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NAVIGATION LOCKS ON THE MISSISSIPPI

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The opening date for some of the navigation locks and dams goes back into the late 1800's. Locks at that time were only about 144 feet long and 36 feet wide. As time passed it was soon discovered that one of the major problems with locks was the size and speed of transfer through the lock. Locks built in the early 1900's were larger (600 feet) but even this length was too small as river traffic increased. Some locks in later years have reached the 1200 feet range. One of the major bottlenecks on the Mississippi has been the lock at Alton, Illinois (No. 26) which is being replaced with a new lock and dam 2 miles, downstream from the existing. The old No. 26 consisted of a 600 and 360 foot lock. The new system will have a 1200 and 600 foot lock. Standard tows are of the 1200 foot variety and therefore can lock through without requiring the tow to break up.

The Corps has an annual report that covers around 275 operable locks and dams. The report shows location, size of lock, type of streamflow, year opened and authorized channel. Next to the size, the problem most encountered is the operation of the mechanical system that controls the water flow through the lock. Lock gates were the lift type (chain or cable operated) and could cause binding and/or sometimes flotation (not closing tightly). A major concern to determine the upper stream closure type will be the weather. North areas where the build-up of ice is a problem, the lock will be required to use the lift type of gate, while southern areas can use the miter gate which can swing open against the current. Most of the new installations, using the miter gate at the upper end of the lock, will use a arrangement of a large hydraulic cylinder, rack and gear to deliver movement through an arm to finally move the miter gate. This action is accomplished in a horizontal plane. The same type of action, through the use of hydraulic cylinders and a combination of lever arms, is used to open and close the tainter valves used to fill and empty the lock. Normally these are located in the vertical plane. The use of hydraulic gives a much more positive movement to the components.

Much of the remaining portions of this presentation will pertain to the lock and dam No. 26, presently being installed between Alton, Illinois and St. Louis, Missouri.

This project started in 1980 with the first contract providing a cofferdam and almost all of the main dam. The 25-acre cofferdam was the largest ever placed in the Mississippi. The contract presently underway included a 23-acre cofferdam and the construction of the large lock. Later a contract for the smaller lock and remaining dam work will be awarded. The total cost will be close to one billion dollars. A unique and much needed portion of this project is the ability to have two-way traffic. Most locks share a common wall which allows only one direction of traffic. These locks are 350 feet apart thereby allowing upstream and downstream vessels to lock through simultaneously.

There is a possibility the Corps could add an 80-Mw power-plant at some later date. Some of the best benefits have come from the cofferdam testing program. The stage-one cofferdam consisted of 95-feet long interlock sheet piles, forming sand-filled cells, 63 feet in diameter. Based on 1971 design, following long accepted criteria, piles were about one third embedded, one third in water and one third above normal river level. Studies of other cofferdams indicate that conventional methods might be overly conservative. By the use of soil pressure sensors and other strain gauges it was determined that the maximum tension occurs at about one fourth of a cell's height above the bed and not at the riverbed as previously thought. As a result, cells did not have to be as deeply embedded (shorter piles) and riverbed restoration was minimized. Tests are being continued on the cells of the second cofferdam.

The second cofferdam was closed in March 1986 and dewatering was started. Major concrete pours started in June 1986. In October came the ultimate cofferdam test. A massive flood. When the flood water came within 6 inches of the top of the cells, the decision was made to flood the cofferdam to prevent severe damage should it be overtopped. Flooding was accomplished by reversing the dewatering process. When about one half full, part of the toe failed, knocking out part of the dewatering equipment. Control of the system was lost so to prevent further damage, two "emergency spillways" between cofferdam cells were removed.

It took the contractor approximately two months to clean up the mess. Damages are in the millions.

Another unique feature of this project is the installation of a bridge, cantilevered from the upstream face of the dam. The concrete is furnished from a batch plant on the Missouri River bank. The concrete travels over 800 feet on conveyors across the bridge, down the length of the cofferdam and laterally across the lock. The longest run to a pour is close to 3000 feet.

The typical lock operating equipment for Southern areas would be as follows:

1. Miter gate operating machinery: The miter gate machinery consists of a hydraulic cylinder which operates a sector gear by means of a geared rack attached to the piston rod. A sector arm attached to the sector gear operates the miter gate by means of a gate strut.

2. Valve operating machinery: The tainter valves are raised and lowered by means of a horizontal trunnion mounted hydraulic cylinder and piston rod which is pin connected to a rocker, mounted on a support base imbedded in the concrete of the valve recess. A strut assembly connects the lower rocker pin to the tainter valve lifting pin.

3. HYDRAULIC CYLINDERS:

3-1. General: The miter gate and tainter valve hydraulic cylinders shall be the heavy duty "mill type", commercially available and the product of an established cylinder manufacturer having had experience in the design of large hydraulic cylinders for similar use. The cylinders shall have a minimum publish pressure rating of 2,000 psi, for the valve cylinders and 3,000 psi for the gate cylinders. The general arrangement, piston travel and type of mounting and piston rod connection for the miter gate and tainter valve cylinders are shown on contract drawings.

3-2. Piston rod: Piston rods for the tainter valve cylinders shall be made from high strength medium carbon, alloy, steel, case hardened to not less than 45 Rockwell "C" and to a minimum depth of 0.09 inches. Piston rods for the miter gate cylinders shall be made from stainless steel conforming to ASTM A 546, type XM25, aged at 1000 degrees Fahrenheit. The rods shall be of the size shown on the drawings, and shall be ground, polished and hard chrome plated. Plating shall be a minimum of 1.2 mils thick and shall be polished to 16 micro-inches.

3-3. Piston: The piston shall be of one-piece alloy cast iron construction, machined concentric with the centerline of the piston rod. The piston shall have a wide surface contacting the cylinder body to reduce bearing loads during mechanical deflection. The piston shall be locked to the piston rod with a lock pin. The piston shall be fitted with cast iron piston rings. Rings shall be closely fitted in order to obtain minimum clearance leakage. The piston for the tainter valve cylinders shall be modified to provide a zero leakage type packing which will hold the valve in any position.

3-4. Gland: The packing gland shall be designed for easy removal of VEE type packing and rod wiper without disassembly of the cylinder. The gland shall have a long bearing surface inboard of the seals and the length of the bearing shall be not less than 75% of the rod diameter and shall be made of SAE

660 bronze or equal. The primary seal shall be multiple "VEE" type and designed to withstand the operating pressure outlined in paragraph entitled General. A secondary seal shall be provided as a wiping ring to clean the rod of dirt when entering the cylinder. All seals shall be compatible with the hydraulic oil used.

3-5. Cylinder body: The cylinder body shall be the manufacturer's standard steel body with welded flanges for rigid construction and maintenance free operation. The heads, caps and mounting shall be either cast, rolled, or forged steel. The finished cylinder and piston rod shall be smooth and straight of uniform diameter and shall be normal to the plane of the finished flanges. The cylinder bore shall be precision honed to true circles. The diameter in any transverse plane shall not be more than 0.005 inch greater than the specified nominal diameter. The diametral dimensions found in any one transverse plane shall not differ from each other by more than 0.002 inch. Two diametral dimensions, taken approximately 90 degrees apart, shall be sufficient to establish the diameter and roundness in any one transverse plane spaced at intervals of approximately one foot along the length of the bore. The surface of the cylinder bore shall be finished to within 16 micro-inch.

3-6. Shop assembly and tests: Each gate operating machine shall be assembled in the shop in the presence of a representative of the Contracting Officer on the bases or supports as shown on the drawings, with the exception that the gate strut will not be connected. Each gate operating assembly shall be satisfactorily operated through not less than the equivalent of three complete gate operations. The units shall be closely checked to insure that all necessary clearances have been provided and that no binding occurs in any moving part. The gate strut shall be completely assembled in the shop with spring cartridges, and spring assembly lubricated and in place, and the pins in place. Before disassembling for shipment, each piece of each shop-assembled machinery shall be match-marked to facilitate erection in the field. Disassembly of machinery may be made in units to suit shipping facilities. The hydraulic cylinders shall be shipped with the pistons and piston rods in place and the cylinders filled with oil.

4. OIL PUMPS: The hydraulic oil system pumps, of the size and type as hereinafter specified shall be furnished and installed as shown on the drawings. The pumps shall be constant speed, 860 rpm, variable volume, radial piston type with 5-position, remote operated, solenoid control for four preset pumping rates of 40 gpm for fast miter gate opening (1.5 min), 20 gpm for slow miter gate opening (3.0 min), 10.5 gpm for fast tainter valve opening (4.0 min), and 7.0 gpm for slow tainter valve opening (6.0 min). The above pumping rates as applied to the solenoid control head compare respectively to solenoid No. 1 (or A) for fast miter gate, solenoid No. 2 (or B) for slow miter gates, solenoids 1 and 3 (or A and C) for fast tainter valve, and solenoids 1 and 4 (or A and D) for slow tainter valve. The fifth position shall be neutral or zero pumping rate to permit no load pump motor starting. The individual controls for each pump shall be capable of adjustment from zero to full flow capacity of the

pump at each adjustable volume control, so that flow rates can be varied by operator as required by river conditions. The pumping rate in each pumping position shall remain practically constant under all load conditions. The two identical pumps, one to serve the hydraulic machinery on the lock left wall and one to serve the hydraulic machinery on the lock right wall shall each be capable to delivering a maximum rate of 55 gpm at 1100 psi at 860 rpm. Each pump shall be equipped with adjustable hydraulic choke devices to control the speed of shifting between the various pumping rates. Initial adjustment of shift speed shall be set for 3 to 5 second operation. Each pump shall be complete with super charging gear pump, integral high pressure relief valves, pressure gage, suction valve with built-in back pressure valve, and filter with gage and flow control valve. The pumps shall be oil gear pump No. DM-3511-MX or equal.

5. HYDRAULIC OIL: All hydraulic oil for filling the lock hydraulic system and for field testing shall be furnished by the Contractor. All hydraulic oil, whether for shop testing or field installation, shall be filtered through a 5 micron filtration unit immediately prior to filling any unit or system. The oil shall be Shell Oil Co. Tellus 23 or equal. In addition to the oil requirements for filling and testing the system, two 55 gallon drums of oil for future use shall be furnished by the Contractor and shall be stored at the job site as directed by the Contracting Officer.

6. OIL FILTER: The oil filter shall be full flow, permanent type installed in the common oil return line to the tanks as shown on the drawings. The filter shall be 24" diame-

ter, using multiple filter cartridges, rated for a working pressure of not less than 60 psi and capable of handling no less than 125 gallons per minute of hydraulic oil having a viscosity of 1,000 SSU. The filter shall be base mounted on legs to supply ample piping clearance, and also to facilitate cleaning under, and around filter. The filter cover shall be the quick opening type with swing bolt fasteners to permit easy access to cartridges. A cover lifting device with a hand wheel operator shall also be provided. Cartridges shall retain particles larger than 10 microns and with a Beta ration of (B10=75) and shall remove all free water from the oil. Pressure gages shall be installed on the filter to indicate pressure drop across the filter pack. One set of spare filter cartridges shall be furnished, after the system cleaning operation is complete, and shall be stored in the lock control station.

In conclusion I would like to say that the Corps of Engineers probably has more experience in locks than any other organization. We are constantly learning new things about lock operation and hopefully this knowledge is used for renovation or installation of new locks. We feel our new installations represent the latest technology available.