ABB automation for the Mo.S.E. flood barrier

ABB is supplying and installing control automation and anti-intruder systems for the MO.S.E flood barrier system at the Lido, Malamocco and Chioggia inlets of the Venice lagoon

Summary

The Mo.S.E. (Italian acronym for Modulo Sperimentale Elettromeccanico) flood barrier system is a civil and environmental engineering project led by the construction consortium Consorzio Venezia Nuova. The purpose of the flood barrier is to block high tides and storm surges from the Adriatic Sea that regularly enter the Venetian Lagoon through three inlets and flood the historic city of Venice and other areas of the lagoon.

The Venetian Lagoon is separated from the sea by 50 kilometres of sandbars that are broken up by the Lido, Malamocco and Chioggia inlets. Every six hours salt water tides pass through the inlets, receding as briny water and flushing out the lagoon.

A variety of factors have made the lagoon vulnerable to high water surging through the inlets from the Adriatic Sea, including erosion caused by port development and activities, subsiding land and rising sea levels, periodic wind conditions that push waves into the lagoon, as well as the surrounding drainage basin that empties rain and water into the lagoon.

The installation of 78 independently operated steel gates across the three inlets is designed to shield the lagoon from the main problem of surging floodwater, and protect its towns, villages and people, as well as its historic, artistic and environmental heritage, from both major and minor floods. The MO.S.E barrier is now about 80 percent complete.

MO.S.E description

The gates consist of hollow, hinged metal boxes that are fixed to large prefabricated concrete bases embedded into the sea floor. The box structures are 20 meters wide and from 18.5 – 29.5 meters long, depending on their location. Installed, they will comprise four flood barriers to the lagoon – two at the Lido inlet, which is the widest and most complex since it leads to two distinct canals, and one each at the Malamocco and Chioggia inlets.

All three inlets have been strengthened with new concrete walls and embankments, including the sockets that connect them to the mobile barriers.

When not in use, the gates are filled with water and lie flat and invisible on the sea bed. When they are needed, the water inside is pumped out with compressed air, and the gates lift into position aided by their own buoyancy. The entire barrier system can be deployed in 30 minutes, isolating the lagoon and protecting the historic city from tides as high as 3 meters.

The barrier is also flexible. Depending on winds, atmospheric pressure and tide level, all inlets can be closed simultaneously, or just one inlet at a time can be closed, or each inlet can be partially closed. With independently operated gates, the MO.S.E flood barrier has been designed to meet all eventualities.

An ABB distributed control system (DCS) comprises the ‘brain’ of the entire MO.S.E system, and is being installed to safely operate the project’s barrier gates and anti-intruder security systems.

Barrier operations

When activated, the 78 single gates will emerge from the seabed in sets of four to block the passage of water between the lagoon and the Adriatic. Gaps just a few centimeters wide between the gates allow only a small amount of water to get through. There are about 20 gates at each of the four barrier positions.

Designed to incline at roughly a 45° angle, the gates are held in place by the control system, which continually adjusts the quantity of water that provides ballast, or counterweight, inside the hollow structures. To open the barrier, the gates are refilled with water until heavy enough to return to their at-rest position, flat on the seabed.

Although the MO.S.E barrier functions are basically simple, there are a variety of critical execution needs. For example, the barriers must safeguard the Venetian Lagoon and the city of Venice, but not interfere with normal maritime traffic flow in and out of the lagoon. Safeguarding the coasts, lagoon life and city of Venice makes the barrier a strategic national project, which demands vigorous and vigilant anti-intruder and cyber security protection systems to keep out hackers and unauthorized entries. In addition, there is the possibility of natural gas leakage penetrating the subsea structures at the inlets, saturating the environment and rendering it potentially explosive.

MO.S.E systems must therefore manage different operational, architectural and safety functionalities, while integrating with external safety systems.

MO.S.E control automation

The operational control, emergency shutdown (ESD) and anti-intruder systems of the MO.S.E flood barrier are integrated and run by an ABB Symphony® Plus distributed control system (DCS).

The control and ESD systems are sized to manage the entire barrier, from Lido-Treporti to Chioggia, and manage about 40,000 cabled I/Os, 160 redundant CPUs, and 3,000 serial signals. The project includes two control systems, both in backup configuration (one can step in to replace the other), and a further SIL 3 ISD system, as a redundancy for safety function (SIF).

In other words three independent systems can operate and back each other up, providing system availability equivalent to 0.999999999934657 (for SIF). The solution has RIO (remote I/O) cabinets dedicated to the tunnel's auxiliary equipment, which are directly connected to CPUs in the tunnels via copper PROFIBUS DP connections.

Control centers

MO.S.E systems must be certified for a variety of important functionalities, including backup configuration of memory cards; equipment and ATEX II3GxdeIICT4 switchboard; SIL 3 HW control system; cyber security; remote management; remote control from different control rooms; remote diagnostics; and maintenance.

Video surveillance and anti-intruder systems are deployed in sensitive areas throughout the barrier system, and must verify potential risks to the system and workers in terms of safety, water leakages, fires, etc, as well as detect and prevent unauthorized access to the system.

Barrier operations are monitored in three control rooms. The Treporti control room will mainly be configured to manage all of the locks (Treporti, Malamocco and Chioggia). The Malamocco and Chioggia control rooms will mostly concentrate on managing the barriers at those inlets, but in addition are configured to manage all barriers. The main control room is installed at the restored Arsenal, the former shipyard of the Republic of Venice, located in the city center. This coordinating control center will remotely monitor the whole MO.S.E installation.

The control room is where all decisions are made regarding gate operations. The MO.S.E barriers are not completely automated, meaning surge barrier control is not entirely delegated to software, but must be initiated by human decision. The barrier will be activated on the basis of direct measurements from tide gauges at the inlets.

Alternative lagoon access

Four new locks will enable boat and ship passage into the lagoon even when the flood barrier is deployed. Three are for small craft at the north and south inlets. The lock at the middle inlet of Malamocco will enable large freighters and passenger ships into the lagoon, providing 100 percent access to the port of Venice and the industrial port of Marghera at all times.

ABB supplied medium- and low-voltage switchgear, distribution transformers and an uninterruptible power supply system for the Malamocco lock electrical system, and a Symphony Plus DCS to control the mechanical hydraulic auxiliary system that opens and closes the lock gates. The DCS is based on S+ Operations and the

latest HPC800 high-performance controllers. ABB is also responsible for design, engineering, erection, installation and commissioning of the whole solution.

At the northernmost Lido inlet, a new artificial island has been created which enables two different barriers to be built at this location. One closes the deeper canal used for tankers and large passenger ships; the other closes a shallower passage leading to the northern part of the lagoon.

The new island is the home to service buildings controlling the barriers. In addition, three storm ports are available for boats and ships that are temporarily blocked from the lagoon when the barriers are closed.

Maintenance

ABB's control system is easy to maintain. Since all the main components are redundant (controllers, switches, servers) and most can be quickly replaced, the continuity of the plant is guaranteed and outages will be rare. Also, dedicated software to manage and monitor grid infrastructure and related main components provide a constant overview of the health of the whole supervision grid.

In terms of maintenance and reliability, ABB's solution delivers many strengths, such as online configuration of plant controllers; ability to quickly replace I/Os; HMI structure and components; diagnostic software for grid infrastructure; SNMP protocol to monitor components connected to the supervision grid; and configuration and remote maintenance for HART / PROFIBUS instrumentation.

Conclusion

This ambitious project is filled with cutting-edge innovation and technology that is being used to solve a centuries-old problem - saving Venice from the waves that lap so greedily at its shores, at a time when rising sea levels and ever more unpredictable weather patterns threaten its future.

ABB is proud to be involved with a development that will safeguard Venice and the Venetian Lagoon over the long term. The capacity of ABB's Symphony Plus control system to easily integrate electrical equipment is an important differentiator, as is the platform's unique ability to be easily scaled and customized for different sizes and complexities of application. Meanwhile, ABB cyber security provides solutions that can be applied to most control systems, and utilizes data collection, industry standards, best practices, robust technology and system security expertise to help companies protect their most valuable assets.

It is a combination that will manage and protect one of the greatest hydraulic engineering projects the Venetian Lagoon has ever seen.

MO.S.E quick facts

- Four mobile barriers are under construction at the lagoon inlets (two at the Lido inlet, one at Malamocco and one at Chioggia)
- The project utilizes 1.6 kilometers of mobile barriers
- There are 18 kilometers of linear worksites on land and at sea
- MO.S.E has a total of 78 gates
- The smallest gate is 18.5 by 20 by 3.6 meters (Lido–Treporti row)
- The largest gate is 29.5 by 20 by 4.5 meters (Malamocco row)
- One lock for large shipping at the Malamocco inlet enables port activities to continue when the gates are in operation
- Three small locks (two at Chioggia and one at Lido-Treporti) allow the transit of fishing boats and other smaller vessels when the gates are in operation
- There are 156 hinges, two for each gate and a number of reserve elements
- Each hinge weighs 42 tons
- The gates can withstand a 3-meter maximum tide (to date, the highest tide has been 1.94 meters)
- MO.S.E is designed to cope with a 60-centimeter rise in sea level
- 30 minutes is needed to deploy the gates
- 15 minutes is required to lower the gates back to the sea bed
- During a tidal event, the inlet will stay closed for 4/5 hours, including barrier raising and lowering times
- The site currently employs 4,000 people directly or indirectly