

Drive & Control profile

Smooth Sailing:

Panama Canal Modernizes Locks with Bosch Rexroth Hydraulic Solution

Ships from all over the world travel through the Panama Canal every day. In a single year over 14,000 vessels on international voyages, representing approximately four percent of world trade, pass through this famous waterway. In 1998, the Panama Canal Authority decided to accelerate its mission to upgrade the Canal to meet projected demand increases, as well as to modernize cumbersome mechanical systems and streamline operation and maintenance. One key area identified for upgrade in the \$700 million project was the waterway's trademark lock operating system. The system was in need of a complete overhaul of its antiquated mechanical design.

In addition to the widening of Gaillard Cut and an increase in the towboat fleet, the modernization effort sought to bring the lock system's mechanical elements, which dated back to the early 1900's, into the 21st century to meet a projected 20 percent increase in traffic. As part of



Ships from all over the world use the Panama Canal every day. Bosch Rexroth helped improve the Canal's throughput by providing a new hydraulic system that replaced the mechanical drives on all 80 miter gates.

this effort, Bosch Rexroth Corporation's Industrial Hydraulics business unit was awarded a multi-year contract to manufacture new hydraulic systems for the Panama Canal locks' miter gates.

Hydraulic Drives for Lock Operation

The Panama Canal is a 50-mile-long canal connecting the Atlantic Ocean to the Pacific Ocean. Winding through one of the narrowest and lowest areas of the isthmus' long mountainous terrain, the Canal crosses the Continental Divide at an elevation of 85 feet above sea level, which is the normal operating level of Gatun Lake, although it can be filled close

to 88 feet in elevation. The canal runs northwest to southeast with the Atlantic entrance 33.5 miles north and 27 miles west of the Pacific entrance. Travel through the canal by the average ship requires about ten hours.

A ship may enter from the Atlantic, for example, and sail from Limon Bay at the Cristobal Harbor sea level breakwater to Gatun Locks. It would then be raised 85 feet to Gatun Lake by three lock chambers. The water used to raise and lower vessels in each lock comes from Gatun Lake by gravity through a system of main culverts that extend under the locks from the sidewalls and the center wall. From Gatun



Bosch Rexroth hydraulic power units operate the miter gate cylinders. Each cylinder is operated by one power unit.

Lake the ship would travel 23.5 miles to the north end of Gaillard Cut at 85 feet above sea level to the Pedro Miguel Locks. At these locks the vessel is lowered 31 feet into Miraflores Lake. A mile further south, the vessel enters Miraflores Locks and by two lock chambers is lowered another 54 feet to the Pacific Ocean level.

As each ship is raised and lowered in the lock chambers, which are 110 feet wide, by 1,000 feet long, they are sealed in the lock on either end by miter gates. Rising stem valves and cylindrical valves are then activated to change the water level, either lifting or lowering the vessel to the next water level ahead. Previously, all of the miter gates, rising stem valves and cylindrical valves had mechanical drives since their inception in the early 1900's. However, over the last six years, Bosch Rexroth has systematically replaced the antiquated mechanical drives of the miter gates with hydraulic drive systems—effectively improving lock efficiency and functionality and streamlining daily operations and maintenance.

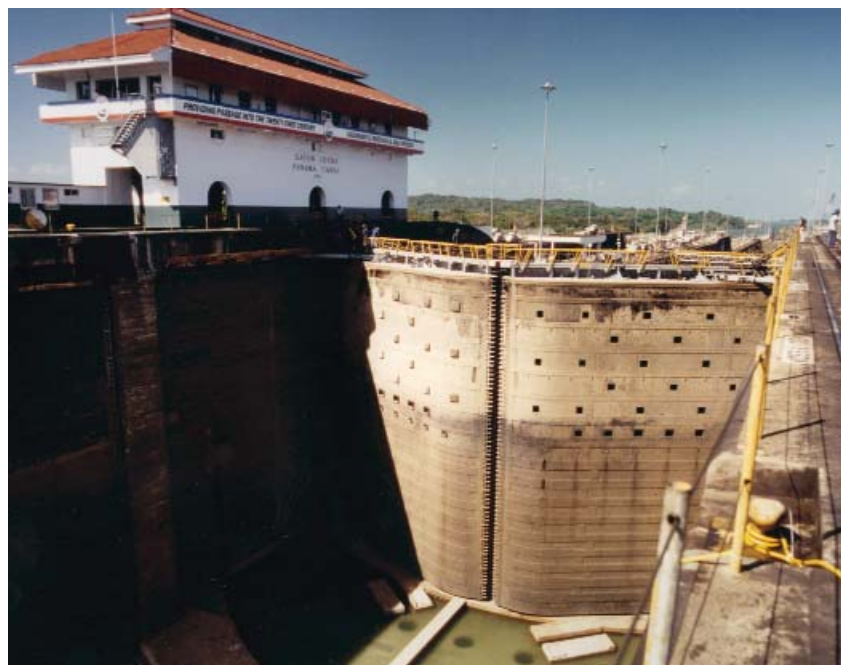
To date, Rexroth has provided the replacements for all of the mechanical units that open and close the lock miter gates with hydraulic drives. Each system includes custom hydraulic power units using Rexroth AA4VSO pumps, custom manifolds, stainless steel tanks, piping and safety and instrumentation items, plus customized hydraulic cylinders with base mounting attachments—all of which focus on the key criteria of simplified operation and maintenance.

A component of the hydraulic solution, the AA4VSO axial piston variable displacement pump with 125 ccs and EO₂ hydraulic displacement control, supplies stepless displacement control via a proportional valve with electrical feedback of the swivel angle. The pump is a swashplate design for open circuit operation, and its flow is proportional to the input speed and displacement. Pump

displacement is infinitely variable through regulation of the swashplate angle and is capable of providing the necessary flow to obtain the application's required 3,000 psi operating pressure.

Unique features of the cylinders employed by each gate system are their Ceramax[®] and CIMS (Ceramax[®] Integrated Measuring System) technologies. Ceramax[®] is a proprietary ceramic coating applied by a plasma spray process to the cylinder's rod to enhance the rod's corrosion resistance. CIMS is a highly reliable, failsafe and accurate stroke measuring system that works with Ceramax[®] as a position feedback device. Advantages of CIMS include unlimited stroke length, accuracy, ease of interfacing and the ability to replace or service while the cylinder is installed.

According to Louis Prieto, Rexroth systems engineer, one condition for



Miter gates shown in closed position with the water out of the chamber. The size of the gates provides a perspective for the load on the cylinders.

replacement of the old mechanical drives was that the new hydraulic cylinder assemblies interfaced with the original strut anchor on the miter gates and adapted to the original machinery foundation. In addition to hydraulic power units and cylinders, Rexroth supplied the associated electronic controls, including the central control systems, data acquisition and data logging for all lock operating machinery. Furthermore, for a complete turnkey system, Rexroth also supplied and assisted with the installation of all interconnecting piping. On another application at the canal, Rexroth supplied hydraulics for a large number of locomotive winch drives, which are used to safely guide the ships through the locks by providing stable positioning to avoid accidental damage to the ships and the locks.

“The custom-designed and manufactured PLC-based control system operates using an Ethernet network as the primary and a remote I/O network as a backup. Both networks are based on multiple fiber-optic self-healing ring technology and is the backbone of the locks’ machinery Centralized Control System (CCS),” explained Prieto.

Previously the control room operators utilized a mechanical interlock system at each lock station. This required the operator to reach and manually turn handles until the lock chambers



The hydraulic cylinder is mounted to the cardanic ring, which was designed to adapt to the existing footprint.

were at the appropriate lockage status. Now, with the hydraulic upgrade, the operator controls the lock from one station, eliminating the need to manually turn the control handles. As a result, there is also a reduction in the manpower required in the control room. Operators can also monitor performance, allowing for maximum operating efficiency and streamlining data acquisition for preventive maintenance.

“The hydraulic technology has generally reduced the maintenance requirements, inventory stock, and operations downtime,” said Carlos G. Patterson, Panama Canal project engineer program coordinator for the Locks Division and leader of the design and implementation team of the Machinery and Control Systems Conversion. “It has also increased the level of technical knowledge among engineers and technicians.”

Prieto agrees. “Today, unlike before, there is the ability to proactively schedule maintenance activities, such as changing filter



The hydraulic cylinder is attached to the miter gate. Bosch Rexroth’s black Ceramax piston rod coating helps protect against corrosion.

elements during regularly scheduled outages,” described Prieto. “Furthermore, the hydraulic cylinders require almost no routine maintenance.” To date all 80 of the Panama Canal’s miter gates are working well with Rexroth hydraulics and controls, which have successfully delivered the increased reliability and reduced downtime sought by the Panama Canal Authority.

Patterson adds, “Since the conversion to hydraulic technology, the canal has consistently improved its throughput. Although this is a result of a combination of several changes or improvements, the hydraulic technology has been an important contribution.”

The Authority and Rexroth are currently working to upgrade vehicular gates by converting the old mechanical drives to hydraulic drives similar to those for the miter gates.

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