Acceptance criteria for pitting corrosion of CRA in oil and gas production environments

PUBLISHABLE SUMMARY

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Background

New oil & gas developments frequently require selection of a Corrosion Resistant Alloy, either solid or lined/clad on a steel substrate, to mitigate corrosion. Optimum selection is necessary to avoid excessive material costs whilst ensuring safety, and will allow cost effective front end engineering design (FEED) when material selection issues arise. Alloys may be prone to pitting corrosion in service conditions, particularly at welds, thus necessitating laboratory testing. However, there is no standardised in-situ testing protocol for assessing performance under elevated temperature and pressure, nor associated acceptance criteria. This project aims to develop a standard method that can be used worldwide, based upon reliable acceptance criteria, to differentiate between non-propagating and incubation of propagating pits in short term tests and to optimise material selection and qualification.

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Objectives

- To define a simplified standard method for autoclave material selection (qualification) testing of CRA materials, which also may be applied to welds and overlay.
- To define reliable acceptance criteria for pitting corrosion in autoclave testing of CRA materials in realistic oil & gas production environments.

Project Outcome

The progress of the work was reported to the Sponsor Group via interim reports issued prior to Progress Meetings. Meetings were held at approximately six monthly intervals from the project start and culminating with a meeting to review the final report.

The final report summarised the work undertaken and results obtained, and include the recommended simplified approach for testing CRA pitting behaviour for use in weld qualification, and materials selection, and the associated acceptance criteria.

Benefits

- Development of pitting acceptance criteria will allow optimisation of cost effective materials selection and weld qualification. A rational basis will be available to compare performance of different materials or material performance in different environments.
- Development of a standard test method will allow reliable qualification tests to be undertaken worldwide, e.g. close to fabrication sites thus minimising time required for qualification.

Participants

The Sponsor Group c comprised:

- BP Exploration Operating Co Ltd
- Health & Safety Executive
- ENI S.p.A

Scope of Work

The principles on which the work was based were (i) that electrochemical monitoring during test would allow confident definition of whether any pits formed were stable or metastable and (ii) that electrochemical 'activation' of the samples at the start of the test would ensure that the pit initiation process occurred and that these pits would then have an opportunity to develop.

Electrochemical tests were carried out using Type 316L (UNS S31603) austenitic stainless steel material, in CO_2 and H_2S-containing, high temperature and high pressure environments. These were carried out in a modified autoclave with a commercial pressure balance reference electrode attachment.

Short-term tests were conducted to establish the pitting limits, ie critical pitting temperature (CPT), pitting potential (E_p) and repassivation potential (E_{rp}) of 316L samples. These used a standard three- electrode electrochemical set-up. Tests were also conducted using a two working electrode set-up to determine the CPT with electrochemical noise monitoring as test solution temperature was increased at a rate of 5ºC/hr. In tests to determine the CPT with electrochemical noise, some were conducted with external polarisation and some without external polarisation at the rest potential. A CPT value was obtained using this technique for parent 316L material in a representative brine containing sodium bicarbonate, CO_2 and H_2S.

Accelerated pitting tests were conducting on parent 316L material at CPT -5ºC, CPT and CPT+5ºC. Pitting was electrochemically induced by subject the samples to various levels of potentiostatic polarisation and various time intervals to establish the optimum conditions to induce pitting. This was followed by current noise monitoring to determine whether the samples repassivated or induced pitting continued to propagate.

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Price and Duration

The project had a duration of 2 years and a budget of £150,000. It was funded by 3 Sponsors each making a contribution of £50,000. The fee for additional companies buying-back into the project results is £50,000

Further Information

For further information on how a Group Sponsored Project (GSP) runs please visit:

http://www.twi.co.uk/services/research-and-consultancy/group-sponsored-projects/

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