How can we optimize tunnel safety and availability?

With integrated fire safety solutions that provide high-level protection for people and reduce the risk of structural damage.

Answers for infrastructure.
Put your tunnel fire safety on the right track with a professional partner

The issue of fire safety in road, rail, and mass transit tunnels has gained high visibility in Europe in recent years following a series of dramatic incidents and fires which led to human casualties, major structural damages, and lengthy disruptions of the transport system with hard felt impact on regional economies.

Studies show that in a context where aging tunnels must cope with changed traffic patterns and volumes, and where ever longer new tunnels are built in increasingly challenging urban or geological environments, effective mitigation of the fire risks and their far-reaching consequences is paramount. This requires a holistic approach to fire safety, where it becomes as much an integral part of incident management processes as of day-to-day operations.

Solutions from Siemens are based on a long history of innovations in the fields of fire and incident detection, evacuation, and response. Drawing from often unique technologies and a company-wide expertise in the specificities of tunnel structural and operational challenges, we go beyond meeting the most recent tunnel safety standards: Our solutions contribute to maximum tunnel availability and deliver optimal return on investment to tunnel owners and operators over the entire life cycle of the facility.
Driving tunnel safety forward

■ The “people” challenge
The potentially heavy human cost is at the forefront of international tunnel safety concerns, particularly in fire situations. A number of factors distinguish a tunnel fire from a fire in a conventional building: They indicate that the escape environment for people worsens in a tunnel, due to longer escape distances and time, panic and disorientation caused by reduced visibility, the potential for very strong and rapidly growing fire sources and more rapid smoke spread and stratification at floor level. Tunnel fires also cause extremely rapid heating rates, which not only can lead to structural spalling and even collapse but can also make fire fighting efforts more dangerous and time consuming. Fire prevention is of course the first priority, but it is essential to also integrate appropriate fire detection and response systems that will further slow down structural degradation, ensure safe people evacuation, prevent fire spread, and facilitate fire fighting efforts.

■ Protecting critical tunnel infrastructure – an economic must
A healthy road, rail, and mass transit transport network is essential to the economic health of entire regions and even countries. They keep them accessible – and thereby competitive and attractive to industries and investors. Indeed, lengthy closures of damaged tunnels following an accident or a fire have in the past translated into long-term economic consequences and extensive impact on the fire from a fire in a conventional building: A number of factors distinguish a tunnel fire from a fire in a conventional building: They indicate that the escape environment for people worsens in a tunnel, due to longer escape distances and time, panic and disorientation caused by reduced visibility, the potential for very strong and rapidly growing fire sources and more rapid smoke spread and stratification at floor level. Tunnel fires also cause extremely rapid heating rates, which not only can lead to structural spalling and even collapse but can also make fire fighting efforts more dangerous and time consuming. Fire prevention is of course the first priority, but it is essential to also integrate appropriate fire detection and response systems that will further slow down structural degradation, ensure safe people evacuation, prevent fire spread, and facilitate fire fighting efforts.

■ Meeting exacting standards every time
National and international safety directives are now in place to address the prevention and mitigation of incidents in tunnels, especially those originated by fire hazards. From the Directive 2004/54/EC to the European Technical Specifications for Interoperability (TSI) on Safety in Railway Tunnels (SRT), minimum requirements were defined for 4 key areas: infrastructure, operation, transport network users, and incident management. At Siemens, we build on our extensive tunnel knowledge to help you address these areas cost-effectively, whether you are looking to upgrade your safety system or to start a new tunnel project. Our systems are tailored to meet international and local tunnel safety standards and product approvals, such as VdS, LPCB, FM or UL.

■ Holistic tunnel fire safety – trust the expert
Siemens brings over 150 years of knowledge in fire safety technology development and applications. Our expertise covers the entire fire safety value chain, from prevention to detection, response, and recovery: Our comprehensive solutions enable tunnel operators to manage risks as a single end-to-end concern, include remote facilities and network monitoring, and the coordination of incident response with emergency services.

■ A winning long-term partnership
With Siemens, you can count on one reliable partner over the lifetime of tunnels, and across all disciplines: We support tunnel owners and operators around the world with complete mobility solutions, including fire safety, security, power supply, lighting, communications, and traffic control systems. Our sophisticated solutions – combined with extensive services encompassing system consulting, design, installation, training, monitoring, and maintenance – are tailored to each project’s specific operational and regulatory requirements, keeping tunnels running in the long term and providing verifiable return on investment.

Address fire safety concerns for tunnels of all types with solutions from Siemens.

(1) The Mont Blanc tunnel fire is estimated to have cost the Italian economy between €350–450 millions and €500 millions per year throughout the loss of that particular connection with France. Source: UPTUN WP7, D71.

The Channel tunnel fire of September 2008 led to reduced service during the 5-months repair work, adding an estimated €120 millions in lost revenues to the €80 millions repair costs. Source: Eurotunnel.
Maximizing tunnel fire safety with totally integrated solutions from one partner

Siemens combines its unique technologies, expertise, and all-encompassing services into holistic tunnel safety solutions that deliver measurable long-term value.

**Prevention through design**
Siemens is a partner that gets involved from day one: working alongside architects, engineers, and contractors, our fire safety experts build on their in-depth knowledge of tunnel fire development patterns to conduct thorough risk analysis and system evaluations. They can design systems that not only deliver optimal fire safety, but also optimize operational readiness, maximize incident response efficiency, and facilitate self-rescue concepts for users – all this within today’s regulatory requirements, whilst leaving room for future expansions or upgrades.

**Early incident detection through complete situational awareness**
While studies show that accidents or fires are actually less likely to occur in tunnels than on open roads (1) or tracks, the potential human and economic costs of tunnel incidents can be much more dramatic. Early awareness of potential risks is therefore of the utmost importance (2). Siveillance from Siemens addresses this very concern, and reliably identifies, monitors and reports objects and situations that can lead to accidents and potentially fires. This universal video application platform analyzes video streams and generates alarms when defined safety rules are violated, e.g. slow or stopped traffic, wrong way drivers or lost loads.

**Advanced fire detection for improved incident containment**
In the confined environment of tunnels, with potentially highly hazardous materials such as petrol or chemicals and temperatures reaching 1100 °C within 10 minutes, risk containment is key to protecting lives and the infrastructure itself. Fire safety solutions from Siemens combine sophisticated detection and verification technologies that enable a fire to be rapidly detected and precisely located, but also provide timely intelligence on its progression and the risk to users, fire fighters, and the tunnel itself. Our video smoke detection solution uses Siveillance technology with patented edge extraction process, enabling operators and intervention forces to remotely gather valuable information on smoke characteristics and changes inside the tunnel. For even more targeted fire fighting, it can be combined with our FibroLaser solution: This redundant fiber optic linear heat detection cable can detect a fire within 1 minute and pinpoint its location within 3 meters of the ignition point – exceeding the most stringent road (3) and rail safety standards. Contrary to other such systems on the market, the FibroLaser cable is constantly tested during operation, ensuring high system availability. During service, a system test is done in the technical room, so tunnels can remain open. As an alternative to video-based smoke detection, tunnel smoke detectors can be used for early and reliable detection even in tunnels where high ventilation levels or heights give smoke the opportunity to cool down.

(2) 2004/54/EC §2.14: Automatic incident detection or fire detection systems are mandatory for all tunnels with a control center.
Reliable detection of external threats to tunnel safety
Air intake shafts can become weak points as they could allow external conditions to negatively impact environmental conditions inside the tunnel. For example, smoke caused by acts of vandalism at the air shaft openings above ground could be sucked into the tunnel and rapidly compromise both visibility and user safety. Aspirating smoke detectors (ASD) from Siemens – positioned inside the tunnel near the air intake shafts – measure smoke density, triggering a pre-alarm if critical safety levels are reached.

Optimize response with quick alarming and safe evacuation
With longer distances between emergency exits, evacuation could be impaired by early structural spalling before critical smoke, visibility, toxicity, and heat levels have even been reached inside the tunnel. Rapid evacuation is therefore paramount, and requires the ability to immediately broadcast alarm messages to users.(4) Voice evacuation solutions from Siemens are activated on alarm, sending out pre-recorded instructions or live announcements at the same time as flashing evacuation lights are lit up along the escape route. This ensures users are instantly aware of the danger and evacuate immediately. In addition, fire safety solutions from Siemens offer a secure and direct connection to the control center of the tunnel and fire department.

Keeping critical systems running
As part of keeping tunnels open and safe for traffic, technical rooms housing critical systems (control cabinets for fire systems, ventilation, traffic signals ...) should be protected against fires, as, although usually not a threat to human life, they can also affect tunnel availability. In this environment, fire detection solutions need to cope with usually slow fire developments – a challenge Siemens addresses with Sinteso™ S-LINE smoke detectors, based on its innovative ASATechnology™, which offers exceptional detection response to these fire types and Genuine Alarm Guarantee. On confirmed alarm, automatic extinguishing is triggered. Here, Siemens recommends Sinorix™ CDT with innovative constant discharge technology, which floods the room with natural agents in 60 seconds, extinguishing the fire reliably and without damaging the equipment.

Incident recovery with measurable return on investment
With one integrated solution addressing all steps of the fire safety process, tunnel operators and owners are able to manage operational fire safety and incident response and recovery more effectively, thereby reducing the costs of tunnel closures, repairs, and traffic diversions. For an all-round measurable return on investment.

Highlights

- Expert advice and support during every phase of a project delivers an all-encompassing fire safety concept
- Benefit from nearly 50 years experience in tunnel fire safety
- Fire alarm with precise information on the fire size, location, and direction
- Effective fire detection and extinguishing ensure critical systems function at all times
- Measurable return on investment with fewer tunnel closures and repairs and lower overall management costs

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(3) Both ASTRA and RSV standards require linear heat detection with a localization capability of 10 m maximum.
(4) 2004/54/EC, §2.16.3: Loudspeakers are mandatory in shelters and exits in all tunnels >500 m.
Keeping all tunnel operational and safety systems under firm control

At Siemens, we know that in the complex tunnel environment, seamless interaction between the various sub-systems and technologies is paramount to ensuring the highest safety levels, improving tunnel availability, and lowering operational costs.

**One partner, one tunnel solution**
Working with Siemens brings added value in many ways: our broad expertise in everything tunnel related comes together with for example 1 system to manage all tunnel safety and functional requirements, from day-to-day operation to emergency management. At the core of the tunnel operation sits the SITRAFFIC ITCC (1) tunnel control center, which enables the central control and monitoring of all tunnel technical systems:
- Fire detection, evacuation, and extinguishing
- Automatic incident detection
- Power supply and distribution
- Traffic detection, control, and signal
- Emergency call/Public address
- Lighting
- Ventilation
- Environmental monitoring

As all systems sit on one platform, pre- and post-incident analysis and reporting to the relevant authorities is facilitated. (Directive 2004/54/EC, Art. 15.)

**Complete integration for accurate response**
This powerful integration capability – combined with our comprehensive know-how in tunnel safety and operational systems – ensures that the appropriate systems work together to provide the optimal tunnel environment, whether it be to ensure seamless traffic flow or in response to a specific event. All sub-systems are tightly integrated on the automation level to enable the operator to have the system react automatically to incidents with minimum necessary interaction, thanks to scenario-based processes, e.g. increasing ventilation if levels of CO rise too quickly, or triggering traffic signal systems at the entrance of a tunnel to divert traffic in case of an accident.

**Continuous reliability and availability with comprehensive services**
Our service portfolio covers the entire life cycle of tunnels, from design and consultancy to implementation, maintenance or modernization, all the way to operator training or financing. Our SafeGuard proactive remote service, for example, ensures critical system deviations are identified before they become problems. Combined with our “Guaranteed Repair Time” for critical systems, this ensures that all fire safety equipments are up and running at all times. This global service concept ensures that your tunnel not only benefits from the latest technological developments, but also operates at optimal levels, meeting your targets for traffic flow reliability, environmental control, and of course operational costs.

**Highlights**

- Optimal operational safety and efficiency thanks to integrated multi-discipline system management
- Total functional control, from day-to-day operation to emergency management
- Centralized event handling and effective supervision thanks to sophisticated data processing and user-friendly graphical interfaces
- Highest tunnel availability thanks to SafeGuard proactive remote services and our “Guaranteed Repair Time”

(1) International Traffic Control Center.
Fire control panels
The Sinteso FC20 fire control panels with integrated power supply offer a logical, menu-driven user interface with interactive, dialogue-based procedures. Network up to 32 panels via FCnet (ideal when multiple tunnels are monitored via 1 control center). The panels are accessible remotely over Ethernet (remote operation, system diagnosis/configuration changes, simple maintenance, and troubleshooting).

Voice alarm system
The E100 voice alarm system linked to loudspeakers in shelters and exits. Automatically activated by the fire detection system on confirmed alarm, and capable of broadcasting live or pre-recorded evacuation messages to users to ensure safe and rapid evacuation of the tunnel tubes.

Extinguishing control panels
The XC10 range includes control units for single or multiple (up to 16) detection zones/extinguishing sectors. All relevant incidents are forwarded to connected fire control panels. The XC10 units also interface with ventilation systems.

Linear heat detection
The FibroLaser fiber optic cable detects both radiated and convected heat, reducing the influence of air-flow on the detection rate. It gives instant information on the fire size, direction, and speed, the number of fire sources, and the temperature inside the tunnel (with graphical visualization, data refresh cycle time <15 seconds). The cable is maintenance-free (operating life of 30 years).

Smoke detectors
Early fire warning by smoke detection in road tunnels with high ceilings and ventilation levels thanks to the continuous measurement of smoke concentration. These detectors are also ideal in environments with corrosive atmospheres, and offer fog suppression by heating. A temperature sensor enables the location of fires. Signal output via relay contacts or Profibus.

Aspirating smoke detection
Aspirating smoke detectors enable early and reliable detection of fires in highly ventilated zones: they can be positioned in the technical room or at air intake points inside the tunnel to prevent external environmental conditions (e.g. smoke caused by fires of criminal origin) to affect the continuity and safety of the traffic through the tunnel.

Point type fire detectors
Sinteso S-LINE detectors are based on the ASA technology developed by Siemens. The range includes optical, thermal, and combined fire detectors (e.g. for rooms containing electrical cabinets), a multi-sensor model for smoke, heat and carbon monoxide (e.g. for shelters), and EX models (e.g. for use in the emergency power supply storage room).

Manual call points
For immediate manual actuation of an alarm, manual call points are placed along the exit routes.

Alarm indicators
In the complex environment of tunnels and technical rooms, alarm indicators ensure that the danger area is immediately identifiable even if the detector in alarm status is not visible.

Sounder and sounder beacons
Sounder and sounder beacons provide both acoustic and optical alarms, ensuring that tunnel users and staff are immediately alerted even in noisy environments such as in shelters or in the tunnel tubes.
Access control

The range of SiPass access control systems provides a very high level of security without compromising convenience. Access readers at the technical rooms’ doors restrict access to critical systems to authorized personnel. SiPass systems integrate in existing IT environments and support advanced multi-site identity management, remote connectivity, and integration with video surveillance and intrusion detection.

Control center

The ITCC from Siemens caters for tunnels of all types and sizes, allowing not only the traffic guidance and control equipment, but also the light, air, and power supplies, the fire detection systems, pollution measurement, or emergency call systems to be centrally managed. Integration takes place at automation level for increased redundancy and reliability.

Automatic incident detection

Video surveillance inside the tunnel and the technical room. Automatic incident detection inside the tunnel using Siveillance technology: this universal video application generates events when user-defined safety and security rules are violated. Video streams can be analogue (CCVS), video over IP or pre-recorded MPEG4 and AVI files. PAL and NTSC supported.

Input/output modules

For the connection with potential-free contact, used to acknowledge or activate technical states (e.g. door, ventilation, portable fire extinguisher).

Intrusion detection

Detection of unauthorized entries into the technical rooms with comprehensive intrusion detection systems. Scalable systems with powerful alarm management tools, high immunity to false alarm, and integration with video surveillance and access control systems.

Extinguishing with Sinorix CDT N₂

For outstanding and rapid extinguishing. This technology is widely used in data centers and therefore ideal for tunnel technical rooms: the nitrogen-based agent is harmless to people, the environment, and the electrical infrastructure. The unique constant discharge technology employed ensures minimum overpressure and turbulences, reducing the risk of further damage to critical systems.
Zurich-West bypass, Switzerland
The west-bypass has a significant regional importance, relieving the city of Zurich and its surrounding agglomerations from heavy commuter traffic (ca. 60,000 vehicles a day), whilst improving the road connections both for passenger and cargo transport. Of the 10.6 km constituting the west-bypass motorway, 8.4 km are in tunnels with parallel twin-tubes and 2+1 traffic lanes (representing 27.8 km of tunnel tubes in total). The last tunnel to open in the autumn of 2009, the Islisberg tunnel, is also the longest with 4950 m.

Safety was a central consideration in the design and now operation of the 6 tunnels. But to concentrate and simplify installation, operations, maintenance, and services, the requirement was for the same technical equipment to be used in all tunnels. The fire safety systems, therefore, had to be adaptable and scalable enough to provide each tunnel with the safety levels required by the Swiss ASTRA regulations, regardless of the tunnel’s own specifics and safety challenges.

Siemens was chosen to supply the fire safety equipment and systems in all 6 tunnels, as well as maintenance and repair services. In total, 36.5 km of FibroLaser linear heat detection cable were installed to ensure rapid and accurate fire detection and location inside the tunnels. As the tunnels’ availability heavily relies on the continuity of critical operational systems, all technical rooms are equipped with 1500 Sinteso smoke detectors, and with alarm signaling devices. The fire safety systems are autonomous but networked with the overall tunnel control systems to enable a coordinated incident response through the interaction with the lighting, ventilation and smoke extraction, traffic control, video surveillance, and communication systems.

The high performance of the fire safety systems – and therefore the protection of critical tunnel systems – is ensured through comprehensive services provided by Siemens as part of its Advantage™ Services offering, which includes a guaranteed 24-hour repair time and preventive maintenance.

HSL – High Speed railway Line, the Netherlands
By connecting the Netherlands to the European High Speed railway network, the HSL (High Speed Line) line opened new opportunities for the region. Safety was key throughout the project, from design to operation, both to safeguard the availability of this essential economic link to the rest of Europe (availability target of 99.46% for the first 25 years), and to deliver on the sustainability promises.

In addition to the power supply, ETCS signaling and GSM-R communication systems, Siemens supplied the fire safety systems for the aqueduct and the 4 tunnels constructed especially for the 125-km long line – one of which is the bored tunnel with the world’s largest diameter (15 m). Overall, the tunnels are equipped with 599 manual call points and flashing lights near the escape routes. The technical rooms and escape platforms are fitted with 887 AlgoRex smoke detectors and 56 aspirating smoke detectors – recommended for highly ventilated areas. The entries/exits of all tunnels are also monitored with SISTORE CX video surveillance systems prevent copper theft, and the maintenance yard with SISTORE CX EDS video motion detection. A high level of integration was required to ensure optimal incident mitigation, with all fire safety, security, traffic, lighting, ventilation systems combined through SITRAFFIC in each tunnel’s control center and the main control center.

Siemens was also entrusted with comprehensive services for the tunnels – based on the Advantage Services portfolio – encompassing consultancy and risk assessment (RAMS calculation) as well as fire safety system design, installation support, commissioning and training, preventive and secondary corrective maintenance (with a guaranteed 24-h response), and future modernization – all essential in securing the HSL’s sustainability.

This combination of optimal use of technologies and services ensures optimal availability and safety for what is a ground breaking rail line in the Netherlands.

Optimal tunnel safety – experience speaks for itself
Answers for infrastructure.

**Megatrends driving the future**
The megatrends – demographic change, urbanization, climate change, and globalization – are shaping the world today. These have an unprecedented impact on our lives and on vital sectors of our economy.

**Innovative technologies to answer the associated toughest questions**
Throughout a 160-year history of proven research and engineering talent, with more than 50,000 active patents, Siemens has continuously provided its customers with innovations in the areas of healthcare, energy, industry, and infrastructure – globally and locally.

**Increase productivity and efficiency through complete building life cycle management**
Building Technologies offers intelligent integrated solutions for industry, commercial and residential buildings, and public infrastructure. Over the entire facility’s life cycle, our comprehensive and environmentally conscious portfolio of products, systems, solutions, and services for low voltage power distribution and electrical installation technology, building automation, fire safety and security ensures the:
– optimum comfort and highest energy efficiency in buildings,
– safety and security for people, processes, and assets,
– increased business productivity.

Siemens Switzerland Ltd
Industry Sector
Building Technologies Division
International Headquarters
Gubelstrasse 22
6301 Zug
Switzerland
Tel +41 41 724 24 24

Credits: Picture shown on page 9 (top right) courtesy of Rijkswaterstaat HSL-Zuid/Ton Poortvliet.

The information in this document contains general descriptions of technical options available, which do not always have to be present in individual cases. The required features should therefore be specified in each individual case at the time of closing the contract.

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