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Industrial Member Report Summary – Key Findings for Industry

Validation of the Proposed R6 Strain-Based FAD Using Pipe Test Data and FEA

TWI Core Research Programme

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Industrial need

Motivated by continuously rising worldwide demand for energy, oil and gas companies are increasingly exploring and developing new reserves in more challenging environments such as offshore in deeper waters or on land in Arctic or near-Arctic locations. Pipelines installed in such regions may be subjected to axial plastic straining combined with internal pressure, eg due to lateral buckling, frost heave or seismic ground movements. Offshore pipelines may also experience axial plastic straining during installation eg by reeling or other methods where the welded pipe strings are bent around reels or formers as part of the laying process.

In parallel to a number of research activities in strain-based design, which focused on the oil and gas sector, there has been a renewed interest in strain-based fracture assessment using a failure assessment diagram approach (SB-FAD) for inclusion in R6. This report provides an evaluation of the SB-FAD approach proposed by Budden et al. focussing on the most recent revision to this approach. The evaluation was conducted using experimental results from full-scale tests on pipe samples containing circumferential crack-like notches, and tested under bending loading, together with results from elastic-plastic finite element analyses (FEA), simulating the full-scale tests.

Key Findings

Results from full-scale tests on pipe samples containing circumferential crack-like notches have been used to evaluate the SB-FAD approach proposed by Budden and co-workers at British Energy for inclusion in R6. The main results from this study are as follows:

- The driving force curves (J vs strain) predicted using the proposed Option 2 SB-FAD fall consistently below the FEA curves such that J is underestimated by 20 to 45% for the range of notches considered.
- The driving force curves predicted using the proposed Option 1 SB-FAD are relatively close to the FEA curves. The predicted curves generally lie below the FEA curves for the notches located in materials which exhibit a yielding plateau, and are either in good agreement with or lie above the FEA curves for the other cases (material exhibiting low or strong work hardening).

The above results are not unexpected given the size of notches and stress-strain curves considered; and are consistent with previous studies involving comparisons with FEA results. These indicated that the proposed SB-FAD was likely to provide increasingly more conservative assessments as smaller flaws were considered, and less conservative (potentially non-conservative) assessments for larger flaws and/or materials with no or low work hardening.

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