Behavior of Corroded Pipelines Under Cyclic Pressure Project 153K

2nd QUARTERLY PUBLIC REPORT

Period: July through September 2005

Consolidated Research and Development Program to Assess the Structural Significance of Pipeline Corrosion

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Background

Metal loss due to localized corrosion and pitting of pipelines can significantly increase the risk of rupture. Therefore, it is vitally important to accurately determine the residual strength of corroded pipelines so that proper remedial actions may be taken to avoid catastrophic events. Although historical methods and practices for inspection and integrity assessment have led to an overall safe and reliable pipeline infrastructure with a low frequency of failures, public expectations concerning pipeline safety are growing, and industry is committed to pursuing further improvements. Consequently, new US regulations and sophisticated inspection technologies have burdened many operators with large quantities of data that are often difficult to interpret and apply within the framework of existing assessment guidelines. Clearly, the industry needs a technically sound, comprehensive and integrated approach to assess and mitigate the effects of localized corrosion in gas and oil pipelines, and to assure appropriate pressure-containment safety margins.

Several methods have been developed for assessment of corrosion defects, such as ASME B31G, RSTRENG and LPC. These methods were developed using an early fracture mechanics relationship for toughness-independent failure of pressurized pipes and were empirically calibrated against a database of full-scale burst tests for thin wall pipes. Some work has already been done to address the limitations of existing assessment methods available to the industry. The objective of this project is to establish the potential for fatigue failure from corrosion.

Summary of Progress this Quarter

A literature review has been completed. Three-dimensional linear elastic finite element model construction for pipe (D/t) ratios of 40, 72 and 100. In each case the pipe is subjected to internal pressure loading and a pressure end load to represent an end force on the pipe. Corrosion damage is modeled as circumferential grooves orientated both axially and circumferentially. Defect depths of 20%, 40%, 60% and 80% of the wall thickness have been considered.

Three dimensional linear elastic finite element model construction for 36” diameter (914.4mm) x ½” wall (12.7mm) pipe ((D/t) ratios of 40, 72 and 100) has been completed. In each case the pipe will be subjected to internal pressure loading and a pressure end load to represent an end force on the pipe. This is consistent with the FE analyses undertaken for other corrosion projects undertaken for PRCI. Corrosion damage in the form of circumferential grooves orientated both axially and circumferentially has been modeled. Defect depths of 20%, 40%, 60% and 80% of the wall thickness have been considered.

The results of the analyses were discussed with PRCI Ad Hoc Chair (Wytze Sloterdijk) and PRCI Corrosion/Mechanical Damage Consultant (David Batte) on 9 August 2005.

Results

A literature review to ascertain if there is useful information in the public domain regarding stress concentration factors (SCFs) of corrosion defects in pipelines has been completed. A search was made in recognized texts such as those by R.E. Peterson (Stress Concentration Factors, John Wiley & Sons) as well as recent pipelines and pressure vessel conference proceedings from ASME (e.g. International Pipelines Conference, Offshore Mechanics and Arctic Engineering Conference). It has been concluded that there is little information (either analytical or experimental) to determine SCFs in pipelines with corrosion defects. No general formulas can be used to determine SCFs and the consensus of opinion is that SCFs have to be generated on a case by case basis using finite element analysis and validated using full scale tests. This is precisely the approach taken in this project.

Future Activities

Work over the next quarter will continue to focus on estimating SCFs at metal loss defects. Results will be calibrated from the most promising methods using numerical data generated from previous and ongoing projects. A large proportion of analyses have been completed and currently being post-processed.

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