4. The failure pressure of damaged PCCP with SCL-C was modeled. The digital results indicate that there was no significant difference between SCL-C and SCL-P systems up to 160 psi internal pressure.
5. Strains in the SCL-P system were approximately 15% lower than SCL-C as pressure digitally increased to 500 psi internal pressure.

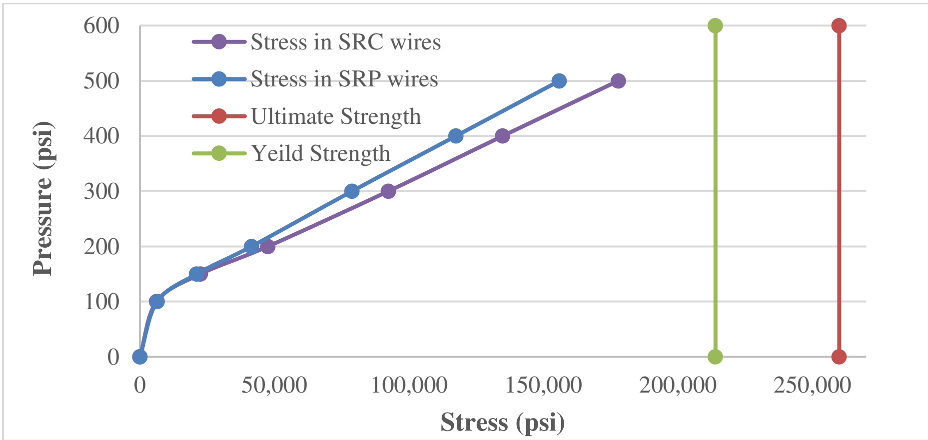

Figure 11: Comparison between the level of stresses in steel components between SCL-C and SCL-P under 500 internal pressure

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Harnessing Advanced Inspection Technologies to Assess Metallic Water Transmission Mains

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ABSTRACT

In October 2019, the City of Vancouver teamed with Pure Technologies, a Xylem brand (Pure) to perform a condition assessment on a section of the Charles Street Transmission Main. The project utilized a high-resolution ultrasonic condition assessment tool that inspects the pipeline while still in service, identifying areas of wall thickness loss, and assessing lining and out-of-roundness. The condition assessment tool is free-swimming, which allowed this critical transmission main to remain in service during the inspection. The inspection was completed on a 2.9-km section of the 800-mm riveted steel Charles Street Transmission Main, installed in 1912. As part of the project, Pure also inspected this section of pipeline using other technology as a prescreening acoustic tool to locate leaks and pockets of trapped air. While the prescreening inspection did not detect acoustic events characteristic of leaks, the free-swimming ultrasonic condition assessment tool identified five pipe sections with wall loss anomalies. Pure provided dig sheets to identify the location of those pipes. In July 2020, the City of Vancouver excavated one of the pipe sections that showed wall loss anomalies which validated the results. Once exposed, the City decided to apply petrolatum tape to the pipe exterior to slow the progression of corrosion, as corrosion can lead to significant blowout type failures. Their proactive approach to pipeline management helped mitigate the risks of main failure, including loss of service due to unplanned shutdowns and potential for property damage to customers. With the information provided from the inspection, the City of Vancouver is now armed with powerful new insights to prioritize investment and reduce the incidence of dangerous, expensive, and unplanned water outage events.

INTRODUCTION

The City of Vancouver Waterworks purchases treated drinking water from Metro Vancouver and operates a city-wide network of transmission and distribution water mains to supply water to customers. In 2019, Waterworks delivered 109.7 billion liters of drinking water throughout Vancouver.

The City of Vancouver is responsible for the installation, operation and maintenance of its water distribution system which includes: 1,488-km of water mains, 101,354 service connections, 21,868 meters, 6,517 hydrants, 25,000 valves, and 28 pressure reducing valve stations. Transmission mains are essential to convey large volumes of water throughout the City. Of the 1,488-km of water mains in the City, transmission mains (larger than 300-mm in diameter) account for ~5% of the total system length.

The Charles Street Transmission Main was installed in 1912. It is 800-mm riveted steel pipe and is a critical main that conveys water within East Vancouver. In 1975, the City added cement mortar lining to the pipeline as a response to corrosion-related leaks, and to mitigate internal corrosion. While this lining has helped extend the useful service life of the main, the City was interested in using current technology to better understand the existing condition and extent of corrosion along this transmission main. Corrosion related main failures can cause unplanned shutdowns of the transmission main, which can impact a significant number of customers due to loss of service. Condition information allows the City to make informed and proactive asset management decisions, including any rehabilitation or renewal work.

The City of Vancouver worked with Pure to inspect a section of the Charles Street Transmission Main. The scope of work began near the intersection of Charles St and Windermere St at an existing 900-mm access and ended near the intersection of Charles St and McLean Dr. Figure 1 shows and approximate layout of the inspected section of the 800-mm Charles Street Transmission Main. The inspected alignment is comprised of approximately 2.9-km of 800-mm riveted steel pipe and it was inspected with the PipeDiver Ultra ultrasonic condition assessment tool and with the SmartBall acoustic inspection tool.

Figure 1. General alignment and inspection scope of the 800-mm Charles Street Transmission Main

The ultrasonic condition assessment tool is a free-swimming and capable of 25+ kilometer deployments, that directly measures pipe wall thickness of metallic water pipelines using high-resolution ultrasonic technology. The ultrasonic condition assessment tool inspects the pipeline while still in service, measuring wall thickness and assessing lining and out-of-roundness. It navigates through most valves, sharp bends and tees, and is inserted through existing appurtenances, enabling deployment through existing access ports with no need to dewater.

The wall thickness loss inspection provides quantitative wall thickness measurements while differentiating between interior / exterior defects and identifying outlets, valves, joints, and other pipeline features. The ultrasonic condition assessment tool reported detection threshold is 2-inch x 2-inch x 20% wall loss, with smaller area defects reported if wall loss is ≥ 40%. Metal wall loss and other feature locations are reported by pipe section from the upstream joint and clocked to the pipe circumferentially.

Out-of-roundness of metallic pipelines can cause coating cracking and can impact the structural integrity of the pipeline. The out-of-roundness data collected by ultrasonic condition assessment tool identifies the maximum and average out-of-roundness for all pipe sections of the inspection run.

The ultrasonic condition assessment tool consists of several bodies including the sensor module, onboard data acquisition and storage module, and battery modules to power the onboard electronics and tool tracking devices during an inspection. The ultrasonic pulses travel through and interact with the pipe wall as the tool moves along the pipeline, as demonstrated in Figure 2. The receiving time of the reflected ultrasonic signal is changed where wall thickness variation exists. The reflection of ultrasonic waves is measured by the sensor module and recorded on the storage module of the tool.

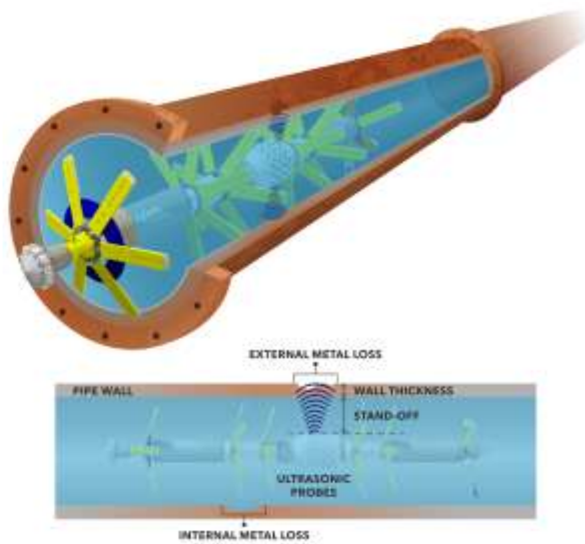

Figure 2. PipeDiver® Ultra Condition assessment Platform – Ultrasonic Technology

Post-inspection, the recorded data is then processed into a visualized form from which pipe wall loss areas and depths can be analyzed. Figure 3 presents a typical visualization of a spiral welded steel pipe with and without a wall defect. The defect is an indication of pipe wall thinning identified by separation variations between two ultrasonic reflections from internal and external pipe wall.

In additional to performing a pipe wall assessment, an acoustic leak detection survey was completed with the acoustic leak and gas pocket detection tool., The technology is a free-swimming, acoustic-based tool that detects audible activity associated with leaks or pockets of trapped gas in pressurized pipelines. The acoustic inspection tool assembly comprises a water-tight aluminum alloy core containing a power source, electronic components, and instrumentation that includes an acoustic sensor, tri-axial accelerometer, tri-axial magnetometer, GPS synchronized ultrasonic transmitter, and temperature sensor. A protective outer foam shell encapsulates the aluminum core and provides a larger surface area by which the device is pushed by the hydraulic flow of the fluid in the pipeline. The foam shell also reduces the ambient noise from the rolling action, resulting in a near-silent background environment. The acoustic inspection tool assembly is deployed into the flow of a pipeline, traverses the pipeline, and is captured and extracted at a point downstream. During the inspection, the acoustic tool's location is tracked at known points along the alignment to correlate the inspection data with specific locations. Figure 4 below is a representation of the acoustic leak and gas pocket detection tool inspecting a pipeline.

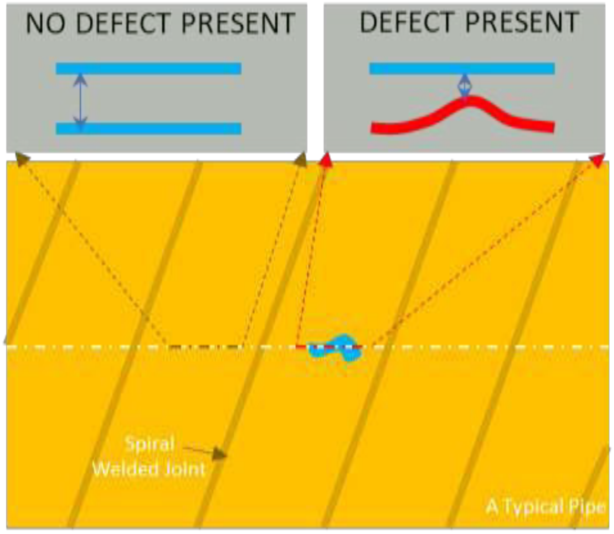

Figure 3. Typical Wall Defect Visualization

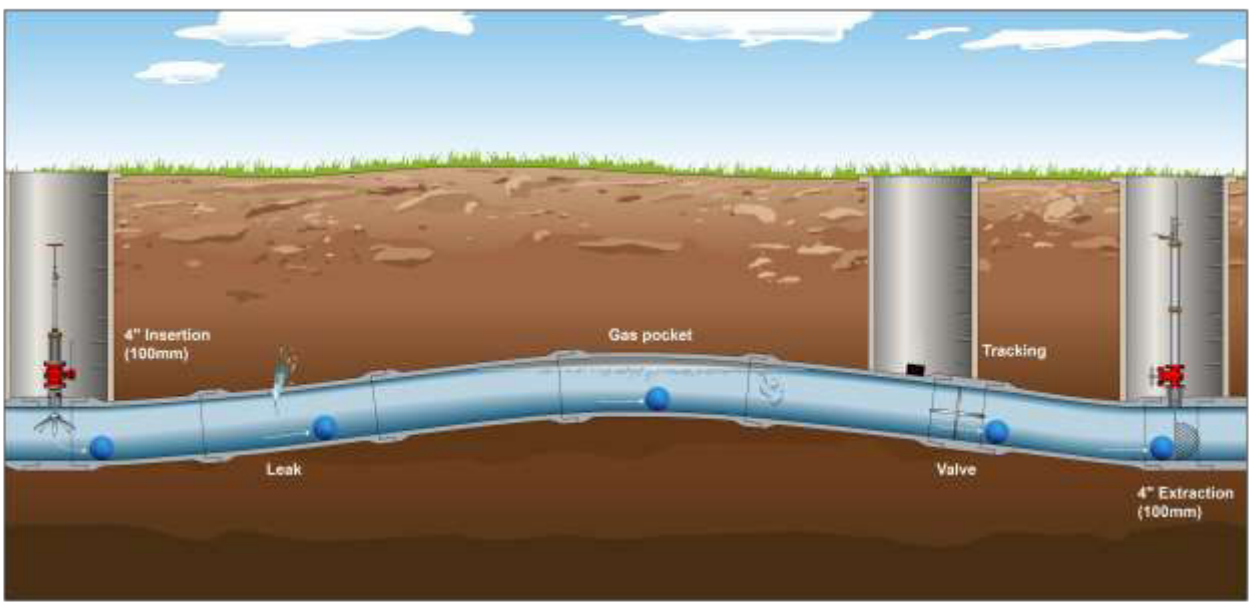

Figure 4. SmartBall Inspection Tool

CHARLES STREET TRANSMISSION MAIN PIPEDIVER ULTRA AND SMARTBALL INSPECTIONS

On October 17, 2019 both inspection tools were manually inserted into the Charles Street Transmission Main through an existing 900-mm access port. Figure 5 is a photo of the free-swimming ultrasonic condition assessment tool prior to inspection.

Figure 5. Free-swimming ultrasonic technology

Upon data analysis, the acoustic inspection tool did not detect acoustic events characteristic of leaks or gas pockets. From a total of 1,656 pipe sections inspected with the ultrasonic condition assessment tool, only five (5) were identified with defects with wall loss ranging from 4% to 24% based on the as-built average nominal pipe wall thickness of 7.94 mm and 9.53 mm, all of the reported defects with wall loss occurred along a 100m section of the pipeline. Figure 6 summarizes the inspections results.

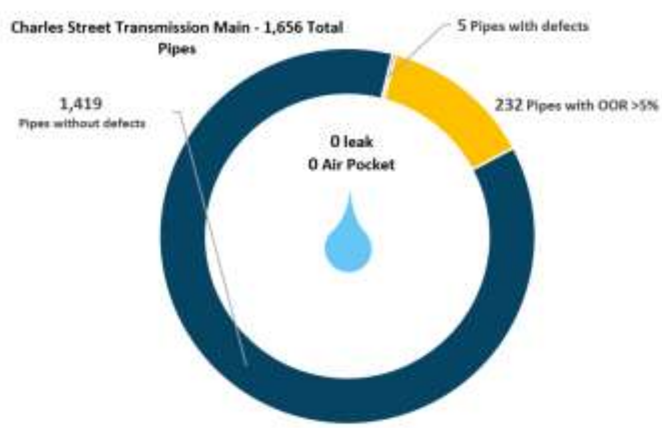

Figure 6. Charles Street Transmission Main – PipeDiver® Ultra and SmartBall™ inspection results

Additionally, 232 pipe sections were found to have out-of-roundness over 5%. The out-of-roundness data collected by the PipeDiver Ultra is demonstrated in Figure 7 below, the red dot line is the shape of the pipe cross-section, and the blue dash line is the desired circular shape of the pipeline.

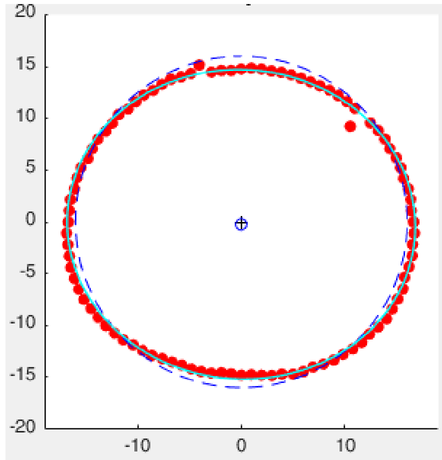

Figure 7. Example of Out-of-Roundness data collected by the ultrasonic condition assessment tool

VALIDATING THE RESULTS

On July 14, 2020 the City of Vancouver exposed the pipe section with the largest wall loss defect that was identified during the ultrasonic condition assessment and conducted a validation of the results. Dig sheets (Figure 8. Example of dig sheet) were provided to the City of Vancouver for the pipe section which was subsequently successfully located.

Figure 8. Example of dig sheet generated to pinpoint pipe sections with wall loss

The City of Vancouver confirmed the reported wall loss defect; the defect was located at the invert of the pipe section as shown in Figure 9. During this examination, the City also observed many smaller diameter corrosion pits on the sides and, to a lesser extent, on the top of the pipe section as well. The corrosion pitting not detected by the ultrasonic condition assessment tool were smaller in size that the reported detection threshold for this tool. Pure Technologies is working on optimizing the analysis software utilizing machine learning algorithms that could improve detection and the reported detection thresholds in the future.

Figure 9. Heat map generated with the ultrasonic condition assessment tool data

The City of Vancouver confirmed that the wall loss detected by the ultrasonic condition assessment tool ranged from 1-3 mm in depth (with some corrosion pits up to 6 mm in depth), but was more widespread compared to other reported wall loss areas and formed a large patch of corrosion approximately 45 cm x 15 cm (Figure 10). This large patch suggested that the corrosion was more uniform, or that smaller corrosion pits had bridged together, which increased the potential for a significant blowout failure.

Figure 10. Wall loss defect validated by the City of Vancouver

The City also noted that corrosion appeared to be limited laterally to the section identified by the ultrasonic condition assessment tool and adjacent pipes were in comparably good condition.

Due to the rivets on the pipe, it was not possible to install a repair clamp and instead the pipe exterior was coated with petrolatum tape to slow the progression of corrosion on the pipe until a more permanent repair can be completed.

CONCLUSION

Both the PipeDiver Ultra and SmartBall free swimming inspection tools operate while the pipeline remains in service, providing utility owners with an easier and less costly alternative to inspection methods that require shutdown or dewatering.

With the information provided by the inspection, the City of Vancouver is now armed with powerful new insights to prioritize investment and reduce the incidence of dangerous, expensive and unplanned water outage events. The City will be exploring options to replace or rehabilitate the portion of main with defects in the short term while deferring the full replacement of the entire main to a later date. This has allowed the City to prioritize their short-term budget on higher risk transmission mains.

ACKNOWLEDMENTS

Pure Technologies would like to acknowledge with much appreciation the City of Vancouver staff that was very supportive during the planning, execution and validation of this project, without their enthusiasm to explore new non-destructive condition assessment technologies we would not be able to present this information.

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How Pipe Bursting Brings More Bang for Your Water Rehab Buck

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ABSTRACT

While there are countless utilities and municipalities that understand the benefits of pipe bursting for gravity sewer replacement, dozens of utilities have utilized programmatic pipe bursting to replace aging water infrastructure. What they have learned could benefit other water utility providers that are experiencing increased potable pipeline failures combined with a shrinking budget. This paper will review the upwards of a decade of water pipeline pipe bursting programs implemented by the following select utilities: Billings (MT), Bismarck (ND), Cheyenne Board of Public Utilities (BOPU, WY), Consolidated Mutual Water Company (Lakewood, CO), Lee's Summit (MO), Monroe (NC), and St. Clair Shores (MI). Collectively these utilities have replaced over a half million feet of pipe via bursting. All of them have found pipe bursting to cost less and impact the community less versus when they replaced lines via conventional dig and replace. Common and unique themes will be reviewed from these utilities whose preference is to rehabilitate their aging water infrastructure almost exclusively, on an annual basis, via pipe bursting. Shared and utility specific challenges that were faced in order to make these programs successful will be highlighted. Actual savings and/or increased infrastructure replacement will be demonstrated as well. A summary will be provided for characteristics that have made pipe bursting work for these utilities and which may be most applicable to other utilities.

INTRODUCTION

Pipe bursting is a well-established trenchless method of pipeline rehabilitation or replacement that has been in use in the United States for several decades. The process was first developed in the United Kingdom in the late 1970s as a process for replacing natural gas pipelines without having to excavate a trench for the entire existing alignment. The pipe bursting process is a form of pipeline rehabilitation that replaces the original pipe with a new pipe that is the same diameter or larger. Once the process started being performed in the United States (US), the technology was also modified and used to replace water and wastewater pipelines. Existing water mains between 4- and 36-inches in diameter have been successfully pipe burst in North America with millions of feet of pipe having been replaced using the pipe bursting method. The slow growth of pipe bursting for water mains resulted from the following cost concerns: use of temporary bypass and frequent excavation due to replacement of laterals, gate valves, fire hydrants, tees, and bends. In addition, probably the biggest deterrent was the misconception that only high density polyethylene (HDPE) pipe could be pulled in and used with pipe bursting. The concern was that most potable water agencies were unfamiliar with HDPE, they had not used it, and they did not have fittings or repair materials to use on HDPE. Even with temporary bypass piping and service lateral connection and appurtenance excavations, the total amount of excavation, export and import of materials, and resurfacing are far less than traditional open