EARLY DETECTION SAVES LIFE : HI-TECH SYSTEMS FOR FIRE DETECTION

Hubert Schinkinger
WAGNER Alarm- und Sicherungssysteme GmbH, D
E-mail: info@wagner.de

ABSTRACT

Life is saved as soon as a traffic light changes to “red”.

The objective is to achieve the earliest possible detection of a fire in a traffic tunnel in order to prevent further traffic access into the danger zone and to avoid vehicles from blocking rescue and escape routes.

The advantage of the optical detection principle of intelligent air sampling smoke detection systems is the speed at which reliable detection of a fire can be achieved, gaining decisive seconds for the implementation of counter measures which will result in saving life. Even before a driver or passenger has realized that a fire danger exists, reliable detection and respective alarm procedures can take place. Most important of all, only a real fire scenario will result in an alarm! The proposed detection system is immune to the deceptive phenomena common to traffic tunnel environments.

Tests lasting several months have been carried out in the 10 kilometre long Plabutsch Tunnel, proving impressively the advantages of air sampling smoke detection:

The systems high reliability and detection integrity is based on the analysis of the particles seen by the detection system when plotted against typical fire pattern algorithms stored individually in each and every detection systems CPU.

Traffic lights in future will change to “red” at the earliest possible stage of fire development, allowing the fight against smoke and fire to be implemented without any delay.

With the solution presented here today, the Plabutsch Tunnel is exemplary, and can be regarded as being the safest traffic tunnel in Europe.

Key words: Fire protection
Smoke detection
Air sampling smoke detection system
Fire detection
Tunnel safety

1. Life is saved as soon as a traffic light changes to “red”.

The primary objective in the event of a tunnel fire is to allow all persons fast and safe rescue from the tunnel, and escape from the deadly fumes that present the most immediate threat to life. Achieving this will make the task of fire fighters and rescue workers so much easier. The less people and vehicles in the tunnel, the better!

That is why the earliest possible detection of a fire, and the immediate restriction of further traffic flow into the tunnel is so important. In addition, it is important to prevent vehicles that have already entered the tunnel from continuing their journey deeper into the tunnel, and getting closer to the source of the fire. An intelligent traffic signalling system can be used to achieve this. The Fire Detection System assumes responsibility for the all important activation of the intelligent traffic signalling system, and provides the triggering impulse.
2. Conventional Detection Methodologies reach their limitations

In order to achieve early detection of a fire, optical smoke detection devices are often chosen because visible smoke particles form the first detectable signs of a fire. Conventional type smoke detectors are stretched to the limits of their capabilities when confronted with the aggressive nature of the tunnel environment. Temperature fluctuations between –20°C and +35°C, humidity, rain, fog, and snow which is transported by the traffic into the tunnel, high dust concentrations caused by braking and tyre friction, must not impair or influence the reliable performance of the tunnels fire detection system. This is the reason for the common use of linear thermal detection systems in road tunnels to date. Such systems may well detect the fire at some stage, but the effective measurement of a fire in terms of heat development only becomes possible at a much later stage in comparison with that of the smoke particle production. (Picture 1). Valuable time, needed for safe rescue is lost.

To prevent such a loss of time in the future, a very special and innovative aspirating smoke detection system has been developed especially to match the extreme and harsh environmental conditions prevalent in a traffic tunnel.

![Fire Development Chart](image)

Picture 1: Fire Development Chart
3. Air Sampling Smoke Detection System – Function principle

The function of an air sampling smoke detection (ASD) system is easily explained. The system comprises of an air sampling pipe network and a detection unit that incorporates air flow monitoring circuitry, a ventilator fan and an optical smoke detection sensor (Picture 2).

With the aid of the ventilator fan, air samples are continually taken from the tunnel section in question and passed through specially designed holes sited at equal distances along the length of the air sampling pipe network, back to the detection unit. Different hole diameters ensure a constant and equal distribution of air samples taken throughout the pipe network and tunnel section. Specially pre-fabricated air flow reducing clips allow each hole to be sized exactly, which is vital for the correct function and integrity of the air flow monitoring system. Blockage or rupture of the pipe network can be detected and reported, helping to maintain the reliability of the detection system at all times.

Air samples once inside the detection unit, are analysed for smoke particle content. Response characteristics can be adjusted to meet the requirements of ambient conditions. A fire can be detected at its incipient stage due to the ability of the detection unit to recognise even the smallest concentration of smoke particles, irrespective of their size or colour.

For a number of years now, the wide and growing variety of successful ASD-system smoke detection applications such as recycling plants, diesel locomotives, industrial production facilities, and horse stables to name only a few, have lent proof of the reliability and impressive superiority of intelligent ASD systems in the field of fire detection.
4. Air Sampling Smoke Detection System for Traffic Tunnels

The ASD system developed especially for tunnels incorporates a 3–stage filter system which is designed to remove the airborne dust particles that contaminate the tunnel atmosphere, before the air is passed from the air sampling pipe network into the detection unit. Smoke particles, however, are allowed to pass through the filter without obstruction. Vehicle exhaust emissions that would normally lead to unwanted false alarms are effectively screened out by the intelligent evaluation based on algorithms. Actual detection values measured within the detection unit are compared with a large number of complex, real fire development characteristics which are stored as algorithms within the detectors CPU. In this way, absolute detection stability and real alarm reliability is achieved. (Picture 3).

5. Test Installation in the Plabutsch Tunnel

An intensive and long term study of all aspects of tunnel fires, involving tunnel safety experts and fire engineers has culminated in the development of an air sampling smoke detection system, especially for this application. As a testing ground for this development project, the Plabutsch tunnel, frequented daily by more than 20,000 vehicles, and renowned for being the busiest tunnel in Austria, was selected for installation. The Plabutsch tunnel was built to relieve the traffic density around the city of Graz in Austria between 1983 and 1987. Stretching for 9.755 meters, the tunnel is Austria’s second longest road traffic tunnel in use today. The Plabutsch tunnel (Picture 4) is ventilated by a 100% full length air flow duct which is divided into five sections of equal length.

Picture 3: Principle of intelligent evaluation based on Algorithms

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The fresh air duct above the tunnel ceiling supplies the tunnel with fresh air through diffusors of 20 x 50 cm in size, mounted in the tunnel ceiling at intervals of 6 meters.

Exhaust gas extraction vents of 50 x 100 cm in size, are sited at intervals of 12 meters along the axis of the air return duct. In the event of a fire, heat resistant motors open the vents for each section of the tunnel allowing the total cross section of the duct to facilitate forced extraction of the smoke and gases. The air sampling detection pipe network was mounted at the centre of the tunnel ceiling above the road along the tunnels axis. A total of 12 air sampling holes were introduced along the pipe network. The detection unit was installed in an adjacent technical room, permitting unimpeded access for maintenance purposes.

6. Fire tests in the Plabutsch Tunnel

After a three month test period without any system faults or false alarms, several different qualified fire tests were carried out in the tunnel together with the tunnel operator and the authority having jurisdiction over fire safety in road traffic tunnels. It only required 3 standard type PUR mats to cause the ASD system to register the first of three possible stages of fire alarm. Shortly after lighting 8 similar mats, the third and highest level of detection was achieved. A linear, thermal system installed in the tunnel showed no reaction to the tests at all.
7. Conclusion

The conclusion of the 3 month long tests in the 10km Plabutsch tunnel have made the advantages of using air sampling smoke detection systems in the tunnel very clear. Intelligent ASD systems with their Algorithm based analysis and processing detect fire fast and reliably. The specially developed tunnel ASD system from Wagner, opens a new chapter in the history of tunnel fire safety for all its users. Traffic signals can now go to „red“ in time, the fight against the fire and the deadly fumes exhumed by it can begin much earlier. These will remain the decisive factors in saving life.