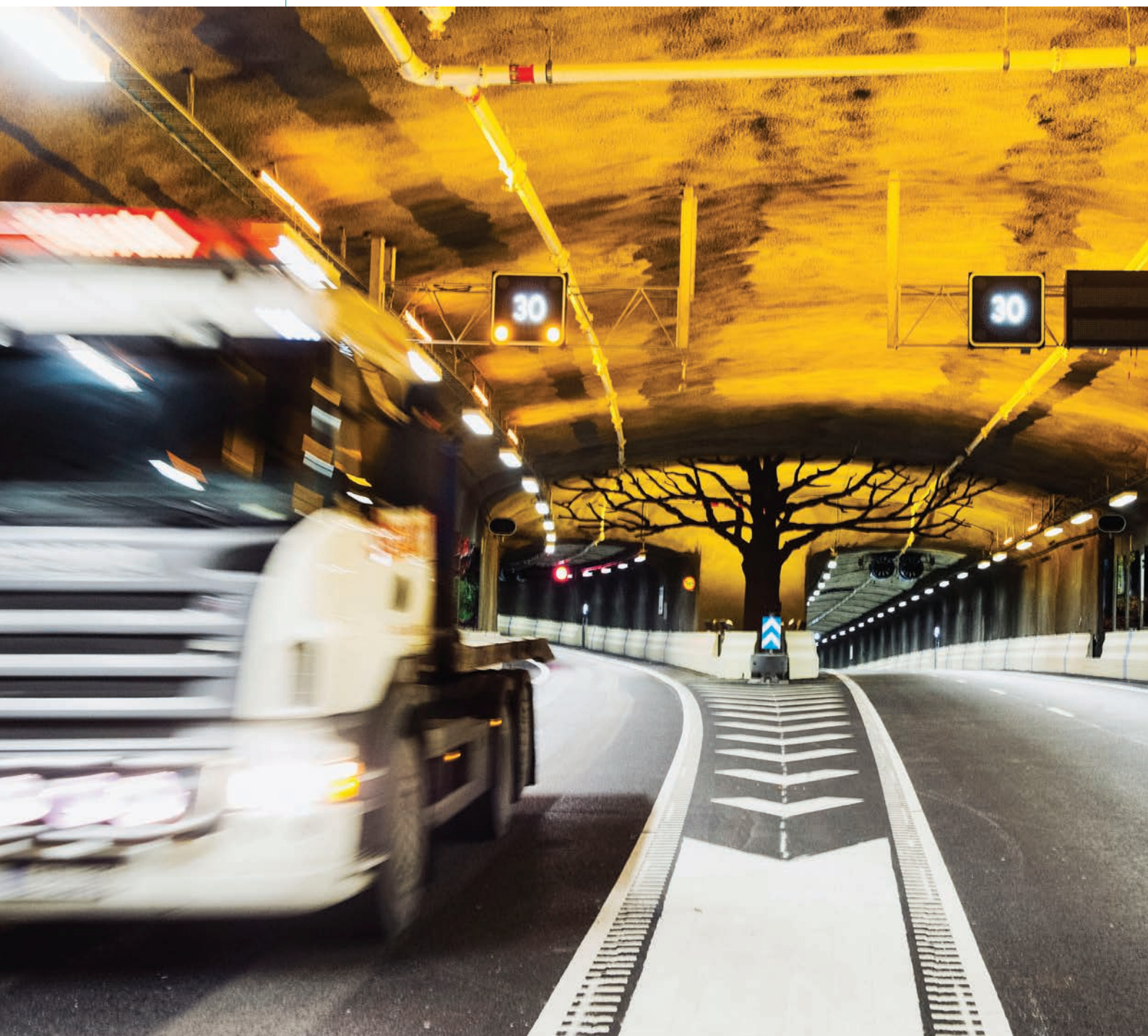


# KEEPING TUNNELS SAFE

The critical role played by certified smoke extraction motors in keeping tunnels safe is explained by **Pekka Uusitalo**, Key Account Manager for ABB Motors and Generators







**In the event of a tunnel fire, lives depend on the** ability of extraction fans – and the electric motors driving them – to disperse toxic fumes and smoke quickly and efficiently. This is not a job for an ordinary motor. In particular, smoke extraction motors must be capable of withstanding the high temperatures generated in fire zones and continue to work reliably under these extreme circumstances. When the need for extraction fans is at its greatest, there can be no room for motor failure.

Just as motors deployed in explosive environments are subject to strict regulations, motors used to extract smoke from tunnels must meet stringent certification standards. Indeed, the motor's safety function is so vital that fan manufacturers should look not only for regulatory compliance but for additional assurance of reliability and performance.

### WHY THEY ARE EFFECTIVE

Today, smoke extraction motors tend to serve a dual purpose. In normal daily operation they are part of the comfort ventilation system which maintains tunnel air quality. Vehicle exhaust-polluted, stale and warm air are removed and replaced by fresh, cool air to enhance comfort, health and visibility.

Ideally, the motors are controlled via variable speed drives (VSDs), so that fan settings can be adjusted according to need – and not limited to a choice between 'off' and 'continuous full speed'. In modern tunnel control systems, VSDs make fan-speed adjustments in response to information from sensors which monitor the pollutant levels.

When a fire starts, the motors switch to their emergency role of providing exhaust ventilation. Even small fires can result in a rapid build-up of heat and gases within the confined space of a tunnel. Carbon monoxide, especially, will soon reach lethal concentrations if it is not quickly dispersed. To maximise the chances of saving lives, smoke dispersal must begin immediately and continue for the duration of the fire or the evacuation process.

As well as removing smoke, gases and heat from the tunnel, the fans replenish supplies of fresh air so people can survive to escape or be rescued. By maintaining smoke-free evacuation and access routes, they also enable emergency services to reach the fire location. 📍

### Top and bottom left:

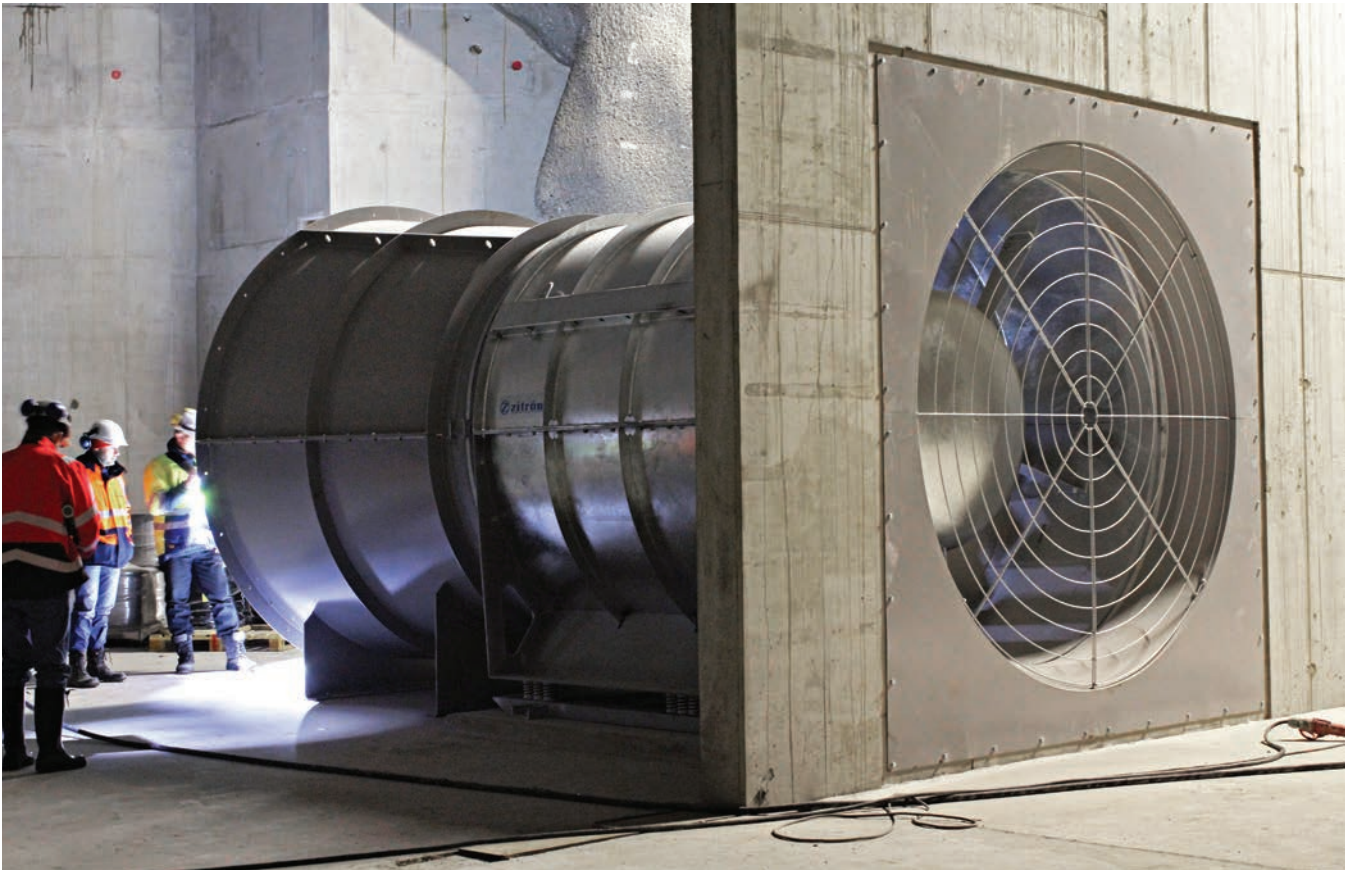
As well as removing smoke, gases and heat, fans replenish supplies of fresh air so people can survive to escape or be rescued PHOTO: ABB

### Below:

Fan motors are ideally controlled by variable-speed drives (VSDs) to allow adjustable fan settings which can also save energy PHOTO: ABB







**Above:** Smoke extraction fan installed for the extension of the Helsinki metro, Finland PHOTO: ABB



**Above:** A fan's smoke extraction motors must withstand high temperatures and continue to work reliably under extreme circumstances PHOTO: ABB

**Table 1: EN 12101-3 classes of motor/fan combinations, temperatures and running times in those temperatures**

Class	Temperature	Maximum time
F200	200°C	120 minutes
F300	300°C	60 minutes
F400	400°C	120 minutes

➤ In addition, fans can be used to establish differential pressure between zones to prevent the spread of smoke, gas and fire. In this situation, the ability of VSDs to make fast changes in the direction of fan-driven air flow is an important advantage.

## REGULATORY STANDARDS AND CERTIFICATION

In the European Union, safety requirements for motors and fans used in ventilation systems for closed or underground public spaces are defined by European Standard EN 12101-3. Its full title is: 'Smoke and Heat Control Systems – Part 3: Specification for powered smoke and heat exhaust ventilators'.

This is considered the most demanding international standard. It specifies the requirements, test methods and approval procedure for both ventilators and motors, and its detailed provisions cover issues such as whether fans are mounted vertically or horizontally.

Fundamentally, a smoke extraction motor must be able to operate at a high temperature, and must do so over a period long enough to allow escape from the fire. EN 12101-3 establishes three classes, according to how high a temperature the motor and fan combination can actually tolerate and how long they can continue operating in such heat.

A further class, F250 (250°C, 120 minutes), has been established through testing according to the EN standard.

The legal responsibility for obtaining tests and resulting CE marks for a combined motor and fan rests with the fan manufacturer. However, for peace of mind, ABB also has its motors tested and certified separately by a third-party certification body. Each is designed and certified for both direct online (DOL) and VSD operation, and for use in both normal ventilation and emergency situations. It is required to test and certify the complete package, and this has to include the specific VSD for variable speed packages.

## FAN MANUFACTURERS' REQUIREMENTS

In essence, a smoke extraction motor has much in common with other cast-iron-framed, industrial, low-voltage electric induction motors. The primary difference lies in its adaptations for heat resistance. These include special bearings – containing high-temperature grease, and heat-resistant cables. Even the motor insulation material must be selected specifically to be able to resist elevated temperatures.

While complying with regulations is essential, fan manufacturers can gain further confidence in the safety of motors by considering their quality and durability

characteristics. There are also choices to be made in terms of specification to match the individual needs of each fan or tunnel project.

Bearing design is a key issue. The stresses on a motor's bearing system during emergency operation vary considerably depending on whether the motor is mounted with a horizontal or vertical orientation. To cope with high axial and radial shaft forces, motors can be specified with angular contact or double-angular contact ball bearings.

On top of the standard range of motor sizes and features, fan manufacturers may request customisations ranging from different paint or coating materials to special monitoring and measuring attachments. Motor power outputs typically go up to about 350 or 400kW, but occasionally a project requires 1,000kW. Motor designs must be adaptable to these and other varying project demands.

In any project, price is a key factor – although costs should never be cut at the expense of safety. In addition to purchase cost, buyers should consider ongoing expenses. Ventilation systems are large energy consumers, so high-efficiency motors make good sense. Using VSDs to control them adds further efficiencies, as it avoids unnecessarily high fan speeds and power consumption, reduces wear and maintenance, and extends equipment life.

The nature of large tunnel projects is such that fan manufacturers need a lot of support and flexibility from their motor suppliers. Specifications may be altered at any stage – requiring design and manufacturing changes, along with extra documentation and administration. Good co-operation is essential.

## SMOKE EXTRACTION MOTORS IN ACTION

Recent projects applying smoke extraction technology include the West Metro, which has added almost ➤




**Left:**

A typical smoke extraction motor PHOTO: ABB





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## TECHNICAL | SMOKE EXTRACTION

14km to the Helsinki metro system in Finland.

This extension is used by around 100,000 passengers per day.

ABB supplied 32 specialised smoke extraction motors for fans manufactured by Spanish-based ZITRON, a leading global producer of tunnel ventilation equipment. Each fan weighs around 6,000kg. The motor and fan combination, meeting the most rigorous classification, will operate at 400°C for two hours.

At West Metro, there are two parallel tunnels, with cross-connections every 150 to 200m. Vertical shafts – 15 in total – are spaced around 600 to 700m apart. These provide for emergency escape routes, pressure equalisation, ventilation and smoke removal.

On detecting a fire, smoke extraction using two vertical shafts can begin in five minutes. The smoke is extracted via one shaft, while the other feeds the tunnel with fresh air. By maintaining an over-pressure in the cross-connecting tunnels, escape routes can be kept practically smoke-free.

In Asia, the all-weather Chenani-Nashri highway tunnel covers four lanes of traffic over a distance of almost 11km, connecting India's northernmost state, Kashmir, with the rest of the country. Its transverse ventilation system and parallel escape tunnel keep drivers healthy and safe. Separate ducts are used to remove exhaust air and replace it with fresh. In this case, ABB supplied the system's motors and their controlling VSDs.

An important feature of the VSDs deployed here is their 'fireman's override' input. This allows the fire service to switch fans rapidly from ventilation mode to smoke extraction or pressurisation mode, to maintain escape routes. In this condition, the drive is programmed to make the motor and fan 'run at all costs' – even to destruction. In other words, many of the alarms and warnings that would normally stop the motor to avoid damage are ignored so that precious extra minutes of air can be gained.

### A SIGNIFICANT CONTRIBUTION TO TUNNEL SAFETY

Modern ventilation and smoke extraction technology has improved the comfort and respiratory health of tunnel users. More importantly, it has greatly increased their chances of surviving fires. While tunnel developers recognise this, and specify their designs accordingly, smoke-related safety ultimately depends on effective co-operation between manufacturers of ventilation fans and motors. Use of specialised, certified smoke extraction motors is a good starting point, and expert consideration of the many other issues and choices involved ensures the safest and most dependable results. ■

### FURTHER INFORMATION

For further information visit:

<https://new.abb.com/motors-generators/iec-low-voltage-motors/industries-applications/smoke-extraction-motors>