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**Fully Structural Renewal of 39-inch PCCP Water Transmission Main
with Swagelining™ and HDPE**

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1. ABSTRACT

Gulf Coast Water Authority (GCWA) and the City of League City, Texas were faced with the need to renew a critical 39-inch PCCP water transmission main. The 39-inch PCCP water main, owned by GCWA and operated by League City, required replacement of approximately 6,800 feet along Calder Road.

ARKK Engineers, a Houston based consulting firm, evaluated numerous rehabilitation and replacement methods in which Swagelining™ was selected.

This paper will outline the design phase and selection process as traditional slip lining was considered including an alternate for a compressive tight fitting HDPE pipe. The design criteria required a fully structural solution capable of 125 psi operating pressure. The Swagelining™ process was selected over slip lining due to the additional flow capacity and the contract was awarded to Murphy Pipeline Contractors.

This paper will also outline the construction phase, including the Swagelining™ process, the pipe installations performed by Murphy Pipelines, and the challenges associated with the installation of a 1000mm (39.4 inch OD) DR 17 HDPE pipe. The 2.32-inch wall thickness pipe was pulled through a single swage die in four pulls ranging from 1,250 feet to 2,100 feet in length.

The Calder Road Project represents the largest diameter, fully structural pipe installed to date in North America utilizing the Swagelining™ technology. The utilization of this technology with HDPE pipe allowed the owner to meet all design parameters and increase the flow capacity. Swagelining™ offers a solution for pressure pipe renewal that is unique in today's trenchless pressure pipe market.

2. PROJECT BACKGROUND

GCWA had identified a major potable water supply main in need of replacement. The 39-inch PCCP water transmission main, owned by GCWA and operated by the City of League City, feeds a water plant supplying water to the western quadrant of the City of League City. The transmission main, originally constructed in 1971 to supply surface water to the City of Galveston, interconnects between GCWA's Thomas S. Mackey Water Treatment Plant

and the City of Houston's Southeast Water Purification Plant. In addition, this approximately 6,800 foot section of Calder Road was scheduled for reconstruction and widening.

3. DESIGN PHASE AND SELECTION PROCESS

GCWA issued a very complex Request for Competitive Sealed Proposals (RFCSP) to allow GCWA to select the best materials and method for rehabilitation. The proposal included a base price for slip lining allowing HDPE or PVC. Alternate 1 included slip lining with higher pressure classes of HDPE or PVC, and alternate 2 included the Swagelining™ method with HDPE. Although not everything allowed was proposed, GCWA received proposals from five contractors.

After reviewing the cost and capacity of the pipeline, GCWA along with their partner the City of League City awarded the highest grade to Swagelining™ with HDPE based on the evaluation criteria. Final Internal Diameter (ID) with Swagelining™ resulted in 33.86-inches, over 4-inches larger than slip lining with PVC or HDPE (Figure 1). The City of League City could satisfy their demand with the slip lining option; however, since the Calder Road potable water transmission line also provides an interconnect between the City of Houston's Southeast Water Purification Plant and the GCWA's Thomas S. Mackey Water Treatment Plant, GCWA provided funding to pay the difference in cost between slip lining and Swagelining™.

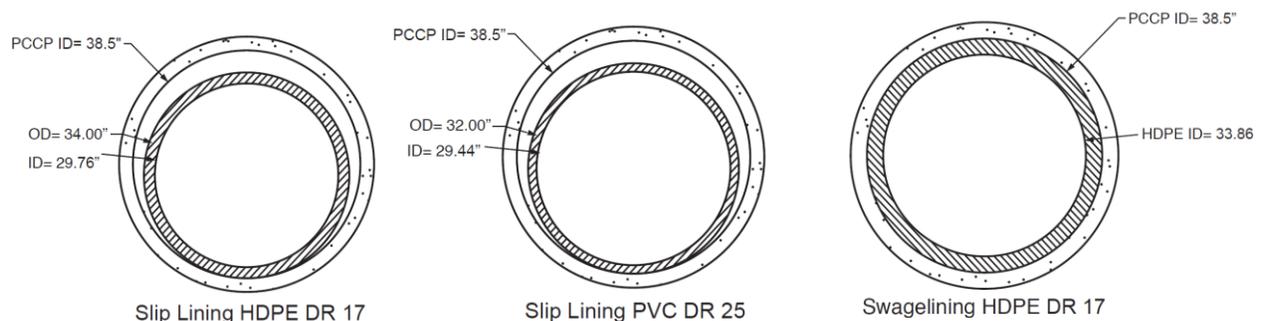


Figure 1: Final ID comparison between slip lining and Swagelining™.

4. SWAGELINING™ HISTORY AND OVERVIEW

The Swagelining™ technology was developed over 30 years ago by British Gas in conjunction with United Utilities. With an extensive list of successfully completed projects across the globe, the technology has been proven in many extreme projects spanning three decades onshore and subsea. Projects have been completed for water, sewer force main, mining, hydrocarbons, chemicals, bulk products and gas distribution. The overall confidence of the technology originates from an extensive physical testing program conducted by British Gas over several years. The process was established after extensive analysis of material behavior during and after die reduction. A major result of the research and development program was the development of the liner system design software. This software program, which is utilized for each project, ensures installation stresses do not compromise the integrity of the HDPE.

The Swagelining™ technology specifies a High Density Polyethylene (HDPE) pipe with an outside diameter larger in size than the inside of the host pipe to be renewed. After the HDPE is butt fused to correspond to the pull distance, the pipe is pulled through a single reduction die immediately before entering the host pipe. This reduces the HDPE pipe temporarily below the ID of the host pipe allowing it to be inserted (Figure 2). While the towing load keeps the HDPE under tension during the pull, the pipe remains in its reduced size. The HDPE remains fully elastic throughout the reduction and installation process. As the liner pipe is not permanently deformed by Swagelining™, the release of the towing load after insertion is the catalyst for the liner to revert back towards its original size. As its original size is larger than that of the host pipe, the HDPE pipe expands until it is halted by the inside diameter of the host pipe. This produces a residual strain that is locked in the liner and maintains pressure against the inside of the host pipe, even in the absence of internal pressure from the product conveyed.



Figure 2: Swagelining™ process as HDPE is pulled through the reduction die.

The effectively natural compressive tight fit produced by Swagelining™ provides value for clients looking to maximize the final ID of the pipeline. Due to the tight fit, thin walled HDPE liners and semi-structural HDPE pipe can be installed in which operating pressure is delivered through the host pipe. In circumstances such as the Calder Road 39-inch PCCP water transmission main which required a fully structural solution, Swagelining™ can install a fully structural HDPE PE4710 pipe such as DR 17 with a working pressure rating of 125 psi, allowable total pressure during recurring surge events of 187 psi and allowable total pressure during occasional surge events of 250 psi (ASTM F714, ASTM D3035 and AWWA C901). Higher working pressure ratings above 125 psi can also be achieved.

5. CONSTRUCTION PHASE

Calder Road runs parallel to 1-45 in League City, Texas. The urban area is a combination of residential and commercial use, with a Big League Dreams Sports Park in the middle of the project. The project limits encompassed a very tight area as Calder Road is a 22 foot wide single lane two way road with a 10 foot wide easement. The 39-inch PCCP water transmission main was located along the edge of the pavement among a congested utility corridor. While shutting down both lanes would have eased construction, only a one lane shutdown was allowed.

The rehabilitation of the 6,800 linear feet of the PCCP 39-inch diameter waterline included the replacement of four 36-inch diameter butterfly valves, additional three 36-inch x 24-inch diameter tees with gate valves, the replacement of two air relief valves, the addition of three blow-off valves, installation of a 39-inch x 36-inch flanged reducer, placement of two large thrust restraint blocks, and a bypass (Figure 3, Figure 4 and Figure 5). The placement of valves, blow-offs and tees were relocated based on the constructability of the project and the needs for the future expansion of the City of League City Water Plant on Calder Road. The north end of the project was extended about 300 linear feet to an existing 36-inch diameter butterfly valve. The south end of the project required the addition of a flanged reducer, butterfly valve and blow-off. Thrust restraints were required at the north and south end of the project to protect the existing transmission main from stresses during construction. Each thrust restraint included an ellison type pipe clamp along with over 40 cubic yards of concrete. During construction the existing water plant was connected to the City of Houston water supply or the GCWA water supply through a 12" diameter bypass laid mostly above ground. The project layout was designed to meet the needs of the roadway construction along with the expansion of the Calder Road Water Plant.



Figure 3: Left and middle picture of 24-inch stub out by sidewall fusion with Flange Adapter connected by downhole butt fusion. Right picture of 24-inch Gate Valve bolted on to Flange Adapter.



Figure 4: Left picture of downhole butt fusion connecting HDPE in receiving pit. Middle picture of 36-inch side actuated butterfly valve. Right picture of 39-inch by 36-inch PCCP flange reducer.



Figure 5: HDPE connections using Flange Adapters with stainless steel back up ring and stainless steel bolts.

To minimize the impact of the project to the surrounding community Murphy Pipelines designed the project layout in which four installations ranging from 1,250 feet to 2,100 feet in length were accomplished. The long pull lengths were beneficial as they allowed for long fused sections of HDPE to be installed eliminating future leak potential and aided in the reduction of excavations by 87% of what open trench would have required.

For each pull, the 50 foot lengths of HDPE were butt fused using a rolling McElroy 1648 machine to correspond to each pull length. While the pipe was fused, crews performed a visual inspection of the interior of the PCCP waterline. This step is critical as it identifies any major obstructions, location and degree of bends and condition of host pipe interior which determines if any cleaning is required. Finally, a proving pig was pulled through. A proving pig is a short section of HDPE fabricated one to two millimeters larger than the installation OD of the HDPE during Swagelining™ operations. Its purpose is to eliminate risk by ensuring a free bore path.

Once a free bore path is confirmed, Swagelining™ operations would begin (Figure 6). To complete each pull, a specific bank shoring plan was implemented to compensate for the amount of force required to pull the long lengths of HDPE with a wall thickness of 2.32-inches through a single swage die. Two types of constant tension pulling equipment were used for the project; Hammerhead 173 ton pulling machine and a TT Technologies 143 ton pulling machine. Both machines performed well and without incident. As part of the liner system design process, Murphy Pipelines utilized their software program to ensure installation stresses on the HDPE met the ASTM standard for the tensile yield design factor.



Figure 6: 1000mm (39.4-inch) OD HDPE pipe enters single swage die. The HDPE pipe is temporarily reduced below the ID of the 39-inch PCCP host pipe to allow for insertion.

After the HDPE pipe was completely pulled through the host pipe (with pull lengths of 1,250 to 2,100 feet), the pulling force was removed. This allowed the HDPE to naturally revert back towards its original diameter until halted by the inside diameter of the host pipe forming a compressive tight fit (Figure 7). While dependent on ambient temperatures, the HDPE is typically allowed to relax overnight to regain full reversion for most thin walled and semi-structural Swagelining applications. Due to the thicker wall of this fully structural application, the HDPE needed longer to revert to regain full reversion.



Figure 7: Tight compressive fit of HDPE after reversion.

6. SUCCESSES AND CHALLENGES

A major challenge with the project was the location of working within a tight utility corridor with limited room for construction activity. This challenge was addressed early on through extensive communication with all parties involved with an emphasis in working with local businesses and homeowners to understand and meet their demands. The success of this project ultimately required an extensive amount of team work and coordination. GCWA, League City, ARKK Engineers and a number of other local agencies showed great resolve in working with Murphy Pipeline crews to properly plan, adapt and execute the project.

The other major challenge was installing a fully structural HDPE PE4710 DR 17 pipe with a 2.32-inch wall thickness. The thick walled HDPE pipe required more tonnages during installation than most thin walled or semi-structural Swagelining™ applications. This placed a higher importance on bank shoring, HDPE butt fusion operations and pulling equipment.

7. CONCLUSION

The Calder Road Project represents the largest diameter, fully structural pipe installed to date in North America utilizing the Swagelining™ technology. The utilization of this technology with HDPE pipe allowed the owner to meet all design parameters and increase flow and capacity. The larger final diameter with Swagelining™ vs. slip lining had significant benefits for the project economics. Gulf Coast Water Authority will be able to realize a higher value by delivering more water to its customers, both now and in the future.

As communities across North America face the challenges of aging medium and large diameter water transmission and sewer force mains, Swagelining™ has been proven as a technology that can add a tremendous amount of value for renewal and replacement. The method's advanced engineering agenda through research and development coupled with its ability to meet various pressure requirements from thin walled to fully structural make Swagelining™ a vital method to be considered.

8. REFERENCES