Divers Use Sliplining For Underwater Siphon Repairs

by Rita Tubb • Managing Editor

W.H. Streit Inc., Hammonton, NJ, and sister company, Walker Diving Contractors recently completed a major underwater sliplining project to repair two inverted siphons under the Schuylkill River in Philadelphia, PA.

The two companies became involved in the project in November 1998, shortly after the City of Philadelphia detected flow problems in its sanitary sewer. The system handles dry weather flow of 60 million gpd, and three time that amount when it rains. About 12 percent of the city's wastewater sewer flow is collected at the Schuylkill River pump station, which serves as one of the major interceptors flowing into one of the treatment plants.

The pump station where the construction was recently completed dates back to the late 1940s. The original system consisted of two parallel 50-inch I.D. siphons that extend 600 feet across the Schuylkill River. At each end of the siphons, vertical shafts measuring 20 feet in diameter were constructed that tie into the siphons about 100 feet below grade.

Gregg Sparks, vice president of W.H. Streit, said that when the siphons were originally constructed, crews had started the excavation at grade and then blasted vertical shafts at each side of the river. To facilitate the river crossing, a tunnel was blasted through the rock beneath the riverbed. To form the shafts and siphons, 50-inch diameter, 1/8-inch thick steel liner was installed and concreted into place.

"At the time of construction, the steel liner served as part of the original form work to create the concrete shafts and siphons," Sparks explained. "Essentially, the liner construction method provided two isolated side-by-side siphons that were separated by concrete."

Flow problems

According to Sparks, the City of Philadelphia Water Department first detected flow problems in the dual siphon system during routine maintenance operations. City crews regularly use mechanical clam buckets to clean out heavy deposits trapped in the grit pits located at the bottom of the vertical shafts.

However, about 18-months ago, crews reported that when attempting to lower clam buckets into the shafts, the buckets often hung up and could not be retrieved. On other occasions, crews had reported retrieving a substantial amount of 1/8-inch thick steel while mucking out the pits.

Eventually it became impossible for crews to get a mechanical clam bucket to drop into the shafts. After several attempts to resolve the problem, City of Philadelphia Water Department's George Collier contacted Walker Diving.

Harold Einhorn, vice president of Walker Diving, indicated that after visiting the job site, he committed to conducting an inspection dive inside one of the shafts the following week. The objective was to have a diver start from just below the surface, where the sewage spills into the vertical shaft.

Einhorn recalled that when the diver was lowered down inside the shaft on a stage, the descent reached only about 12 feet below the water line before the shaft was almost completely closed off. Upon returning to the surface the diver reported that the steel liner inside the shaft had peeled away from the concrete pipe wall. Along with the flow, debris entering the system was being trapped by the peeling liner and restricting the water flowing into the shaft.

Einhorn said divers also entered the remaining three shafts and the outcome was the same. "After descending only a few feet below the water line, the detached liner and debris made further descent into the respective shafts impossible."

As noted by Einhorn, it was suspected that corrosion had caused the extensive deterioration in the lines that the diver detected during the initial inspection dive.

At that point, the city retained W.H. Streit and Walker Diving to inspect the shafts and siphons and conduct line cleaning operations.

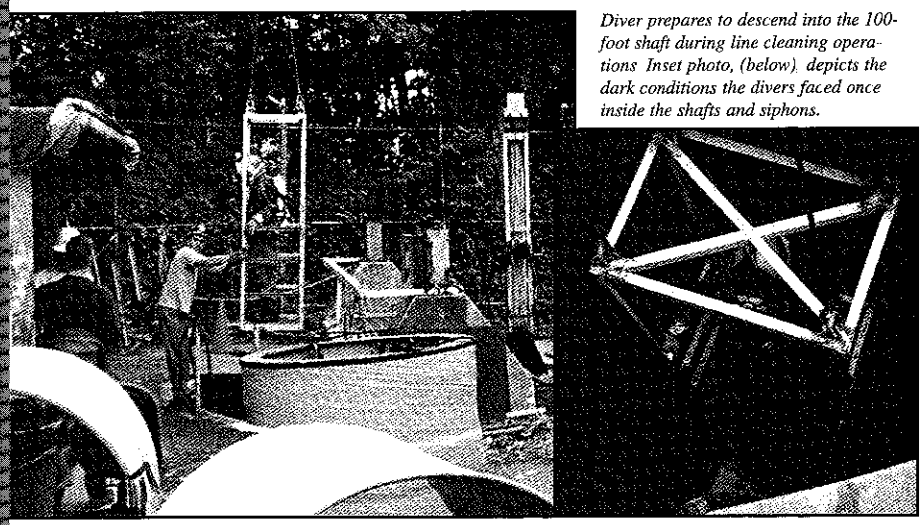
Line cleaning operations

Einhorn said that given the amount of steel and debris the divers had observed during the initial inspections, plans called for the divers to work their way through the vertical shafts before beginning any debris removal inside the siphons.

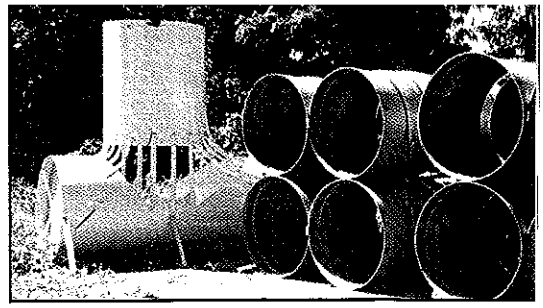
Since the water inside the shafts reached depths of up to 65 feet, the equipment spread mobilized to the site included a decompression chamber, air compressors and emergency air bottles. "We also had a full compliment of men, including stand-by divers and tenders as well as emergency and back up equipment for safety purposes," Einhorn said.

"The turbid "gray water" entering the system," Einhorn continued, "presented problems as well. During line cleaning operations inside the shafts and siphons, the divers would be working in basically zero visibility. Also, the contaminated gray water entering the system made it necessary for the divers to wear sealed watertight suits to prevent any exposure during the dives."

Because of the water depth inside the shafts, which ranged from 65 to 85 feet, the divers were restricted to the amount of time



Diver prepares to descend into the 100-foot shaft during line cleaning operations. Inset photo, (below), depicts the dark conditions the divers faced once inside the shafts and siphons.



Beetle Florida Inc. supplied the 3 5-foot joints of filament wound fiberglass pipe (right) used on the project The short pipe length allowed divers to rotate the pipe from vertical to horizontal at the bottom of the shaft and then position it inside the 50-inch siphon for final line tie-in

they could stay down. Einhorn stated, "We normally get 40 to 50 minutes of dive time in water depths above 65 feet, which is about what we got on this job."

The underwater burning equipment that the Walker crew used to cut away the mangled steel inside the shafts was a Broco torch. Powered by a welding machine and using oxygen for gas, the rod tip of the torch heats up to about 10,000 degrees F Einhorn said the equipment proved to be sufficient to allow the divers to melt the tangled steel and cut their way down into the vertical shafts.

As quickly as the liner inside the shafts had been removed, preparations were under way to begin cleaning the two siphons

Looking back on this phase of the job, Einhorn stated that since the Broco torches used to remove the steel in the vertical shafts tend to produce gases that build up, the divers cut and removed the liner from inside the siphons using hydraulic underwater saws

Einhorn described the condition of the steel liner inside the siphons as "much more deteriorated than had been observed in the shafts."

After the divers advanced only about 15 feet inside the first siphon they discovered that the top of the pipe was missing Upon further investigation they found that a breach had occurred that was allowing water to cross over from one siphon to the other. Complicating things further were areas inside the siphons where the steel liner had only partially detached from the pipe wall. This had allowed water to flow in behind the liner and create a backpressure that either accelerated the peeling process or bowed the liner in such a way that it created a major line obstruction.

Although divers spent almost five months burning and sawing away at the peeling liner, following heavy rains, peeling was again visible in areas where the steel had previously been removed.

Einhorn indicated this was an ongoing problem throughout the project "It wasn't just a couple of localized areas where the detaching occurred," he said. "In all, crews spent almost five months clearing several tons of steel and debris from inside the shafts and siphons."

Upon completing this phase of the project, Walker's crews conducted final line inspections and carefully measured areas where voids had been located Next, a closed circuit television (CCTV) inspection was conducted of the breach area.

Sliplining decision

The next order of business for Walker Diving was to discuss corrective measures with city engineers. However, after the city's technical team viewed the video and learned the extent of the breach, they strongly felt that any attempt to divert the massive flow into a single siphon could compromise the entire system.

The solution ultimately devised to repair the system was to slipline the two 50-inch diameter siphons with 44-inch diameter pipe. At that time, the city asked Walker Diving to suggest and demonstrate a method of sliplining to facilitate the needed repairs.

Einhorn is quick to point out that the configuration of the system posed somewhat of a problem. Each siphon had a 90 degree vertical bend at each end to accommodate the shafts extending up to the surface, which limited the length of the pipe joints

that could be used on the project.

Continuing, Einhorn said the method devised to slipline the siphons called for lowering 3 5-foot pipe joints down through the shaft, rotating them from vertical to horizontal, and then positioning them in precise position inside the siphon for final pipe pull in

A short time later, Walker Diving's crew set up at the site and used a 44-inch pipe joint to demonstrate that the sliplining technique was feasible, When the contract went our for bid, W. H Streit was low bidder on the project and was awarded the contract.

Still unresolved, however, was the pipe selection. Because this was an emergency project, the City of Philadelphia had to have the project completed as quickly as possible Bids were solicited from various pipe manufacturers that could produce the pipe needed for the project within a very short time frame.

According to Sparks, two different pipe manufacturers indicated that they could supply the pipe to meet the city's design criteria. One of those responding was a steel pipe manufacturer and the other was Beetle Florida Inc , a fiberglass pipe manufacturer

As the project manager of record, W.H. Streit was charged with making the final pipe selection. Sparks said that after meeting with the two pipe manufacturers and carefully evaluating the two products, the filament wound fiberglass pipe was considered a better match for this particular application. "Not only did the fiberglass pipe provide the 60 psi external pressure rating needed to ensure a safety factor when the annual space between the old and new pipe was grouted, it was also stronger and lighter Moreover, the bell and spigot joint design could be configured in such a way that a diver could make the necessary underwater joint connections by feel."

In preparation for the sliplining operations, W H. Streit connstructed a mockup of the system off site The primary purpose of the mockup was to allow the divers to familiarize themselves with the underwater tasks they would soon be performing in virtually zero visibility

W.H. Streit Project Manager, Pete McCarthy, said, "We were fortunate to be able to obtain some test pieces of the fiberglass pipe selected for the project. This allowed the divers to practice rotating the pipe inside the shafts and familiarize themselves with pipe joint makeup and rigging configurations that would be used once the sliplining operations got under way"

Underwater sliplining

McCarthy noted that once the underwater sliplining began, the job became much more intense. Under the direction of diving supervisor Joe Morrison, members of six-man dive teams were charged with following each respective pipe joint down through the shaft, rotating it from vertical to horizontal, disconnecting the lifting ring and then aligning the 3 4-foot fiberglass pipe joint inside the existing 50-inch diameter siphon. As the diver returned to the shaft, the winch operator was signaled to begin pulling the pipe in tight to make the final joint connection Once the joint was secure, the diver retrieved the lifting ring and returned to the surface and the procedure started again

The divers repeated these functions 400 times to complete the 1,200 feet of sliplining inside the two 600-foot siphons

Once the pipe joints were pulled together inside the 600-foot siphon, Edwin Brady Construction Company, Paris, KY, pumped a special underwater grout from the surface to a series of fittings in the pipe that create a watertight foam bulkhead and anchored the liner pipe to the host pipe and provided a water tight seal As quickly as this work was completed, crews with Pacific International Grouting, Bellingham, WA, began pumping a low density cement grout between the existing pipe and the fiberglass to anchor and securing everything in place

In describing repairs to the voids discovered inside the siphons, Sparks said these were filled with a low density grout.

During sliplining operations, pipe joints fitted with pump ports had been strategically placed where the breach was located. In this way, vent tubes could be placed inside the breach and grout pumped in to fill the void. "When the divers observed grout coming back through the vent ports into the pipe, they knew the breach between the two siphons had been completely sealed," Einhorn said.

After completing the horizontal sliplining portion of the project, the four 50-inch I D vertical shafts were sliplined as well Much less involved, the shafts were sliplined by lowering 25-foot sections of pipe into the shafts and then bolting them to the shaft wall. According to Einhorn, the same grouting method used inside the siphons was employed at all four shaft locations

According to Sparks, the project provided everyone involved with some unique challenges Hopefully our experince and success on this project will allow us the opportunity to be involved in similar type projects in the future.

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