U.S. Department of Transportation

Nonlinear Harmonic-Based Mechanical Damage Severity Criteria for Delayed Failures in Pipelines - DTRS 56-04-T-0001

OPS ACCOMPLISHMENTS

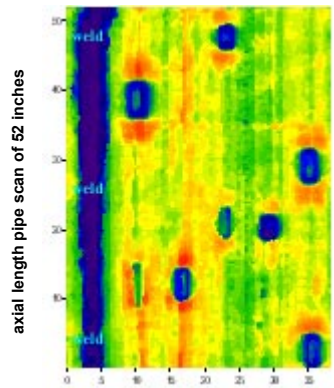
Pipeline Safety Research and Development for Other Pipeline Safety Improvements

Challenge

Delayed failures occur in transmission pipelines when damage related to cracks accumulates over time at gouges, initiating pipe rupture. Although delayed failures are a small fraction of total pipeline incidents they can have tragic consequences involv-ing loss of life. Current inline inspection (ILI) equipment cannot detect cracking at mechanically damaged sites nor determine the likelihood of delayed failure. Gouges result in strain anomalies that are readily detected by changes in oscil-lating magnetic fields measured by nonlinear harmonic (NLH) sensors. NLH sensors have demon-strated capabilities for detecting and severity-ranking strain anomalies due to gouges. The challenge is to demonstrate that NLH technology can also detect and prioritize the time-dependent accumulation of damage that leads to delayed failures.

Technology

The NLH method consists of impress-ing an alternating magnetic field onto the inner surface of a pipe and sens-ing the response due to magnetic property changes from straining of a thin surface layer of material. The objectives of this investigation are to:
1) increase pipeline safety by formu-lating NLH-based defect severity criteria related to delayed failures in pipelines; and to
2) enable the developed NLH tech-nology to be transferred to ILI service providers through collaboration with Tuboscope Pipeline Services (Tuboscope).



NLH signals from a scan of pressurized 12-inch diameter pipe clearly indicate the strain anomalies associated with eight gouges and the weld running the axial length of the pipe.

Accomplishments

Gouged dents have been fabricated in four 12-inch diameter pipes and four NLH scanners have been manufac-tured. The gouged pipes have been subjected to over 10,000 pressure cy-cles to induce fatigue damage at the defects. To date, failures (leaks) have been observed at four defects. Peri-odic NLH scans have been performed on the inside surfaces of the pipes during the cycling. The response sig-nals clearly indicate the presence of the gouges on the outsides of the pipes.

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Test arrangement showing an NLH scanner, four gouged pipes and a typical gouge (inset).

Benefits

NLH-based ILI equipment for pipelines that detects and prioritizes the severity of mechanical damage with respect to delayed failures in pipelines will significantly increase safety and enable more effective management of maintenance and repair. Development of an NLH-based inspection tool will be facilitated by close cooperation with Tuboscope and members of PRCI.

Future Activities

Continued pressure cycling and NLH inspections supported by analyses of the NLH response signals to relate them to the number of applied cycles and the propensity of the defects to delayed failure. Defect severity guidelines will be drawn up and their implementation on ILI tools assessed with Tuboscope.

Partners in Success

- Pipeline Research Council International, Inc. (PRCI) www.prci.com
- Tuboscope Pipeline Services, www.tuboscopepipeline.com
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