TUNNEL SAFETY:
WATER MIST FIRE SUPPRESSION SYSTEM
IN AN AUSTRIAN ROAD TUNNEL

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ABSTRACT

The first road tunnel equipped with a water mist fire suppression system is operated in the city of Linz to increase the level of safety in terms of minimising the consequences after a potential tunnel fire. Prior to this first installation this innovative fire protection system was tested and certified by notified institutes of the European Community.

Aquasys Technik GmbH, from Linz, Austria, has developed and designed a water-mist system for efficient fire fighting in tunnels. The main objection for this innovative fire suppression system was to utilise and optimise the specific properties and advantages of water mist as a fire suppression agent, which we already successfully utilised in other applications, for the very specific requirements of tunnels to significantly improve safety and property protection in case of a fire there.

The tunnel fires of Mont Blanc, Tauern and Gotthard obviously demonstrated the main problem of fighting a fire in a tunnel: the rapid fire developed to a size where the extreme temperatures within the tunnel hindered the fire brigade from access to the scene.

From these experiences the objective of a water mist system in tunnels were derived in cooperation with leading experts: Quick response to the outbreak of a fire by suppressing the fire in the earliest possible emerging stage in order to prevent temperature from rising to dangerous dimensions to protect persons and tunnel structure and to limit the development of smoke by preventing the spread of the fire. Additionally the water mist system provides a significant benefit to the fire brigade when entering the tunnel for extinguishing the source of the fire. The only way to comply with this objective is to install the water mist system directly within the tunnel.

Due to our philosophy of empirical evidence, we decided to demonstrate the specific properties of water mist, which in no way are comparable with the properties of sprinklers, in full scale tests. For that reason Aquasys contracted the erection of a 200 m tunnel in the size of a two lane motorway. In this tunnel a ceiling, a smoke exhaust system and the Aquasys water mist system were installed, and a number of full scale fire tests with a fully loaded truck (HGV semi-trailer) mock-up were carried out there.

The official full scale test programme was then conducted by two notified bodies, the IBS (Institut für Brandschutzechnik und Sicherheitsforschung GmbH) Austria and the VdS GmbH (former: Verband der Schadenversicherer) Germany. The test programme comprised a series of full scale fire tests at different longitudinal wind speeds and was successfully passed! This validated and certified water mist system for suppression of tunnel fires was then applied to an Austrian road tunnel in the city of Linz.

Key words: water mist, tunnels, fire suppression, tunnel safety
1. WATER MIST IN ROAD TUNNELS

1.1. Basics of water mist

Water mist as ejected from specific designed nozzles consists of tiny water droplets properly distributed at the scene of the fire. These fine dispersed water droplets provide an immense water surface in the area of the fire which results in an improved heat transmission from the fire to the water. As a consequence the water mist is evaporated with high efficiency due to the heat release of the fire. The two main effects of this optimised evaporation, which are responsible for the efficiency of fire suppression by use of water mist are: the expansion of the vapour on the one hand and the energy demand of the evaporation process on the other hand.

When evaporated water expands its volume, which leads to an oxygen depletion in the immediate vicinity of the fire and which subsequently could suppress the fire. Beside this physical fact water also needs energy input for the evaporation process. This energy demand can be covered by the thermal energy of the fire, which leads to a high efficient cooling of the environment around the fire. It is the simultaneous presence of both effects which causes the high efficiency of water mist for fire suppression.

1.2. Safety in road tunnels

In times where traffic increases every year the potential danger to each passenger is rising significantly, especially in confined spaces as tunnels are. An accident in a tunnel leads to a stand still of traffic in the tunnel, which results to an accumulation of persons at the area of danger. If fire is involved at such an accident a life threatening situation for all passengers emerges.

The tunnel fires of Mont Blanc, Tauern and Gotthard obviously demonstrated the main problem of fighting a fire in a tunnel: the fire developed to a size where the extreme temperatures within the tunnel hindered the fire brigade from access to the scene.

From these experiences the objective of a water mist system in tunnels were derived together with a number of experts: Quick response to the outbreak of a fire by fighting it already in it’s emerging phase in order to prevent temperature from rising to a dangerous dimension to protect persons and tunnel structure and to limit the development of smoke by prohibiting the fire to spread. Additionally this helps the fire brigade to enter the tunnel to extinguish the source of the fire.

The only way to comply with this objective is to install the water mist system directly within the tunnel.

Such a water mist system can easily be activated by a proper tunnel fire detection as available on the market and provides following advantages:

As a consequence the impact to persons and to the tunnel construction due to a fire accident will be appreciably reduced and the break of operation of the tunnel due to subsequent damages of such accident will be minimised.
1.3. Configuration of the water mist system in the tunnel

The Aquasys water mist system is installed inside the tunnel and consists of:

- pumping units outside the tunnel (at the portal),
- a main line throughout the entire length of the tunnel,
- nozzle lines installed under the ceiling of the tunnel and a
- control unit, which also provides the interface to the detection system.

2. CERTIFICATION OF THE AQUASYS WATER MIST FOR TUNNELS

2.1. Certification Tests

Due to our philosophy of empirical evidence, we decided to demonstrate the specific properties of water mist which in no way are comparable with the properties of sprinklers, in full scale tests. For that reason Aquasys contracted the erection of a two lane motor way tunnel, meaning approximately 10 m with, nearly 5 m height of the ceiling and 200 m long. Additional to the water mist system this tunnel is also equipped with a smoke exhaust system to simulate conditions as applicable in a real operational tunnel.

In this tunnel a full scale HGV mock-up was placed, entirely loaded with timber pallets and 12.5 % shredded plastics. For monitoring the conditions in the tunnel during a full scale HGV fire an array of numerous temperature sensors were distributed in the tunnel. Additionally a certified fire detection was installed to simulate the fire alarm conditions in reality.

In the year 2001 a series of full scale fire tests with a fully loaded truck (HGV) mock-up were carried out in this test tunnel at different longitudinal wind speeds with the objection to prove the efficiency of water mist for fire protection of tunnels. This official full scale test programme was conducted by two notified bodies, the IBS (Institut für Brandschutztechnik und Sicherheitsforschung GmbH) Austria and the VdS GmbH (former: Verband der Schadenversicherer) Germany.

The result of the full scale fire test programme was, that the Aquasys water mist system successfully passed all criteria as required by the notified testing institutes.

These criteria were:

- successful prevention of spread of the fire
- providing access to the scene for the fire brigade to finally extinguish the fire, which was the main problem of the tunnel fires in the past
- protecting the tunnel structure and prevent the concrete from spalling

By issue of the according certificates the notified bodies VdS Germany and IBS Austria documented that all criteria of the fire tests were successfully passed and that a water mist system is state of the art technology for fire protection in tunnels.
3. APPLICATION OF WATER MIST SYSTEMS IN TUNNELS

The validated and certified water mist system for the protection of road tunnels is already applied in an Austrian tunnel in the city of Linz. This tunnel is a two lanes bi-directional tunnel, one lane each direction and equipped with longitudinal ventilation without intermediate ceiling.

The water mist system consists of a machinery room outside the tunnel where the pump units and the control system are installed. Inside the tunnel the main-line is installed in order to transport the water throughout the entire length of the tunnel. At this mainline the section valves are located which activate the respective fire suppression section of the tunnel. These fire suppression sections cover an area of about 30 m each. Which section valve to be opened in case of a fire is controlled by the fire detection system.

With installation of the water mist fire protection system the safety level of this tunnel is considerably improved.

Beside the just presented application of water mist for protection of road tunnels, such system can also be used for fire protection inside a railway tunnel:

Back in 1996 a truck on a freight shuttle train in the 50km long Channel Tunnel between France and Great Britain caught fire. The fire lasted 7 hours and destroyed ten trucks, half of the shuttle train and damaged the channel tunnel in a way that the repair took six months and the resultant loss of income was about 300 Millions Euro.

As a consequence Eurotunnel undertook an extensive research programme to improve asset protection in the event of a fire in the tunnel. This included wind tunnel tests in France, and tests with real fires inside a purpose-built wind tunnel in Northern England. Those tests clearly showed the technical superiority of the water mist technology.

As a result Eurotunnel decided to equip its fleet of freight shuttle trains with an on-board–fire-fighting–system from Aquasys which is installed directly on the HGV-carrier- wagons for a quick and efficient response in case of a truck fire.