NGA NORTHEAST GAS ASSOCIATION
NYSEARCH

Technology Brief

Electromagnetic Time Domain Reflectometry (EM-TDR) for Pipeline Integrity

Description: Evaluate and select a non-destructive evaluation (NDE) method to evaluate natural gas transmission pipelines.

Status: Feasibility proven. Field tests pending.

BENEFITS

The benefit of this project is that it allows the development of a new natural gas pipeline Direct assessment (DA) tool for the identification of defects in transmission natural gas pipelines. This method could offer an extended detection length of at least hundreds of meters while providing immunity from background acoustic noise. This tool could provide the industry with a very substantial improvement in DA of natural gas pipelines.

BACKGROUND

Natural gas transmission pipeline integrity is of great interest to the industry and has been the focus of substantial NYSEARCH resources over the last 20 years. NYSEARCH has made major advances in both Direct Assessment (DA) and In-Line Inspection (ILI) of unpiggable pipelines through the development of the Explorer family of robots. DA is still plagued by short ranges, while ILI still requires substantial expenditures in operating the robots, site preparation, and installation of necessary infrastructure. Thus, the need to develop alternative technologies still exists.

ILI offers the highest level of accuracy and the most comprehensive information regarding pipeline integrity. However, given that it is expensive to implement, the use of tools outside the pipeline is desirable as it minimizes cost and does not require tapping into the pipeline, which ultimately may generate safety issues.

Since DA offers limited range and limited accuracy, as compared to ILI, increasing the accuracy and range of DA tools could provide the industry with a substantial increase in defect detection capability at a fraction of the cost of ILI.

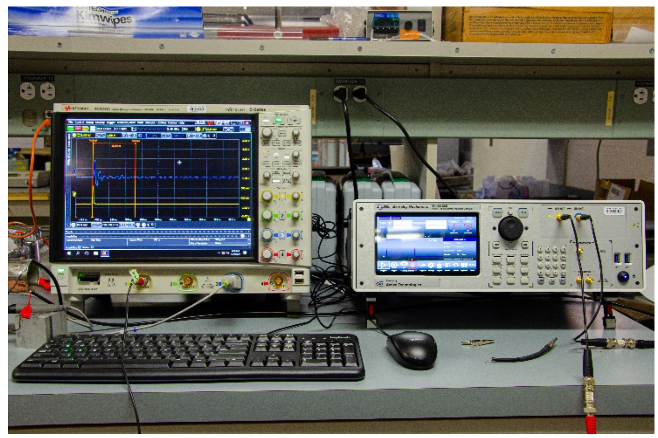

Figure 1: Equipment Set-Up

EM-TDR is a mature technique developed to identify and locate faults in metallic cables. It has evolved to identify and locate discontinuities in the electrical path in printed circuit boards, aviation wiring, and in measuring ground movement in geotechnical applications. An EM signal is emitted in the metallic structure and if the structure has a uniform impedance and is “properly terminated”, there is no reflection of the wave. However, if there is an impedance change at some point from a discontinuity such as corrosion, damage, etc., then part of the wave is reflected back to the source. The magnitude and phase of the reflected wave and the time it takes to return to the point of origin are used to determine the type and extent of the defect and its location along the length of the structure. The wave amplitude, frequency and shape determine the range and accuracy of the technique in the particular application.

Lawrence Berkeley National Laboratory has worked to use this technique in natural gas well environments with some initial success. The method shows much longer inspection ranges than existing techniques, and only requires access to the pipeline at a single point. Variations in materials and pipeline geometry have a significant effect on this technique's performance and tuning.

TECHNICAL APPROACH

The goal of this project was to design, develop, and test a laboratory prototype tool based on EM-TDR technologies, and to conduct a feasibility study to verify the method for use in DA pipeline integrity inspections.

The work for this project focused on building a laboratory prototype system to conduct a feasibility study on the potential of this method to provide DA of pipeline conditions, which included a detailed laboratory and field study to evaluate its ability to detect common defects in natural gas transmission pipelines.

At the outset, the initial feasibility evaluation focused on a literature survey and case studies, including ongoing work for natural gas well applications, to determine system specifications as per established experience. Numerical modeling was used to develop numerical simulations to model natural gas pipeline applications, including initial parameterization studies that included different values of attenuation coefficients, EM signal parameters and pipeline geometry and degradation.

An EM-TDR system prototype was built and its performance was validated through controlled laboratory tests. These initial tasks have provided the critical datasets needed to validate and calibrate the models for initial sensitivity analysis and allowed NYSEARCH to make the first determination that the EM-TDR method is viable for the intended purpose.

Based on the encouraging results of the aforementioned tasks, continuing work will focus on laboratory experiments simulating natural gas pipeline damage scenarios, such as corrosion, metal loss, mechanical damage and cracks, to understand the sensitivity of the EM-TDR signals to well characterized damages. Simultaneously, numerical model improvements will focus on extending the capabilities developed in the baseline models to include simulation for damages under realistic conditions. Upon the successful completion of these last two (2) tasks, NYSEARCH will initiate a pilot scale field demonstration where tests will be carried out in an actual natural gas pipeline for pilot scale system demonstration where comparisons will be made with existing DA commercial systems, such as performance comparison with UT/EMAT systems, to determine commercialization potential.

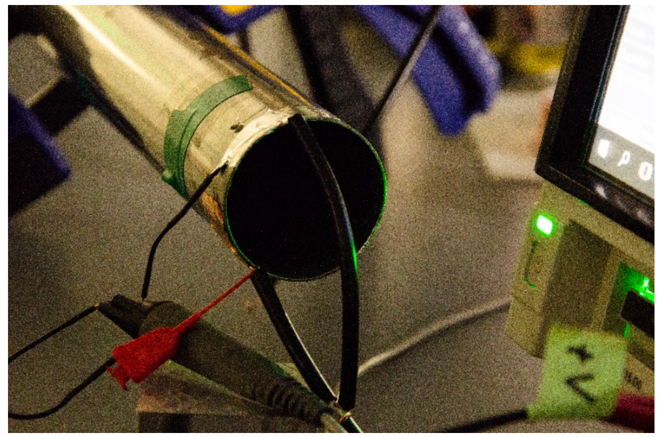

Figure 2: EM-TDR

PROGRAM STATUS

From preliminary studies, there are positive indications that the EM-TDR method and resulting tool could provide a significant improvement in DA of natural gas pipelines in identifying various anomalies.

Highlights

- Numerical modeling and simulations led to prototype development.
- In Phase I, LBNL successfully developed a laboratory prototype for method testing and validation.

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