# Early warning fire detection in underground stations

**Based on UN's world urbanisation prospects, the total amount of megacities – urban conglomerations with more than 10 million people, such as Shanghai or Lagos – will quadruple in just 40 years. The cities will grow by nearly 600 million inhabitants in this process. An efficient, safe, reliable and relatively inexpensive mass rapid transit system (MRT) is therefore a key factor to avoid traffic collapses and reduce pollution. MRT is largely taking place underground.**

**Markus Mueller**

Stations, as well as tubes, are confined spaces with limited escape capabilities. In case of a fire incident, thousands of travellers will be trapped, hard to reach and are likely to panic. The prevention of mass panic reactions is therefore a priority for Underground operators. An Early Warning Fire Detection System, supporting multiple alarm thresholds, each one linked to a tested and maintained response scenario performed by regularly trained intervention forces, will help the Underground operator to keep control. Professionally planned and implemented, an Early Warning Fire Detection System will avoid fatalities, reduce loss, and speed up recovery. It also contributes to a positive image of the MRT and by this improve its acceptance and usage.

## Risk, cause and damage

With the rapid urbanisation, the Underground has gradually become a very important part of public transportation. Due to the special nature of its operation, which is largely underground, evacuation of trains and stations in case of a fire incident, naturally take longer time. Consequently, the risks for injuries or even fatalities rise significantly, in particular if a fire incident happens during crowded rush hours. Early notification of a potential fire threat is therefore essential to gain the extra time needed to allow the emergency rescue services to evacuate endangered passengers.

▼ **The piston effect causes high airflow speed with peaks exceeding 20 m/s.**

**Markus Mueller is Director for Vertical Application Management at Securiton AG.**







The level of fire protection in Underground stations has increased in recent years and statistics show that numbers of casualties are decreasing, which – for sure – is good news. However, the risks for fire, and indeed the number of fires, in Underground stations have not diminished significantly, as statistics show:

- Roughly two out of three safety incidents in Underground stations are caused by fire, ranked before explosions and train derailments[1]
- Causes for fires are power line failures in about one out of four cases, followed by mechanical failure and arson[2]
- Where smoking on the platforms is still allowed, it poses one of the largest risks for fire – in particular in combination with a littering problem on the tracks[3]
- In Washington DC, in the United States, in the second half of 2017 a total of 51 fires were reported, whereof 24 (47%) were caused by trash or debris catching fire and 23 (45%) were caused by electrical arcing of some kind[4]

On the basis that the number of fires remains high, it is safe to assume that damage to the infrastructure, the disruption of service and the resulting economic damage as well as the damage to reputation (e.g. trust of the public regarding the general safety of the service) is significant. But for all that, statistical data of such damage is sparse.

Key to reducing damages mentioned above, is the implementation of an Early Warning Fire Detection System with multiple alarm thresholds in combination with tested and maintained response plans, adequately adapted to the individual alarm thresholds.

## Challenges

The design of such an Early Warning Fire Detection System faces a number of challenges to overcome. The most prominent challenges are:

- Significant changes in the airflow due to the piston effect of trains pulling in and out of the station, with peak airflow speed exceeding 20 m/s. This causes a dilution of the smoke particles and smoke becomes «invisible» to standard point type detectors operating at regular sensitivity.

▲ **Escalators are confined spaces, fire protection is challenging.**

- Complex ceiling structures, with electrical installations in ceiling voids in the station halls and on the platforms obstruct an easy installation of fire detectors. This complicates the process of their testing and maintenance substantially.
- Smouldering fires – caused by overloading, overheating or short-circuiting – in power and equipment rooms typically develop over a long period (hours, if not days). Such fires produce only smallest amounts of smoke particles in their incipient stage.
- Installation of detectors in confined spaces and a greatly obstructed accessibility of the detectors for maintenance and testing purposes. This is a major challenge when protecting escalators and elevator shafts from fire.

Designing the fire alarm system with conventional fire detection equipment, such as point type smoke and/or heat detectors, will nowhere near meet these challenges. First and foremost, standard fire detection equipment cannot trigger pre-alarms and is therefore not suited for designing a staged response plan. A smoke aspirating detector, for instance the Securiton ASD 53x series, is the ideal fit to meet all the challenges mentioned above. Apart from their high smoke sensitivity, these devices also feature three pre-alarm levels and two alarm levels, which allow for designing an adequate multi-stage response plan.

## Application scenarios

Smoke aspirating detectors can be applied in various scenarios throughout an Underground station. Following are five key scenarios for designing Early Warning Fire Detection Systems in Underground stations:

- **Void ceiling structures on the platforms and in the station halls**
  The pipe is installed in the ceiling void and capillary sampling points are placed in the ceiling panels. With this approach smoke resulting from smouldering cables installed in the ceiling void as well as smoke resulting from fires on the platforms or the station halls themselves is detected in the early stages of the fire. Thanks to the devices powerful fan, changes in the airflow speed due to the piston effect are not an issue. In addition, the maintenance and testing of the detectors is significantly simplified, because the detection units are mounted in easily accessible locations.
- **Power and equipment rooms**
  These areas of the Underground station can be protected in two ways: (1) Installing the pipe underneath the ceiling for general open space

protection or (2) above the individual cabinets to allow for object protection. In this case, an additional smoke sensor in each segment of the pipe allows for smoke localisation. Both approaches allow for the detection of a fire in its early stages and give the response forces more time to react to the situation, for example shutting down that part of the equipment causing the smoke before evacuating the whole station.

- **Escalators and elevator shafts**
  The pipe is installed in the truss underneath the tracks of the escalator or vertically inside the elevator shaft. In both installations, smoke caused by overloading, overheating or short-circuiting will be detected at a very early stage. In addition, conveniently placed test sampling holes allow for simple maintenance and testing in such confined or even inaccessible locations.

- **Ventilation ducts**
  Installing the pipe across the sectional area of the duct of the ventilation system allows for the monitoring of larger cross sections than with a simple point type smoke detectors. In addition, the higher sensitivity of the smoke aspirating detector allows for an early detection of smoke in the area of the station ventilated by this duct. In this instance, a performance-based design approach will help to shape the solution in such a way, that it will not conflict with codes and standards in force.

- **Monitoring on all echelons**
  Networking the aspirating smoke detectors installed throughout the station and connecting them to a management system (e.g. the Securiton Universal Management System UMS) in the station's control room, allow the station operators to have a full overview of the smoke levels detected all over the station. Furthermore, UMS acts as a gateway to propagate vital information about the station to the Underground line's operation centre.

## Benefits

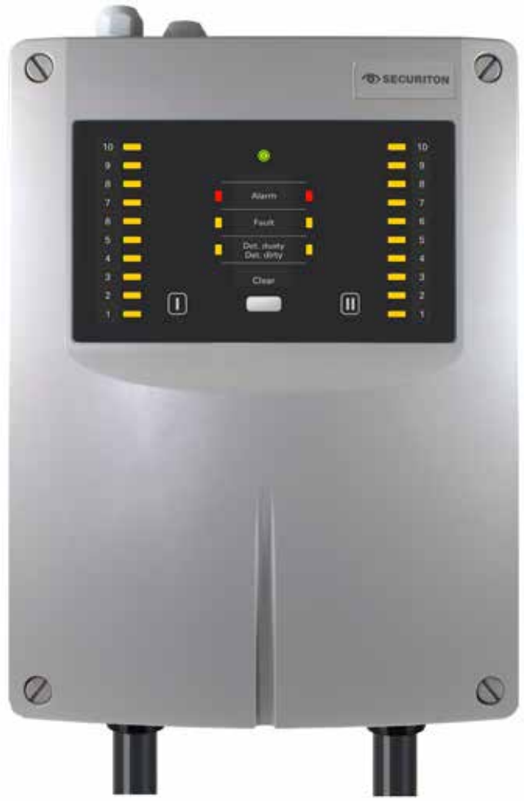
When designing Early Warning Fire Detection Systems for Underground stations, using smoke aspiration detectors in scenarios mentioned above, the operator profits from these key benefits:

- Business interruption, economic damage and damage to the reputation is minimalised. Early Warning Fire Detection Systems will insure that the intervention forces have timely warnings on fire incidents, a tested and maintained response plan insures that their intervention is both effective and on target.
- The risk of mass panic and resulting injuries – or even casualties – is considerably reduced. Early warnings will significantly help in informing the people within the Underground station – or within a certain area if the station – about the incident and conducting an evacuation in an orderly manner.
- The full operability of the fire protection system is heightened. Carefully located detection units and conveniently designed sampling holes in the pipes help reducing cost for testing and maintenance and facilitate the prompt repair of defective components.
- An overall smooth and ordered operation of the service is ensured. Integration of early warning information from aspirating smoke detectors with other safety related information in a management system will ensure a timely and adequate response of the intervention forces.

## Success stories

Among others, Securiton ASD successfully protect stations in these Underground systems:

- Metro Madrid, Spain
- Metro Rotterdam, The Netherlands
- Metro São Paulo, Brazil
- Metro Shenzhen, China
- Metro Guangzhou, China
- Metro Shenyang, China
- Metro Shanghai, China




**▲ The SecuriSmoke ASD 535 meets all the challenges faced in Underground stations**

**For more information, go to www.securiton.com**

**References**

1 Subway Fire Cause Analysis Model Based on System Dynamics: a preliminary model framework, Wen-yu Yan, Jing-hong Wang, Jun-cheng Jiang, Procedia Engineering 135 ( 2016 ) 431 – 438, https://www.sciencedirect.com/science/article/pii/S1877705816001569

2 Analysis of natural and man-made accidents happened in subway stations and trains: based on statistics of accident cases, Heng Yu, Yimin Wang, Peiyun Qiu, and Jiacheng Chen, MATEC Web of Conferences 272, 01031 (2019) https://doi.org/10.1051/matecconf/201927201031

3 U.S. Fire Administration, Topical Fire Research Series Volume 2, Issue 13 February 2002, Rail Terminal Fires

4 New Metro stats: More fires, more bus injuries, wtop.com, https://wtop.com/tracking-metro-24-7/2018/02/new-metro-stats-fires-bus-injuries/ (retrieved on 2019/10/31)