NEW REQUIREMENTS FOR AUTOMATIC FIRE DETECTION SYSTEMS IN TUNNELS WITH STATIONARY FIRE FIGHTING EQUIPMENT

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1. ABSTRACT

Automatic fire detection systems have become standard equipment in road tunnels in many European countries in the past. Mainly linear type heat detectors, based on sensitive sensor cables, have been installed. Other techniques are on the way and are partly used for the detection of smoke, or at least for an early warning of danger. Requirements for the automatic fire detectors have already been quite hard, but for the activation of stationary fire fighting systems, additional and higher specifications must be fulfilled by those systems. This paper gives a short overview of the new requirements and presents the tests, which have been performed to prove the ability of one of the most common automatic fire detection systems on the market.

2. FIRE AND SMOKE DETECTION

The detection and localisation of fires along the length of road tunnels is achieved by continuous monitoring of the ambient temperature with temperature sensitive sensor cables. Two different techniques are offered on the market: measurement systems based on optical fibres and cable systems with integrated electronic temperature sensors. Both types are well known and not to be described within this paper.

To detect smoke in tunnels and to give an early warning of probable danger, signals from the air quality measure equipment can be used in addition to the linear heat detectors. Video based incident detection systems are more and more able to detect the presence of smoke, beside the recognition of accidents, stopped vehicles, wrong way drivers or persons on the lanes.

3. STATIONARY FIRE FIGHTING EQUIPMENT AND THE REQUIREMENTS

After the tunnel catastrophes of the year 1999, the public as well as the experts have extended their discussion about active stationary fire fighting equipment. A number of suppliers of such technologies have performed practical tests under full scale conditions, for example in the test gallery of Hagerbach in Switzerland or in the Spanish test facility "San Pedro de Anes".

Different to Japan, where sprinkler systems are used in long tunnels since many years, in Europe the installation of water mist systems is the most probable. For this technology, a reliable automatic fire detection system is requested to activate the controlled valves in case of a fire at the right place under all circumstances, with or without human confirmation.

The combination of the electronic linear heat detector LIST with water mist systems has already been successfully done with belt conveying systems in lignite power stations in different countries. Road tunnels, however, have other dimensions and environmental conditions in regard of wind speed are different.
The following requirements for fire detectors are generally valid in tunnels:

- Availability and reliability of the fire detection system must be high.
- Temperature conditions at the portals are different to those in the middle of a tunnel, which means that the detection system must be adaptable.
- Ventilation can lead to fast changes in temperature, which may not result in false alarms.
- Electro-magnetic disturbances may not influence the detection system.
- Subzero temperatures are normal in many countries. Sensors must be reliable at very low temperatures.
- Aggressive exhaust fumes and salts, humidity and fog, dust and dirt, as well as vibration may not influence the functionality of the fire detection system.
- The localisation of a fire must serve the requirements of the ventilation system.
- False alarm rate at very low level.

If a water mist system shall be activated by the linear detector,

- availability and reliability must be extremely high,
- the localisation of a fire must be guaranteed with a precision of very few meters
- even with the maximum natural air flow
- and with the lowest possible false alarm rate.

**Availability and Reliability:** in case of a fire, the automatic linear fire detector is probably the only system, which can give the right and necessary information about the fire and its location. Air quality measurement equipment is installed in distances, which are too far for a precise fire place indication. Information through CCTV might be obstructed (stopped truck in front of the concerned camera) or impossible (dark screen due to smoke).

Approved linear fire detection systems like LIST have been certified by authorities, who have tested the systems components on several national and international standards. The operation must be guaranteed even in case of missing power. So uninterruptable power supplies are mandatory. Redundant systems will continue the monitoring of a tunnel even if components fail.

**Localisation of a fire:** the maximum available water for the fire fighting system is limited. Those systems have extinguishing sections of typically 20 to 30 m. After a fire alarm has been released, the concerned fire suppression section will be activated, and normally the both neighboured sections, too.

The demands, for example of the German guideline for tunnels, RABT 2003, to detect a fire with a resolution of 50m, is therefor not sufficient for this application. An activation released by video detection systems fail due to the same reason.

LIST sensor cable systems in tunnels with fire fighting systems have sensors at least every 8m, in Austrian projects, the distance between the sensors is 4m. The place of the sensors is fixed for all time. There is no drift or any other influence, which might result in an indication of a wrong place of the fire.

**Air flow:** it must be ensured, that the fire will be located with the same precision even at the maximum air flow, which can appear in a tunnel. There are tunnels in mountaineous areas, where the natural air flow can reach 10m/s or even higher. The fast and precise fire detection can be done under these conditions only by reacting on the heat radiation. Convectional heat will affect on the wrong location. Any smoke detection will falsify the fire place, too.
The LIST sensor cable is very sensitive to heat radiation, due to its construction, and gives the exact location of a fire even with high wind speed.

**False alarm rate:** a fire detector, which gives a remarkable number of false alarms, will cause costs, risks the disregard and will be switched off at last. If a fire suppression system in an operated road tunnel will be released erroneously, the consequences can be awful. Only fire detection systems of good reputation and with good experience are therefore suitable.

A special scenario should be mentioned at this point: a stationary fire fighting system is designed to suppress a fire on a determined location. As real fire events of cars and trucks have shown, vehicles release smoke before they stop already. Any alarm from a point, which has been already passed by this vehicle, may not be the base of any automatic process, which, once initiated, can't be transferred instantly and automatically to another location.

4. **THE PROOF OF THE SUITABILITY**

The LIST sensor cable system has been involved and has been used in a number of practical full scale fire tests to prove that it meets the a.m. requirements:

In September 2000, tests have been successfully passed in the Austrian Felbertauerntunnel. Fire detection with a precision of 4m has been recorded with a wind speed of 10 m/s.

In September 2003, a full scale of fire tests in the Hagerbach test gallery with a number of real cars and slow starting fire event has proved, that the LIST sensor cable system meets the demands for the special project of the French highway tunnel of the A86 around Paris, where passenger cars will drive on two levels in one tube. This tunnel will be equipped with a water mist system, the installation of the LIST sensor cable has already started.
In October 2003, in the Mona-Lisa-Tunnel in Linz, Austria, a test has been performed with the operational LIST fire detection system, which ensured, that the later installed water mist system will not be activated, if trucks with hot loads (asphalt) will use the tunnel.

Further tests in combination with fire suppressing systems have been performed in the Scheetunnel in Germany, in the Higashyama Tunnel in Japan and again in the Hagerbach test gallery for a series of fire tests.

Fire tests as one part of the acceptance procedure of new tunnels with LIST sensor cables have been passed successfully according to RVS and RABT in many recent projects.

5. CONCLUSION

Reliable automatic fire detection in tunnels has become more important than ever. The recognition of smoke, based for example on video detection, is a sensible supplementation of the current safety equipment in tunnels. A next step of improvement might be the installation of fire suppression systems, with new and higher demands on the automatic fire detectors. Linear heat detection systems have proven that it needs those demands.