Reprint from ABB Review, 2/2011

A mine of efficiency
Sophisticated ABB technologies extend life of Aitik copper mine

Aitik, Boliden's impressive open-pit copper mine in northern Sweden, recently modernized its complete mining operation to double production capacity and extend the mine's lifespan to 2030. In spite of the low ore grades, Boliden runs a highly profitable mine due to its efficient operation. ABB contributed to this success by supplying a large range of products and systems to power and operate the entire site.

A mine of efficiency

ABB is helping extend the life of the massive Aitik copper mine by making it more efficient

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– Some 1,000 km north of Stockholm, Sweden, past the Arctic Circle, lies an impressive open-pit copper mine, known as Aitik. Although the proportion of metal found at the Aitik copper mine is low – less than 0.3 percent – it is a highly profitable mine because it is run so efficiently. In fact, operations have recently become even more efficient – a $790 million modernization of the entire mining operation has enabled the mine operator Boliden to double its production capacity and extending the life of the mine to 2030. ABB has contributed to this success by supplying a range of products and systems to power and operate the entire site.

ABB delivered the world's first gearless mill drive to the Lafarge cement company in France in 1969, and the 6.4 MW machine is still operating today.

Located near Gällivare, in the arctic Lapland region of Sweden, the copper deposit at Aitik was discovered in the 1930s. However, mining there began only in 1968 when technology was sufficiently advanced to profitably extract the metal. Although the ore grading is low – 0.25 percent copper, 0.1 g gold per ton ore, and 2 g silver per ton ore – these metals are nevertheless worth digging for. In 2006, Boliden made its largest investment decision to increase output at the mine in the form of a three-year, $790 million upgrade.

Among the products and systems supplied by ABB are 650 motors, 230 drives and variable-speed drives, two 22.5 MW gearless mill drives, two 2 × 5 MW dual-pinion drive systems, four 1.4 MW permanent-magnet motors, 23 distribution transformers, gas-insulated switchgear, a harmonic filter system, the extended process control System 800xA and of course a comprehensive service contract → 1.

Mining at ABB

ABB has a long history in mining solutions. The company delivered the first drives and controls for a mine hoist at the Kolningsberget iron mine in Norberg, Sweden, in 1891 – 120 years ago! It has also delivered more than 600 new hoists and modernized hundreds of existing plants. A mine hoist delivered around 1930 by ASEA, a predecessor company of ABB, to the Zinkgruvan zinc mine in Sweden is still in operation today. ABB has several other firsts in mining history – a predecessor company, VEM, delivered the first bucket chain excavator and conveyor bridge in 1949 as well as the first conveyor belt in 1960.

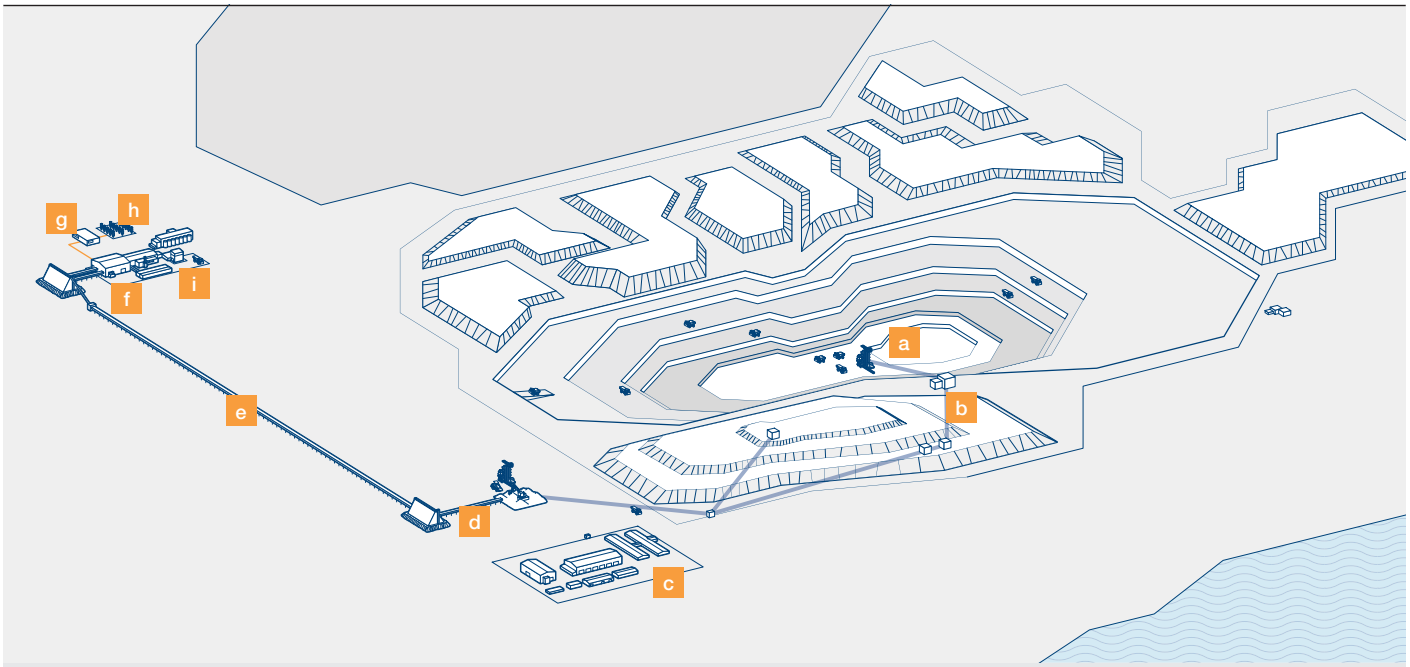
ABB has also pioneered the development of gearless mill drive (GMD) systems – giant motor and drive systems that power ore mills.[1] They are more reliable and energy efficient than traditional mill drive systems and increase mill productivity. ABB delivered the world's first gearless mill drive to the Lafarge cement company in France in 1969, and the 6.4 MW machine is still operating today.

The first ABB GMD system for mineral processing was for a copper concentrator at the Bourgainville mine in Papua New Guinea in 1985. Since 1969, ABB has delivered or has on order more than 100 GMD systems around the world. Over the years, the systems have become larger and more powerful; in 2010, ABB delivered three of the world's most powerful gearless mill drive (GMD) systems ever made to Minera Chinalco's Toromocho mine in Peru. The GMD for the 40-foot SAG mill has a power rating of 28 MW, and the GMDs for the two 28-foot ball mills have a power rating of 22 MW. All of them are designed to operate at the extreme altitude of 4,600 m above sea level. In 2010, ABB received an

Title picture
Aerial view of the Aitik copper mine in Gällivare, Sweden. The open-pit mine is 3 km long and 405 m deep. Photo copyright Boliden/Lars Devall.

Footnote
1 See also "Driving value" in *ABB Review* 1/2011 and "Smooth operation" in *ABB Review* 2/2011.

1 Overview of ABB's delivery to the Aitik mine



[a] In-pit crusher
- Motors
- Drives

[b] Underground conveyor
- Motors
- Drives
- Distribution transformers

[c] Truck workshop
- Low-voltage switchgear

[d] Intermediate storage
- Low-voltage switchgear

[e] Overland conveyor
- Motors
- Drives
- Distribution transformers

[f] Concentrator plant
- Gearless mill drives
- Dual-pinion drive systems
- Permanent magnet motors
- Distribution transformers
- Low-voltage switchgear
- Motors
- Drives

[g] Substation
- Gas-insulated switchgear
- Transformers
- Medium-voltage switchgear

[h] Harmonic filter system

[i] Control room
- Extended Automation System 800xA

order to supply a 28 MW GMD for the world's first 12.8 m diameter SAG mill. But the most powerful GMD systems currently in operation – 22.5 MW – are those used in Boliden's concentrator plant in Sweden; they drive the huge 11.6 m autogenous (AG) mills. In terms of volume, the Aitik mills are the largest in the world with their astonishing length of 13.7 m.

Ensuring reliable and stable power through the delivery of electrical infrastructure and related equipment is also a cornerstone of ABB's contribution to mining. Automation has been a key component as well, providing the means to precisely control processes and equipment, optimize production throughput, improve worker safety, and operate with the most efficient use of materials and energy resources. Since 1883, ABB's predecessor company ASEA has been delivering electrical power and control systems to major mining operations throughout the world. Some of ABB's high-profile projects are highlighted in → 2.

Operations at the Aitik mine

A weekly blast at the Aitik mine produces enough ore for Boliden to process 106,000 tons each day. This is enough to keep the massive, 100 ton trucks – with wheels 3.4 m high – filled, hour after hour → 3. Each of the trucks delivers about 200 tons of ore to a crusher located inside the 405 m deep pit, where it is reduced to 30 cm rocks and transported via underground conveyors to an above-ground storage area. At a speed of 4 m/s, another conveyor carries the ore to the concentrator plant. ABB motors and drives power the conveyors, with total 7 km in length. At the concentrator plant, the SAG mills driven by the two 22.5 MW gearless mill drives – the most powerful in operation today – grind the ore down to particles, processing a total of 4,400 tons of ore per hour. The

> ABB has delivered some 650 electric motors and drives for the new installations at Aitik.

2 Some of ABB's high-profile mining projects

- Engineering, supply and installation of the OIC pellet plant and port facility in Sohar. The delivery includes the plantwide electrical infrastructure and electrical equipment such as HV, MV and LV switchgears, transformers, motor control centers, variable-speed drives and an ABB's extended automation System 800xA.
- Construction of the Toromocho copper concentrator located at 4800 masl in Peru. The delivery includes the GMDs for the mill drives as well as the plantwide electrification such as MV and LV distribution, MCCs, MV and LV drives, containerized electrical rooms as well as the plantwide extended automation System 800xA.
- Construction of Vale's new Moatize coal plant in Mozambique beginning in 2009. The delivery includes ABB's extended automation System 800xA, all medium- and low-voltage power distribution systems, drives, motors and other auxiliary equipment.

3 Massive, 100 ton trucks with wheels 3.4 m high are used to carry 200 ton loads to the crusher inside the pit at Aitik. Photo by Peter Tubaas.

4 ABB drives are installed in the 7 km of conveyors that transport the ore to the concentrator plant at Aitik.

particles are put into flotation tanks filled with reagents, foaming agents, compressed air and chalk, and some 500,000 liters of water are added each hour. This chemical treatment allows the metal to float to the top for easy separation. The resulting concentrate (chalcopyrite, containing 25 percent copper) is transported by rail to Boliden's smelter in Rönnskär, some 400 km southeast of Gällivare.

ABB technologies throughout the mine

Efficiency is truly the key to productivity at the Aitik mine and ABB has provided the technologies that are making it possible for Boliden to double its production capacity to 36 million tons of ore per year.

Conveyor drives

An impressive 7 km of conveyors transport the large chunks of ore to the concentrator plant where they are ground further → 4. The use of such long conveyors means that there are more demands placed on the mechanical devices and power supply. Controlled soft starting, and controlled operation and protection of the equipment, are thus important. Consequently, choosing the optimal drive solution for the conveyor is critical.

ABB has developed technology specifically to meet overland conveyor requirements. ABB's overland conveyor (OLC) drive solutions, used throughout Aitik, provide OLC-specific functionality such as load sharing, soft start under all load conditions, various braking and stop functions and more. These solutions take into account performance, efficiency, capital costs, flexibility and optimization of operation, reliability and aging of the conveyor equipment, the number of parts subject to wear and tear, compactness of the motor and a motor design that allows easy and rapid change of pulleys and pulley bearings.

Motor and drive systems

ABB has delivered some 650 electric motors and drives for the new installations at Aitik. The motors range in power from 4 kW to 5 MW and are used at almost every stage of the mining process. They drive the crushers in the mining pit, the conveyors carrying the crushed rock to the concentrator, the grinding mills, the pumps supplying water to the mills and removing the tailings left after the concentration process, as well as the fans regulating air quantity.

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Many of the motors used at Aitik must operate 24 hours a day, 365 days a year – like the mine itself – and often in very dusty conditions. What's more, any outdoor equipment at the site must be able to withstand temperatures that can drop as low as −45 °C in the winter. These factors make reliability one of the most important requirements of the motors and drive systems.

Substation and harmonic filter

Mining is an energy-intensive activity and the Aitik expansion project has required the construction of two additional power lines to the site. A new, higher-capacity substation was also required to manage the additional incoming power.

ABB has delivered a 170 kV substation based on gas-insulated switchgear technology, which has reduced the size of the installation by 80 percent → 5. The substation has two incoming power lines from the utility, ensuring delivery of electricity even if one line fails. Three 80 MVA transformers lower the voltage of the incoming power for use in the mine. These transformers can handle the same amount of power required by a city of 100,000 people.

Electricity is distributed throughout the mine via 24 kV switchgear from ABB's UniGear family of equipment. The substation and the two power lines are monitored and protected by ABB's Relion® relay protection. The power equipment ensures the highest possible reliability of the power supply, keeping the mine running night and day.

ABB has also supplied a harmonic filter system, which enables Boliden to avoid damage to its own equipment as well as disturbance to the local power supply which could lead to fines from the utility. The harmonic distortions in the grid are kept below the limits given by the IEC (International Electrotechnical Commission) and local standards and the installed

5 ABB's 170 kV gas-insulated switchgear distributes electric power to the mine.

6 ABB's gearless mill drives power two massive grinding mills, which are the world's largest at 13.7 m long and 11.6 m in diameter.

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filter and power-factor correction system ensure the power factor is equal to or higher than 0.99.

Gearless mill drives

Mill drives are a critical component in mineral processing. They combine huge capacity and brute strength with energy-efficient operation to grind ore into smaller particles for further processing. Gearless mill drives (GMDs) are the largest variety and the absence of a gearbox and other mechanical components increases their efficiency while reducing the need for maintenance.

The main component of a GMD is a colossal motor integrated onto the mill shell in which the ore is ground. The motor is equipped with a drive which starts the mill smoothly without any mechanical stress. The GMDs at Aitik have a rating of 22.5 MW, making them the world's most powerful in operation today → 6. The mills they power are 13.7 m long and 11.6 m in diameter – the world's largest by volume – and each has a grinding capacity of 2,200 tons of ore per hour. ABB gearless mill drives provide the huge capacity needed while keeping energy consumption low, and without reducing power quality.

Energy consumed in grinding can be 50 to 70 percent of the total energy used to process ore. Drives are an energy-efficient way to match mill speed to the needs of the grinding process. With no moving parts between the motor and the mill shell, a gearless mill is also extremely strong and can reliably process vast quantities of ore.

Control system

The entire mining process at Aitik – including the concentrator plant, conveyor systems, pumping stations and even the mine's own sewage plant – is controlled by ABB's Extended Automation System 800xA → 7. System 800xA integrates a diverse assortment of equipment, systems and applications to provide a common visual interface. The mine's IBM Maximo maintenance system is also completely integrated into System 800xA.

Boliden wanted to increase the number of faults reported by its operators. In the old plant, with a traditional non-integrated solution, this was a complicated and time-consuming process. As a result, operators didn't report all faults they observed. The integrated solution makes it dramatically easier for operators to report problems to the maintenance department. Now operators simply click on the object they want to report, choose "create fault report", describe the problem and submit the report, which then becomes available in Maximo. Maintenance staff receives correct information and can take action immediately. Integrating the maintenance system ensures early fault detection, thus giving operators the possibility to inform the maintenance team about malfunctions prior to a breakdown or unplanned shutdown. The risk for production interruptions and unplanned shutdowns is greatly reduced. Since integrating its maintenance system in System 800xA, Boliden has increased its fault reporting five-fold. Integrating IBM Maximo is a key success factor for shifting to predictive maintenance at Aitik.

7 The control room at the Aitik copper mine

ABB's Extended Automation System 800xA controls the entire plant and each piece of equipment throughout the mine.

8 HTC smartphones are being used as handheld units on which to run System 800xA

Soon, engineers, operators, supervisors and the like will each have their own HTC smartphone to supervise and control the plant.

Aitik also integrated the document management system into System 800xA, giving operators fast and easy access to the correct instructions, drawings etc., directly, which enables quick and accurate decisions and actions.

In addition, Aitik is also one of the first industrial sites to apply the new international standard IEC 61850 that defines communication within and between electrical components. This means that System 800xA provides a single environment by which to control and supervise process automation equipment, power automation equipment as well as protection, switchgear, transmission and distribution equipment. Aitik gains a total picture of the entire plant plus the opportunity to run it more effectively. When running their processes, workers at Aitik enjoy full control of power supply and automation at the same time. If a problem arises within the power side, the process can be immediately adapted in the smoothest and most efficient manner, letting Aitik balance energy supply and consumption more effectively. The integration of the electrical control system with the process control system at the plant increases productivity and reduces stoppages by permitting a single strategy in the areas of engineering, maintenance and operations. Furthermore, the adoption of a global standard based on the latest technology enables lower installation and operational costs, as well as enhanced visibility of power usage and consumption.

Finally, Aitik personnel have the ability to run the complete System 800xA on HTC smartphones ➔ 8. This enables immense flexibility in supervising, controlling and maintaining the plant.

Service for grinding applications

A smoothly running mill is a must to meet economic goals. And to keep your mill operating on an optimal level you need a strong service partner like ABB. For two years now Boliden Aitik relies on ABB as preferred service partner. With our long-term service agreement we help Boliden's grinding systems (in total: 2 gearless mill drives (GMD) and 2 dual-pinion drive systems) to perform optimally.

The long-term service agreement covers the entire range of ABB services with life cycle services, scheduled maintenance and remote services. Thanks to this broad service approach ABB is always available when support is needed – either via remote connection or via phone. ABB teams in Sweden and Switzerland perform the services for Boliden. With these experienced teams we guarantee the customer availability directly on-site within 4 hours.

If service efforts are concentrated on specific areas only (e.g. drive system), possible failures of other components could be overseen. Therefore, life cycle services are the ideal solution to have a complete overview of your system's condition. Thanks to this service approach our ABB experts were able to alert Aitik of a temperature related transformer problem during planned maintenance which would have gone undetected otherwise. This comprehensive service contract provides Boliden 99% availability of its grinding applications.

"The service agreement with ABB is of great benefit for us – especially the life cycle services. When we had problems with the GMD system, ABB detected that the transformers did cause the problem. This case proved to us again that ABB has the right skills, the right staff and the right processes to perform its services. We always get appropriate support when we need it. Therefore, we are very satisfied with our ABB service agreement."

Mikael Burck, Head of Electric Division, Boliden Aitik

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