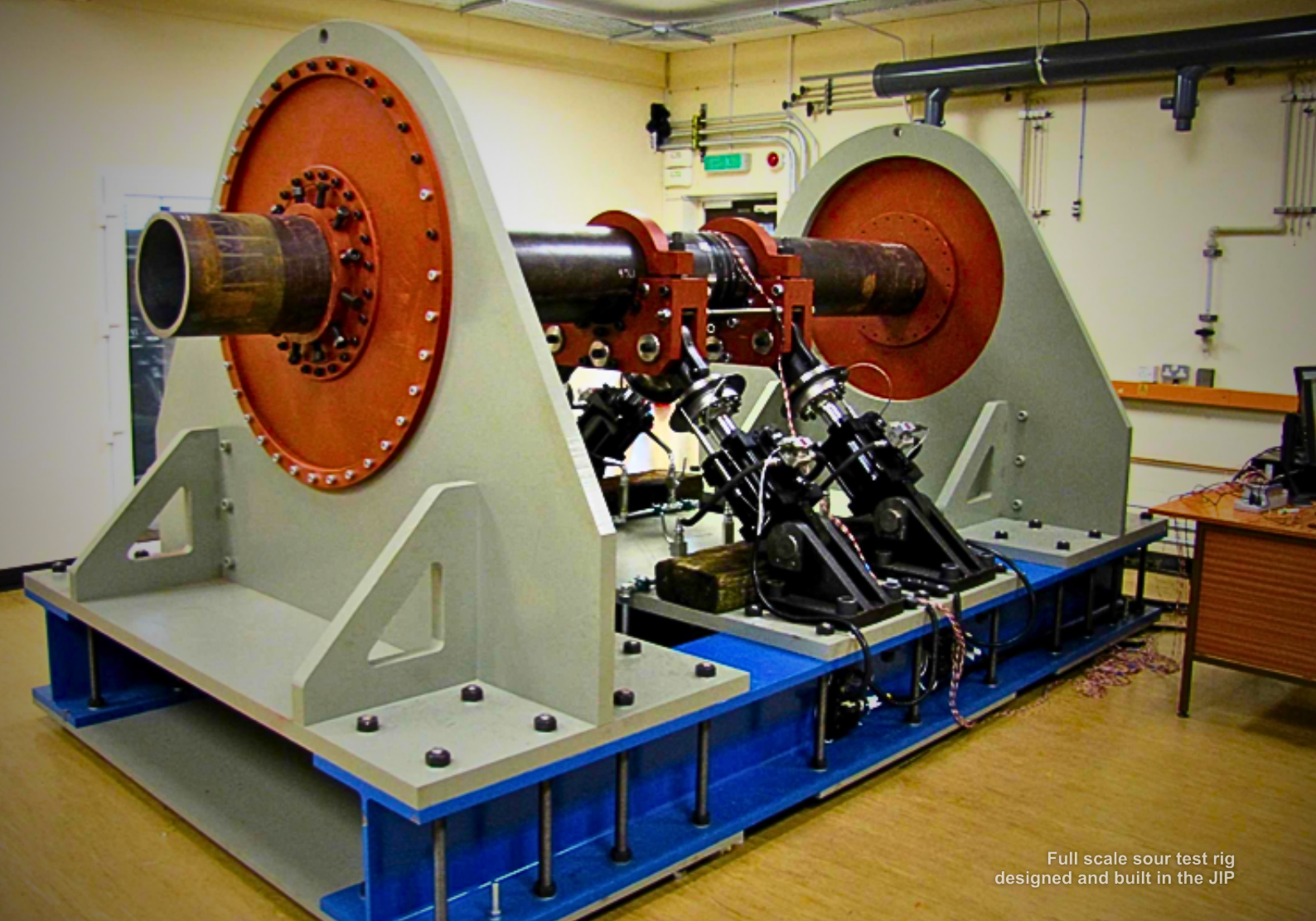




Full scale sour test rig
designed and built in the JIP

Fatigue Design for Risers in Sour Service via Full Scale Testing

**JOINT INDUSTRY PROJECT OUTLINE
20324**

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Summary

Steel catenary risers (SCRs) are commonly used within deepwater oil and gas developments, and fatigue performance is often a critical factor in overall design.

Resonance fatigue testing of full scale girth welds has become standard industry practice to demonstrate adequate performance. However, these tests alone take no account of aggressive service environments such as sour production fluids.

In these instances qualification testing is usually a two-stage process involving resonance fatigue testing to demonstrate the required performance in air, and strip fatigue testing (in air and in a sour environment) to determine a fatigue life 'environmental knock down factor' EKDF that is then applied to the base design curve. This approach accounts for both size effects (i.e. the difference between strip and full scale testing) and environmental effects individually, and has been adopted on many projects.

However, the validity of the approach has not been demonstrated. There was therefore a need for a better understanding of the sour performance of girth welded riser pipe by full scale experiment.

This project developed a method for performing fatigue tests on full scale welds in pipes containing a sour environment. By comparing results of full scale resonance fatigue tests, strip tests in air, strip tests in a sour environment and full scale sour tests, the EDKFs from direct comparison of full scale tests were found to be lower. To understand the results, detailed investigations were carried out, including metallurgical examination, residual stress measurements, fatigue crack growth rate measurements and fracture mechanics assessments.

Scope of Work

Phase 1 of the project involved the design and manufacture of a test machine capable of testing full scale pipe welds with an internal sour environment.

The pipe material used in this project was 323.9mm OD x 20.8mm WT seamless Grade API 5L PSL-2 X65QS. Test welds were all single-sided with unbacked roots, all in the 5G welding position. The welds were riser-quality, manufactured by Serimax.

The fatigue testing involved testing of:

- Twelve full scale joints in air using the resonance technique;
- Six full scale joints containing a sour environment;
- Six small scale strip tests in air and six small scale strip tests in sour environment.

The sour environment used was 1psi (7kPa) partial pressure of H₂S in CO₂ with a pH of 5.0 at a temperature of 25°C.

The EDKFs were calculated by comparing the strip test results in air and sour, and the full scale results in air and sour. Detailed investigations of the cracked specimens and test welds were carried out, that included metallurgical examination, residual stress measurements, fatigue crack growth rate measurements and fracture mechanics assessments.

Objectives

- Characterise the sour corrosion fatigue behaviour of risers, by testing full scale girth welds in a sour environment.
- Examine the validity of the current two-stage design process.
- Develop riser fatigue design guidance based on direct qualification of full scale welds in sour service.

Benefits

- Elimination of excessive conservatism of the current two-stage approach to environmental knock-down factors (EKDF), providing significant cost savings and greater design flexibility.
- Greater confidence in likely material behaviour in service resulting from a more direct means of quantifying material performance.
- Improved understanding of fatigue in sour environments leading to enhanced safety by reducing the risk of corrosion fatigue related failure.

Participants

The Sponsor Group comprised:

- Chevron Energy Technology Company
- ExxonMobil Upstream Research Company
- PETROBRAS - Petroleo Brasileiro SA
- SAIPEM S.P.A
- Serimax
- Subsea 7
- Tenaris - Tubos de Acero de Mexico SA
- TOTAL

Project Outcome

- Fatigue test data for C-Mn girth welds in a typical sour service operating environment using both strip tests and full scale testing, with commentary on the approach used to calculate EKDFs.
- Residual stress measurements, fatigue crack growth rate measurements, detailed post-test metallographic examination of the welds tested with commentary on the significant results and observations.
- Validated guidance for design of risers, based on a full scale sour service riser fatigue design curve.

Price and Duration

The project had a duration of five years and a budget of £1,200,000. There were eight Sponsors each making a contribution of £150,000.

The fee for companies wishing to access the full project reports by buying-back into the project is £80,000.

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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