Pipeline Condition Assessment

Using Non-Destructive Testing Methods

By Jennifer Steffens, P.E.

In their early years, non-destructive testing (NDT) societies were mostly composed of medical X-ray technicians. Since the term "destructive," even when preceded by "non," does not initiate a general sense of comfort to a medical patient, NDT is now dominated by the material sciences.

In order to be considered a truly non-destructive technique, the method of inspection should neither impair an asset's future usefulness or structural integrity. Ideally, the method would also have little impact to the typical operation of the asset to be inspected. NDT, as it relates to prestressed concrete cylindrical pipe (PCCP), was primarily limited to visual and sounding inspections but in the past decade, technological advances have increased the applicability of NDT inspection methods for pipeline infrastructure. Through the implementation of a proactive condition assessment and subsequent program to address deteriorated pipelines, owners and operators are able to identify short-term repair needs, plan for long-term improvements, and ultimately optimize the pipeline asset's useful life.

In order to develop a comprehensive condition assessment solution, the benefits and limitations of a NDT method must be carefully evaluated to ensure the tool or technique is providing the most applicable data. While the benefits and data outputs for NDT methods are well defined, each of these techniques have limitations of either their deployment methodology or data resolution/applicability provided. Therefore a thorough condition assessment program will deploy complementary technologies in order to provide a complete pipe assessment. Various NDT technologies for PCCP include visual and sounding inspections, sonic/ultrasonic testing, electromagnetic surveys, and leak detection. A visual inspection of the interior of a pipe is perhaps the most common NDT technique implemented for all pipe materials. When visually inspecting a pipe you can identify signs of distress that may be of concern, such as cracks, spalls, carbonation and other indications of advanced deterioration. While this technique is valuable for identifying pipes of immediate concern, significant advances in technology have made it possible to identify underlying defects in a pipe such as leaks, broken wire wraps in PCCP and wall thickness loss, which may otherwise go undetected by a visual inspection. These inspections establish a baseline of the current condition of the pipeline enabling the owner to make appropriate decisions regarding the pipeline's management.

Data collected during these NDT inspections can be reviewed and combined to provide a "snapshot" of the current condition of the surveyed pipeline. After identifying areas in need of immediate repair, long-term management of the pipeline can be addressed by considering the rate of deterioration on a distressed pipe section. Rate of deterioration can be determined by performing regular inspections, implementing monitoring strategies/technologies and/or applying statistical modeling to estimate remaining useful life. While effective, the approach of repeating inspections over time to define a deterioration rate is not as common as it once was due to the associated costs and inconveniences of inspections (e.g. bring a pipe out of service). The state-of-the-art approach to PCCP asset management is developing a baseline of the pipe's existing condition, conduct repairs on pipes with high risk associated with failure, and implementation of an acoustic monitoring program. Acoustic monitoring technologies include surface mounted systems and acoustic fiber optics (AFO) that measure prestressing wire breaks in PCCP in real-time. Long-term monitoring of pipelines uses baseline data provided by the inspection technologies, as well as specialized structural modeling and analysis to assess the structural impact of each wire break on an individual pipe section. By using the baseline data, acoustic monitoring and structural analysis, the owner/operator is able to evaluate the potential risk associated with the ongoing deterioration of a specific pipe.

Understanding the remaining useful life of a pipeline allows the owner/operator to plan for appropriate repairs in a pro-active and cost-effective manner. Estimations on rates of deterioration by acoustic monitoring allow the remaining useful life to be maximized and therefore using the maximum value of the asset. Repairs can then be scheduled for individual sections of pipeline that are deteriorating at higher rates than the pipeline as a whole allowing for their replacement or refurbishment well in advance of potential, and costly, failures. Maintenance efforts can be focused on these pipes of interest and immediate action can take place where necessary and postponed when possible. Traditionally, decisions to replace or repair existing pipelines have been based on maintenance reports, failure history, flow testing, type, size and age of the pipe and visual inspection. Using non-destructive methods of inspection and monitoring provide reliable information related to the overall condition of the pipeline without relying on excavations.

Non-destructive testing methods are capable of determining a pipeline's current condition and can ensure its integrity and reliability, or lack thereof, for the estimation of the remaining useful life. Utilities can extend the safe and economic operation of the pipelines in their network by developing informed risk management strategies. Over the past decade, PCCP inspections using the methodologies described above have found 4 to 6 percent of pipe sections with damage, with less than 1 percent requiring repair. Proper management of this 4 to 6 percent can provide significant cost benefit to owners/operators of PCCP since recent data has shown the cost for inspection, selective repair, and management of the pipelines is less than 5 percent of the capital replacement cost.

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