City of Houston 30-inch Water Transmission Main Replaced by Compressed Fit HDPE Lining

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PROJECT BACKGROUND

City of Houston was faced with the need to renew a critical 30-inch well collection line. The steel cylinder reinforced concrete (SCRC) and prestressed concrete cylinder pipe (PCCP) water main required replacement of approximately 7,600 feet near the Katy Addicks Pump Station along Scenic Ridge Drive.

The existing 30-inch main was 37 years old and beginning to show numerous operational problems due to joint leaks.

DESIGN PHASE AND SELECTION PROCESS

During the design phase and selection process various construction methods such as open cut, slip lining, CIPP and a compressive tight fitting HDPE pipe (Swagelining™) were considered.

The design criteria required a fully structural Class IV solution capable of 60 psi operating pressure. Overall, the hydraulic cross section needed to be maintained as large as possible requiring an I.D. of liner 28-inch or greater within the 30-inch I.D. host pipe. The optimized thickness of the liner required was 1-inch or less including maintaining various other required parameters such as vacuum pressures, live loads and ground water.

Open cut was eliminated early in the design phase due to the limited 60 foot ROW, congested utility corridor and mature landscaping of the residential neighborhood. Slip lining was also eliminated early in the design phase due to the required flow of the system in which slip lining would have reduced the final internal diameter below the 28-inches required. During the bid process, CIPP and the compressive tight fitting HDPE lining process were allowed.

Among many factors, the compressive tight fitting HDPE process was selected because it is trenchless and less disruptive to the residents, required less time for installation, offered a long design life with the new HDPE and was less expensive. Also, the implementation schedule could be accomplished in low water demand season.

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 PE4710 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 I.D. of the host pipe allowing it to be inserted (Figure 1). 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 1: 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 I.D. of their 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 30-inch PCCP and SCRC water transmission main which required a fully structural stand-alone solution, Swagelining™ can install a fully structural HDPE PE4710 pipe. Higher working pressure ratings can also be achieved. In addition to meeting internal pressure loads, the HDPE installed met all external loading requirements and was also utilized in the insertion and receiving pits.

CONSTRUCTION PHASE

Scenic Ridge Drive is an urban residential area (Figure 2). The project limits encompassed a very tight area with a 60 foot ROW. The 30-inch water transmission main was located along the edge of the pavement among a congested utility corridor.

The rehabilitation of the 7,600 linear feet of the 30-inch diameter waterline included the replacement of three 30-inch diameter butterfly valves with 48-inch operator manholes, three 16-inch butterfly valves, one 24-inch butterfly valve, the replacement of five air relief valves and various cross connections (Figure 3 & 4). The placement of valves, blow-offs and tees were relocated based on the constructability of the project.

Figure 2: Residential area with limited ROW and mature landscaping. 30-inch HDPE pipe enters insertion pit.

Figure 3: 30-inch diameter butterfly valve with 48-inch operator manhole.

Figure 4: Fused HDPE bends forming one continuous length of pipe.

To minimize the impact of the project to the surrounding community, Murphy Pipelines designed the project layout in which installations ranged from 600 feet to 1,700 feet in length. 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 89% 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 (Figure 5). After each fusion weld cooled, the external roll-back bead was removed to allow clearance through the swage die. While the pipe was fused, crews performed a visual inspection of the interior of the 30-inch 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 O.D. of the HDPE during Swagelining™ operations. Its purpose is to eliminate risk by ensuring a free bore path.

Figure 5: McElroy fusion machine welding 30-inch HDPE within a tent.

Once a free bore path is confirmed, Swagelining™ operations would begin. 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 pipe. A constant tension TT Technologies pulling equipment was used for the project. The machine 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.

After the HDPE pipe was completely pulled through the host pipe (with pull lengths of 600 to 1,700 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 6). While dependent on ambient temperatures, the HDPE is typically allowed to relax overnight to regain full reversion for most Swagelining applications.

Figure 6: Tight compressive fit of HDPE after reversion.

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. City of Houston, FCM Engineers, inspection 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 utilization of this technology with HDPE pipe allowed the owner to meet all design parameters and increased the flow. With the smooth wall of the HDPE pipe (C-factor of 150), flow increased after lining the host pipe with HDPE compared to the old flow rate prior to rehabilitation of the 30-inch water main.

CONCLUSION

The 30-inch water transmission main project represents the first Swagelining™ project completed by the City of Houston, whom has a long history of utilizing trenchless technologies. Success of the technology is critical as Houston and other communities look for methods to renew their medium to large diameter water transmission and sewer force main pipeline networks. Swagelining™ offers a solution for pressure pipe renewal that is unique in today's trenchless pressure pipe market.

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 remarkable value for renewal and replacement. The method's advanced engineering agenda through research and development coupled with its ability to meet various internal pressure requirements from thin walled to fully structural, including designing for external loading make Swagelining™ a vital method to be considered.