Liu, M., Wang, Y.-Y., Horsley, D., and Nanney, S., Multi-Tier Tensile Strain Models for Strain-Based Design Part 3 – Model Evaluation Against Experimental Data, Proceedings of the 9th International Pipeline Conference, September 24-28, 2012, Calgary, Alberta, Canada, Paper no. IPC2012-90660

Abstract

This is the third paper in a three-paper series related to the development of tensile strain models. The fundamental basis [1] and formulation [2] of the models are presented in two companion papers. This paper covers the evaluation of the models against large-scale experimental data which include a total of 24 full-scale pipe tests with and without internal pressure [3,4] and 30 curved wide plate (CWP) tests [5,6]. The 24 full-scale pipe specimens are nominally X65 grade (12.75" OD and 12.7-mm wall thickness) and made by two manufacturers. The actual yield strength of the two pipes differs by approximately 14 ksi. The girth welds are made with three welding procedures, creating three weld strength levels. The full-scale test program are designed to evaluate the effects of internal pressure, weld strength mismatch, pipe strength, pipe Y/T ratio, flaw location, flaw size, and toughness The 30 CWP specimens are from 36" OD and 19.1 mm wall thickness X100 pipes. The girth welds are made with two welding procedures, creating two slightly different weld strength mismatch levels. The CWP test specimens expand the range of material grade and wall thickness for the model evaluation. The model evaluation demonstrates that the overall correlations between the experimental test data and model predations are similar when the model predictions are made with Level 2 and 3 procedures and various toughness options. The Level 2 procedure with Charpy energy option and Level 3b provide the best overall one-to-one correlation between the test data and model prediction. The Level 3b shows greater scatter than Level 2 with the Charpy energy option. The most significant contributor to the TSC variations and the difference between the measured and predicted TSCs is the strength variation in the pipes. A small variation in the strength can lead to a large variation of the measured remote strain even when the flaw behavior is essentially the same. For the 24 full-scale pipe tests, a strength variation of 1 ksi in the pipes would explain the large variations of the measured TSC in comparison to the model predictions. The TSC models produce consistent results that capture the overall trend of the test data.

Keywords

Strain-based design, Tensile strain capacity, Full-scale test, Curved wide plate test, TSC model evaluation