HEAVY MOVABLE STRUCTURES, INC.
NINETENTH BIENNIAL SYMPOSIUM

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Greenville Yard Transfer Bridge Hydraulic & Control System

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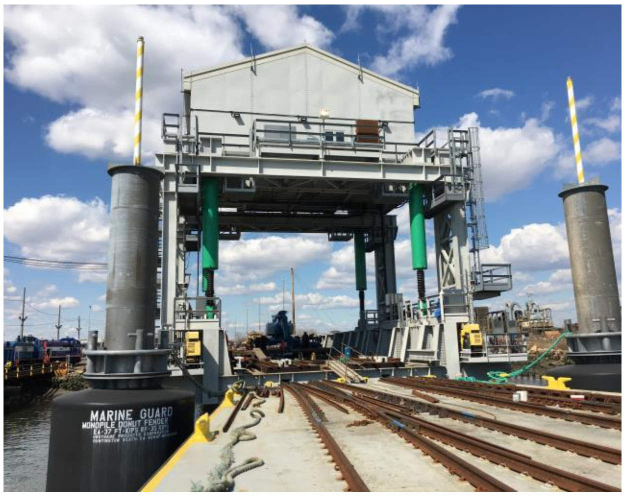
GREENVILLE YARD TRANSFER BRIDGE NO. 10 HYDRAULICS & CONTROLS

Abstract

The GREENVILLE YARD TRANSFER BRIDGE NO. 10 is a hydraulically driven movable transfer bridge. It is part of Greenville Yards redevelopment initiative launched by the Port Authority of NY & NJ in Jersey City, NJ. This unique facility transfers freight rail cars containing refuse to and from car floats for cross harbor transfer to their sister facility at the 65th Street Terminal in Brooklyn. Without this transfer bridge the rail cars would need to be routed from NYC up through Albany, NY and back down through New Jersey, an extremely long and costly trip. The structure is comprised of a Bridge Span, an Apron Span and a Gantry superstructure. The 121' Bridge span is attached to an abutment back-wall with a heel bearing and allows for vertical motion with a range of +4% to -6% grade. The 38' Apron span is attached to the end of the Bridge span with a hinge and also has a range of +4% to -4% grade with respect to the structure. There is a Gantry structure that supports four clevis-mounted hydraulic cylinders which support the Bridge and Apron spans and serve to independently articulate both the Bridge and Apron spans. Using independent controls, an operator can position the structure at various configurations to accommodate the safe transfer of rail cars from a car float (barge) onto land and from land onto a car float.



Introduction

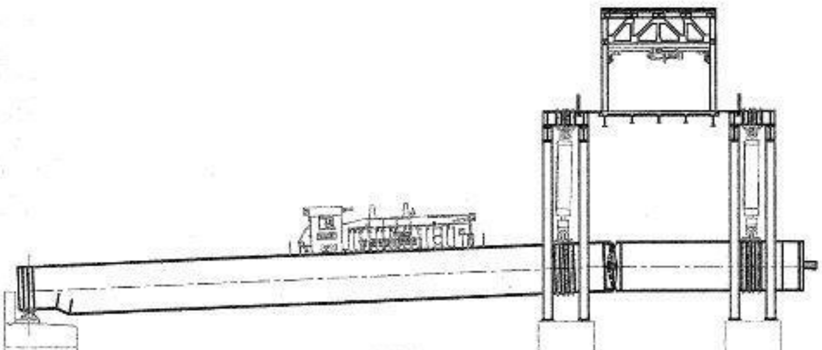
All hydraulic pressure and flow required for bridge movement is created by one hydraulic power unit (HPU). The HPU is controlled by the Programmable Logic Controller (PLC). The motion of the cylinders is initiated by the PLC and the HPU responds to these commands by energizing pumps and valves accordingly.

The system utilizes two 26" bore x 12 foot stroke hydraulic cylinders that articulate the Bridge span and two 26" bore x 12 foot stroke hydraulic cylinders to articulate the Apron span.

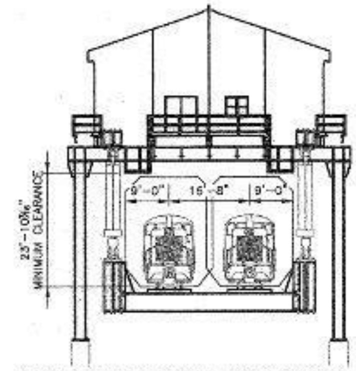
There are four 6" bore hydraulic cylinders that Drive and Pull four lock bars into and out from their respective receivers located on the rail car float. When driven, lock bars provide for rail alignment between the Apron span and the car float.

All functions of the transfer bridge are controlled and monitored by a redundant PLC which utilizes feedback from inclinometers to control the exact bridge position and angle.

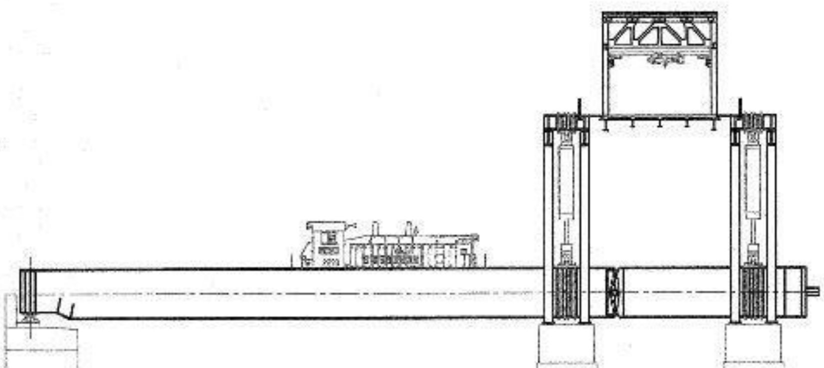
The below drawings depict a side view of the bridge and apron at different tidal positions.



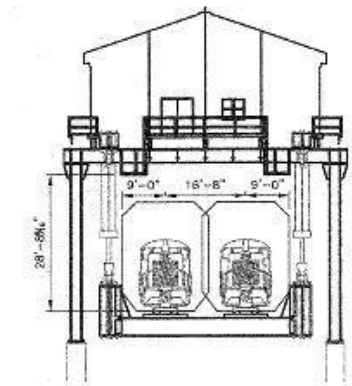
BRIDGE ELEVATION
MAX UPWARD POSITION +4.0%



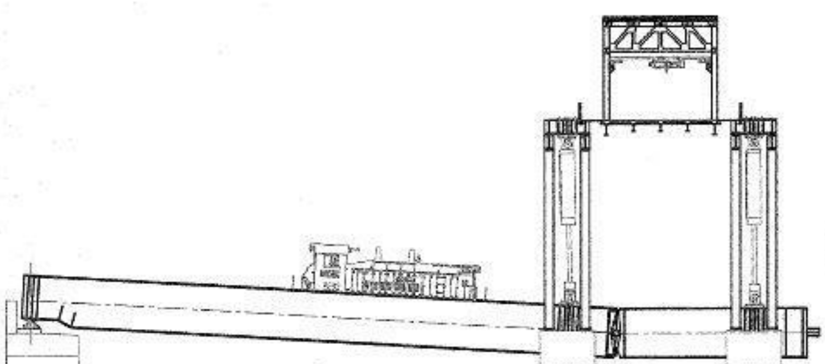
BRIDGE SECTION AT APRON PIER
MAX UPWARD POSITION +4.0%



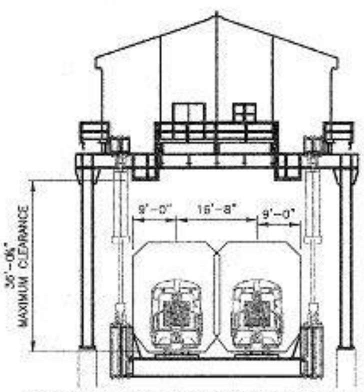
BRIDGE ELEVATION
NEUTRAL POSITION +0.0%



BRIDGE SECTION AT APRON PIER
NEUTRAL POSITION +0.0%



BRIDGE ELEVATION
MAX DOWNWARD POSITION −6.0%



BRIDGE SECTION AT APRON PIER
MAX DOWNWARD POSITION −6.0%

Hydraulic System

All hydraulic pressure and flow is created by one HPU. The HPU is controlled by the Programmable Logic Controller (PLC). The motion of the cylinders is initiated by the PLC and the HPU responds to these commands by energizing pumps and valves accordingly. The HPU consists of the following major components;

• One 1,000 gallon hydraulic reservoir
• Two 100 horsepower pump/motor groups to drive the Apron cylinders
• Two 150 horsepower pump/motor groups to drive the Bridge cylinders
• One 20 horsepower pump/motor group dedicated for filtering and cooling
• One 10 horsepower pump/motor group for Park mode
• Hydraulic Valves, filters, plumbing and sensors
• Air cooled heat exchanger
• Electrical Junction Enclosure with local indication lights

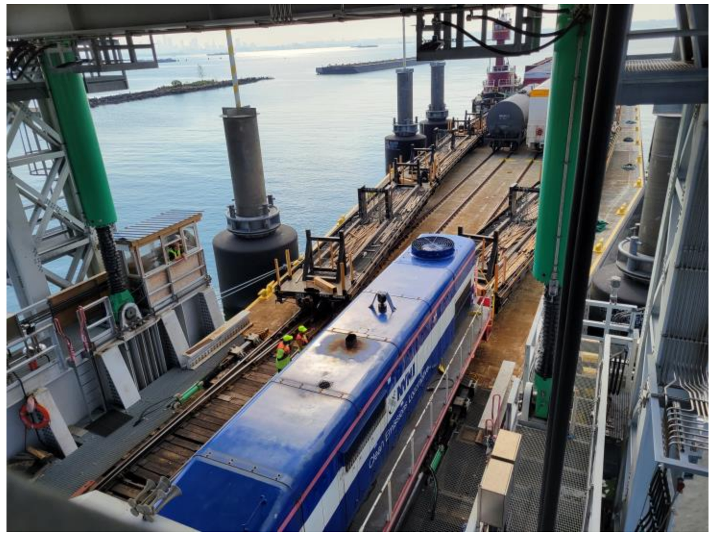
Two Parker Hannifin PV270 series piston pumps drive the apron cylinders with 240 GPM oil flow with two more Parker PV270 piston pumps supplying another 240 GPM flow to the bridge cylinders.
Both the apron and bridge cylinders employ 3 way servo-proportional valves on the rod end to lift and lower the cylinders. The cap end of these cylinders utilizes reducing valves to set the cap end pressure to a constant 400 PSI for natural frequency stiffening and control force when extending the cylinders.
The syncing of all 4 hydraulic cylinders relies on the feedback from strategically placed inclinometers on various parts of the bridge feeding back to the control system which in turn proves command signals to Atos servo-proportional 3-way DIN valves for fine control of oil flow into and out of the cylinder rod ends.

To secure the barge (car float as the rail workers call it) into place, four lock bar cylinders (seen here in green) will drive in and retract out four lock bars from their respective receivers located on the rail car float. These lock bars specifically provide for rail alignment between the apron span and the barge. As the rail cars are towed off the barge and on to the apron the cylinders tension the connection between barge and apron to assure track alignment.
The feedback of proximity switches assure proper connection as part of an alarm circuit.

There is a smaller hydraulic pump set that is designed to allow the cylinder to extend and retract with the tide when a barge is simply "parked" at the edge of the bridge apron. This is called the "Park Mode" pump and will run 24/7 while a barge is parked.

Control System

The control system contains (2) redundant ControlLogix Allen Bradley PLCs that run in "hot swap mode" with indications of fault modes. If one PLC were to fail the other would engage immediately. There are 12 inclinometers to measure bridge angles. All 12 inclinometers are active at all times while the system is constantly reading 6 axes of movement. The inclinometers are mounted in pairs and the average of the pair is processed as the angle of the axis. Should one inclinometer of any pair fail, the partner inclinometer's reading will be processed. Once the locomotive or rail cars enter the bridge, the bridge span's inclinometer feedbacks are processed to prevent any transverse skew "tilt" via closed loop PID loops which and send signal to the hydraulic valves to make sure the bridge raises evenly. Often more hydraulic pressure will be required on one side of the bridge to prevent transverse skew. This control process is called transverse skew control.
The control system will also allow the apron span to transverse skew or "tilt" to match to the transverse skew "tilt" of the barge should the weight not be centered on the barge. When the system knows that the lockbar cylinder is fully extended it will stop motion on the corresponding apron cylinder to allow the apron to align to the tilted car float. This is all set up in the PLC logic.

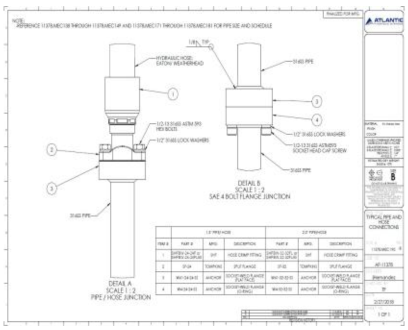


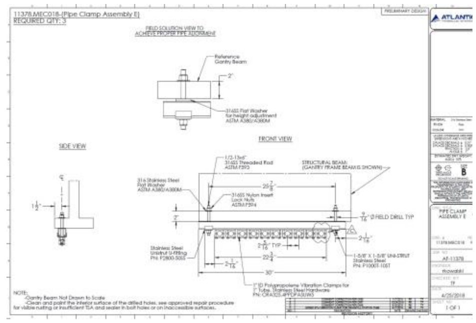
When a barge with rail cars is connected to the apron of the bridge and the lock bars are all in place, the "Float Mode" of the control system kicks in. In this mode the cylinder will move automatically and will allow the apron to float with the barge as the cars are removed or loaded and the barge position changes with respect to the water surface. This is accomplished through a closed loop servo pressure control circuit on the rod side of the cylinders that will force the pressure into the rod end of the cylinder in the case where load is removed from the barge or release pressure from the cylinders in the case where load is added to the barge. The feedback for this circuit comes from pressures transducers located at the rod side of the cylinders.
Alarms and faults corresponding to transverse skew which would lock up one cylinder and move the other to reset.
Min/max apron and bridge angle indication feedback
The park mode is the float mode with no activity on the barge and a small hydraulic pump will float the apron to match the parked barge and move slowly with the tide, this is on 24/7 when there is no barge activity. An emergency backup generator to power the park mode pump is available for continuous operation for up to 48 hours. This generator is set up to only operate during unattended power outages which occur while the system is in Park mode. This generator is not capable of driving any of the 4 main hydraulic pump-motors. It is only required to run the (smaller) Park mode pump when requested.

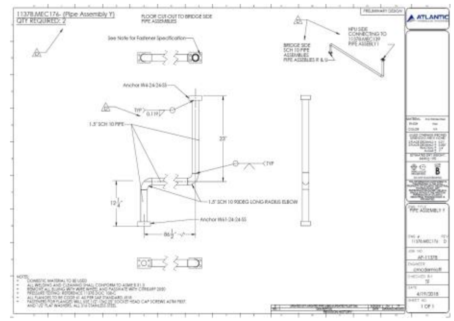
The hydraulic pump-motors are powered and controlled from a Motor Control Center. Each pump-motor requires a dedicated contactor, overload and circuit breaker. All pump-motors have a dedicated HOA switch (Hand, Off, Auto). This allows for automatic (PLC controlled) or manual (hand-operated switch controlled) operation of the motor. The park mode pump-motor is the one exception. It is powered from a stand-alone motor starter enclosure which contains a soft-start style motor starter.

Installation & Commissioning

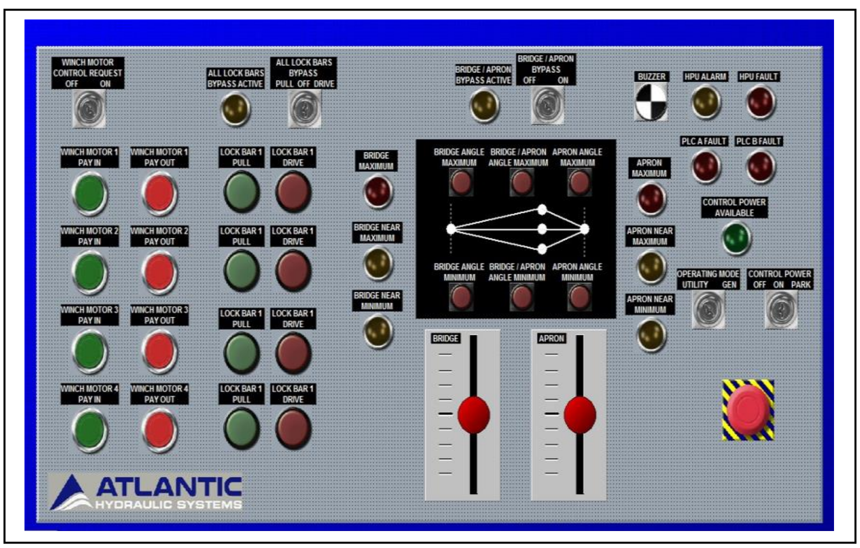
Atlantic's scope included tubing, piping, hose, supply and installation. The specifications required some FEA (Finite Element Analysis) studies and heavy scrutiny on all clamping mechanisms. Full drawings were supplied of every connection and Atlantic's project manager was onsite for the piping, tubing, hose install and flushing process.







Commissioning was conducted in many stages from simply moving the cylinders, to articulating the cylinders for pin insertion on the bridge/apron, to moving the bridge & apron unloaded, to purposely loading up one side of the bridge & apron while tuning the transverse skew control.



Being that that owner requested push buttons because of weather concerns on the bridge, there are push buttons and relays on the control panel, Atlantic engineers created our own HMI interface panel for tuning and diagnostics during the commissioning process. This allows for on the fly tuning of the PID loops on the transverse skew control as well as interpreting diagnostic alarms without guesswork during the commissioning and testing process.

Conclusion

In January of 2020 testing was completed and the first barges with full payload pulled into the apron as a waiting locomotive is ready to transfer the rail cars from the barge and to their final destination. Since that time, the system has run through rain, shine, snow and salt spray. Usual maintenance is required on the hydraulic system and hiccups occur at times. Atlantic's controls engineers are at the site within hours of a problem because remote access to the control system is impossible due to security measures taken by the owner.