Corrosion Fatigue of Steel Catenary Risers in Sweet Production Conditions Phase II - Inhibited, Scaling Environments

PUBLISHABLE SUMMARY

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Background

Work on Phase I of this project (TWI Group Sponsored Project 15474) provided valuable insight into the corrosion fatigue behaviour of API 5L X65 strength level C-Mn steel riser welds in sweet, high CO_2 environments. It demonstrated that non-conservative corrosion fatigue endurance data could be generated in the absence of an inhibitor in a freely corroding condition in sweet, high concentration CO_2 environments. This was apparently because metal loss due to corrosion eliminated crack initiation features.

At the stage when fatigue crack growth may start in service, the surface will have been exposed to the service environment for some time, whereas if data are measured in the laboratory at high stress range, this will not be the case. Thus, a pre-conditioning technique was proposed which could be used to create conditions which allowed the development of carbonate scales in relatively short timescales.

This follow on JIP developed further data to ensure a sound understanding of performance of steel catenary risers in sweet production environments that are inhibited and where scaling due to precipitation of iron carbonate occurs. The same welds were tested as in Phase I, under conditions where scaling will occur, with and without inhibition.

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Objectives

- Generate corrosion fatigue endurance data for girth welds in C-Mn steel catenary riser pipe material operating in sweet environments with inhibitor and surface scaling.
- Develop understanding of the effects of different environmental variables on the sweet corrosion fatigue behaviour of C-Mn steel catenary risers with a view to enabling selection of worst case conditions, to aid qualification testing.

Project Outcome

Test procedures for carrying out corrosion fatigue endurance tests in a sweet environment under scaling conditions have been developed and employed successfully on narrow gap automatic GTAW girth welds in DNV OS F101 SML 450 1FU (approximately equivalent to API 5L X65) linepipe. Results have raised questions with regard to the interactions between mechanical effects of cyclic loading, corrosion per se, and scaling on the surface and within cracks. Current indications are that the most conservative conditions with regard to fatigue endurance in sweet, high CO_2 aqueous environments, at relatively low stress ranges (which are likely to be most representative of service conditions) are with inhibitor, and probably non-scaling. The fatigue limit observed in air cannot be relied upon under these conservative conditions.

This work has confirmed the difficulty of identifying worst case conditions for sweet corrosion fatigue testing, and the importance of a detailed knowledge of the environmental conditions during test. For project specific testing, it is therefore important to model and monitor the principal environmental variables as closely as possible. It has nevertheless been shown that inhibition can reduce endurance, and that testing at a moderate frequency can also give shorter lives.

Benefits

- Increased confidence in fatigue design and qualification requirements of steel catenary risers for sweet service with data to support optimised material selection if variation in behaviour between riser pipe grades is observed.
- Reduced likelihood of failure of steel catenary risers in sweet service thereby minimising the risk of loss of containment, with associated environmental impact and unplanned production downtime.
- Extension of knowledge of sweet corrosion fatigue to more realistic conditions to improve confidence in prediction of performance for systems where scaling will occur.

Participants

The Sponsor Group comprised:

- BP
- Shell
- Petrobras
- Statoil

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Scope of Work

Corrosion fatigue tests were carried out in both scaling and non-scaling conditions, with and without inhibitor addition. Pre-scaling was carried out according to a procedure developed with this project. Fatigue endurance tests were conducted under direct axial loading on strip specimens machined from the girth welds. Fatigue tests were conducted under load control with constant amplitude sinusoidal loading. Tests were conducted to complete separation/maximum displacement, or to a target maximum endurance.

Price and Duration

The project had a duration of 2 years and a budget of £360,000. It was funded by 4 Sponsors each making a contribution of £90,000. The fee for additional companies buying-back into the project results is £90,000.

Further Information

For further information on Joint Industry Projects (JIP) and their operation, please visit:

http://www.twi.co.uk/services/research-and-consultancy/joint-industry-projects/

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