

# More than Just Fire Detection: Fibre Optic Linear Heat Detection (DTS) enables Fire Monitoring in Road- and Rail-Tunnels

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## ABSTRACT

Field trials in 1:1 scale under authentic environmental conditions have been performed in co-operation with the SP Technical Research Institute of Sweden to reveal the capabilities of Distributed Temperature Sensing (DTS) to quickly detect different types of fire, to localize fires precisely and to monitor fire size and spreading accurately over an extended period of time. Nowadays these enhanced characteristics are beyond the scope of fire detection technology but absolutely vital to activate and supervise tomorrow's fire protection systems.

## INTRODUCTION

Underground transport facilities are sensitive links in the economic chain carrying thousands of people and tons of goods (including dangerous goods) every day and they are growing in importance. Therefore safety precautions are vitally important and the work involved is related to the high potential risk. By far the biggest risk is a fire out of control. There is a great danger to life from toxic gases, exceedingly high temperatures, total loss of visibility, limited means of escape and the panic reactions of drivers and passengers. At the same time it causes serious damage to the infrastructure of the transport facility.



For that reason higher and higher demands are being placed on fire protection in tunnels. On one hand side, the operators want real value protection and on the other hand, public authorities demand the best possible protection for the general public from systems fraught with risk. Keeping important protection systems fully functional over a specific period of time (fire detection equipment, ventilation, extinguishing systems, escape route signalling etc.) is just one requirement which must be met by modern fire protection systems. To fulfill these rising demands, new protection concepts are needed, where the protection level is not only defined as simple sum of single protection measures, but as the reasonable and efficient interaction between the protections systems including the fire brigade.

Vital information is an indispensable precondition for these interactions like:

- Fast and reliable fire detection with precise indication of the fire location without being influenced by high speed air currents.
- Automatic activation of traffic control and people evacuation guidance systems and the alerting of the emergency service i.e. fire brigade.
- Fire spread and size assessment at the scene of accident to activate and supervise ventilation and /or suppression systems adaptively and to give vital information to the fire fighting forces.
- Control of success of countermeasures.

As an example of automatic supervision and a step in this direction, the emergency system of a newly refurbished tunnel in France uses the precise localisation of the fire through the fire detection system to adjust the longitudinal ventilation until the wind speed at the point of fire is close to zero. Consequently the smoke remains at that point of fire and the extraction is much more efficient.

### TEST GOAL

Full fire monitoring for automatic supervision of fire protection systems in tunnels - which this paper deals with, is still new and is under development. 1:1 field trials under authentic environmental conditions have been performed at the SP Technical Research Institute of Sweden in Borås, Sweden. Amongst others, the goal of this research project was to test the capability of the DTS technology to:

- detect many different types of fire fast and reliable
- provide high durability / survivability during the fire
- monitor the fire development in order to offer vital information
- control the installed extinguishing system



### TEST SETUP

The 1:1 fire tests have been conducted in a tunnel mock-up (L x W x H: 16m x 6m x 6m) equipped with non-combustible wallboards, 2 doors and observation windows. To simulate hidden fires and fires below a goods wagon a locomotive mock-up (L x W x H: 2.27m x 2.25m x 2.20m, located 1m above ground) has been used, a rail wagon mock-up (L x W x H: 4.8m x 2.4m x 3.0m) served to simulate open fires on a goods wagon. The tunnel mock-up has been equipped with a foam extinguishing system generally utilized to suppress fire in tunnels without any passenger volume e.g. tunnels of freight railway lines. A fiber optic sensor cable has been installed under the ceiling of the tunnel mock-up using 1m clamp distance. The overall length of the sensor cable was about 1250m. To imitate a tunnel length of 6.5 km additional 5373 m optical fiber has been attached between control unit and sensor cable. The AP Sensing Linear Heat Series- N4387A with 2 optical channels each 8km in



measurement range served as fire detection control unit. The DTS system has been configured according EN 54-5 A1 standard approved by the German VdS. Although the system offers 5 alarm criteria, just 4 different alarm parameters have been utilized.

### TEST PROGRAM

Eight different model fires have been applied to evaluate the performance of the fire protection system (detection system + deluge system). The response time is sub-divided showing the response characteristic of each single alarm-criterion. All test sequences have been run with a pattern starting the DTS system 1 minute before the ignition of the test fire. 30 to 90 seconds after triggering of the first alarm the extinguishing system has been activated manually. The foam production went on until the heat release has reached a minimum – real time controlled by the DTS linear heat detection system.



### TEST RESULT

All open pool fires have been detected within 30 to 40 seconds after ignition, which means a detection in half the time required by the German RABT (RABT e.g. defines the tunnel fire detection requirements). Even hidden pool fires triggered an alarm within 60 seconds after ignition. Due to the slow fire development of wood pallets the response time was in the range of 2 minutes. In all cases the first alarm has been triggered by the rate-of-rise criterion while the temperature at the ceiling was still below the maximum trigger temperature. Whereas the pool fires have been detected by the fast rate-of-rise criterion the wood pallet fires have been covered by the medium rate-of-rise criterion consequently. All test results showed the capabilities of the DTS system to detect different fires in very short time suitable to fulfil special regulations being made in tunnel application (e.g. RABT, RVS, ASTRA etc.). The maximum temperature detectable under the ceiling is a function of the heat release and the time given the fire to develop. It has reached 360°C with the 2.4 MW hidden pool fire and more than 1100 °C with the 9 MW open pool fire. The used sensor cable survived all fire tests and thus the DTS system was capable to monitor the fire during the test and to provide vital information as shown in figure 1.

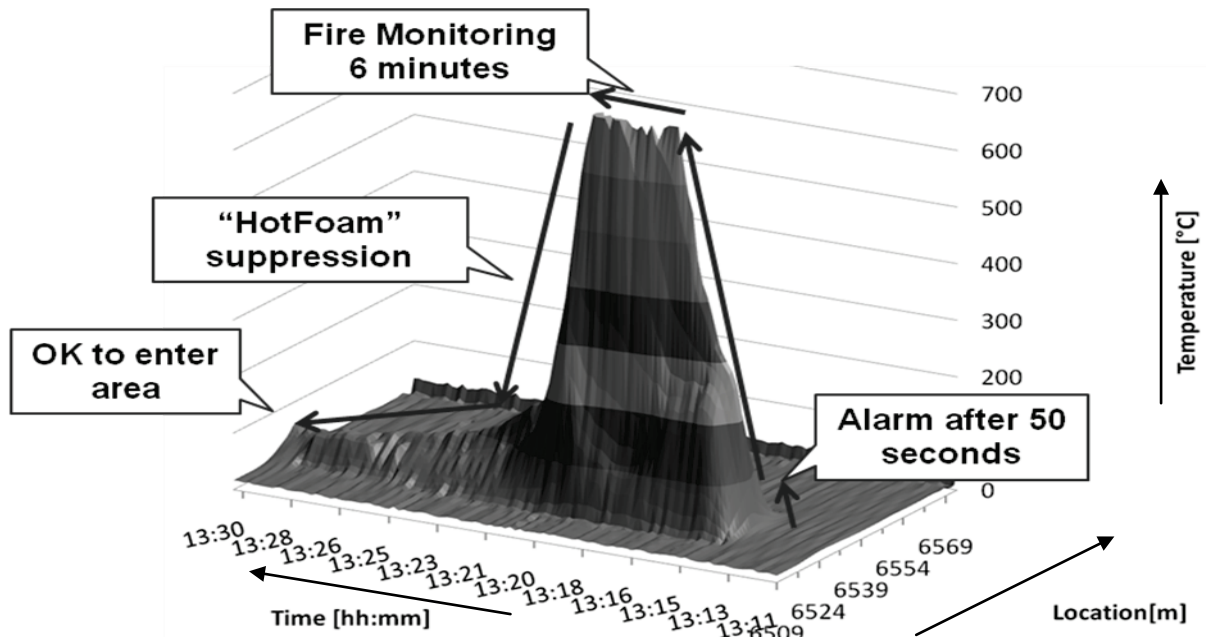


Figure 1 Fire Monitoring of hidden diesel fire with a HRR of 7,4 MW using AP Sensing Linear Heat Series control unit N4387A.

Figure 1 shows the result of the hidden fire inside the locomotive mock-up using diesel fuel and a pool with a surface of 4.5 square meters. The HRR was calculated to 7.4 MW. About 40 seconds after ignition the first alarm condition has been recognized by the DTS system. After another 10 seconds, the alarm condition has been confirmed and the alarm was triggered by the fast rate-of-rise criterion reliably. The maximum rate of temperature growth was 50°C / 10s at the early stage and the growth rate slowed down slightly to 35°C / 10s until the maximum heat release rate of 7.4 MW has been reached after 200 seconds. The full growth fire has been monitored by the DTS system over a period of 6 minutes before the deluge system has been activated. The maximum detectable temperature during the steady state stage was 706°C. After activation of the deluge system the DTS Linear Heat Detection System observed a rapid drop in temperature with a cool down rate of approx. 60°C / 10s. Within 80 seconds the temperature dropped from 700°C to less the 200°C but it needed additional 6 to 7 minutes to cool down the fire area then safe to be entered.

**CONCLUSION**

The 1:1 fire tests conducted at the SP Technical Research Institute of Sweden in Boras, Sweden in co-operation with Tyco Fire /Scum demonstrated the capability of a DTS Linear Heat Detection System to detect different fires fast, reliable and to monitor the fire development even with temperatures beyond 1000°C. The DTS Linear Heat Detection system is able to provide vital information about fire location, fire size, heat release and fire spreading during the entire process of the incident. Therefore the DTS technology becomes an ideal measurement instrument to supervise the activation and execution of prevention systems like fire suppression system, emergency ventilation system and the mission of fire brigades.

**KEYWORDS:** DTS, fiber optic linear heat detection, tunnel safety, fire monitoring, sensor cable