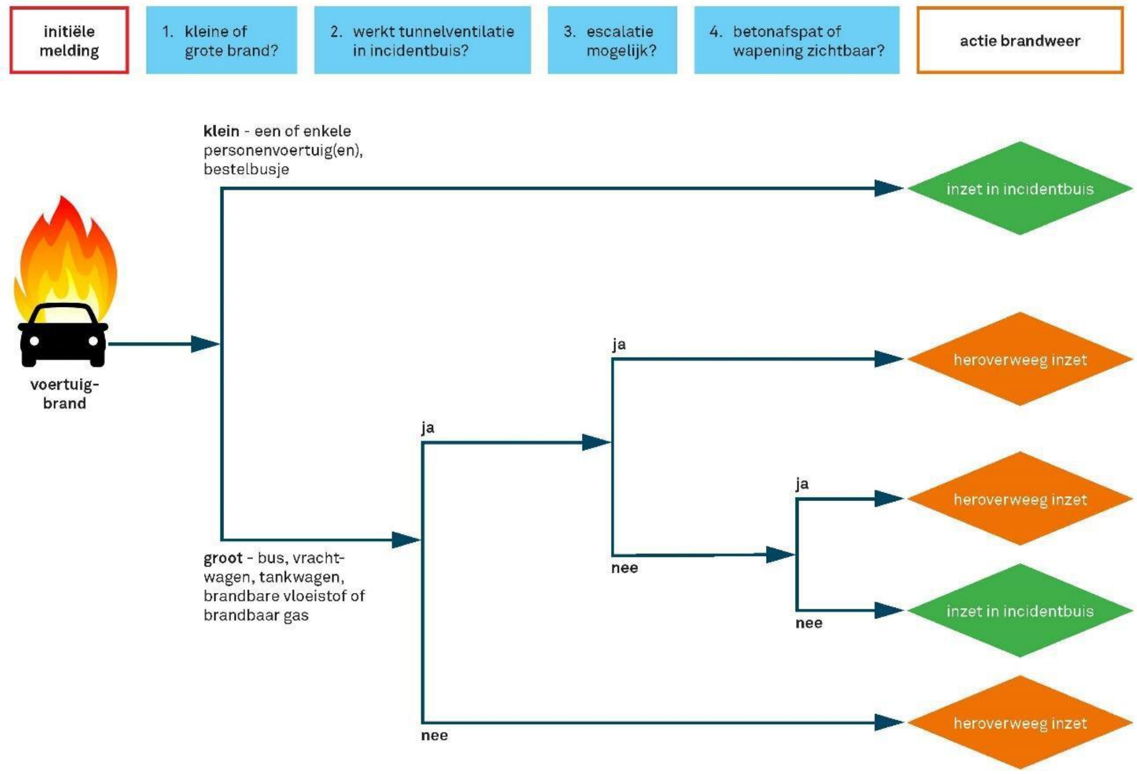

Figure 3.1 Decision diagram for fighting fires in read tunnels

There are three situations in the decision diagram where deployment is reassessed outside the tunnel ('reassess deployment').

The three are listed below (from top to bottom in the diagram) with a course of action for each when additional information has become available.

1. Large fire: large vehicles burn, tunnel ventilation works and escalation is possible. If enough cooling power can be built up (to cool the vehicles and one extra jet to cool the concrete), deployment can take place in the incident tube.
2. Large fire: large vehicles burning, tunnel ventilation works, escalation does not seem possible and concrete spalling and/or reinforcement are visible. Same as situation 1.

3. Large fire: large vehicles burning and tunnel ventilation not working. If the fire is approachable and there is sufficient cooling capacity (to cool the vehicles and one extra jet to cool the concrete), a deployment can take place. If not, deployment cannot take place in the incident tube.

For all three of these situations, slightly more risk can be taken if a rescue operation is required. But first the fire must be extinguished, unless there is no risk of escalation; in that case, a rescue operation can also be started immediately.

The decision after reassessment therefore also depends on:
- the accumulated and present operational capability (is there sufficient cooling power?)
- the approachability of the fire
- the risks involved for the fire brigade itself.

4 Tool 2 for the officer-in-charge: operational capability table

Alongside a decision diagram as a tool, it is important for the officer-in-charge to have a tool that can help with the question of which and how much equipment can be used to fight the fire. This has been worked out by means of two activities. Firstly, we studied what is known in the scientific literature about fighting tunnel fires (Instituut Fysieke Veiligheid 2019). Secondly, we discussed tunnel fire scenarios on the basis of this scientific knowledge. This took place in a session (19 February 2019) with officers-in-charge and duty officers whose work involves planning and tunnel fire fighting.[7] Six scenarios were presented to them, which were visualised and provided with key figures of the size of the fire and its development (Table 1).

Table 4.1 Tunnel fire scenarios

Scenario #	Vehicle	Fire capacity (MW)	Time to peak capacity (minutes)
1	Passenger vehicle	5-10	10
2	Multiple passenger vehicles	10-20	20
3	Delivery van	15-30	10
4	Bus	45-60	15
5	Lorry including load	50-150	15
6	Tanker with flammable liquid	200+	unknown

As a rule, reconnaissance is always carried out in the event of a tunnel fire. Offensive action is only taken under two conditions:

> physical accessibility of the fire
> sufficient extinguishing capacity to extinguish the fire.

According to all those present, in practice those preconditions will usually not be met in the case of a tunnel fire with a burning vehicle the size of a bus (scenario 4) or (in theory) in the case of a tunnel fire with a fire capacity of 50 MW or more (scenarios 5 and 6). In all cases,

[7] This session was attended by: Ron Beij (Amsterdam Amstelland Fire Service), Eric Dielemans (Zeeland Safety Region), Hans Godding (Limburg-Zuid Safety Region), Tom Pauwels (Zeeland Safety Region), Jennifer van Strien (Haaglanden Safety Region), Ricardo Weewer, Jos Post, Jan Maarten Elbers (all IFV). Nils Rosmuller (IFV) chaired the session.

the officer-in-charge decides whether or not to take offensive action, based on the circumstances. For example, in the case of a traffic jam (upwind and/or downwind), the fire may not be easily accessible and it may not be possible to meet the first precondition. In this case, even if the fire capacity is less than 50 MW, as in the case of several burning passenger vehicles (scenario 2), it is possible that no offensive action is taken. If offensive action cannot be taken, defensive action is taken. Defensive action means: extinguishing and cooling from outside the incident tube to facilitate rescue operations.

The following two tables, 4.2a (scenarios up to 50MW) and 4.2b (scenarios of more than 50MW), provide rules of thumb for fighting fires. The tables show the operational aspects on which the officer-in-charge must take a decision and the corresponding suggestions for use. The amount of water can be drawn from the emergency station (upwind of the disaster) or possibly from the water tender, acting as if it were a standard vehicle fire as far as possible.

Some exceptions include:
> a highly abnormal vehicle fire (e.g. with a lot of smoke): withdraw and make a new plan
> a burning lorry or bus: act according to the situation
> a lorry or tanker completely on fire: withdraw.

Table 4.2a Fire scenarios 1/2/3 (passenger vehicle/multiple passenger vehicles/delivery van) and operational preferences

Operational aspect	Preference
Tactics	Reconnaissance, offensive
Use extinguishing agent	2 Low pressure (LD) with manifold from support station
Water source	Support station (possibly a water tender (TS))
Use of breathing air	Always everyone
Thermal imaging camera	Always
Number of teams	1 TS, 6 persons. Exception is an electric vehicle, then extra cooling capacity, in the form of 1 extra TS, 1 LD in the vicinity (tunnel and other vehicles.

Table 4.2b Fire scenarios 4/5/6 (bus/lorry/tanker) aand operational preferences

Operational aspect	Preference
Tactics	Defensive, reconnaissance (can fire be reached; is there enough water?), build up op. capability Offensive, once operational capability in place. What is needed then, see below:
Use extinguishing agent	Min. 5 low pressure (LD)
Water source	Water tenders in support tube
Use of breathing air	Always
Thermal imaging camera	Always
Number of teams	1 platoon

Another exception is a burning tanker lorry with a flammable liquid or gas. This is a rare but at the same time very risky situation with a major impact on the safety of personnel and on the stability of the tunnel. The advice is to deploy as many cooling monitors as possible and to leave the incident tube as quickly as possible. This should be done in the knowledge that sufficient capacity can be built up in the meantime to be able to deploy in the incident tube later.

5 Some practical tips

While developing the operational action perspectives, we learned about various practical tips which have not been included in the action perspectives due to the high level of detail. However, because they can be of real value to the officer-in- charge during fighting fires, they have been listed below.

No	Tip
1	Use the emergency telephone in the support tube for a final update from the Traffic Control Centre on the development of the fire.
2	Communication in the incident tube can take place via C2000 (a tunnel is a 'special coverage location' (SCL)) or via the support station cabinet. The 'direct mode of communication' does not work between the two traffic tubes because of the concrete dividing wall.
3	The number of the same escape door may be different in the support tube than in the incident tube.
4	When the fire has been located, also look briefly into the incident tube through a door downwind to see if there are any vehicles with persons in them.
5	In the case of liquid fires and extinguishing activities, consider the run-off of the liquids both downwards over the carriageway (due to the gradient of the carriageway) and to the side of the carriageway (due to the cambering of the carriageway).
6	In case of extreme fires, also consider cooling the environment/structure.
7	When ventilation is no longer required, ask the tunnel manager to turn it off. This will considerably reduce the noise in the incident tube and make communication easier.

Reading list

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Annex 1 Visualisations of key concepts

Visualisation of a tunnel

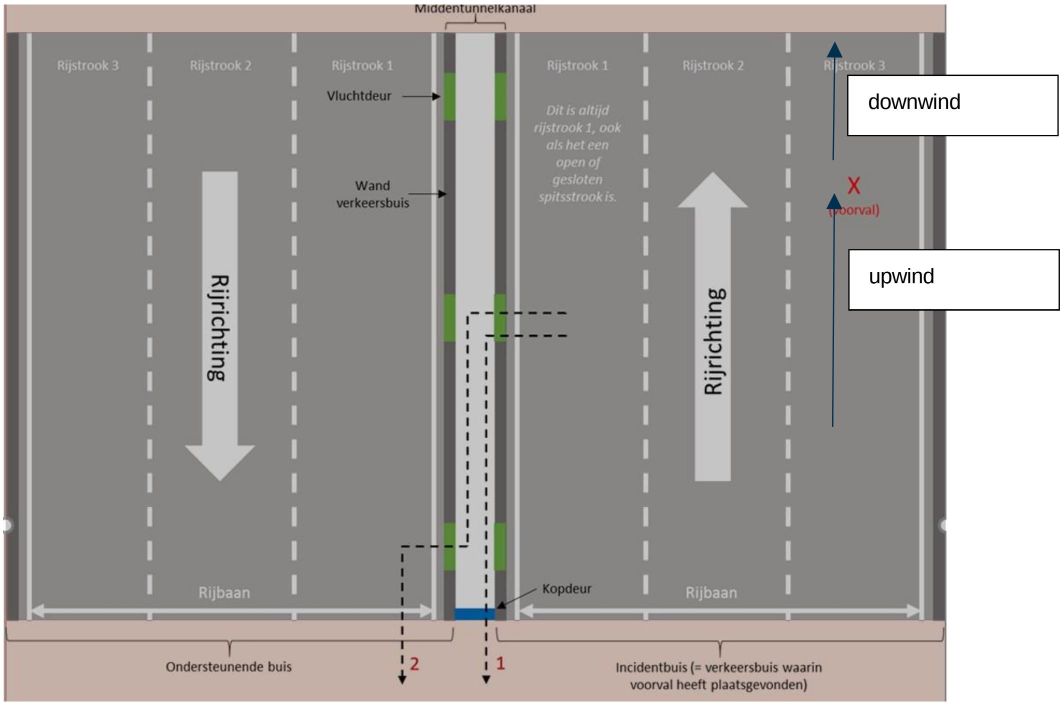

Figure B 1.1 Tunnel with central tunnel channel, support tube and incident tube, downstream and upstream of the accident

Visualisations of exposed reinforcement and concrete spalling

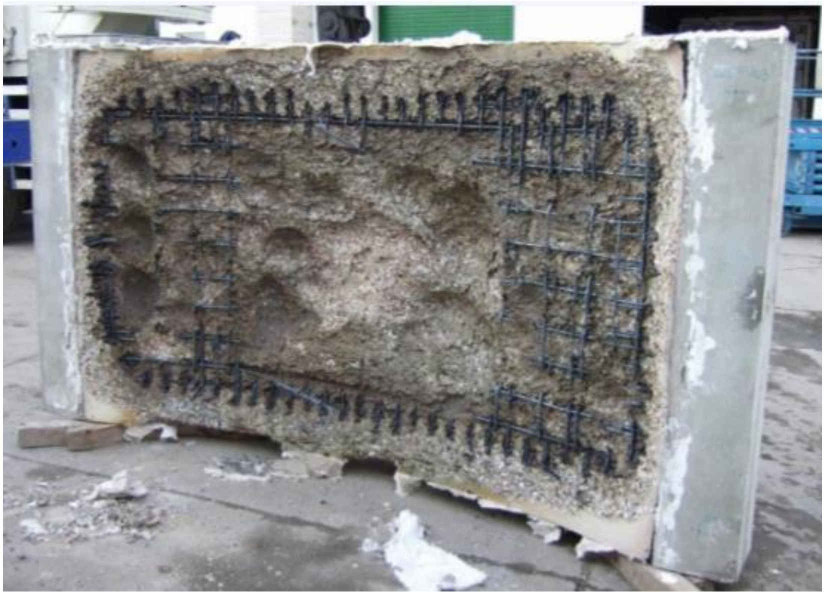

Figure B 1.2 Exposed reinforcement. Photo: MFPA Leipzig GmbH

Figure B 1.3 Concrete spalling in the Victory Boogie Woogietunnel (The Hague).
Photo: Frank Haring (project organisation Rotterdamsebaan)

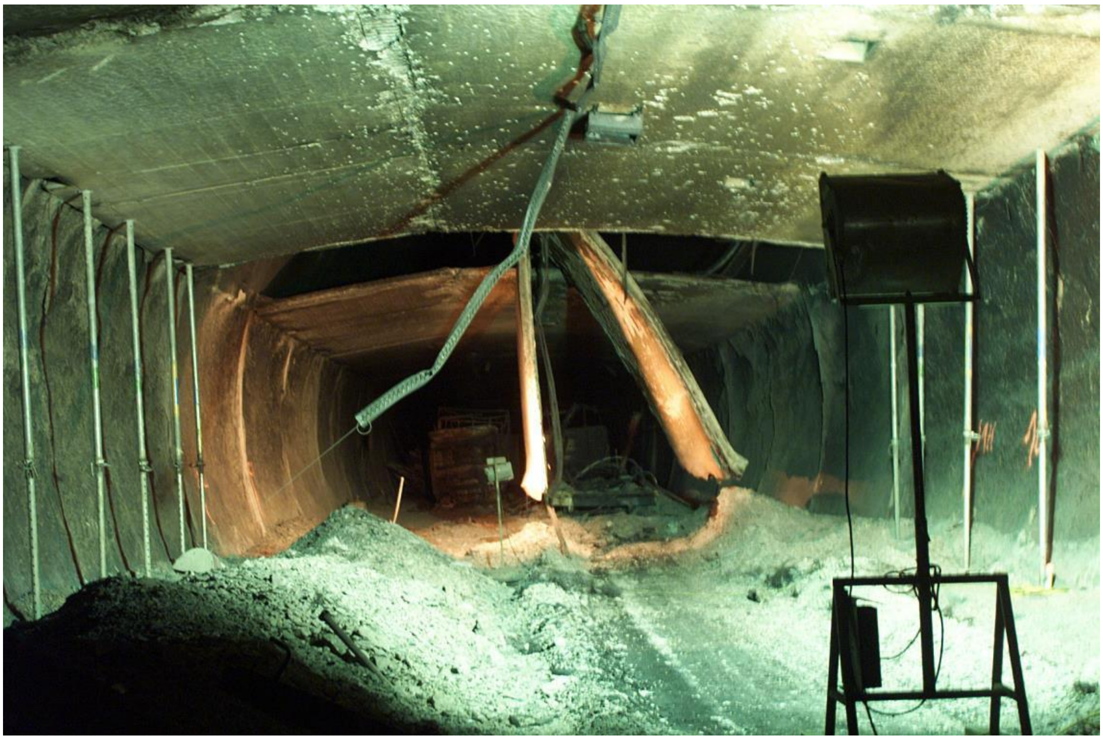

Figure B 1.4 Indication of concrete spalling: chunks of concrete on the road surface.
Photo: www.neumayr.cc

Annex 2 Fire capacities and visualization

This annex consists of two parts. The first part deals with fire capacities and the second part with visualisations that can be used to estimate the size of the fire.

Part 1

There are various tables with fire capacities for different vehicle fires in tunnels. Based on those sources, some ranges of fire capacities and the time it takes to reach peak capacity are presented below. These figures are only intended as a guide for the officer-in-charge.

Table B 2.1 Summary of key figures from the literature on tunnel fires

Vehicle	Fire capacity (MW)	Time to peak capacity (minutes)
Passenger car	5-10	10
Multiple passenger cars	10-20	20
Delivery van	15-30[8]	10
Bus	45-60	15
Lorry including load	50-150	15
Tanker with flammable liquid	200+	??

Below are the data on which the above table is based.

[8] Based on Cheong, Spearpoint and Fleischmann (2008).

Table B 2.2 Fire capacities used by NFPA 502

	Experimental HRR		Representative HRR	
Vehicle	Peak HRR (MW)	Time to peak HRR (mins)	Peak HRR (MW)	Time to peak HRR (mins)
Passenger car	5-10	0-54	5	10
Multiple passenger cars	10-20	10-55	15	20
Bus	25-34	7-14	30	15
Heavy lorry	20-200	7-48	150	15
Tanker with flammable liquid	200-300	-5	300	-

NFPA 502 uses the above values, based on fire experiments, as guidelines for fire capacities (HRR=heat release rate, in megawatts (MW)) and the moment of reaching peak capacity (Peak HRR, in minutes (mins)).

Table B 2.3 Fire capacities according to Oosterveld (University of Twente, 2013)

Vehicle		Fire capacity
Passenger car		5 and 10 MW
Lorry		25, 50 and 100 MW
Tanker	Small pool fire	50 MW
	Medium pool fire	100 MW
	Large pool fire	200 MW

Oosterveld compiled the above table of fire capacities on the basis of a literature study.

Table B 2.4: Fire capacities according to Rosmuller (2017)

Tunnel	Type of fire	Fire capacity (max MW)	Fire capacity (average MW)	Source
Mont Blanc (1999)	Lorry with margarine and dozens of vehicles	180	75-100	PIARC 2006
Tauern (1999)	Multiple collision with lorries (spray cans) and dozens of passenger cars	120	approx. 90	PIARC 2006
Heinenoord (2014)	Lorry with salt-laden drums on pallets	65	50-60	Efectis 2015

Rosmuller (2017) has listed the fire capacities of some exceptional fires based on related reports.

Part 2

Visualisations can help the officer-in-charge to estimate the size of the fire. Below are two photos of tunnel fires, the first with a passenger car on fire and a fire capacity of between 5 and 10 MW and the second with a lorry on fire and a fire capacity of more than 200 MW.

Photo: Erwin van der Lem, District8

Photo: ANP/EPA PHOTO KEYSTONE/CANTONSPOLIZEI TESSIN/MAI-hh

Figure B 2.5 Visualisation of fire capacities