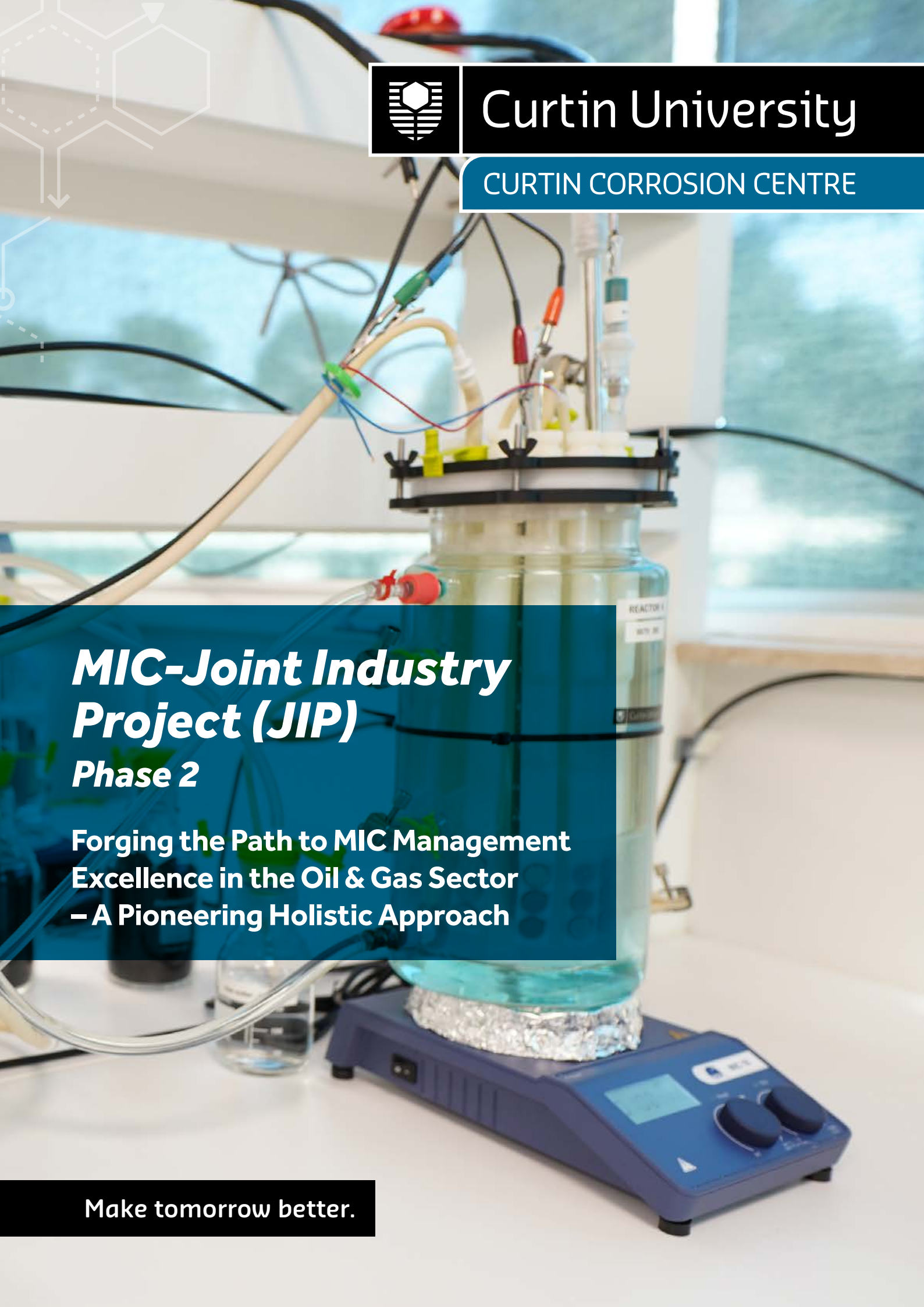


Curtin University

CURTIN CORROSION CENTRE

MIC-Joint Industry Project (JIP)

Phase 2

Forging the Path to MIC Management Excellence in the Oil & Gas Sector – A Pioneering Holistic Approach

Make tomorrow better.

MIC-JOINT INDUSTRY PROJECT (JIP)

Business case - Why MIC?

Microbiologically Influenced Corrosion (MIC), driven by microscopic organisms and their metabolic activities, constitutes a significant threat that compromises the integrity of pipelines and equipment. Renowned for its unpredictability, MIC silently corrodes metal substrates, resulting in rapid and localised deterioration. Management of MIC presents substantial challenges and demands considerable financial investments. Effectively addressing this corrosion issue requires the promotion of robust engagement between industry and academia, ensuring the transfer of knowledge and the application of the latest innovations to tackle MIC challenges. Establishing this collaborative framework is crucial in navigating the complexities of MIC and developing proactive strategies for its prevention and control. Furthermore, prioritising research initiatives becomes paramount to foster the creation of innovative tools and effective methodologies for the assessment, mitigation, and monitoring of MIC.

Objective

Building upon the successful outcomes of MIC-JIP Phase 1, the primary aim of Phase 2 is to enhance the efficacy of mitigation strategies, particularly in challenging scenarios such as those involving deposits. The project will also persist in its commitment to developing innovative tools and methodologies for predicting, diagnosing, and monitoring MIC. This endeavour seeks to advance our comprehension of MIC phenomena, contributing to the secure and efficient management of MIC across oil and gas production, storage, and transportation facilities. By leveraging the knowledge gained in phase one and incorporating new insights and technologies, the overarching goal is to fortify the industry's resilience against MIC-related challenges and ensure the integrity of critical infrastructure.

Microbial activity testing

Unlocking Opportunities: Joining the MIC-JIP Advantages

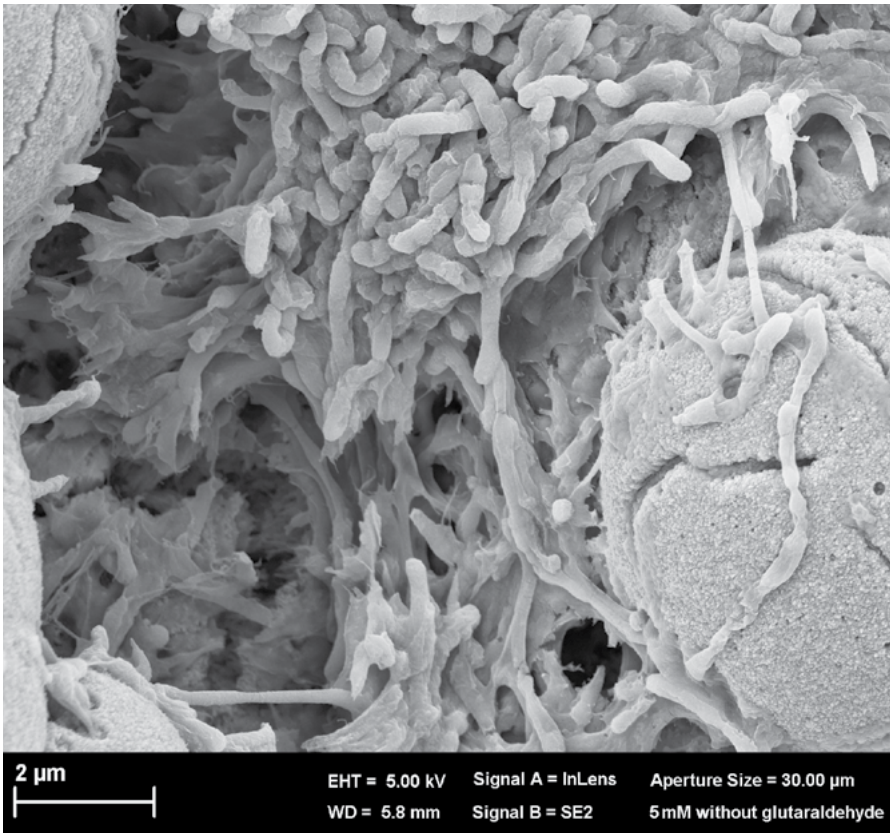
The MIC-JIP initiative aims to offer the following benefits to its members:

- Comprehensive assessment of the current and alternative (if applicable) chemical treatments (one for each member).
- Enhancement and optimisation of MIC treatment strategies.
- Opportunities for innovation and the integration of advanced technologies.
- Access to cutting-edge MIC laboratories and expert staff.
- Provision of training and educational opportunities for company staff within the JIP.
- A platform for knowledge sharing and networking among industry peers.
- Comprehensive MIC risk assessments for new JIP members (if required).
- Access to the MIC prediction models developed during Phase 1.
- Priority access to MIC consultancy services at discounted rates.

Meet the MIC-JIP Phase 2 Pioneers

MIC-JIP Phase 2 will be under the governance of an Industry Steering Committee. Curtin University's representation on this committee will consist of Dr. Silvia Salgar and Dr. Erika Suarez renowned MIC subject matter experts. The Steering Committee will convene quarterly through teleconferences, and critical project milestones will be reviewed annually during the Steering Committee Review seminar.

- ✓ Participation fee is AU$ 160K per annum.
- ✓ Expected start-up: Q3 2024.
- ✓ Duration: 3 years with a provision to extend for a further 2 years.
- ✓ A minimum of three (3) companies is required.
- ✓ Curtin University will sponsor one PhD scholarship.



Carbon steel covered with a copious biofilm of Shewanella oneidensis

About us

The Curtin Corrosion Centre (CCC) has developed world-class capabilities for the in-depth study of MIC phenomena. Through collaborative partnerships with various research centres both at Curtin University and internationally, CCC has extended its research prowess, offering cutting-edge technology and methodologies to investigate microorganisms and their impact on infrastructure and processes within the resources sector.

Our multidisciplinary MIC team has forged successful alliances with industry groups, resulting in over 50 funded projects totalling approximately $5 million in the past 10 years. CCC's distinctive approach harmonises expertise in microbiology, materials science, and corrosion science to delve into MIC mechanisms, providing invaluable insights into the industry's MIC risk assessment.

Through extensive fieldwork and close industry collaboration, CCC has pioneered the establishment of the first-ever repository of microorganisms, encompassing a diverse range of different species and microbial consortia sourced from Australian oilfields.

At CCC, our MIC facilities are equipped with specialised laboratories conforming to the Personal Containment Level 2 (PC2) standards. These cutting-edge facilities are furnished with biofilm equipment, such as CDC bioreactors and flow biofilm systems with biostuds, as well as multielectrode array systems for analysing the spatiotemporal electrochemical

Lab simulation of field conditions for MIC testing

behaviour of metals under biofilms and other deposits. Our electrochemical instruments and advanced optical and fluorescence microscopes further enhance our capabilities to study MIC using a interdiciplinary perspective. Additionally, the MIC facilities houses a molecular microbiology laboratory equipped to perform cutting-edge DNA and RNA-based analyses. Our international collaborations have paved the way for pioneering MIC research employing advanced metagenomics, metatranscriptomics, and bioinformatics to unravel the intricate relationship between microbial activities and corrosion.

Onsite sampling for microbiological assessment

What is involved in the MIC-JIP Phase 2?

Specific themes with independent milestones will be developed as follows:

THEME 1: FLOW LOOP

Unlocking MIC Insights with dynamic studies

In the world of corrosion control, understanding the intricate details of MIC is paramount. Our MIC Flow Loop studies aim to revolutionise the way we perceive and mitigate this corrosion phenomenon.

Why Dynamic Studies Matter

MIC has been a constant challenge for different industries like oil and gas. The missing piece of the puzzle often lies in the dynamic nature of fluid flow. Our MIC Flow Loop studies will be designed to address this gap and shed light on how flow velocity affects microorganisms and the kinetics of corrosion reactions.

Key Insights:

- Biofilm characteristics in dynamic systems will be a key focus of our studies, as we anticipate significant variations under these conditions. This critical insight will underscore the importance of considering fluid dynamics in future MIC assessments.

- The future impact on MIC severity will be better understood through our research, as we expect changes in biofilm characteristics to directly correlate with MIC severity. This understanding will enable us to predict and manage corrosion risks more effectively.

- Our upcoming studies are poised to reveal that optimising biocide treatment will be more effective when fluid velocity is considered. This knowledge will empower the industry to make informed decisions about future corrosion control measures.

MIC Model Validation

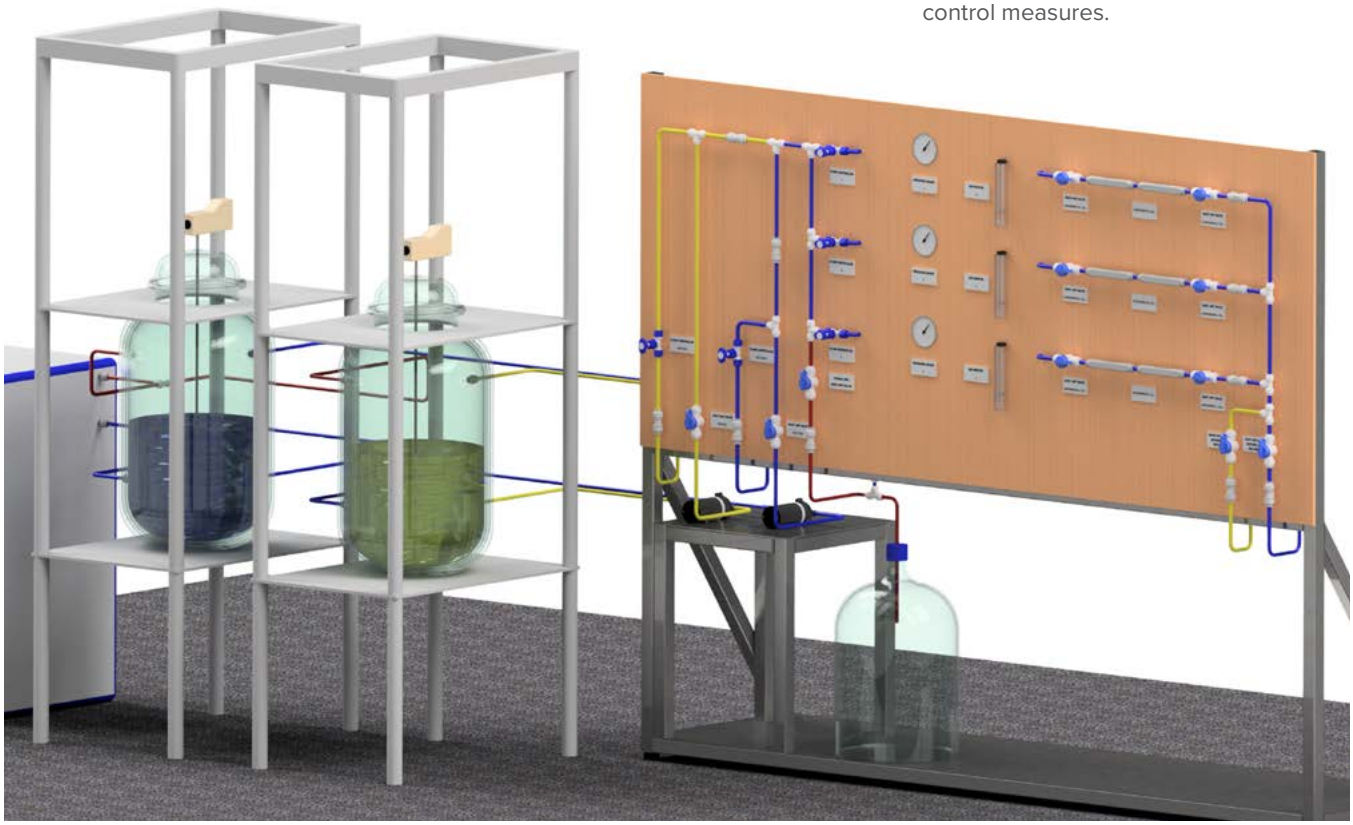
The MIC Flow Loop will play a crucial role in validating the interconnection of nodes and probability values within the existing MIC prediction models developed as part of the MIC-JIP Phase 1. By confirming the accuracy of these models under dynamic conditions, the models will be ready to be used by the JIP members to predict and manage the MIC corrosion risk more effectively.

THEME 2: MIC MITIGATION

MIC mitigation is a critical aspect of corrosion control, and our comprehensive approach aims to address this challenge effectively. We have outlined three subthemes that include biocide selection, biofilm regrowth testing, and the applicability of shock treatments, all contributing to the development of a robust strategy for combating MIC.

Biocide Selection

The primary goal of this phase is to develop a fundamental understanding of how biofilms respond to and resist commonly used biocides within the specific context of each industry partner. At CCC, we have honed expertise in assessing chemical treatment efficiency against biofilms, employing both in-situ and ex-situ techniques. Utilising surface analytical methods, molecular microbiology, and electrochemistry, we aim to investigate biofilms response to mitigation treatments. Furthermore, compatibility testing will be conducted with current corrosion inhibitors and oxygen scavengers applied to the system. This stringent evaluation ensures that the selected biocide does not adversely affect other corrosion control measures.



MIC Flow Loop design

Biofilm Regrowth Testing
Following the establishment of chemical treatments, understanding the potential for biofilm regrowth and determining the frequency of required treatments become crucial. This phase aims to ascertain the time needed for microbes to reestablish an active biofilm community. Such insights will provide critical information to formulate sustainable treatment plans that effectively uphold the prevention of MIC.

Shock Treatment (optional)
In select cases, particularly when dealing with mature biofilms and stubborn deposits, the applicability of shock treatment strategies must be evaluated. This approach is considered a potent tool for addressing the most challenging cases of MIC. By utilising a resilient consortium, we will study the efficacy of augmenting biocide doses and increasing treatment frequencies on mature biofilms established in deposits where normal treatments seem to be less effective. Developing optimised mitigation strategies capable of effectively controlling recalcitrant biofilms will ensure the longevity of vital infrastructure and assets.

THEME 3: MIC SENSORS

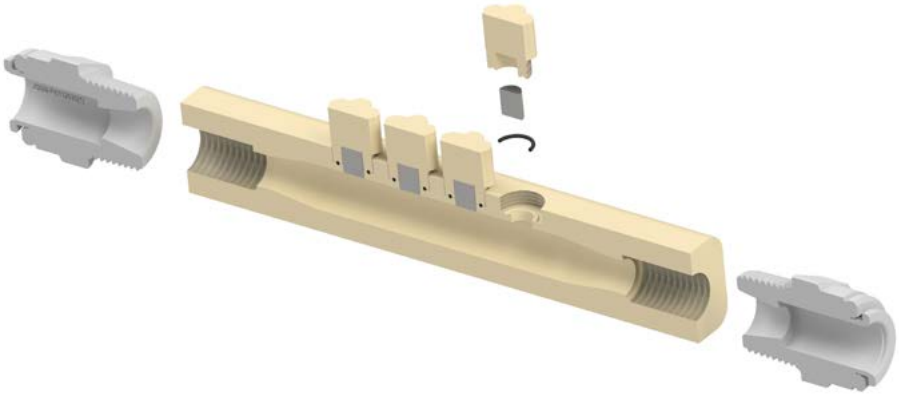
The dedication of this phase to exploring electrochemical techniques for MIC sensors aligns with the industry's demand for tools capable of early detection and monitoring of unwanted microorganisms. The goal is to assess different electrochemical signals for sensing the initiation of localised corrosion influenced by microbial action and comparing them with existing commercial corrosion sensors. This comparative analysis aims to identify the potential value of investing resources in the development of an innovative tool, with the future vision of integrating biological components for MIC detection through biosensor technology.

This comprehensive evaluation encompasses diverse sensor types, technologies, and deployment strategies, with rigorous testing under both static and dynamic conditions. The collected data will undergo meticulous analysis to gauge the accuracy, reliability, and sensitivity of these sensors in detecting corrosion rates and patterns influenced by microbial activities. The outcomes will not only inform potential advancements in corrosion detection but also contribute to meeting industry demands for reliable and advanced tools in the ongoing battle against MIC.

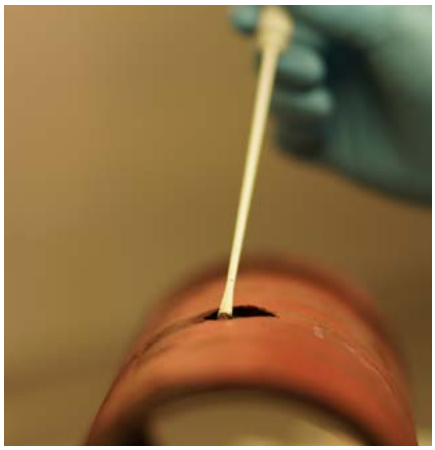
THEME 4: MIC baseline assessment (optional)

Enhanced MIC-JIP Participation
The baseline assessment is specifically designed to empower new members with a comprehensive understanding of MIC within their facilities. It entails the sampling and characterisation of microbial communities. During this phase, we will also pinpoint areas within your facilities that are susceptible to MIC.

Advanced Characterisation Techniques
This characterisation process goes beyond conventional methods. Our team employs cutting-edge techniques, including both DNA and innovative RNA-based approaches. These advanced methods are complemented by sophisticated bioinformatics tools, representing a core expertise of CCC.



Biofilm and corrosion monitoring device integrated to the MIC Flow Loop



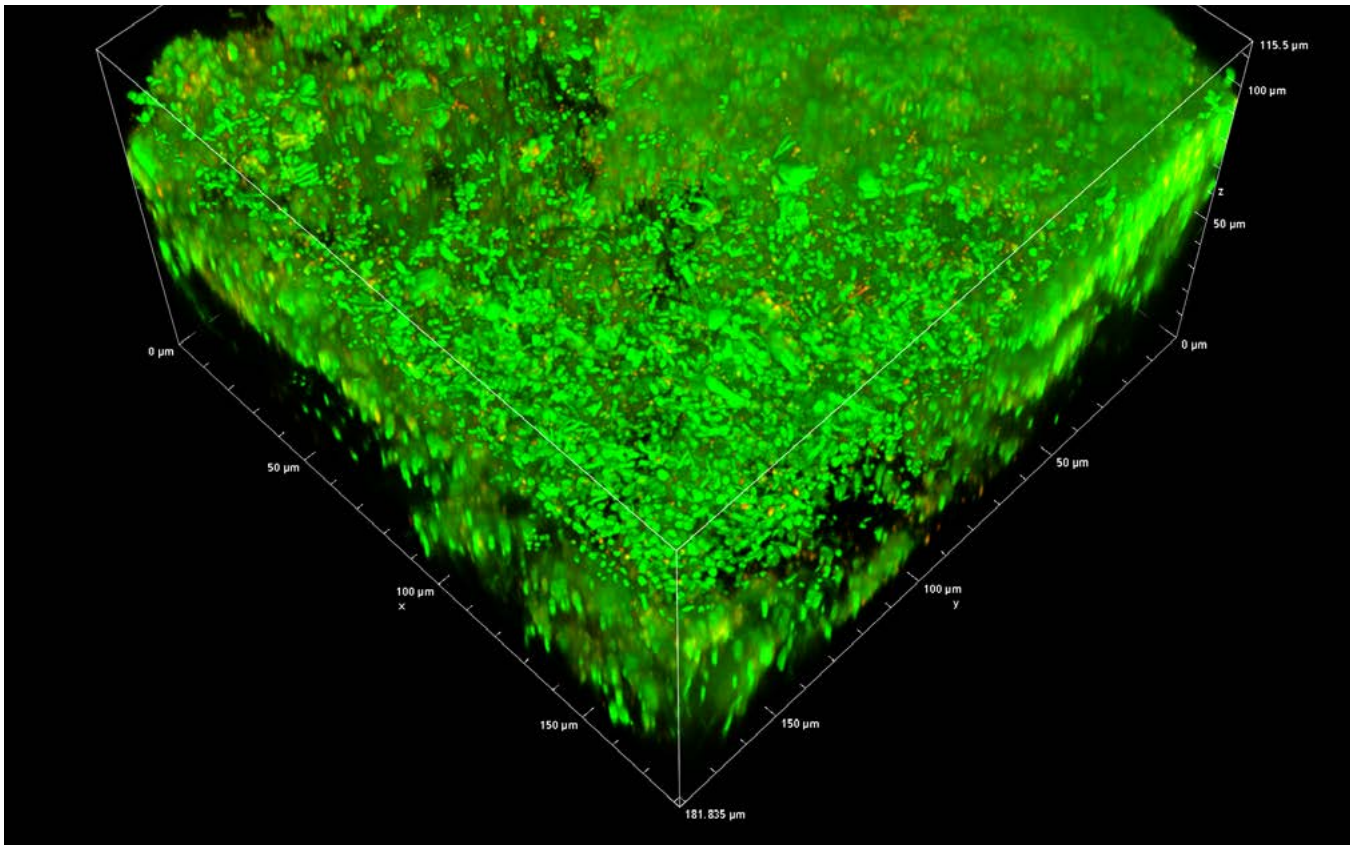
MIC sampling on corroded pipe

Key Benefits and Outcomes
Identification of MIC-susceptible areas: through the baseline assessment, CCC will precisely identify the areas in your facilities that are most vulnerable to MIC. This targeted knowledge empowers every JIP member to focus their mitigation efforts where they matter most.

Advanced Molecular Insights
Our utilisation of RNA-based approaches and advanced bioinformatics tools provide unparalleled molecular insights into the microbial communities causing corrosion. This depth of understanding is a crucial asset for effective MIC control.

Customised MIC mitigation strategies
The data obtained from the baseline assessment will prove invaluable in shaping the outcomes of MIC-JIP Phase 2. Armed with this comprehensive understanding of your facility's microbial communities and MIC susceptibility, you will be well-prepared to customize your MIC mitigation strategies, ensuring that Phase 2 initiatives are not only more efficient but also align seamlessly with your corrosion control objectives.

Note: *The MIC baseline assessment, while immensely valuable, is an optional component and is not included in the price of MIC-JIP Phase 2. This additional opportunity is tailored to those seeking a deeper understanding of MIC within their facilities and is available as an independent choice for interested members.*



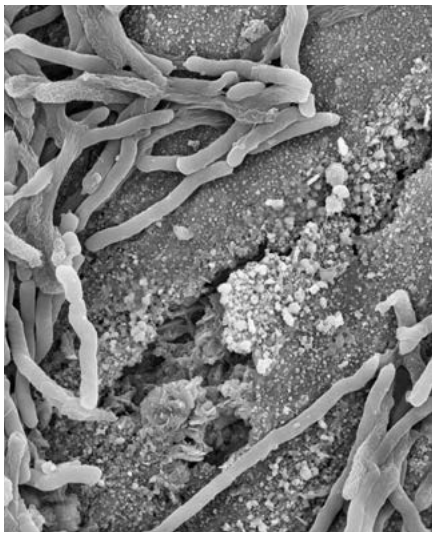
Confocal laser scanning microscopy (CLSM) image of a biofilm formed on stainless steel

MIC Consultancy Services

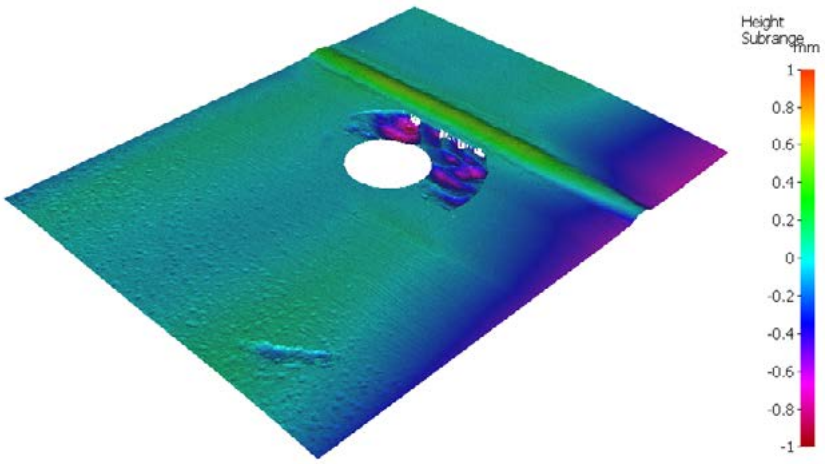
Our dedicated team assist industry partners with MIC challenges. Drawing upon our team's expertise and experience, we review or create MIC guidelines and offer tailored solutions across various scenarios. As part of the services, we actively participate in industry meetings to address MIC challenges, analyse data, and provide actionable recommendations. At MIC Consultancy we support each company, regardless of the scale of the challenge.

Advantages:

- **Customised solutions:** Working closely with our partners to understand each facility's intricacies, corrosion concerns, and industry requirements, ensuring that the solutions provided are tailored to each situation.
- **Proactive MIC management:** Accessing MIC advisory services empowers our industry partners to adopt a proactive approach to corrosion control. Rather than reacting to MIC-related issues as they arise, our team can assist each member in implementing preventive measures and predictive strategies to mitigate corrosion risks effectively.
- **Cutting-edge solutions:** Our team stays at the forefront of MIC research and development, ensuring that each company receive the most innovative and effective solutions available.



Field consortium grown over a carbon steel surface



Crevice corrosion triggered by microorganisms on 316 SS heat-affected zone

- **Cost Efficiency:** By engaging our consultancy services, each member can potentially reduce costs associated with corrosion-related downtime, repairs, and asset replacement. The aim is to optimise resources and extend the lifespan of critical infrastructure.

Note: *As valued MIC-JIP members, you enjoy priority access to our MIC consultancy services. While these services are available to assist with your MIC challenges, it's important to note that they are optional, and additional costs may apply.*

For further information

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