

Fire-fighting system for car tunnels

Description

The invention relates to a fire-fighting system for tunnels, with a stationary extinguishing apparatus.

5 The increasing number of long tunnels, in particular car tunnels, also increases the risk of fires in the tunnels which, in many cases, can turn into catastrophes. The experience of recent years shows that, within a few minutes, a car fire in a tunnel can generate such great heat that the fire spreads to neighbouring cars and a major conflagration develops. The heat generated in the process and the conflagration gases that develop have an effect on persons inside the tunnel concerned which is extremely dangerous to health and is
10 often even fatal. The tunnel-fire catastrophes of 1999 not only frightened the public and the authorities, but also showed that no plans or even systems currently exist for combating such catastrophes. For this reason, the tunnel operators are being urged to retrofit existing tunnel facilities with active fire protection and to include such systems in the planning of new facilities, "active fire protection" being understood to mean an
15 extinguishing system coupled to a fire alarm.

The sprinkler technology installed hitherto in some few cases of application has not proved successful. At wind speeds of more than 2.5 m/sec, such as are caused in any case by the tunnel ventilation, automatic sprinklers trigger too late and, even then, often
20 in the wrong place. When the sprinklers open too late, however, no extinguishing takes place and, as a result of the intensive vaporisation of water, a reduction in visibility and powerful heating-up of the waste air occur, and this leads to problems in evacuation. In addition, the large quantities of extinguishing water cause pools of combustible liquid which spread in an uncontrolled manner. It is also becoming apparent that sprinkler-type
25 extinguishing has little effect on the seat of the conflagration, since the fire is protected by the body of the car and is sheltered from the spray. At the same time, the wind fans the fire powerfully and blows the drops of water away.

30 The most recent safety analyses concerning tunnel fires therefore call for the following protection targets:

- reduction of the intensity of the fire at the point of conflagration,
- cooling of the area surrounding the point of conflagration,
- cooling of the conflagration gases inside the extinguishing zone to below 50°C,
- prevention of the fire from spreading to neighbouring vehicles,
- 5 • washing-out of the aerosols in the smoke, in order to guarantee an adequate range of visibility.

10 These protection targets are intended to make it possible for the persons concerned in the region of the conflagration to have sufficient time and clarity of vision to reach safety, and for the operational forces (fire brigade) to be able to move forward to the point of conflagration without being endangered.

15 The intention is now to indicate, by means of the invention, a fire-fighting system for tunnels, in particular car tunnels, which fulfils the aforesaid protection targets to the greatest possible extent.

20 The object set is achieved, according to the invention, through the fact that the stationary extinguishing apparatus is constituted by a locally activatable water-spray extinguishing apparatus which has a main supply line and a water reserve, the said water reserve being constituted by the said main supply line.

25 The locally activatable extinguishing apparatus is the prerequisite for being able to keep the consumption of extinguishing medium, and thereby the reserve of the latter, within limits, and for the water-spray extinguishing apparatus attaining an extinguishing capability which is sufficient for extinguishing, or at least containing, a car fire. The provision of a water reserve by the main supply line makes it possible to dispense with large and expensive water tanks in long tunnels.

30 The fire-fighting system according to the invention is so designed that the fire can be contained until intervention by the fire brigade is possible. For the reason the fire catastrophes initially mentioned assumed catastrophic proportions was not least because it was impossible, on account of the heat in the tunnel, for the fire brigade to advance even into the mere vicinity of the seat of the conflagration.

35 A first preferred form of embodiment of the fire-fighting system according to the invention is characterised in that the tunnel to be protected is subdivided into extinguishing sectors with a minimum length of 25 to 30 m.

A second preferred form of embodiment of the fire-fighting system according to the invention is characterised in that the water-spray extinguishing apparatus has nozzles connected to the main supply line via sector valves, and a gas pressure reservoir for a propellant gas for delivering the water to the said nozzles.

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A third preferred form of embodiment of the fire-fighting system according to the invention is characterised in that a detection apparatus for locally precise fire detection is provided, and that, when the said detection apparatus responds, activation of the water-spray extinguishing apparatus takes place in the extinguishing sector concerned and in the two immediately adjoining extinguishing sectors.

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A fourth preferred form of embodiment of the fire-fighting system according to the invention is characterised in that the water reserve has a water-holding capacity for a 30 minute extinguishing operation in the aforesaid extinguishing sectors.

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A fifth preferred form of embodiment of the fire-fighting system according to the invention is characterised in that the main supply line is divided up into a number of parallel lines between which there is a hydraulic link at at least one point.

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A sixth preferred form of embodiment is characterised in that a gas pressure reservoir is provided at each of the two ends of the main supply line, and that the two gas pressure reservoirs can be used selectively.

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Another preferred form of embodiment of the fire-fighting system according to the invention is characterised in that the detection apparatus is constituted by a linear heat-signalling system with a detection cable mounted on the tunnel ceiling, or by a video-type smoke-detection system.

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The water-spray extinguishing apparatus is preferably designed in such a way that a higher nozzle pressure is available at the beginning of an extinguishing operation than after a time interval of 5 to 10 minutes has elapsed.

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The invention will be explained in greater detail below with the aid of an exemplified embodiment which is represented in the single drawing; the latter shows a diagrammatic overall representation of a tunnel 1 equipped with a fire-fighting system which consists of a fire-detection apparatus and an extinguishing apparatus. The fire-detection apparatus is a linear heat-signalling system of the Fibrolaser type (Fibrolaser is a

registered trademark of Siemens Building Technologies AG, Cerberus Division, formerly Cerberus AG), which substantially consists of a glass fibre cable 2 mounted on the ceiling of the tunnel 1 and a measuring instrument 3 containing a laser light source and an optoelectronic receiver.

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The light generated by the laser is coupled into the glass fibre cable 2 and guided in the longitudinal direction thereof. Fluctuations in the density of the quartz glass give rise to continuous scattering (Rayleigh scattering) which in turn gives rise to attenuation of the laser light. In addition, further scattering of the light, so-called "Raman scattering", occurs as a result of thermal grid fluctuations of the glass material.

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A fraction of the scattered light drops into the aperture angle of the waveguide and is diffused in both the forward and backward directions. The scattered light can be detected with a photodetector; the local temperature of the glass fibre can be determined by evaluating the intensity of the scattering. Local analysis of the temperature profile along the glass fibre cable 2 takes place by measuring the attenuation of the waveguide light. The magnitude of the fire is a function of the length of cable heated up: a short heated-up length corresponds to a small fire and a long heated-up length corresponds to a large fire.

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The signal from the optoelectronic receiver is processed and evaluated in the measuring instrument 3. The evaluating unit 3 is connected to a system control centre 4 in which central control of the fire-fighting system takes place. The system control centre 4, which obviously does not have to constitute a structural unit, is linked to both the fire-detection apparatus and the extinguishing apparatus. In addition, there is a link from the system control centre 4 to a tunnel control centre 5 in which all the control systems and monitoring systems of the tunnel 1 converge and the necessary announcements take place and the necessary actions are triggered. Examples of such actions are traffic regulation, controlling the ventilating system, controlling the emergency lighting, controlling an evacuation system and informing the persons in the tunnel via acoustic and/or optical means, such as illuminated panels or loudspeakers. The tunnel control centre 5 has a link to the operational forces in order to be able to alert them in the event of deployment. There is likewise a link from the system control centre 4 to the fire brigade for automatically alerting the latter in the event of a fire.

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Alternatively, the fire-detection apparatus may be constituted by a video-type smoke-detection system which has a number of video cameras 6, of which only one is represented in the drawing. Video cameras of this kind, such as are installed in most

tunnels for monitoring traffic, can be modified in such a way, by means of a suitable processor and suitable signal-processing, that automatic smoke-detection is possible with the aid of the video image. Suitable systems are described, for example, in US-A-5 237 307 and in WO 00/23858, the disclosure in which is hereby expressly referred to. The video cameras 6 are likewise linked to the system control centre 4. The video-type smoke-detection system triggers an alarm in the event of a fire in just the same way as the linear heat-signalling system 2. This alarm is verified by the operator in the tunnel control centre 5, something which is possible in a simple manner with the aid of the images from the video cameras 6, and extinguishing is then triggered. It is also possible, after a certain delay of, for example, 90 to 120 seconds after the responding of the fire-detection system, to trigger automatic extinguishing if no reaction has taken place in the tunnel control centre 5 during this delay.

The extinguishing apparatus is a so-called "water-spray" extinguishing apparatus with nozzles 9 for spraying a mist of fine water drops, which nozzles are connected to a main supply line 8 via opening fittings referred to as "sector valves" 7. The sector valves 7 can be actuated individually via a control line 14 connected to the system control centre 4. The main supply line 8 is connected to a water reserve, for example a water tank. As the motive agent for delivering the water to the nozzles 9, use is made of a gas pressure reservoir 10 which consists of a number of high-pressure gas cylinders 11 in which, for example, nitrogen or air is stored at a pressure of 200 bar. However, large gas tanks at lower pressures may also be used.

The high-pressure gas cylinders 11 are connected via valves 12 to a pressure line leading to the water-reserve apparatus. This pressure line contains a throttle 13 by means of which the delivery pressure in the pressure line, and thereby also in the main supply line 8, is throttled to an optimum nozzle pressure. A water-spray extinguishing apparatus of this kind is described in European Patent Application No. 00 97 647.7, the disclosure in which is hereby expressly referred to. The sector valves 7 and the valves 12 can likewise be actuated via the control line 14.

In the case of long tunnels, the protection targets called for can only be achieved if each tunnel tube is subdivided into so-called "extinguishing zones" in which local extinguishing can be triggered. For without such extinguishing zones, it would be necessary to supply long sections of tunnel with water simultaneously, something which would drive up the water consumption too much. Extensive tests have shown that the most suitable length for such an extinguishing zone is about 30 m. When extinguishing

takes place, three extinguishing zones are always supplied with water, namely the alarm region and the two immediately adjoining extinguishing zones in front and behind.

In the case of tunnels with a length of more than 2 km, the entire reserves of water are stored in the main supply line 8, which is filled with chemically pretreated water (addition of wetting AFFF water additives) and is held in readiness as a reservoir. An equalising vessel 15 with a volume of about 2 m³ is disposed between the main supply line 8 and the throttle 13. The diameter of the main supply line 8 is preferably about 300 to 400 mm, so that around 100 m³ of water can be stored per kilometre. The reserves of gas in the gas pressure reservoir 10 are designed in such a way that the necessary quantity of water is available for 30 minutes in the three extinguishing zones activated. This arrangement has the advantage that a higher nozzle pressure is available at the beginning of inundation than after about 5 minutes. As a result of this, a fire is fought with more water at the outset than during the holding phase until the operational forces arrive. The nozzle pressure at the beginning of inundation is, for example, 9 bar, and the holding pressure about 5 bar. In the three extinguishing zones activated, all the nozzles 9 are always supplied with water simultaneously.

So that, during inundation, the gas flowing in does not displace the water present in the main supply line 8 in the region of the opened valves 7, the connections of the said valves 7 are fitted at the bottom of the main supply line 8. This arrangement guarantees that it is always water and not, for instance, gas that is forced to the nozzles 9. As additional security, it is recommended that there be erected, at each of the two ends of the main supply line 8, a gas pressure reservoir 10 which is capable of carrying out inundation independently of the other one. The second gas pressure reservoir might be used in the event of the operational forces intervening too late. In an extinguishing operation, it is advantageous to always start up the gas pressure reservoir 10 which is further removed from the extinguishing zones activated.

The main supply line 8 can be divided up over a number of parallel pipes with a smaller diameter. These must be linked to one another hydraulically at one or more points within the course of the tunnel. As a result of these hydraulic links, it is possible to prevent the line from running dry in the region of the extinguishing zones activated. The division of the main supply line 8 into a number of parallel lines is particularly recommended in tunnels with gradients.

- 5 Instead of a water-spray apparatus, it is obviously also possible to use a sprinkler apparatus, possibly with additional fine-spraying nozzles. Compared with sprinkler apparatuses, however, water-spray apparatuses possess a series of advantages which make them appear more suitable, particularly for use in car tunnels. These advantages consist mainly in the high extinguishing capability, in the effect of the extinguishing water on the seat of the conflagration, and in the fact that the water-spray apparatus triggers at the right place, under which circumstances the conflagration gases escaping are intensively washed out and cooled, at least over the length of a protection zone.

Patent claims

1. Fire-fighting system for tunnels, with a stationary extinguishing apparatus, characterised in that the stationary extinguishing apparatus is constituted by a locally activatable water-spray extinguishing apparatus (7 - 13) which has a main supply line (8) and a water reserve, the said water reserve being constituted by the said main supply line (8).
2. Fire-fighting system according to claim 1, characterised in that the tunnel (1) to be protected is subdivided into extinguishing sectors with a minimum length of 25 to 30 m.
3. Fire-fighting system according to claim 1 or 2, characterised in that the water-spray extinguishing apparatus (7 - 13) has nozzles (9) connected to the main supply line (8) via sector valves (7), and a gas pressure reservoir (10) for a propellant gas for delivering the water to the said nozzles (9).
4. Fire-fighting system according to claim 2, characterised in that a detection apparatus (2, 3; 6) for locally precise fire detection is provided, and that, when the said detection apparatus (2, 3; 6) responds, activation of the water-spray extinguishing apparatus (7 - 13) takes place in the extinguishing sector concerned and in the two immediately adjoining extinguishing sectors.
5. Fire-fighting system according to one of claims 1 to 4, characterised in that the water reserve has a water-holding capacity for a 30 minute extinguishing operation in the aforesaid extinguishing sectors.
6. Fire-fighting system according to one of claims 1 to 5, characterised in that the main supply line (8) is divided up into a number of parallel lines between which there is a hydraulic link at at least one point.
7. Fire-fighting system according to claim 3, characterised in that the connections of the sector valves (7) to the nozzles (9) are fitted at the bottom of the main supply line (8).



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8. Fire-fighting system according to one of claims 3 to 7, characterised in that a gas pressure reservoir (10) is provided at each of the two ends of the main supply line (8), and that the two gas pressure reservoirs (10) can be used selectively.
- 5 9. Fire-fighting system according to one of claims 4 to 8, characterised in that the detection apparatus is constituted by a linear heat-signalling system (2, 3) with a detection cable (2) mounted on the tunnel ceiling, or by a video-type smoke-detection system (6).
- 10 10. Fire-fighting system according to claim 5, characterised in that the water-spray extinguishing apparatus (7 - 13) is preferably designed in such a way that a higher nozzle pressure is available at the beginning of an extinguishing operation than after a time interval of 5 to 10 minutes has elapsed.
- 15 11. Fire-fighting system according to claim 10, characterised in that the nozzle pressure at the beginning of an extinguishing operation is about twice as high as after the aforesaid time interval has elapsed.

