Beyond Failure Prevention

THE BENEFITS OF PIPELINE MONITORING FOR LARGE-DIAMETER PCCP ASSETS

Xylem's SoundPrint® Acoustic Fiber Optic (AFO) monitoring system is a critical advanced warning system for Prestressed Concrete Cylinder Pipe (PCCP) owners. The platform also plays an important role in helping utilities with diminishing capital budgets save money and avoid unnecessary pipeline replacement.

Of the 100 largest utilities in North America, 90 use PCCP in their large-diameter pipeline network. PCCP failures are usually catastrophic and come at a high social and economic cost. On average, a large-diameter PCCP failure costs $500,000.[1] However, costs can easily climb into the millions in dense areas where failures impact critical infrastructure. A large portion of these costs are related to indirect economic, environmental, and societal consequences. A recent study evaluating 11 large-diameter water main failures found that direct costs to the utility made up only 34 percent of the total while indirect costs made up 66 percent. Six of the 11 failures studied were on PCCP pipelines with diameters from 42 to 96 inches (1050 to 2400 mm), and overall costs ranged from US$6 million to US$22 million.[2]

Prestressing wire wraps are the main structural component of PCCP. Over time, these wire wraps can corrode and snap. Operating conditions, environmental factors, third-party damage, and other variables can contribute to PCCP deterioration. This makes predicting the deterioration difficult and often leads utilities to conclude that replacing PCCP is the best option, especially if they have experienced a large failure.

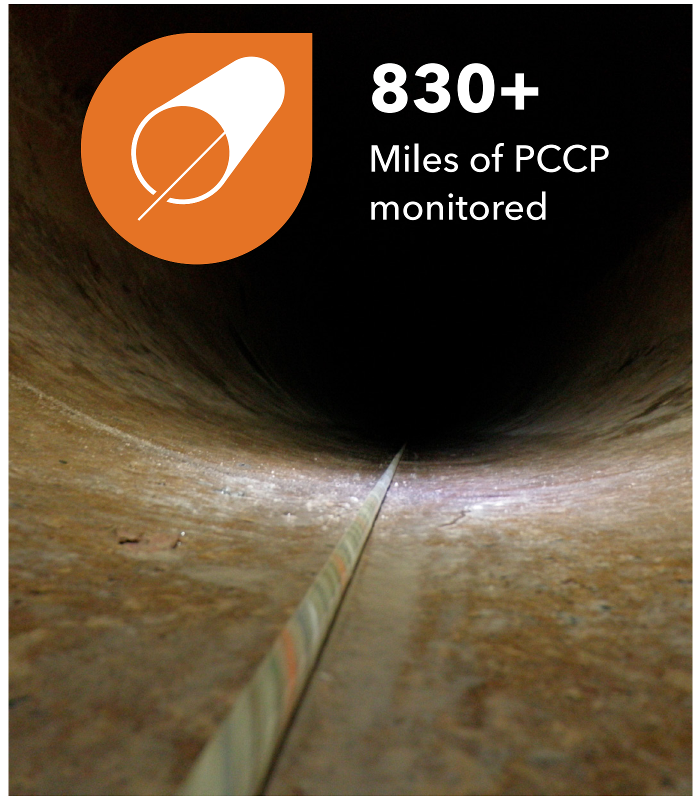
Avoiding expensive, large-scale failures is an important utility priority. However, our data show that PCCP is a very reliable pipe material. Xylem has conducted electromagnetic inspections of more than 5,000 miles (3,100 km) of PCCP, and less than four percent showed signs of distress. Further statistical analysis of PCCP shows that it is roughly 97 percent reliable with 95 percent confidence at 50 years in service.[3] Based on this information, the most cost-effective way to manage PCCP, while avoiding failures, is to implement a proactive management approach.

Best-in-class, proactive PCCP management can significantly reduce risk for utilities

By implementing a proactive management program, utilities can virtually eliminate the risk of failure within their PCCP inventory. Even utilities that have not experienced a large-diameter PCCP failure can realize significant capital program savings by managing rather than replacing these assets. To achieve both failure reduction and capital investment savings, utilities can take the following approach to managing their PCCP.

- **Electromagnetic inspection** to better understand the pipeline's baseline condition by identifying and localizing existing prestressing wire breaks.
- **Structural analysis** that models the pipe under pressure and external loading to determine the number of contiguous broken wire wraps that will cause the pipe to reach a performance limit related to failure.
- **Remaining useful life analysis** using Monte Carlo simulations that indicate how long the pipeline can operate before a failure is expected based on different deterioration simulations.
- **Continuous acoustic monitoring** to identify wire breaks in near-real-time that indicate whether a failure is imminent based on the baseline condition.
- **Electromagnetic reinspection** to reset the baseline level of damage on the pipeline, localize any wire break activity identified through monitoring, and update statistical and remaining useful life models.
- **Engineering recommendations** to determine whether pipelines can continue to operate safely or if individual pipes require rehabilitation or replacement.

This approach has been used successfully by some of the largest PCCP owners in the world to avoid critical failures, effectively develop long-term Capital Improvement Plans, and avoid replacing pipe that has significant remaining operational life.



Monitoring PCCP advances pipeline management to the next level

In addition to electromagnetic inspection, investment in continuous monitoring for PCCP can be a cheaper and less disruptive alternative than operating the pipeline with failures or replacing the pipeline entirely.

PCCP monitoring should be undertaken in the following situations.

- When the utility cannot tolerate any failure because the pipeline is the sole water supply, supplies critical services, or there is unacceptable expected damage based on a Consequence of Failure (COF) analysis.
- When the pipeline has a high COF, and remaining useful life analysis predicts that an unacceptable number of pipe segments are expected to exceed the yield limit inside of the planned lifetime of the pipeline.
- When the pipeline has a high replacement cost and can't be affordably replaced within the capital improvement plan.

Monitoring PCCP increases confidence in capital planning

The economic benefits of avoiding a single PCCP failure are very clear when considering both direct and indirect costs. However, the benefits to capital investment deferral and long-term planning are often even greater. Continuous monitoring of PCCP plays an important role in capital planning, particularly when combined with other strategies.

Electromagnetic inspection provides a snapshot of a pipeline's condition in time. Alone, this inspection data helps utilities understand a pipeline's baseline condition. However, over time, PCCP does not deteriorate uniformly. This means using electromagnetic inspection data alone introduces some uncertainty when predicting a pipeline's remaining useful life for capital planning. Continuously monitoring a PCCP pipeline provides high-resolution data at a much higher confidence interval.

Updating operating life models with continuous data – as opposed to snapshots in time – enables utilities to predict with much greater confidence the amount of time a pipeline can remain in service for long-term capital planning.

Figure 1 shows how continuous monitoring provides much higher granularity of pipeline deterioration data versus electromagnetic inspection alone. Tracking pipeline deterioration over time enables a more accurate prediction of an asset's remaining life. It also enables PCCP owners to intervene ahead of a failure.

Pure Technologies, a Xylem brand completed an economic evaluation for one large U.S. PCCP owner. The evaluation compared the cost of early replacement to using a risk-based management approach. The utility operates a critical 54-inch (1350-mm) PCCP transmission main located under a busy roadway. The aging pipeline is ultimately scheduled for replacement in 2037. Capital replacement is estimated at US$8 million per mile. The utility monitors, regularly inspects, and selectively repairs the pipeline to maintain its safe operation. A 20-year capital cost projection shows that this data-driven approach saves over 70 percent compared to full replacement (Figure 2). Additionally, real-time monitoring has enabled the utility to prevent expensive, potentially catastrophic failures not included in the analysis.

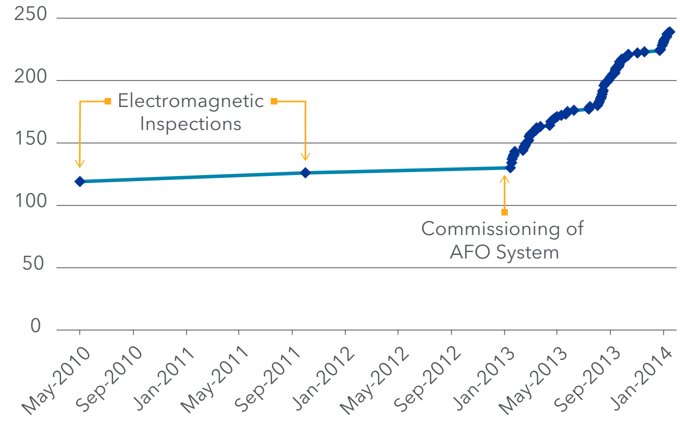


Figure 1. Number of pipes with at least one wire break over the inspection history

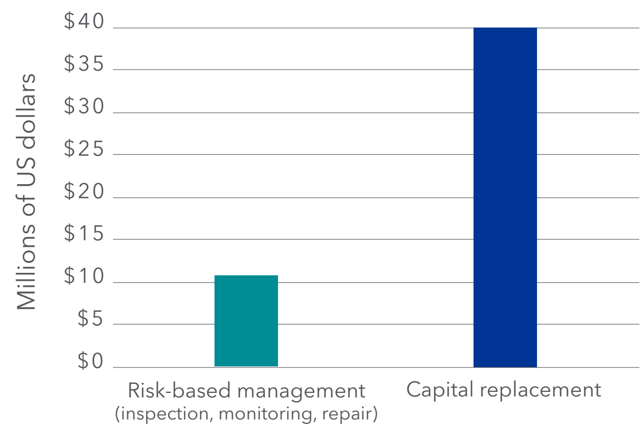
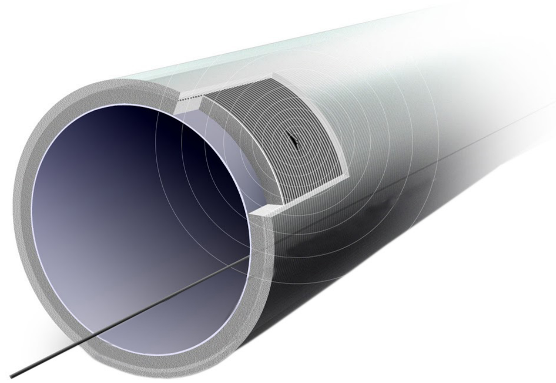


Figure 2. Comparison of 20-year capital cost alternatives

Continuous monitoring provides near-real-time condition information that can augment remaining useful life analysis. This analysis estimates future wire breaks by drawing a random deterioration rate from the distributions. The deterioration rate is then used to compute the number of wire breaks expected over a given time frame. This provides the highest resolution for deterioration modeling because it includes single wire-break deterioration trends and can capture breaks as soon as they occur. This helps improve the accuracy of repair budgeting within a PCCP management program.

The economic benefits of PCCP monitoring



- Intervene on pipes to prevent large-scale failures that have high direct, indirect, and reputational costs to the utility
- Actively track PCCP deterioration and selectively replace pipes instead of replacing an entire pipeline that is 96 percent in like-new condition
- Avoid disruptive large-diameter pipeline replacement projects by actively managing assets to their planned life expectancy or beyond
- Use real-time condition data to update statistical models to make long-term repair and replacement planning more accurate
- Determine the right balance of PCCP risk reduction and cost of risk mitigation strategies based on utility-specific risk tolerance

[1] Peter E. Gaewski and Frank J. Blaha (2007) Analysis of Total Cost of Large Diameter Pipe Failures

[2] Kalyan R. Piratla, Sreeganesh R. Yerri, Sepideh Yazdekhasti, Jinsung Cho, Dan Koo, John C. Matthews (2015) Empirical Analysis of Water-Main Failure Consequences

[3] Based on a 2020 Weibull analysis of Pure Technologies PCCP database and client data sets

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