HI-FOG DEMONSTRATION AT TST, SAN PEDRO DE ANES
FEBRUARY 15 AND 16, 2006

Dipl. Ing. Uwe Klinkhardt. 1
Mariaff GmbH

ABSTRACT

During December 2005 – February 2006 Marioff Corporation Oy conducted an extensive set of over 40 full-scale fire tests in the San Pedro test tunnel. Official parts of the test series were witnessed by the following third party organizations: CEMIM (concentrating mainly in ventilation issues) / Spain, AFITI-LICOF / Spain, Hughes Associates Inc / USA and SP (Swedish Testing and Research Institute) / Sweden.

Three different HI-FOG configurations were evaluated:

- a deluge-type water mist system consisting of open spray heads only,
- a hybrid system consisting of both open spray heads and automatic, thermally activated water mist nozzles, and
- a water mist sprinkler system consisting of automatic, thermally activated nozzles only.

In all configurations the water flux density at the fire location was about the same (i.e. the suppression and control efficiency is the same), whereas the water flux density outside the exact location varied. All three systems were divided in zones of 32 m length.

A considerable safety factor was involved in all the tests. A real HI-FOG System for tunnel would be dimensioned for three full zones for a certain minimum pressure. Most of the tests, however, were run with only one zone open at the minimum pressure, as compared to three zones at the minimum pressure or one zone at a considerably higher pressure.

Different fire scenarios were tested, ranging from passenger vehicles fire up to catastrophic truck-type fires involving wood and plastic. It is worth noting that plain pool fires represent real tunnel fires, which – to the most part – involve solid, Class A materials and have a potential to an ultra fast fire growth practically without an upper limit for heat release rate.

The primary result of the testing was:

1) without the HI-FOG system the fire would have been out-of-control just within a few minutes after it had properly ignited
2) with the HI-FOG system the temperatures in the tunnel were instantaneously and dramatically dropped down to non-damaging levels,
3) the fire was immediately under control and got suppressed during the discharge, and
4) the fire spread was stopped within the ignited vehicle or from jumping from vehicles to vehicle

All official tests are described and evaluated in detail by the third-party organizations in separate test reports.
1. DEMONSTRATION TESTS

1.1. Demonstration test 150206

Two demonstration tests were conducted on Feb 15 and 16, 2006, the other one simulating a fire involving passenger vehicles, the one simulating a lorry. In the fire test, the HI-FOG deluge-type water mist system was applied. In the second test the HI-FOG hybrid-type water mist system was demonstrated.

For safety reasons, the demonstrations were run with relatively short preburn times and a full discharge time of 20 min. For comparison, corresponding temperature results of official tests with longer preburn and discharge times are included in the description on the following pages.

Figure 1+2: Fuel package (real car + 2 x 12 x 9 pallets on the floor level + target cars)

Figure 3+4: Freeburn demo test 150206 – abt 2 min 30 s
official test 230106 – 5 min 11 s
official test 240106 – 7 min 11 s
Ceiling temperature along the tunnel
(red curve – above ignition, orange curves – downstream, blue curves – upstream)

Figure 5: Official test 230106

Figure 6: Official test 240106

Figure 7: Official test 150206

- The effect of different preburn times is seen in the ceiling temperature before activating the HI-FOG system: the longer the preburn time, the higher the ceiling temperature.

- The trend after activating the HI-FOG system is clear: there is an abrupt drop in temperatures immediately after HI-FOG activation. Just above the fire it takes longer to stabilize the temperatures to lower values.

- The differences in the curve of different test just reflect that full scale fire tests are never totally repeatable, but the overall performance is the same.

Temperatures within a cross section downstream from ignition
(red curves – ceiling level, green curves – 1,5 m level, blue curves – 0,5 m level)

Figure 8: Official test 230106

Figure 9: Official test 240106
Figure 10: Official test 150206

Note:
The fire location was different in the January tests, the measurement cross section was 35 m downstream from ignition, whereas in the demonstration test the cross section was only 23 m from ignition.

- The effect preburn times is seen especially in the ceiling and 1,5 m level temperatures before activating the HI-FOG system: the longer the preburn time, the higher the temperatures.
- The trend after activating the HI-FOG system is clear: there is an abrupt drop in temperatures immediately after HI-FOG activation.
- The differences in the curve of different test just reflect that full scale fire tests are never totally repeatable, but the overall performance is the same.

1.1.1. Damage:

Figure 11: 4-5 / 9 stacks damaged, target cars intact

Figure 12: Not damaged stacks

Figure 13: Not damaged stacks
1.1.2. Demonstration test 160206

Figure 14: Intact target car

Figure 15+16: 2 x 14 x 9 pallets on a 1,1 m high stand

4th International Conference ‘Tunnel Safety and Ventilation’ 2008 Graz
The fire is very severe with the open wood pallet configuration: plenty of air is available everywhere within the pallets and the pile is constructed mostly of hidden, burning surfaces.

The effect of different preburn times is seen in the ceiling temperatures both before activating the HI-FOG system and during the discharge: the longer the preburn time the higher the ceiling temperatures and the more severe is the fire. Just 2 min more of free burning increases the severity of the fire considerably and requires more time for getting it suppressed.
The trend after activating the HI-FOG system is clear: there is an abrupt drop in temperatures immediately after HI-FOG activation. Just above the fire it takes longer to stabilize the temperatures to lower values.

The differences in the curve of different tests just reflect that full scale fire tests are never totally repeatable, but the overall performance is the same.

The demonstration test 160206 showed how unexpected things can occur during a large fire: at around 10 min after HI-FOG activation, the fire seemed to increase in strength till it abruptly was reduced again. The behaviour is likely to related to collapsing of piles, first exposing large surfaces of burning material and then fully collapsing and suppressing the fire.

(The cracking sounds heard during the test were related to a plugged assembly body made of brass that finally ruptured after surviving tens on tests – in real installation the assembly bodies are made of stainless steel and, of course, are not repeatedly exposed to open flames.)

**Temperatures within a cross section downstream from ignition**

(red curves – ceiling level, green curves – 1,5 m level, blue curves – 0,5 m level)

**Figure 23:** Official test 020206  
**Figure 24:** Demo test 160206

**Note:**
The fire location was different in the test 020206, the measurement cross section was 35 m downstream from ignition, whereas in the demonstration test the cross section was only 23 m from ignition.

The trend after activating the HI-FOG system is clear: there is an abrupt drop in temperatures immediately after HI-FOG activation.

1.1.3. Damage

**Figure 25:** 4-5 / 9 stacks damaged

(The grey part is destroyed and/or damaged by the fire. Yellow means without fire damage.)
1.2. Summary

The demonstrations described above were tested successfully for the employment in the M30 Tunnel in Madrid and were the base for the planning and interpretation of the high pressure water mist system.

The HI-FOG system makes a decisive difference in the first 10 to 15 minutes of a tunnel fire, the most critical time in the fight to save lives and minimize material damage. The micro-droplets of HI-FOG water mist have a dramatic heat blocking and cooling effect immediately upon activation: in seconds, the temperature of the air surrounding the fire drops to 50°C. The HI-FOG micro-droplets rapidly absorb heat, particularly by evaporation, giving very effective cooling. By curbing the development of the fire’s heat intensity, they also greatly reduce the amount of smoke.

HI-FOG uses substantially less water than conventional sprinkler system: saving related to water supply, storage and drainage can be expected. The system’s high-grade stainless steel components will substantially outlast the equivalent components of a conventional sprinkler system. Savings can be expected here. Furthermore, the performance and cooling capabilities of HI-FOG may allow associated equipment to be operated at cost saving temperatures – every little bit helps in the long run.

HI-FOG is the world’s most tested and approved water mist fire protection system for tunnels. At the specification stage, HI-FOG is similar to a conventional sprinkler system when it comes to dimensioning – sizing zones and deciding on the number of zones that can be activated simultaneously. It does not introduce unwanted complexity into the equation. There is one significant difference. With HI-FOG, the dimensioned water flow rate is much less.

Zone size is decided according to the maximum vehicle length allowed, the expected fire load, the accuracy of the fire detection system, the ventilation technique and the safety margins associated with each of these parameters.