

Minutes of meeting WP13 Corrosion in oil and gas production

Freiburg, 13 September 2007

Introduction

The chairman of WP1 3, Stein Olsen, announced that he would be stepping down as chairman after EUROCORR 2008. A vice-chairman, who will take over as chairman after EUROCORR 2008, will be appointed before then.

It was agreed that the action items from the previous meeting would be dealt with at appropriate points during the current meeting.

Veronique Smanio-Renaud was selected as the winner of the Prize given by ANTIKORR of Russia for the best oral presentation by a young author in the O&G session. Her presentation showed a very structured approach in using acoustic emission as a method to detect HIC in steels.

Jean Kittel informed everyone of a new CEFRACOR committee on O&G. He specifically mentioned the possibility of co-operation with WP13. A possible start of such a co-operation could be a presentation about work on test methods for HE at the next WP13 meeting in 2008.

The Use of Inhibitors in Oil and Gas Production

Chairman: Jim Palmer

Requirements for specialised inhibitor tests

George Winning presented a general philosophy on corrosion inhibitor testing. He discussed both simple and specialised tests and their applicability (see **Appendix A**, which is included as an attachment to these minutes).

Examples of specialised test procedures

Steve Turgoose gave a presentation on how to test for pitting corrosion and preferential weld corrosion. He focused on the required inhibitor dose rate that can vary dependent on the metal surface - clean parent steel, corroded parent steel, welds, corroded welds or existing pits. Testing methods for pitting corrosion and segmented weld testing were discussed (see **Appendix B**).

Galvanic effect of scales on inhibition

Prof. Brian Kinsella presented his work on galvanic effects of magnetite films, with and without corrosion inhibitors. Galvanic currents were measured using a ZRA in a rotating electrode setup and with different area ratios. He concluded that coupling of magnetite with mild steel causes galvanic corrosion and that the efficiency of corrosion inhibitors at reducing galvanic scale corrosion varies (see **Appendix C**).

Discussion regarding EFC document

Rolf Nyborg presented specialised corrosion inhibitor test methods developed in a JIP at IFE. The report from this work describing the different test methods in detail is offered to EFC for publication. The following methods are included: (see **Appendix D**):

- Test of CO₂ corrosion inhibitor performance in the presence of suspended solids;
- Test of CO₂ corrosion inhibitor performance under sand deposits;
- Test of CO₂ corrosion inhibitor performance in systems with oil-in-water emulsions;
- Guidelines for the assessment of clay in produced fluids.

In the following discussion it was agreed that WP13 should publicise this on the home page of the WP13 website. It should be a separate page giving an introduction on testing in general, typically in line with what G. Winning had presented at the meeting. The detailed test protocols offered by the IFE JIP should be placed under specialised test methods.

Action: J. Palmer will develop a proposal with the help of G. Winning and R. Nyborg on how best to present general information on testing on the WP 13 website.

Corrosion Resistant Alloys in H₂S Service

Chairman: Chris Fowler

Testing with elemental sulphur

It was concluded that the paragraph on testing in EFC 17 is sufficient and needs no update.

Loading of C-rings

Chris Fowler presented data from measurements of strain of both C-rings and four-point bend (FPB) specimens. Typically the strain close to the edge of the specimen could be 10 % larger than the strain measured in the middle of the specimens. As specimens normally are stressed based on strain measurements in the middle of the specimen, it means that local yielding will occur near the edges.

There was discussion about how to take this into consideration when stressing specimens, but S. Olsen expressed general scepticism about reducing the stress level to prevent local yielding. This was based on the fact that there will always be local stress raisers when testing welded specimens that are never taken into account. The consensus was that a cautionary note should be put into the document.

Action: C. Fowler to include a cautionary note about stress levels near the edges of FPB and C-rings in the revised version of EFC 17.

Update of EFC publications 16&17

The second editions of both EFC 16 and 17 are now sold out and new editions must be prepared for publications. The following points should be corrected:

EFC16:

- Take out the statement about CP and external hardness of welds;
- Modify the HIC acceptance criteria to be in line with ISO/NACE;
- Check if curves for pH need some cautionary note for high chloride contents.

EFC 17:

- Insert a cautionary note about higher strains at the edges of FPB and C-rings (see above);
- Revise and correct the strain gauge formula (A7.7).

Actions: L. Smith to make suggestions for EFC 16 and C. Fowler for EFC 17, by 31st October.

A New High Strength Corrosion-Resistant alloy for Oil and Gas Applications

Sarwan Mannan presented information about INCOLOY Alloy 945, a newly developed Ni-base precipitation strengthened superalloy (UNS N09945) designed for oil and gas applications. It offers a better combination of high strength and corrosion resistance at a competitive price than the existing commonly-used Ni-base superalloys, Alloys 718 and 925. The high strength is obtained by annealing plus age hardening. The minimum yield strength is 125 ksi. Alloy 945 has passed 90 day C-ring testing for MR0175 / ISO 15156 NACE level VI. The samples were stressed to 100 % of yield strength. The machinability of alloy 945 is between that of Alloys 925 and 718.

Lean duplex

Roger Francis (John Dunn) presented information about AL2003 and Zeron 21LD, which are lean duplex type SS with typically 21Cr, 3.5-4Ni, and 1.8Mo, both with a PREN >30. The strength of these alloys is similar to that of a 22% Cr duplex SS, but the cost is of the same order of magnitude as that of AISI 316. ISO 15156 part 3 states that duplex SS with a PREN>30 can be used up to 0.1 bar H₂S. Testing has been undertaken at 90 °C for the following conditions:

- 20 % Sodium Chloride
- 0.1 bar H₂S
- 1.2 bar CO₂
- pH = 3.5

All materials resisted cracking when stressed to 100 % of the actual 0.2% proof stress (see **Appendix E**).

Update on ISO 15156 / NACE MR0175

C. Fowler gave a short presentation about the latest updates of ISO 15 156/ NACE MR0175. The most important changes were that the statement about CP and external hardness had been removed and that there were new values for AISI 316. All formally approved changes are given in corrigenda published by ISO and NACE.

Corrosion in CO₂ Service

Chairman: Rolf Nyborg acting for Arne Dugstad

Document on CO₂ prediction

Rolf Nyborg presented the background for the “prediction document” that had been presented during the WP13 meeting in 2006. (Presentation enclosed). The idea was to try to make a document describing how to perform CO₂ predictions because presentations from IFE have shown large discrepancies between models. An operators' group for preparation of draft guidelines for CO₂ corrosion prediction was formed in parallel with the IFE Joint

Industry Project. This was an industry initiative chaired by Yves Gunaltun, Total. The participating companies were: Total, Statoil, Hydro, ConocoPhillips, BP, Shell, ENI, Saudi Aramco, and Chevron.

The following comments were made by the reviewers:

- Difficult to follow, little useful information, not much practical help;
- Questions on the two-step evaluation and the likelihood concept;
- No reference to earlier work, i. e. the 1994 EFC green book on CO₂ corrosion prediction, and the de Waard and Milliams model;
- More clear distinction needed between general and localized corrosion;
- May have "commerciality problems" with Appendix 1:
 - Only models evaluated in Kjeller Field Data Projects listed;
 - Not all models evaluated in these projects are listed;
 - Only a few models which the operators group wanted to focus on;
- The document was prepared by the operators group - it is not an IFE document

The discussion that followed revealed that no company is in fact performing predictions as described in the document. No strong views were expressed supporting publication of the document. Based on the rather strong arguments relating to the commercial aspects, it was decided that the document should not be published by EFC. However, it could be presented as a paper at a conference by one or several of its authors.

pH measurements versus modelling in high chloride conditions

This issue was not discussed in the meeting, but has been discussed in previous meetings without any final conclusion having been reached. CAPCIS reported that pH measurements at high chloride contents differed significantly from predicted values. IFE reported, however, that they found generally good agreement between models and measurements. NPL has undertaken measurements that gave values between what CAPCIS and IFE found! A detailed report from NPL is enclosed (**see Appendix F**). This means that this issue is still not resolved and should be discussed at the next meeting in Edinburgh.

NEXT MEETING

The next meeting of WP13 will take place in conjunction with EUROCORR 2008 in Edinburgh at a date to be announced later.