Establishing the Fatigue Behaviour and Optimising Inspection and ECA Procedures for Lined Pipes

JOINT INDUSTRY PROJECT OUTLINE
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Summary

Carbon steel pipes mechanically lined with CRA are cheaper than clad pipe and easier and quicker to manufacture. The liner is often secured in place using weld overlay cladding at the ends. Girth welds can then be produced between sections of lined pipe in the same way as clad pipe, as the weld bevel and subsequent weld are located in the weld overlaid region.

When mechanically lined pipe is subjected to fatigue loading, there is a risk that the point at which the weld overlay interfaces with the liner (the 'weld overlay/ liner triple point') may be the fatigue critical detail.

Data on the fatigue strength of lined pipe with weld overlay is needed by designers during the FEED stage to allow them to specify lined pipe rather than clad pipe, and make the associated substantial savings in cost and lead time.
The ability to reliably inspect girth welds in lined pipe before installation would allow operators to have confidence in the safety of installed lined pipe, leading to increased safety and reliability of riser systems and reduced costs and lead times for sour fields.

This JIP ran from 2012 to 2014 and comprised four work packages: Measuring fatigue performance of MLP, through full scale testing, the development of an ultrasonic inspection technique for inspecting the triple point, developing approaches for engineering critical assessment (ECA) and finite element analysis to model the wrinkling behaviour of the liner.

Scope of Work

To achieve the objectives, four work packages were carried out within the project:

Full scale resonance fatigue testing

The resonance fatigue testing work package involved fatigue tests on 12 specimens of lined pipe, each containing a girth weld in the centre. The liner material in all cases was Alloy 625. Six of the specimens were 12.75in outer diameter, and six were 8.625in outer diameter (three of the 8.625 inch outer diameter specimens were simulated subjected to reeling before testing). Extensive sectioning was carried out on the failed specimens and in addition to an SN curve, a good understanding of the failure location of lined pipe was gained.

Inspection procedure optimisation

The inspection work package used ultrasonic techniques to develop a method of detecting flaws at the weld overlay/ liner transition point from the outer wall of the pipe. Recommendations were provided on the equipment and methods that can be used to detect flaws in this location from the outer wall of lined pipe.

ECA procedure development

- Specific stress intensity factor solutions were generated for the lined pipe geometry which can be used in ECAs.
- Small scale mechanical tests (ie fracture toughness and tensile tests) were carried out to measure mechanical properties and provide background data for the ECA. Fatigue crack growth rate tests on two liner materials (Alloy 625 and 316L stainless steel) were also performed at room temperature and 100˚C.

Numerical modelling

The numerical modelling work package was run by INTECSEA. Finite Element (FE) model(s) were developed to simulate the response of lined pipe in pure bending and work was carried out to determine the sensitivity of lined pipe under bending loads to liner wrinkling.

Objectives

- Produce an SN curve for lined pipe with weld overlay via resonance fatigue testing
- Develop inspection procedures for inspecting the weld overlay / liner transition point in lined pipe with weld overlay
- Consider procedures for engineering critical assessment (ECA) of lined pipe with weld overlay
- Perform numerical modelling to investigate the wrinkling behaviour of lined pipe when subject to high strains

Participants

The Sponsor Group comprised:

- Petrobras
- BG Group
- Tenaris Tamsa
- Saipem SA
- Cladtek
- Technip UK
- Heerema PTL

Project Outcome

- Recommended SN curve for mechanically lined pipe in air.
- Recommendations of best practice for detecting flaws at the weld overlay/ liner interface using ultrasonics.
- Recommendations for how to analyse cracks at the weld overlay/ liner transition region using ECA.
- Estimate of the strain for the onset of liner wrinkling and a parameterised finite element model of lined pipe.

Price and Duration

The project had a duration of two years. It was funded by four fee-paying Sponsors each making a contribution of £120,000 with in-kind contributions provided by three others.

To access the project reports, the fee for companies to buy-back into the project is £70,000.

Further Information

For further information on how a Joint Industry Project (JIP) runs please **visit our JIP section** or scan the QR code.

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