EWI Capabilities to Support the Midstream Pipeline Industry

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The midstream pipeline industry has been an important component of EWI's client base since our founding in 1984. The midstream sector includes onshore and offshore pipeline operators that transport oil, natural gas, and the many refined petroleum and gas products that our economy requires to meet its energy and feedstock needs. EWI has supported the industry through its capabilities in developing nondestructive examination (NDE) tools; specialized testing and computer modeling approaches to support construction, repair, and integrity assessment of critical pipeline systems; materials engineering; and welding process expertise. These capabilities are fundamentally important for the specification and gualification of pipeline materials and welding procedures for construction and repair. This paper outlines the development of advanced computer modeling and full-scale testing to improve methods for predicting failure of corroded pipelines.

Improvements in Corrosion Assessment Methodologies

Standardized approaches such as ASME B31G and Modified B31G have been used since the 1980s to manage pipeline integrity due to corrosion metal-loss. Those methods, however, often result in excessive scatter and overly conservative assessments that can lead to unwarranted repairs or de-rating of pipelines. Over the past three years, EWI has developed more precise methodologies for predicting bulging and burst failure to account for the corrosion defect geometry defined by "bulging factor," "shape factor," and pipe material properties, with the strain hardening rate of the pipe steel being of particular importance. The results are 1) an improved bulging factor and 2) development of a reference stress that accounts for the strain hardening characteristics and yield-to-tensile strength ratio properties of the pipe steel. EWI has shown that the new bulging factor and reference stress elements reduce the predictive bias and scatter in predicted failure pressure assessments as compared to B31G and Modified B31G. In preliminary tests, new failure pressure model has been validated with full-scale test results.

As an example of the modeling effort, Figures 1 and 2 illustrate the stress condition at the predicted burst pressure for flat-bottomed corrosion patches,

one shallow and one deep. These figures show that the bulging behavior remains generally isolated to the corrosion patch with little load shedding to the surrounding pipe. The bulging behavior, whether it remains local within a defect area or extends out into the main pipe body, is controlled by the corrosion defect geometry, internal pressure and the pipe steel properties.



Figure 1. Local contour plot of the von Mises stresses in and around a deep corrosion patch near onset of failure. Note bulging remains within the defect area.



Figure 2. Local contour plot of the von Mises stresses in and around a shallow corrosion patch near onset of failure. Note bulging begins to extend outside the defect area.

Modeling work has been carried out on a broad series of flat-bottomed defects for a range of pipe grades, pipe dimensions and operating pressures.

Burst Tests

Full-scale burst tests were performed to validate the model for a series of machined metal-loss patches

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to validate the predicted failure pressure and failure behavior (leak vs. rupture). The test pipes contained simulated flat-bottomed corrosion defects by machining patches as shown in Figures 3a and 3b. The pipes were made monotonically and pressurized to failure with the actual failure pressure and failure type – whether the failure was contained within the defect patch or not compared with the models. Figure 4 shows one of the full-scale test pipes with the failure remaining within the defect patch area. The result of these analyses provides pipeline operators with enhanced tools for assessing operating pressure, pipe properties and corrosion defect sizes to the likelihood of a rupture or leak.



Figure 3a. Schematic showing approach to machining simulated corrosion defects for full-scale tests.



Figure 3b. A machined, simulated corrosion patch on a fullscale test pipe.



Figure 4. A burst test specimen with a leak in a machined defect patch.



Figure 5. Full-scale burst test with digital image correlation scan showing strain localization in a machined defect patch just prior to failure. The defect patch area contained a series of strain gages with the strain gage wires shown extending around the pipe.

Future Work

Efforts are underway to extend this work to more complex "riverbed" features of corrosion damage and to account for strain hardening variabilities between older vintage pipeline steels and more modern steels.

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Tom McGaughy, Senior Technical Advisor for Structural Integrity and Materials Evaluation, has specialized expertise in fracture mechanics and materials technologies. He is involved in developing client relationships and technology development strategies with the oil, gas, and petrochemical industries, and is Director of the EWI Strategic Technology Committee (STC) for Oil & Gas

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