





Peak power

ABB's ZX0 medium-voltage switchgear and PMA cable protection for the Gotthard Base Tunnel

ANDREAS BEINAT, FELIX INGOLD – Launched in 1993 with preliminary geological test bores, the Gotthard Base Tunnel – the longest rail tunnel in the world – opened in June 2016, a year ahead of schedule. ABB's contribution to this monumental construction project came in many forms – such as over 800 medium-voltage (MV) switchgear units that power the tunnel infrastructure and the many kilometers of robust PMA cable protection for the lighting system in the tunnel.

Title picture

Costing over \$10 billion and with two parallel tubes, each of 57 km long, the Gotthard Base Tunnel relies on an intelligent and reliable electrical infrastructure to ensure safe operation.

1 The tunnel will carry trains only. Shown is the Faido track changeover.



After 20 years of construction, the world's longest railroad tunnel opened in June 2016. In addition to increasing freight capacity along the Rotterdam-Basel-Genoa corridor, the Gotthard Base Tunnel also includes regular passenger services that significantly cut travel time between the north and south of Switzerland. Up to 250 trains a day will use the tunnel when all services are running → 1. It is a testament to the professional engineering and efficiency of those involved in the project that the tunnel was brought into operation a year ahead of the schedule foreseen in 2008.

At that time, ABB was contracted by Balfour Beatty Rail to provide the MV switchgear needed to power the Gotthard Base Tunnel's infrastructure. This 50 Hz technology supplies power for systems that include air conditioning, ventilation, lighting, signaling, communications and safety. Balfour Beatty Rail belongs to the Transtec consortium, which was assigned to install the rail infrastructure by the tunnel builder, Alp-Transit Gotthard AG.

ABB was able to complete this massive order in just six years. The completion of the delivery of 875 units of MV switchgear was celebrated at the installation

site in Schattdorf, Switzerland in August 2014 by representatives of both Balfour Beatty Rail and ABB.

Adapting to on-site conditions

Every 325 m along the twin tunnels, there is a passageway between them → 2. These are also designated as escape routes and every other one is equipped with electrical power. To deliver this power, ABB supplied ZX0 MV gas-insulated switchgear (GIS), which had to be adapted to the difficult on-site conditions. Railroad tunnels come with a myriad of challenges, not least of which is the fine, powdery dust abraded from the train tracks each time a train speeds over them.

ZX0 GIS

Given the importance of switchgear and circuit breakers in ensuring the safe and flexible operation of the endeavor, ABB had to make sure its switchgear fitted the bill under the special conditions encountered in the tunnel complex. ZX0 GIS was the ideal solution for the Gotthard Base Tunnel as it has a modular and compact structure that delivers and distributes energy without interruption at the highest level of availability. With the ZX0, ABB has delivered switchgear

that is reliable, low-maintenance, and easy to configure and operate.

The fact that the ZX0 is gas-insulated brings with it many advantages. It offers the highest level of safety for railway employees, for example, as all live parts are completely touchproof, which means that inadvertent contact with live parts

ABB's MV switchgear supplies power for systems that include air conditioning, ventilation, lighting, signaling, communications and safety.

is impossible and the switchgear can be handled safely during installation and commissioning. No gas handling is necessary on-site because all MV parts are inside a sealed tank, protected from external influence, with no maintenance necessary for the parts inside the tank. This minimizes accidents and danger to human life.

The gastight enclosure protects all components against aging, thus reducing the total cost of ownership and making the ZX0 a cost-effective solution with a low overall lifetime outlay.



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Intensive testing

Given the special challenges faced in the Gotthard Base Tunnel, steps were taken to enhance the ZX0's integrity. For example, ABB designed the ZX0's accompanying local control cubicle in accordance with the IP65 protection rating and also made it dust-tight and resistant to water jets. The design was also able to withstand the pressure variations caused by passing trains.

With the inter-tunnel passageways also being used as escape routes, there were much stricter requirements for arc-fault protection and arc resistance than is the case even for restricted-access areas. The ZX0, therefore, includes a special pressure relief system to eliminate all risk to human safety.

Suitable monitoring

To protect, control, measure and monitor the network throughout the entire tunnel system, ABB provided 500 units of the REF542plus feeder terminal. The REF542plus ensures a stable, uninterrupted energy supply by quickly locating any fault and immediately transmitting the fault type and location information to the tunnel control system.

The feeder terminal also offers remote services, providing access to stored programs and protection data via Ethernet LAN. The REF542plus can execute remote protection in a multistage way so that any faulty parts within the net-

work can be switched off individually. For ease of use, remote access can be handled using a standard Web browser – operators can log on to the feeder terminal from any place at any time, with the appropriate security precautions.

The SMS feature in the new REF542plus release offers operators even more freedom of movement. If the REF542plus registers an event, it can send a notification via text message (SMS) to the operator's mobile phone. The operator can then log on via the Internet to the switchgear, access the REF542plus, remotely analyze the fault and determine how to correct it.

To reduce the occurrence of faults in a power distribution network, it is necessary to analyze how often faults happen. For this, the REF542plus uses GPS (global positioning system) in an innovative way. Instead of using GPS as a geolocation tool, the REF542plus takes advantage of the precise time signal provided by GPS to continuously synchronize its own embedded clock. Faults are time-stamped with a sub-millisecond precision and forwarded to a central location for analysis. These time stamps help to evaluate the causes of faults.

Scope of delivery

ABB has supplied more than switchgear to the Gotthard Base Tunnel. Among other things, the company also supplied the power supply and drive systems for the strongest ventilation system in the world, with a power rating of 15.6 MW. The entire ventilation control system itself – comprising activation and control units for the fans and the tunnel sensors, as well as fire location detection – was also supplied by ABB. A scenario manager provides the corresponding control of the airways for a variety of predefined events.

All live parts are completely touchproof, which means that inadvertent contact with live parts is impossible and the switchgear can be handled safely.

Meeting high reliability demands

All of the tunnel equipment described above is wholly dependent upon a reliable power supply. However, within such long and deep tunnels, exceptional climatic conditions prevail. Air temperatures can exceed 40°C while regular medium-pressure washdown procedures contribute to a relative humidity of up to 70 percent. Moreover, excellent



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fire-safety characteristics are essential for all products used in tunnel infrastructure applications. However, many products currently available on the market are unable to meet the very high safety and reliability standards required.

Alpiq Burkhalter Bahntechnik AG, a partner in the Transtec Gotthard consortium, consulted PMA (a member of the ABB Group and one of the market leaders for high-specification cable protection) regarding a complete, high-specification, end-to-end cable protection system with excellent fire-safety characteristics (flammability, smoke density and toxicity) and high ingress protection (IP68 and IP69K) to withstand the medium-pressure cleaning process.

Although Alpiq Burkhalter Bahntechnik had used ABB's PMA cable protection systems for tunnel projects before, the Gotthard Base Tunnel project presented new challenges and the company needed a flexible, easy-to-install, completely closed cable-protection solution that could withstand the tunnel environment.

Polyamide protection

High-grade, specially formulated polyamide has excellent resistance to ultra-violet (UV) rays and weathering, and offers good impact strength. Polyamide products have outstanding fire-safety characteristics regarding low flammability, smoke/gas emission and toxicity in the event of a fire, all of which are especially important for this tunnel project.

At first, smaller installations under bridges and in tunnels were fitted with PMA products for extensive testing. The results were so convincing that Alpiq Burkhalter Bahntechnik chose PMA products for this world-famous project.

ABB was asked to deliver 21 km of VAMLT conduit along with over 21,000

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BVNZ strain relief fittings and BFH-0 conduit fixation clamps for the lighting system in the 57 km long railway tunnels. More than 10,000 emergency guidance lights and 450 emergency exit



light systems were subsequently equipped with ABB's PMA cable protection products → 3-6.

A strong tunnel system

PMA polyamide-based cable protection systems possess high mechanical strength characteristics such as compression strength and resistance to high-energy impact, combined with high flexibility. They are corrosion free with high ingress protection against water and dust – important in the Gotthard Base Tunnel. They demonstrate high resistance to numerous environmental influences such as chemicals (particularly cleaning agents) and UV, are immune to attack by rodents and have a broad operating temperature range. ABB's PMA cable protection systems have a long lifetime and come with the assurance of dedicated customer service.

The scope of this world-renowned project presented unique technological challenges and as such represents an excellent global reference for ABB's products.

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Further reading

R. Jenni *et al.*, "Switzerland by rail: Supplying traction power for the country's major railway initiatives," *ABB Review* 2/2010, pp. 31-34.