HEAVY MOVABLE STRUCTURES, INC.
FOURTEENTH BIENNIAL SYMPOSIUM

October 22 – 25, 2012

The Power and Automation Behind the Lift and Sector Gates at Seabrook Complex, New Orleans, LA

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Abstract

The Seabrook Floodgate complex utilizes a 95-foot opening sector gate flanked by two 50-foot opening vertical lift gates that tie into T walls connecting to the existing levee system surrounding the city. The project is located at the northern end of the Inner Harbor Navigation Canal (IHNC), near Lake Pontchartrain in New Orleans, Louisiana. The project was constructed for the U.S. Army Corps of Engineers (USACE).

Overhead view of sector and lift gates at Seabrook Gate Complex

The major objective of the project was to work in tandem with the Inner Harbor Navigation Canal Surge Barrier on the Gulf Intercoastal Waterway at Lake Borgne to block storm surge from Lake Borgne and Lake Pontchartrain during storm events. The USACE required that the gates provide 100-year-level of protection against the 1 percent exceedance, meaning +16.0 feet level coverage for all gates.

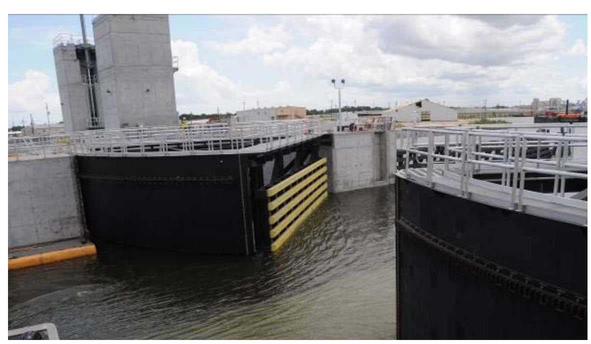
The lift gates at the Seabrook complex are driven by hydraulic systems integrated with closed loop controls for controlled motion. Six different hydraulic power units in conjunction with eight separate remote control stations and consoles and integrated redundant control drive the gates to required storm position.

Introduction

The Seabrook Floodgate Complex is located at the mouth of the Inner Harbor Navigation Canal, also called the Industrial Canal, at Lake Pontchartrain. Alberici Constructors were selected to engineer, construct, install, commission and, for the 2012 hurricane season, operate the gate.

The original design had only one sector gate set at the complex. Further hydraulic studies of channel currents revealed that the gate would yield excessive water velocities so a second sector gate and lift gates were added. The hydraulic system for all the gates was to be designed with multiple levels of redundancy so that any single, reasonable point of failure could be overcome in an emergency.

The gates were designed to close down water flow in the canal in less than 30 minutes. Gate operation is automated and simple from one of several touch screen controls or operator consoles at the complex. All gates are designed so that they can be moved into closed position with total loss of electrical controls and power in an emergency.



View of Sector Gates in the half open position

Two 220-ton sector gates span the 95’ center of the canal. Each gate contains 64 feet of 48” pitch diameter gear that is 6 inches wide on its arc surface. A high torque hydraulic motor with its own 48” pitch gear drives each sector gate on its axis.

Two 120 ton vertical lift gates are raised and lowered by hydraulic cylinders with linear variable displacement transducer feedback and closed loop servo control.

Vertical Lift Gate Hydraulic and Control System

One of four 23’ stroke hydraulic cylinders that lift the vertical lift gates

A total of four hydraulic power units drive four hydraulic cylinders to move both 120 ton lift gates. The hydraulic cylinders have a bore of 12.6” and a stroke of 23 feet. The cylinders contain direct mounted manifolds with counterbalance and emergency lower regeneration functions. Cardanic ring assemblies support the cylinders in an intermediate trunnion position and allow the cylinders to adjust to any offset in lateral or tansverse position of the lift gate, thus avoiding side loading stress on the cylinder rod and rod seals.

Cylinder Cardanic Ring Assembly

Each cylinder has a dedicated servo manifold that contains a Parker D1FH Servo solenoid valve. Servo control manifolds are located on the HPU in the base of each support tower. A key feature of this valve is that it utilizes a fourth spool position to allow free cylinder extension (gate lowering) during a power outage.

Dogging arm with actuating cylinders as gate is about to come to rest

“Dogging Arms” support the gates during the long periods that the vertical lift gates are in the open position, nearly always. This removes any chance of the gate drifting down due to internal hydraulic leakage past the cylinder piston seals. These mechanisms extend out and under the gate frame when at the open position. During the gate closing sequence, the gate is lifted prior to the dogging assembly retraction. Limit switches on the dogging arms signal the control system that the device is fully retracted and the gate can be lowered.

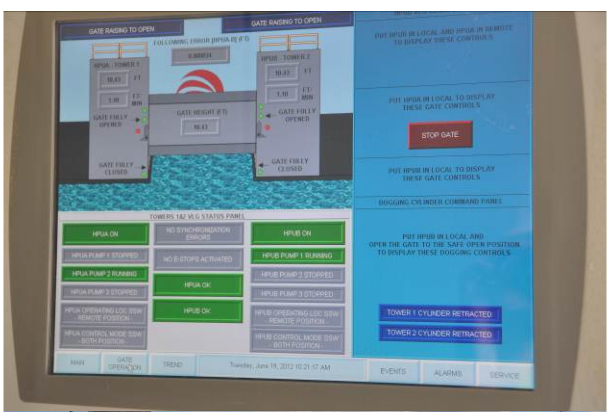
The (4) vertical lift gate hydraulic power units (2 per gate) each contain redundant pump/motor groups, each having a 15 HP TEFC electric motor and a PD40 Parker pressure compensated piston pump. A single motor is in operation during a normal gate movement sequence. If a pump or motor were to fail, the gate would run normally and alert the operator to the faulted condition.

Due to very high humidity levels, a Parker "Kleenvent" air bladder containment system is installed on each hydraulic power unit. This keeps the air in the hydraulic reservoir isolated, yet allows for oil level change in the reservoir without pressurization. This also eliminates water condensation issues that would degrade the hydraulic oil.

Closed-loop air conditioning systems are also utilized on the control enclosures on each hydraulic power unit to provide a cool, dry, clean environment for control electronics. Reliability is of utmost importance on these systems and high heat or humidity in the control enclosure would greatly increase any chance of system failure.

Vertical Lift Gate Hydraulic Power Unit
with Control Panel

Every level in the control system contains redundancy for critical functions, from power entry to feedback. The network architecture for the vertical lift gates contains two hot-swappable redundant Allen Bradley ControlLogix processors on a device level ring network in the HPU on one side of the gate, providing redundancy in both the processors and Ethernet connections. The HPUs on both sides of each lift gate contain an input/output rack and graphical user interface terminal, with a fiber optic cable connecting the HPUs underneath the channel. The graphical user interface allows simplified monitoring and control of gate parameter, machine state, hydraulic process values (pressures, temperatures, fluid levels, etc) and control outputs. Control power for these systems come through an internal UPS, as well as a filter/surge suppressor and power conditioner, to protect sensitive control devices and allow for immediate restart after power failure.



Sample of operator touch screen control at Vertical Lift Gate

Heights of the lift gates are monitored with linear position sensors, one in each cylinder, which provide the extremely accurate and fast digital readouts necessary to maintain tight control to prevent gate skew. As a backup and secondary check, limit switches verify position for critical gate positions, including opened and closed state for remote indication. Similarly, the sector gate position is monitored via robust inductive proximity sensors that count teeth for intermediate position tracking and verify end-of-travel for the fully opened and closed positions.

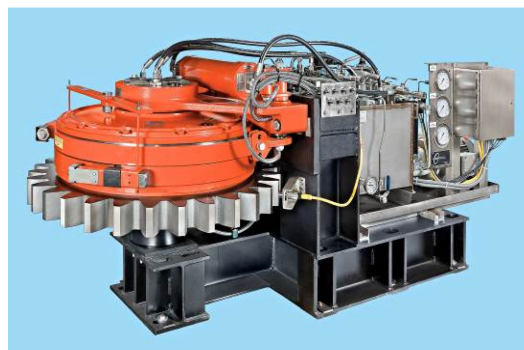
Since one of the driving design criteria was robustness against single point failures, many levels of override options were provided to ensure high availability. Motors and valves can be forced on via hardwired override switches or the graphical user interface. Individual cylinder control for the lift gates can be used to move the gate in the event of control system failure. Even with total power failure, the lift gates can be safely closed with a combination of hand pumping and valve overrides, and the sector gates can also be put into a 'freewheel' state for manual, unpowered closing.

Sector Gate Hydraulic and Control System

The power behind the sector gate hydraulic system is transmitted through (2) Hägglunds hydraulic motors that have a displacement of 2,320 in^3 per revolution. These motors, while running at a system pressure of 3500 PSI, can produce 108,000 ft-lb of torque to be transmitted to the drive and rack gears to rotate the gate.

Drive Gear and Rack Gear on Sector Gate

The (2) sector gate hydraulic power units (1 per gate) each have redundant pump/motor group,s which contain a 15 HP TEFC electric motor and a 1 in^3 gear pump. A single motor is in operation during a normal gate movement sequence. If a pump or motor were to fail, the gate would run normally and alert the operator to the faulted condition.



Sector Gate Hydraulic Power Unit with Hägglunds Motor and Drive Gear

The sequence of operations extends the brake cylinders on the Hägglunds motors to release the brake and allow for motor rotation. Inductive proximity switches count gears and determine position of the gate during motion, including “near open” and “near closed” positions that cause the hydraulic motor speed to ramp down. After end of travel is reached with proper seal compression, the brake is re-engaged.

One of the larger challenges in previous sector gate systems was ensuring proper seal compression, which is essential for full protection against high storm surges. A design modification for independent hydraulic brake control, along with better control timing and sequences programmed into the control PLC, allows for smoother jogging operations and extremely reliable hydraulic holding at the end of travel during brake re-engagement. Additional functionality is allowed by use of a PLC, such as control of reduced speed near end of travel, overtravel protection, jam or stall detection, redundant pump monitoring and control, and recording of maintenance information for the HPU.

Installation and Commissioning

The key to availability and reliability of the hydraulic system is the oil cleanliness. An estimated 500’ of 316SS schedule 80 pipe was welded into place for the vertical lift gates. All piping was welded to ASME spec 31.1, and weld slag working into the piping is a distinct possibility. A 120 GPM oil flushing skid was utilized to flush each leg of the piping to an ISO cleanliness level of 17/15/12. During this period, the servo control manifolds were bypassed, as were the pumps and other couplings, on the hydraulic power unit. The process was repeated for all hydraulic systems. The Seabrook Gate power systems were delivered and installed as a single, preassembled, clean unit.

Although the hydraulic and control systems were fully tested at Atlantic Industrial Technologies' facilities, full loads of the vertical lift gates and sector gates and their geometries could not be exactly simulated. During startup of the systems, adjustments had to be made for normal commissioning settings on items such as counterbalance valves, relief valves, flow control valves, PID control settings, limit switch adjustment. Field adjustments that were necessary to account for emergent properties of the system with real world forces and dimensional tolerances also led to a handful of control and sequence modifications, which meant working flexibility into an otherwise tightly-tolerance position control loop. Full automatic sequence and timing for vertical lift gate parking on the dogging device and the bottom sill, as well as sector gate position and brake holding required days of adjustment and re-adjustment to meet the performance quality and reliability required.

In August of 2012, the new levee gate system was put to the test with the arrival of Hurricane Isaac in the Gulf. The Hurricane Risk-Reduction System, which includes the 16 gates powered by Atlantic Industrial Technologies hydraulic systems, successfully closed, significantly reducing the damage brought by Hurricane Isaac.