



Tunnel ventilation and drainage

Securing safety, reliability and efficiency for critical infrastructures

Solving diverse challenges facing modern tunnel design

From consultants responsible for designing tunnel engineering systems to system integrators combining components that function well together - all require reliable and energy efficient solutions. ABB variable speed drives, motors and generators offer a commercial and technical advantage in any project.



Consultant



“The tunnels I design should meet the strictest safety and reliability codes.”

From safety advice...

- In-tunnel engineering systems aim to protect the health and safety of tunnel users.
- Under normal conditions, ventilation keeps the concentration of motor vehicle emissions low and visibility high. During an emergency, like a fire, ventilation is part of the fire suppression system. It removes smoke and heat from the tunnel, maintains evacuation routes and gives emergency services access to the fire location.
- Drainage systems ensure the water entering the tunnel is disposed of under normal and emergency situations, such as during a storm.

...to high energy efficiency...

- Because tunnel ventilation systems can have high operating costs and consume much energy, making them energy efficient is one of the project priorities.

...technology needs to be simple, yet all-embracing

- Variable speed drives (VSDs), softstarters, motors and generators are critical to the continuous operation of ventilation, drainage and fire suppression systems. The equipment helps meet specific tunnel design requirements, while reducing power consumption and increasing safety for tunnel users.



System integrator



“Component compatibility with common standards and interfaces ensures smooth integration and trouble-free commissioning.”

From easy connection and integration...

- Connecting and integrating components into ventilation, fire suppression and drainage systems must be straightforward, ensuring smooth interoperability.

... to high reliability ...

- Efficient tunnel management requires detailed access to fault logs and operational data for condition monitoring and troubleshooting.

...using world leading protocols and standards

- Support of all major communication protocols ensures VSDs and softstarters are an integral part of a tunnel automation system and can contribute to an overall control strategy.



Tunnel safety inspector



“It’s critical to make sure the tunnel is safe, and its systems are compliant with the industry standards.”

Extreme risks demand...

- Even a small fire can have serious consequences in a confined space like a tunnel. Gases and heat build up quickly and are difficult to disperse. Trapped in a tunnel, toxic carbon monoxide concentrates to fatal levels in seconds.
- During a storm, water can rapidly fill a tunnel, disrupting traffic or even proving to be life-threatening if, for instance, an underwater tunnel leaks.

... rigorous directives and standards...

- Global directives and standards for tunnel ventilation fans specify how long and at what temperatures the fans should operate in extreme conditions. Special attention is given to acceleration and braking time.
- Motors must be tested to EN 12101-3, which is considered the most demanding standard for smoke extraction.

... and advanced safety features

- In emergency situations, VSDs should enter override mode, running fans according to a chosen strategy, ignoring warnings and faults. This allows extended fan runtime in adverse conditions for safe evacuation of tunnel users.



Operating company



“Traffic should be continuous with a minimum risk of emergencies.”

Eliminate operating risks...

- Tunnels are mission-critical infrastructures ensuring vital transport connections, so demand 100 percent availability.

...by utilizing smart functionality

- VSDs feature temperature monitoring, overload, overcurrent, under/overvoltage and other protections and warnings which help prevent failures in the control of ventilation and drainage systems.
- VSDs override function helps protect lives contributing to a safe evacuation during a fire.
- VSDs real-time clock allows fault tracking to know what happened and when.
- Ultra-low harmonic (ULH) drives ensure power quality in the tunnel network, making the power system and equipment connected to it more resilient.

“How to optimize costs?”

Lower expenses...

- Costs can be optimized without compromising tunnel operation continuity and safety.

...through advanced solutions and maintenance regimes

- ULH drives allow for smaller supply transformers, backup generators and cables significantly reducing project costs.
- ULH drives save money by maintaining unity power factor, eliminating reactive power penalties from the utility.
- ABB Ability™ Condition Monitoring service delivers targeted maintenance actions when needed, eliminating regular inspections.
- ABB global service network and maintenance contracts relieve pressure on in-house teams and increase speed of response to critical issues.

Demands of tunnel ventilation and drainage systems during normal operation and emergencies

Every day tunnel fans help remove vehicle exhaust fumes and maintain visibility. In the event of a fire, ventilation manages smoke extraction and supports evacuation. Pump stations dispose of water from tunnels that are below the water table on a constant basis or during storms.

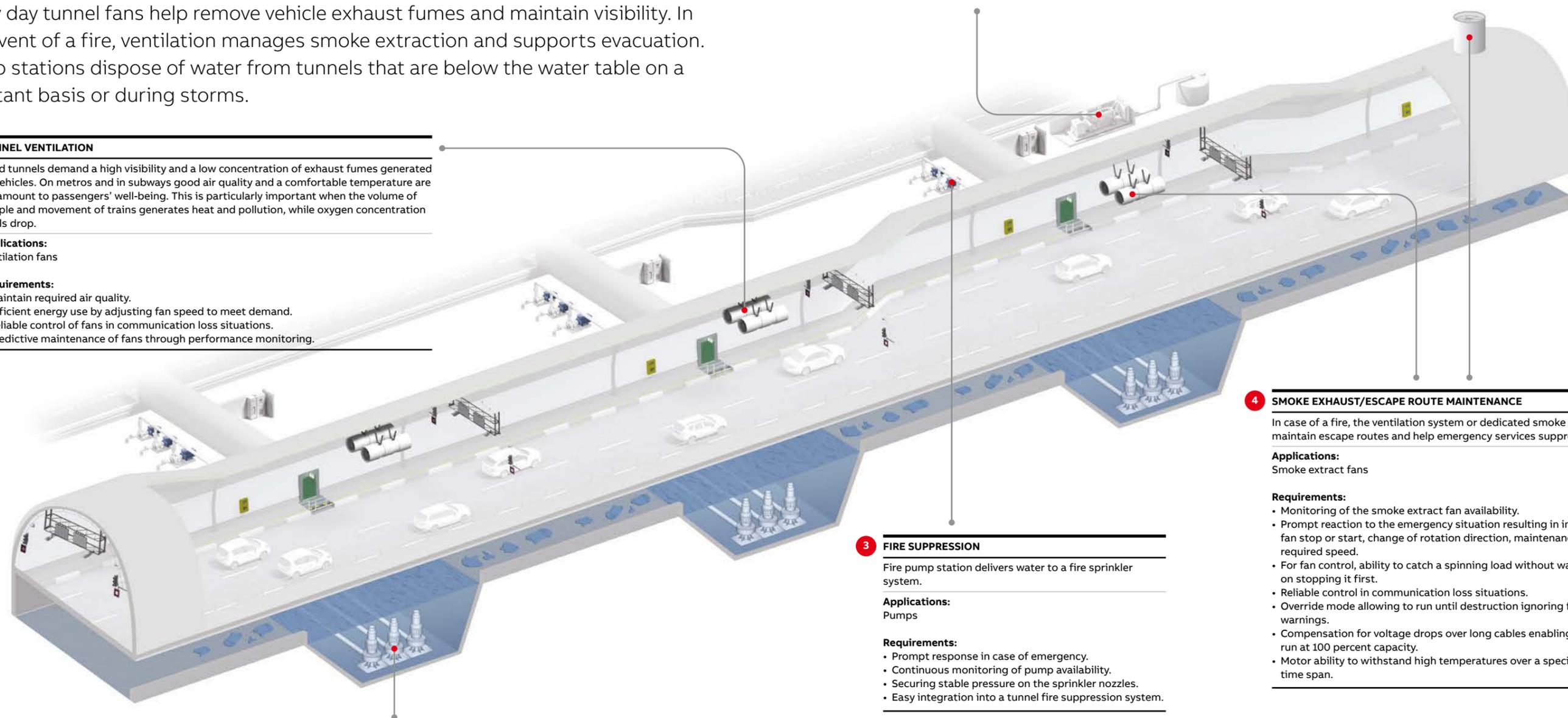
1 TUNNEL VENTILATION

Road tunnels demand a high visibility and a low concentration of exhaust fumes generated by vehicles. On metros and in subways good air quality and a comfortable temperature are paramount to passengers' well-being. This is particularly important when the volume of people and movement of trains generates heat and pollution, while oxygen concentration levels drop.

Applications:
Ventilation fans

Requirements:

- Maintain required air quality.
- Efficient energy use by adjusting fan speed to meet demand.
- Reliable control of fans in communication loss situations.
- Predictive maintenance of fans through performance monitoring.



2 DRAINAGE

Protects tunnel users and underground control rooms/installations by removing water intrusion from infrastructures below the water table, either continuously or in emergency situations during storms.

Applications:
Pumps

Requirements:

- Control of tunnel's water level.
- Continuous monitoring of pump availability.
- Reliable control of pumps in communication loss situations.
- Predictive maintenance of pumps through performance monitoring.

5 EMERGENCY POWER SUPPLY

During heavy storms, the utility power is at its greatest risk of failure. Yet during this time the drainage system needs to be fully functional. The backup generator lies at the core of the entire emergency power system and operates critical loads during electric utility outages.

Applications:
Generator

Requirements:

- Current and voltage harmonics in the tunnel network cause excessive heating in the generator meaning losses and shorter lifetime.
- Harmonics affect the generator's ability to accurately sense its terminal voltage which results in voltage instability in the system.
- Loads with high harmonic content require a larger generator if no harmonic mitigation is used in the system.
- If the power factor is outside the generator's specification, its performance is at risk, so generator oversizing or other compensation measures are required.

4 SMOKE EXHAUST/ESCAPE ROUTE MAINTENANCE

In case of a fire, the ventilation system or dedicated smoke extract fans maintain escape routes and help emergency services suppress the fire.

Applications:
Smoke extract fans

Requirements:

- Monitoring of the smoke extract fan availability.
- Prompt reaction to the emergency situation resulting in immediate fan stop or start, change of rotation direction, maintenance of required speed.
- For fan control, ability to catch a spinning load without wasting time on stopping it first.
- Reliable control in communication loss situations.
- Override mode allowing to run until destruction ignoring faults and warnings.
- Compensation for voltage drops over long cables enabling fans to be run at 100 percent capacity.
- Motor ability to withstand high temperatures over a specified time span.

3 FIRE SUPPRESSION

Fire pump station delivers water to a fire sprinkler system.

Applications:
Pumps

Requirements:

- Prompt response in case of emergency.
- Continuous monitoring of pump availability.
- Securing stable pressure on the sprinkler nozzles.
- Easy integration into a tunnel fire suppression system.

Unlock the potential of tunnel engineering systems

Variable speed drives, softstarters, motors and generators are critical for safe operation of road and rail tunnels. Alongside process continuity and energy savings, there are many application-specific benefits from using ABB variable speed drives and motors on motor-driven applications in tunnels.

	Challenge	Solution	Benefit
 Metro air conditioning equipment	<ul style="list-style-type: none"> High energy consumption 	<ul style="list-style-type: none"> High efficient motor-drive package with motor efficiency up to IE5 Air handler filter monitoring via a VSD which raises alarm when pressure drops due to clogged filter 	<ul style="list-style-type: none"> VSDs typically save between 20 to 60 percent energy compared to damper control system Avoiding clogged filters which can use 15 percent more energy
	<ul style="list-style-type: none"> Air handler uptime 	<ul style="list-style-type: none"> VSDs include protection e.g. overcurrent, overvoltage, motor overheating and overload control Less mechanical and electrical stress with VSDs, opposed to direct-on-line start Smart sensors collect information on fan or pump performance enabling predictive maintenance 	<ul style="list-style-type: none"> Improved passenger comfort at stations
 Tunnel ventilation fans	<ul style="list-style-type: none"> Road tunnel air quality 	<ul style="list-style-type: none"> Using information from sensors measuring COx, NOx and air particle concentration, VSDs control fan speed 	<ul style="list-style-type: none"> Low concentration of car fumes and good visibility in the tunnel
	<ul style="list-style-type: none"> High energy consumption 	<ul style="list-style-type: none"> VSDs adjusting fan speed in accordance with tunnel air pollution High efficient (up to IE5) motors 	<ul style="list-style-type: none"> VSDs typically save between 20 to 60 percent energy compared to fans constantly running at nominal speed
	<ul style="list-style-type: none"> Overly complex tunnel automation system and increased error risk 	<ul style="list-style-type: none"> VSDs offer local control and can extend external PLC control tasks VSDs' fieldbus capability avoids need for external gateways 	<ul style="list-style-type: none"> Decreased infrastructure complexity and costs
	<ul style="list-style-type: none"> Fan control reliability 	<ul style="list-style-type: none"> Control backup in VSDs – in case of external communication loss, VSDs can take over control 	<ul style="list-style-type: none"> Fan continues to run in preset local control mode until external communication is recovered
	<ul style="list-style-type: none"> Voltage drop over long motor cables decreasing the fan nominal power and available airflow 	<ul style="list-style-type: none"> ULH drives with active front end (AFE) boost output voltage guaranteeing full fan motor voltage even when the supply voltage is below nominal 	<ul style="list-style-type: none"> Avoid oversized cables needed to reduce voltage drop over the length to acceptable levels
	<ul style="list-style-type: none"> Brown outs in remote locations 	<ul style="list-style-type: none"> ULH drives with AFE compensate supply voltage fluctuations, ensuring smooth operation 	<ul style="list-style-type: none"> Reduced need for emergency power supply and improved resilience of operation
	<ul style="list-style-type: none"> Harmonics causing transformer overheating and subsequent power outage 	<ul style="list-style-type: none"> ULH drives with AFE reduce harmonics content in the network to an absolute minimum 	<ul style="list-style-type: none"> Network stability and elimination of large active filters for harmonics mitigation No extra costs due to oversized cables, transformers, generators to avoid harmonics related issues Compliance with stringent harmonics standards
	<ul style="list-style-type: none"> Fire emergency handling 	<ul style="list-style-type: none"> VSDs' fireman's override allows regular ventilation fans to be part of a fire suppression system by converting them into smoke exhaust or pressurization units for escape routes maintenance 	<ul style="list-style-type: none"> Safe evacuation for people Access to the fire location for emergency services No undesired tripping of drives in extreme conditions Flexibility in selecting evacuation / fire suppression strategy
	<ul style="list-style-type: none"> Escape route management in case of emergency 	<ul style="list-style-type: none"> VSDs' override mode implemented such that required pressure/ fan speed is maintained to prevent smoke entering evacuation spaces 	<ul style="list-style-type: none"> Eliminating door blockage / smoke propagation due to too high / low pressure Flexibility in selecting evacuation strategy in ever-changing tunnel environment
	<ul style="list-style-type: none"> Fast braking in case of emergency 	<ul style="list-style-type: none"> Drives offer flux braking, braking choppers and regenerative braking techniques 	<ul style="list-style-type: none"> Choose the most cost-efficient and technically feasible solution Regenerative braking eliminates brake resistors increasing installation size and complexity



01

	Challenge	Solution	Benefit
 Smoke exhaust fans	<ul style="list-style-type: none"> Smoke exhaust fans availability 	<ul style="list-style-type: none"> VSDs and softstarters allow fans to start without power system overload VSD-based phase loss check 	<ul style="list-style-type: none"> Smoke extract process continuity Tunnel users' safety
	<ul style="list-style-type: none"> High temperatures 	<ul style="list-style-type: none"> VSDs are tested for operating 1 h at 70 °C Smoke extract motors are certified for operating at 200°C for 120 min, 300°C for 60 min, 400°C for 120 min, 250°C for 120 min 	<ul style="list-style-type: none"> Smoke extract process continuity even at high temperatures
 Drainage pump stations	<ul style="list-style-type: none"> Tunnel flooding 	<ul style="list-style-type: none"> VSDs and softstarters are ready to start the pumps once the water level exceeds safe limits 	<ul style="list-style-type: none"> Control of the water level for tunnel safety
	<ul style="list-style-type: none"> Pump uptime 	<ul style="list-style-type: none"> VSDs supervisory functions indicate upcoming mechanical failures like bearing wear or events like stalled impeller Smart sensors measure pump motor health parameters like vibration and temperature 	<ul style="list-style-type: none"> Water disposing process continuity Tunnel users' safety
	<ul style="list-style-type: none"> Pressure shocks 	<ul style="list-style-type: none"> VSDs or softstarters feature soft pump start and stop which helps avoid pressure shocks 	<ul style="list-style-type: none"> Pump and piping system increased lifetime and decreased operating costs
	<ul style="list-style-type: none"> Pipe leakage or pipe blockage 	<ul style="list-style-type: none"> VSDs indicate if the pressure in a pipe increases to a maximum / drops to a minimum and sends an alarm 	<ul style="list-style-type: none"> Motor, pump or piping system will not get damaged when the pipe is blocked Flood monitoring helps avoid infrastructure damage due to a leakage
 Fire pump stations	<ul style="list-style-type: none"> Fire suppression 	<ul style="list-style-type: none"> VSDs and softstarters help a fire pump station become part of a tunnel fire suppression system acting as a whole 	<ul style="list-style-type: none"> Keeping the people safe and the asset damage to a minimum
	<ul style="list-style-type: none"> Fire pump station availability 	<ul style="list-style-type: none"> VSD-based phase loss check VSDs and softstarters allow pumps to start without power system overload 	<ul style="list-style-type: none"> Successful fire extinguishing

02



01 Fire pump station is a vital part of a tunnel fire suppression system.

02 Ventilation in subway tunnels happens thanks to trains moving the air, but temperature at the stations and passages rises significantly if no air conditioning involved.

Features and functions benefiting tunnel ventilation and drainage systems

ABB offers an extensive range of devices from softstarters and VSDs to motors and generators. Choosing the right products and features is essential for ensuring a safe and energy-conscious tunnel environment.



Variable speed drives

Regenerative capability

- Eliminates the need for braking resistors – energy is fed back into the network. Everything needed for regenerative braking is included in the drive.

Brake choppers

- Provide fast ramp down, together with brake resistors, by converting power to heat.

Flux braking

- Eliminates the need for external braking resistors in low-inertia systems.

Low harmonics

- Built-in active front end and integrated line filter eliminate harmonic disturbances in the network.

Voltage boost

- Full load operation of fans and pumps during voltage sags or voltage drop across long cables.

Flying start

- Reduces wear and saves time by starting a motor while the load is still spinning.

System efficiency

- VSDs increase system's efficiency by adjusting motor speed to the present need.
- Advanced feature, Energy Optimizer, improves energy use by reducing motor magnetic losses.
- Active front end eliminates harmonics-related losses.

Built-in PID control

- Extends external PLC control tasks to reduce automation system complexity and costs.

Fireman's override mode

- Makes the VSD part of a tunnel fire suppression system, protecting people and infrastructure.
- Disables warnings and faults, allowing the drive to run in adverse conditions as long as possible.

Built-in redundancy

- External communication loss is handled seamlessly by a VSD taking control until the external communication is recovered.

Long motor cable support

- Reliable application control even at large motor cable lengths common for tunnels.

Harsh environment use

- VSDs are tested for operating 1 h at 70 °C.
- IP55 units withstand humidity and dust.
- All VSDs have coated circuit boards.

Embedded communication

- Control, monitoring and diagnostics for applications through embedded Modbus RTU, BACnet MS/TP and other optional protocols.



Softstarters

Soft start and stop

- Minimized mechanical and electrical stresses at starts and stops.

Built-in bypass

- Reduced system size and complexity.
- Reduced heat generation from internal losses by activating bypass at full speed.

Harsh environment use

- Process continuity in dusty or wet environments with IP66 keypad and coated electronics.

Embedded communication

- Control, monitoring and diagnostics for applications through embedded Modbus RTU and other optional protocols.

Emergency mode

- Protection features are tuned off to supply power to the motor in adverse conditions.

Standstill brake

- Prevents fans from free-wheeling and always starts from stand still position.



Motors

High reliability

- Protection against external conditions with IP55 as standard.
- Wide range of surface treatment and corrosion protection solutions available.
- Protection against bearing currents with an extended portfolio of solutions including insulated bearings and shaft grounding.
- Bearings locked at D-end to avoid axial play.

Efficiency

- Up to IE5 efficiency to reduce energy consumption and improve total cost of ownership.

Easy installation

- Oversized terminal box as standard to ease installation.
- Flexible cabling solutions.
- Various mounting arrangements including direct drive, belt or transmission.
- Horizontal and vertical mounting.



ABB Ability™ Smart Sensor for motors, pumps and mounted bearings

Minimized unplanned downtime

- Failures are detected well before equipment needs to be shut down, avoiding unplanned downtime.

Reduced maintenance costs

- By changing from scheduled to condition-based maintenance, service costs can be considerably reduced.

Improved safety

- Eliminated need for motor / pump / bearings manual check-ups in locations that are hard-to-reach or dangerous.

Smoke extraction motors

- Operate reliably even at high temperatures of a fire zone.
- Comply with smoke and heat control systems standard EN 12101-3, classes F200-120, F300-60, F400-120, T250-120.
- Maximum performance in both normal and emergency conditions.
- Designed for direct-on-line and VSD operation, both in normal and emergency situations.



Generators

High reliability

- Meet demands for low voltage ride-through events, vibration, mechanical and electrical stresses, fast response times and frequent starts.
- Improve the quality of an electricity supply reducing harmonic content.

Efficiency

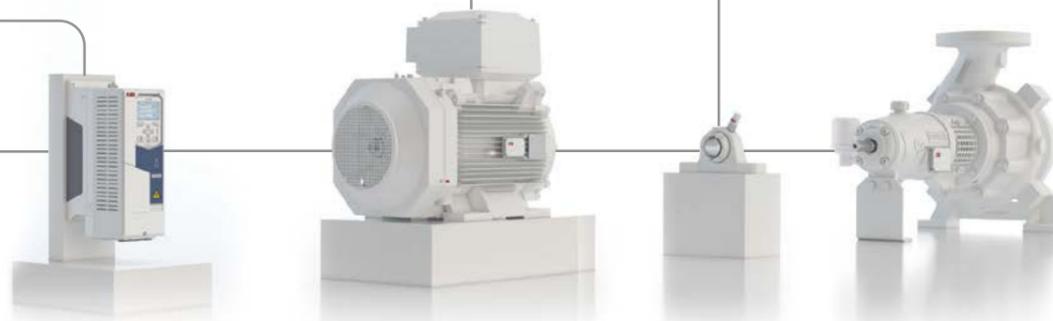
- Reduced fuel consumption for a longer operation in emergency situations.

Compactness

- The best kWh production at given size and weight.

Wide offering

- Available over a large range of operating parameters and enclosures, complying with all internationally accepted standards.



From the facility to the cloud and beyond

ABB Ability™ Condition Monitoring for powertrains optimizes the performance and efficiency of rotating equipment. It enables full transparency on all parameters for VSDs, motors, mounted bearings and applications like pumps.

1

Intelligent powertrain

The powertrain is equipped with sensors and cloud connectivity and can comprise motors, VSDs and mechanical components including bearings, couplings and applications like pumps.

2

Turning data into valuable information

Data gathered from VSDs' built-in sensors and loggers, together with that collected from ABB Ability™ Smart Sensors fitted to motors, bearings and pumps, can be collated, stored and further accessed via the cloud. The ability to gather and analyze this data can reveal information on the status and condition of your equipment, so that you can schedule proactive service.

3

Accessing data for analytics

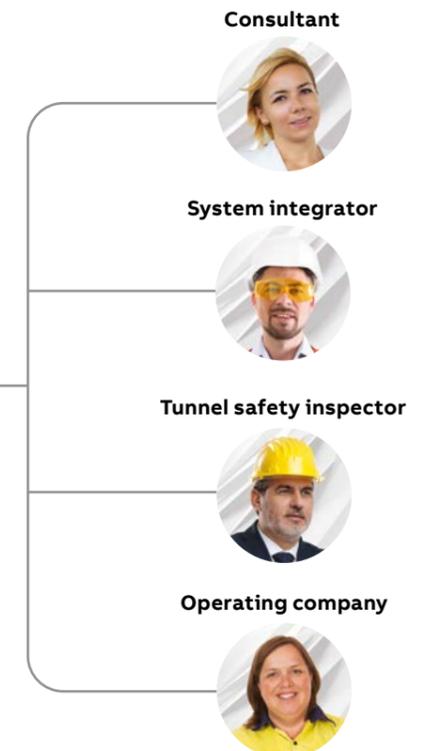
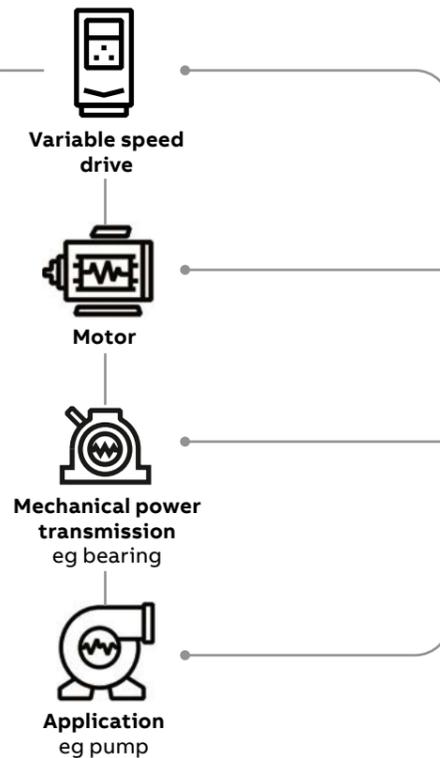
You have access to a monitoring portal to view key operational parameters of individual assets as one unified system. Detailed dashboards give full transparency so that you can take actions that lead to less downtime, extended equipment lifetime, lower costs, safer operations and increased profitability.

4

Gain a digital advantage

Ensuring that the right person has the right information at the right time brings:

- Appropriate response to process challenges, minimizing operating costs.
- Greater insight into various aspects of the process, thereby improving system performance.
- Lower risk of process failure and change the maintenance from reactive to predictive.



Keep your facility running

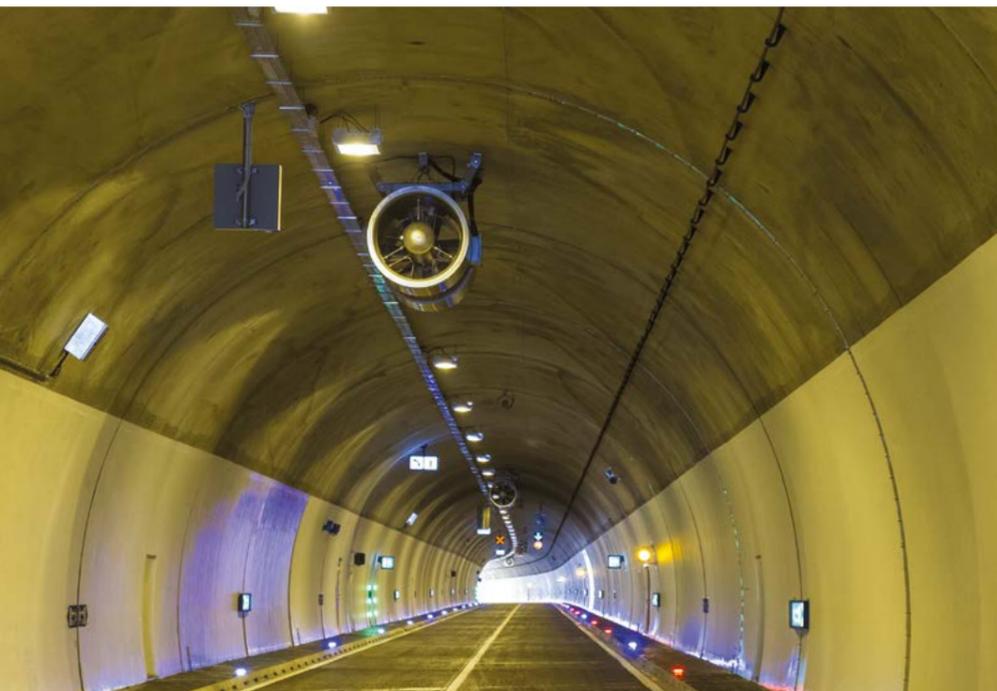
From spare parts and technical support to cloud-based remote monitoring solutions, ABB offers the most extensive service offering to fit your needs. The global ABB service units, complemented by external Value Providers, form a service network on your doorstep. Together they maximize performance, uptime and efficiency throughout the life cycle of your assets.

With you every step of the way

Even before you buy a generator, VSD, motor, bearing or softstarter, ABB's experts are on hand to offer technical advice from dimensioning through to potential energy saving.

When you've decided on the right product, ABB and its global network of Value Providers can help with installation and commissioning. They are also on hand to support you throughout the operation and maintenance phases of the products life cycle, providing preventive maintenance programs tailored to your facility's needs.

ABB ensures you are aware of any upgrades or retrofit opportunities. If you've registered your VSDs and motors with ABB, then its engineers will proactively contact you advising on your most effective replacement option. All of which helps maximize performance, uptime and efficiency throughout the lifetime of your powertrain.



With you, wherever you are in the world

Partnering with ABB gives you access to some of the world's most innovative technology and thinking.

Global reach

ABB operates in over 100 countries with its own manufacturing, logistics and sales operations together with a wide network of local channel partners that can quickly respond to your needs. Stock availability is good, with short delivery times for many products backed by 24-hour spare parts delivery.

In addition, ABB interacts closely with rail and road tunnel industry players including consultants, system integrators, safety inspectors and operating companies to help increase tunnel safety and its engineering

systems reliability and efficiency to an absolute maximum.

ABB has seven global R&D centers with more than 8,000 technologists and invests \$1.5 billion annually on innovation.

End-to-end product portfolio

Alongside its diverse portfolio of VSDs, softstarters, motors and generators, ABB offers tunnels:

- Medium voltage components and systems such as air- and gas-insulated switchgears, uninterruptible power supply units, relays,

ultra-fast earthing switches, Is-limiters to reduce high short-circuit currents and more.

- Low voltage components and systems such as switchgears, uninterruptible power supply units, breakers, industrial plugs and sockets, RCD blocks, power distribution units, remote power panels, a wide range of scalable PLCs and HMIs and more.
- Digital solutions including ABB Ability™ cross-product and system offering providing intelligence all the way to the component level, improving overall visibility and making the system safe, reliable and efficient.

Streamline sourcing

ABB's end-to-end product and services portfolio streamlines your sourcing and purchasing activities and standardizes processes across multiple sites, saving you money on spare part inventories while reducing maintenance costs.





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For more information, please contact your
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