FIRE FIGHTING SYSTEM FOR TUNNELS –
A REPORT ABOUT THE PRACTICAL EXPERIENCE
WITH OUR WATER MIST TUNNEL SYSTEM

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ABSTRACT

Aquasys Technik GmbH, from Linz, Austria, has developed and designed a water-mist system for efficient fire fighting in tunnels. The main target for this research and development project was to optimise the specific properties and advantages of water mist as a fire suppression agent, which we already successfully utilised in other applications, to 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 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 its 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.

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 an intermediate ceiling, a smoke exhaust system and the Aquasys water mist system were installed.

In the course of the year 2001 we performed a number of full scale fire tests with a fully loaded truck (HGV) mock-up in this test tunnel. After having further optimised the water mist system due to the large experience gained from those optimisation the 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 test programme comprised three tests at different longitudinal wind speeds (2 m/s, 5 m/s, 6.5 m/s) whith the water mist system being activated three minutes after detection by an approved detection system and one test where the water mist system was activated after the complete HGV was on full fire. The whole test programme was successfully passed!

Details will be given on the lay out and performance of the system at those test series.

Key words: water mist, tunnel fire, full scale tests, tunnel protection
1. WATER MIST IN TRAFFIC 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 by the factor 1.675, this leads to an oxygen depletion in the immediate area of the fire and subsequent suppression of 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 Traffic 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.

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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 at each portal,
- a main line through the total 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. TEST PROGRAMME OF THE AQUASYS FIRE TEST SERIES

2.1. Test Arrangement

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, about 4,80 m height of the intermediate 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 120 temperature sensors distributed in the tunnel and a few of them in the exhaust ducts and inside the concrete. Additionally two different types of fire detection systems were installed to simulate the real time fire alarm.

Last but not least five mobile ventilation units were placed in the tunnel to provide wind speeds up to 8 m/s in the tunnel during the various tests.

2.2. Test Procedure

In the course of the year 2001 we performed a number of full scale fire tests with a fully loaded truck (HGV) mock-up in this test tunnel After having further optimised the water mist system due to the large experience gained from those optimisation the 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 tests started with the ignition of the mock-up by using a small pool fire within the load and the development of the fire until the detection system provided the fire alarm. After a delay (intervention time) of another three minutes the water mist system was activated and subsequently operated for 33 minutes, as it was assumed that within this time span the fire brigade of a real tunnel should be able to reach the scene.

The certification tests according to the above test procedure were conducted at different wind speeds of approximately 2 m/s, 5 m/s and 6.5 m/s.
Additional to above described test series, the notified testing institutes also required a full scale fire test with delaying the activation of the water mist system not before steady state conditions, which is the worst case with temperatures in the tunnel up to 800 °C.

2.3. Test results

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

These criteria were:

- max. 250°C in a distance of 5 m from the burning HGV to prove that spread of the fire can be successfully prevented (actually the temperatures as measured at this distance were in the range of 50°C!!).
- max. 50°C in a distance of 20 m from the fire to prove that the scene can be accessed by the fire brigade to finally extinguish the fire.
- less than 100°C at 10 mm within the concrete structure of the ceiling to prevent the concrete from spalling (the actual temperature increase of this probe was about 4-5°C at the most).

3. WATER MIST IN RAIL TUNNELS

Beside the just presented empirical evidence from the test programme for Traffic Tunnel Application, also rail tunnels can be protected by a Water Mist System.

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.