VdS VERLAG

Leaflet on

Fire Protection in Road Tunnels

GDV DIE DEUTSCHEN VERSICHERER

IBS

SCHUTZ HAUS Institut für technische Sicherheit

SICHERHEITSINSTITUT

VdS 3502en : 2005-08 (01)

This **D-A-CH** leaflet is jointly published by

- Gesamtverband der Deutschen Versicherungswirtschaft e.V. (GDV),
- Institut für Brandschutztechnik und Sicherheitsforschung GmbH, Austria,
- Institut für technische Sicherheit – SCHUTZHAUS, Austria,
- Sicherheitsinstitut, Switzerland.

1 General

Fire detection and fire fighting systems in tunnels can help to prevent catastrophic loss, caused either by the fire itself or by the resulting smoke, through early fire detection and fire fighting. Their aim is to facilitate

- the escape and rescue of persons,
- fire fighting and
- the protection of the structure.

Notwithstanding, a protection concept should consider all safety measures, such as smoke extraction, monitoring, escape and rescue routes (appropriate safe rooms), lighting, and should adjust these measures to the hazard. Even after the installation of a fire detection and fire fighting system the services of a well-equipped fire brigade with a short attendance time are essential for effective loss limitation. This leaflet provides concepts based on the protection objectives to prevent fire propagation or fire spread and reduce fire smoke, which make a significant contribution to the protection of life and property

2 Rating basis

The fire detection and fire alarm system (FDAS) shall be designed to meet the specific requirements of tunnels. If an FDAS has been approved on the basis of applicable guidelines, then these shall be included in the planning and installation process.

The relevant national regulations pertaining to tunnels also apply.

If no specific requirements for certain issues are mentioned in this leaflet, the guidelines for water spray extinguishing systems apply, e.g. VdS 2109, Guidelines for water spray extinguishing systems, Planning and installation.

The fire fighting system described below can be universally applied to any tunnel. Any variation of the parameters, however, requires further tests in order to demonstrate compliance with the criteria specified in Cl. 4.5.

The following parameters apply to the design of a fire fighting system in a tunnel:

Minimum density of discharge 15mm/min
Proportioning 3% AFFF foam concentrate minimum
Zone area of operation Tunnel width x 30m (corresponding to one extinguishing section)
Total area of operation 3 x tunnel width x 30m
Operating time of water supply Fire brigade attendance time to the most unfavourable point plus 15 min, but not less than 30 min
Operating time of foam concentrate Fire brigade attendance time to the most unfavourable point plus 15 min, but not less than 30 min *Note: The attendance time shall be agreed with the fire brigade.*
Nozzle protection area 9m²
Time of water discharge No later than 30s after alarm valve has opened
Water supply If pumps are used the water supply shall consist of two pumps with one storage tank or three pumps at 50% with one storage tank.

Note: In the case of three water sources at 50%, each water source shall provide at least the pressure required for the hydraulically most unfavourable area of operation and at least 50% of the water rate required for the hydraulically most favourable area of operation.

Any modification to the density of discharge and the arrangement of nozzles shall be supported by a successful fire test and an evidence test in accordance with Cl. 4.

3 Triggering

The selection of a suitable fire detection and fire alarm system with sufficient spatial resolution shall be in accordance with the specific local conditions inside the tunnel (wind speed, air pollution).

Manual triggering devices shall be provided in the tunnel and at the permanently manned location.

The fire detection and fire alarm system shall have co-incidence detection. Fire alarms shall be indicated at the permanently manned location, with the first alarm alerting only the staff at the permanently manned location. The second alarm would automatically release the fire fighting system.

Any power supply and signal processing equipment used in the fire detection and fire alarm system shall meet the requirements of standard EN 54, depending on the designated place of installation (tunnel and equipment rooms). In addition, the specific installation guidelines of the manufactures of the fire detection and fire alarm system shall be observed, provided that higher requirements have been specified. The response behaviour of the system shall be adjusted to the anticipated fire scenarios in the tunnel in consideration of environmental conditions and particularly of ventilation conditions.

Where several control and indicating equipments (CIE) are used, they shall be connected to the main control and indicating equipment. Any faults of the fire detector(s), and a central signal processing unit (CIE and/or central evaluating processor units as components of a fire detector) shall affect no more than a tunnel section of 1,000 metres. Repair works shall start after no more than 12 hours and be completed after 36 hours. During this period alternative safety measures, such as increased video surveillance, shall be implemented.

The performance of the entire fire detection/fire alarm and fire fighting system (especially of the triggering) shall be tested before commissioning and at least once a year.

4 Test description

Some essential parameters met by the fire fighting system defined in Cl. 2 are listed below. These shall be taken into account when testing a tunnel protection system with different specifications. The below criteria represent a framework for the tests and are not exhaustive.

4.1 Fire object

With regard to flammable materials the setup shall correspond to the material composition and the weight of a lorry trailer with load. The fire load should consist of 12,5% plastics, 87,5% wood and 8 lorry tyres. The material shall be covered by a tarp.

Note: The values have been specified in line with the Eureka project "Fire protection in traffic tunnels" (E!499-FIRETUN). The project involved large-scale fire tests carried out in tunnel systems in Norway between 1990 and 1991 as part of the pan-European research initiative EUREKA to promote technology-oriented, market-related products, processes and services for the global civil market (Source: www.eureka.be).

4.2 Release of the fire fighting system

The test setup shall comprise the designated fire detection and fire alarm system. Thus, the actual system or test-specific detection time is taken into account. In the fire test the fire fighting system is released manually after a predetermined detection time plus half the determined detection time as an additional safety factor. In addition, it is important to note that in the test the time before water discharge shall be at least as long as the maximum permissible time specified in the planning and installation guidelines.

The localisation capability of the detection system shall be sufficiently accurate to reliably locate the seat of the fire for the release of an extinguishing zone.

4.3 Air flow

In the tests longitudinal and transversal flows shall be simulated with their respective maximum flow velocities. The flow velocities simulated in the tests represent the application limits (maximum possible flow velocity in the tunnel).

4.4 Tunnel geometry

The tunnel dimensions (width and height) and its geometric shape (profile) shall be specified for the future area of application.

4.5 Test criteria

The following test criteria distinguish between criteria that predominantly relate to tunnel protection and those that are important for the protection of life.

4.5.1 Criteria for the protection of a tunnel against the effects of a fire

In the tests the release of the fire fighting system shall be specified according to the selected fire detection and fire alarm system as per Cl. 4.2. After no more than 2 min from the release of the fire fighting system the temperature shall be ≤ 50°C at a height of 2m in the centre between the tunnel walls at the end of the extinguishing section. The fire shall not spread to adjacent vehicles. In order to verify this, a stack of wood covered by a plastic tarp shall be placed at a distance of 5m from the extinguishing section in addition to the experimental setup as per Cl. 4.1. It is imperative that the stack of wood does not ignite. In addition, the temperature shall not exceed 350°C at a distance of 5m from the lorry setup after 2 min and 250°C at a distance of 5m after 5 min.

4.5.2 Criteria of fire detection and fire fighting systems for the protection of life

In order to guarantee the protection of life the following criteria shall be met in addition to those specified in Cl. 4.5.1:

- After 30 min of fire fighting at least 25 vol.-% of the standard combustible material shall remain.
- 5 min after release of the fire fighting system the temperature at the point with the highest expected temperature shall be ≤ 500°C below the ceiling. The temperature is measured by means of a thermocouple, which shall be placed at a maximum distance of 0,1m from the ceiling and protected against direct water impact.
- At a distance of 5m from the lorry setup the temperature shall not exceed 150°C after 5 min.
- The heat radiation shall not exceed 5kW/m^2 at the end of the extinguishing section 2 min after release of the fire fighting system [cf. Schönbucher, “Berechnung von Sicherheitsabständen bei Störfällen mit brennbaren Stoffen”, in: Schwere Gase und Sicherheitsanalyse IV, Frankfurt 1991].
- The CO_2 concentration shall be reduced by at least 30% on average (5-minute average value) 2 min from the release of the fire fighting system.

5 Scaling

In the absence of a suitable physical calculation method the test results cannot be applied to other scales. The method shall be validated by large-scale and small-scale tests in consideration of the relevant parameters.

Publisher: German Insurance Association (Gesamtverband der Deutschen Versicherungswirtschaft e.V. - GDV)

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