INSTITUTE OF CORROSION

Welcome to ICorr – Institute of Corrosion (ABZ), May 2021 Technical Event.

Institute of Corrosion (ABZ) partnering with:

- SHELL GLOBAL
- and SINCLAIR ENERGY LTD

- 25th May 2021

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“**2 Part Presentation**: Passive magnetometry based corrosion monitoring and mechanistic simulation technology ”

About the TOPICS

- Adoption of advanced monitoring and simulation technologies play a crucial role in paving the way towards predictive maintenance and assuring integrity of oil and gas assets. This presentation will describe the maturation of a corrosion monitoring technology and mechanistic simulation for modelling the inhibited corrosion rates. The corrosion monitoring technology is based on passive magnetometry as a measurement principle and allows monitoring of localised and non-aged based degradation mechanisms. These localised damage mechanisms pose a higher threat to pipe integrity than uniform wall loss mechanisms. The monitoring technology has been developed to provide area coverage on the target CML (corrosion monitoring location) and provide continuous monitoring for 5-10 years. The adoption of passive magnetometry allows placement of the sensor patch on top of coating or thin insulation, as the technique does not require contact with the metal surface. Overall impact and benefits from corrosion monitoring technology can be significantly enhanced if they are used in parallel with a prediction or simulation technology. A mechanistic model has been developed to simulate the performance of corrosion inhibition and thereby prediction of inhibited corrosion rates. The main driver behind the development is that corrosion inhibitors are provided as a black box' from chemical providers, which makes it extremely difficult to model the performance of corrosion inhibitors. The technology is based on an electrochemistry model which allows to test and simulate the inhibition mechanisms, without knowing the underling chemistry of the inhibitor chemical. The simulation can be used to identify both over and under inhibited systems and also reduces the cost of CI (corrosion inhibitor) qualification. Corrosion monitoring and prediction technologies are used as complementary tools. Using each tool on a stand-alone basis has limited value and applicability, however integrating prediction with a real-time feedback loop from sensing allows a step-change in integrity management capability. These technologies can help with generating early warnings of integrity issues and facilitate the transition to predictive operation and maintenance.

Shell Global Solutions

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About the Presenters -1

- **Sieger Terpstra.** Principal Technical Expert at Int. B.V. Shell.
- Sieger has been with Shell for over 40 yrs in specialist Integrity Management roles. He prev. studied Physics/Applied Physics at Rijks Universiteit Groningen. Shell is a global energy company with around 84,000 employees across more than 70 countries. The Company provides exploration, extraction, and processing of gas, oil, and other products, as well as provides business and operational consultancy, technical, and development services. Shell Global Solutions International serves clients worldwide.

About the Presenters -2

- Chetan Laddha is a Subject Matter Expert in adoption of sensor and analytics for integrity management and flow assurance applications.
- Chetan has a diverse background in the O&G industry with technology development and commercialization roles in upstream as well as downstream segment. Chetan has been involved with development of corrosion monitoring and prediction technologies, from early-stage maturation all the way to field deployments. Chetan has an MSc Marine Engineering, Combined degree from University of Strathclyde and University of Glasgow and is a Director of Sinclair Energy Partners who have been supporting Shell over the last 3 yrs.

Q&A

- **Presentation 1 – Sieger Terpstra (SHELL Global).**
  - Selection of Questions to Post-Presentation 25/05/2021

Questions and Answers – ICorr ABZ Technical Event Aberdeen – May 2021

- Q1. What are the Temperature limitations for the technique?

- A1. The sensors and electronics are limited to a maximum temperature of up to 85 Deg.C. The process temperature can be higher, if the pipe could be sufficiently insulated such that the sensors are kept below 85C. The feasibility of high temperature applications is under development. The assumption is that a 1” insulation could allow the process temperature to be >150C and a 2” insulation could allow the process temperature to be increase to 250C. However, increasing insulation thickness also reduces the sensitivity of the technique and hence there is a trade-off between temperature limit, insulation thickness and sensitivity. The aspiration is that further development of the technique will increase the temperature limit to >100C.

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- Q2. What is the impact of thermal Insulation and cladding on the sensitivity?

- A2. The technique performs best when the sensor patch is installed on the pipe with a small stand-off (e.g. 10 mm). If the sensor patch is installed on insulation, there is no impact of non-ferromagnetic cladding (aluminium, stainless steel, plastics, fibre composites. The effect of galvanized steel cladding is expected small but has not yet been tested extensively.

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- Q3. Can WiSense be applied on other geometries (pipes, pipeline, vessels, bends) as shown in the slide with pipe geometries?

- A3. Yes, there are no technical bottlenecks with the use of sensor patches on cylindrical surfaces or bends, except that patches need to follow the surface contour. For larger wall thicknesses (like heavy wall piping, vessels) the main consideration is the ‘stand-off distance’ to the defect: an increase in the distance between an internal defect and the sensor patch will reduce the detection sensitivity.

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- Q4. Do rough Welds need to be ground flat before testing?

- A4. No, the technique has been widely deployed on top of welds. The sensors use a stand-off distance from the surface that can easily accommodate the height of a weld cap.

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- Q5. Are there any effects of Process Fluids/Internal Solids ?

- A5. This is not expected an issue and has not been observed so far from the pilot testing at downstream and upstream facilities. The technique is governed by the magnetic permeability of the material and hence the impact of internal solids is expected to be minimal. More important is the influence from the background magnetic field of a plant: anomalies are introduced due to external magnetic fields, but effective signal processing techniques have been developed to compensate for such anomalies.

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- Q6. Has this new Technology been rolled out within Shell?

- A6. The commercial roll out in Shell will start in 2021. The current priority is to aid wider Production model roll-out. This will not just be for Shell, but for many other Operators. The commercial product will be provided by Yokogawa.

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- Q7. What about Pin Hole corrosion, can this be detected?

- A7. The sensitivity of this technique is related to the volume occupied by the defect. An important parameter for defect volume is the aspect ratio (Width/Depth ratio). Generally, the narrower defects, such as pits, may have an aspect ratio down to 3:1. The technique detects localised defects, but will not be suitable for defects such a pin hole with very small volume. However, I am not aware of any other monitoring technique which can detect pinhole corrosion – the only option is manual inspection. In general performance terms, the technique has shown to detect local defects before they can be reliably confirmed with UT/Phased Array.

Q&A

- **Presentation 2 – Chetan Laddha (Sinclair Energy).**
  - Selection of Questions to Post-Presentation 25/05/2021

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- Q1. What about NORSOK, ECE and other models, how do you feel about these?
- A1. The commercially available models (e.g. NORSOK, ECE) typically simulate the uninhibited corrosion rates. The inhibited corrosion rates are typically obtained by multiplying the uninhibited corrosion rate with the inhibitor efficiency, which is entered as an input by the user (obtained from CI qualification tests).
- The proposed inhibitor model (Inhibitor Optimiser™) simulates the performance of inhibitor as a function of inhibited corrosion rates, and this is achieved by electrochemical modelling of the inhibitor performance on the metal wall. Also the proposed inhibitor model is highly complementary to the existing models, with the latter providing the uninhibited corrosion rates, and the inhibitor model providing the inhibited corrosion rates.

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- Q2. What about adding your work to other existing models ?

- A2. The proposed inhibitor model will be developed as a standalone tool and can be integrated with the existing models (e.g. NORSOK, ECE).
- The Inhibitor Optimiser™ is currently being developed as a web-based tool, accessible via web API.

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- Q3. Can the model also cover the effects of H_2S?

- A3. Currently, the model does not include the capability to simulate the performance of H_2S inhibited corrosion rates. In the longer term, we plan to expand the model to cover H_2S and scaling effects. The current model has a few more limitations, as outlines on slide 19. The model does not yet cover Batch Dosing of CI (corrosion inhibitor) or HT effects.

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- Q4. What about velocity limitations?

- A4. The model assumes good correlation between the Mass Transfer Coefficient of the rotating cylinder electrode and the pipe. The model covers the typical velocity ranges between 0 – 2m/s.

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- Q5. Can the model be used for corrosion of Welds or impact of Internal Geometric effects etc.?

- A5. No, currently the model does not include capability for weld corrosion.

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- Q6. Can the model be used to evaluate anodic and cathodic based inhibitors ?

- A6. The model assumes that organic CI behavioural retardation of anodic and cathodic reactions in the same extent. Some effects are masked, and we would need to adjust for one sided behaviour.

THANK YOU FOR ATTENDING

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