A journal of the Institute of Corrosion

Corrosion Management

Issue 192 July/August 2026

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COATING TECHNOLOGIES FOR CORROSION PREVENTION AND FIRE PROOFING

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Square One Advertising and Design Limited
Neepsend Triangle Business Centre,
Unit 8, 1 Burton Street, Sheffield S3 8BW

Publisher and Managing Editor
Debbie Hardwick
Tel: 0114 273 0132
Email: debbie@squareone.co.uk
Consulting Editor
Shagufta Khan
Email: editor@icorr.org
Design
Square One Advertising & Design
www.squareone.co.uk
Advertising Manager
Jonathan Phillips
Tel: 0114 273 0132
Email: jonathan@squareone.co.uk

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Enquiries and subscriptions to the Institute of Corrosion at the address below:

The Institute of Corrosion
President
Yunnan Gao
Vice President
Anthony Setiadi
Immediate Past President
Stephen Tate
Hon. Secretary
Brenda Peters

Institute of Corrosion, Corrosion House,
5 St Peters Gardens, Marefair,
Northampton NN1 1SX
Tel: 01604 438222
Email: admin@icorr.org
Website: www.icorr.org

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The President Writes



Photo: Dr Yunnan Gao.

Dear Members,

Since my last column, the Institute of Corrosion has continued its active and outward-looking programme across both the UK and the international corrosion community. Over the past few weeks, I have had the pleasure of participating in several important activities that demonstrate ICorr's growing visibility, its expanding international influence, our continued commitment to professional development, and our strengthening engagement with corrosion professionals, students, researchers, and partner organisations around the world.

A major highlight during this period was my attendance at the AMPP Italy International Conference & Expo 2026, held in Genoa, Italy, from 9–12th June 2026. The conference, organised by the AMPP Italy Chapter under the theme "Connecting Experts – Driving Innovation into Corrosion Management", brought together corrosion specialists, researchers, industry leaders, and professional organisations from across Europe and beyond. The technical programme demonstrated the breadth of today's corrosion challenges, covering hydrogen technologies, carbon capture and storage (CCUS), protective coatings, cathodic protection, corrosion inhibitors, inspection and monitoring, renewable energy systems, reinforced concrete durability, and sour service corrosion. The diversity of topics clearly illustrated the increasingly important role that corrosion engineering plays in supporting the global energy transition, infrastructure resilience, and sustainable industrial development.

During the conference, I was also pleased to continue strengthening ICorr's international relationships following our successful engagement at the AMPP Annual Conference + Expo 2026 in Houston earlier this year. Constructive discussions were held with senior leaders from AMPP and the European Federation of Corrosion (EFC), focusing on future collaboration, professional development, international knowledge exchange, and the continued advancement of corrosion science and engineering. As our profession faces increasingly complex global challenges, strong collaboration between professional institutions has never been more important. ICorr remains committed to working closely with our international partners to deliver lasting value to the global corrosion community.

Closer to home, on 21st May 2026, I delivered an online President's webinar for the ICorr Midlands Branch entitled "Discover the Institute of Corrosion (ICorr): Services, Activities and Opportunities for Corrosion Professionals." The webinar introduced engineers, students, and corrosion professionals to the many benefits that ICorr offers, including professional registration pathways, technical resources, training, international collaboration, student membership, and opportunities for professional engagement throughout every stage of a career. I was particularly encouraged by the level of participation and interest shown by attendees, demonstrating the growing recognition of ICorr as the UK's leading professional body dedicated to corrosion prevention and control.

On 28th May 2026, I was delighted to deliver the welcome address at the latest Young ICorr event in Manchester for participants in the 2026 Young Engineer Programme (YEP). The session included mentor introductions, team allocation, presentation of the annual case study, and a technical lecture on failure investigation. The enthusiasm shown by both mentors and participants once again demonstrated the strength of this flagship programme. Developing the next generation of corrosion engineers remains one of ICorr's highest priorities, and it is extremely encouraging to see the programme continuing to grow year after year.

Another significant activity during this period was my continued engagement with students at the University of Manchester. On 26th June 2026, I had the pleasure of delivering a dedicated presentation entitled "Meet the ICorr President – How the Institute of Corrosion Can Help University of Manchester Students." Building upon my earlier visit to meet ICorr Scholarship recipients, the session introduced students to ICorr's free student membership, career development opportunities, professional registration pathways, Young ICorr activities, international collaborations, and the many ways the Institute can support them throughout their professional journeys. I was delighted by the positive engagement from both students and academic colleagues, reinforcing the importance of strengthening links between ICorr and universities to inspire and support the next generation of corrosion professionals.

The same day also saw the successful launch of the ICorr Regional Research Exchange, jointly organised by the ICorr North West and Yorkshire & Humber Branches in collaboration with Young ICorr, the University of Leeds, and the University of Manchester. The inaugural event brought together researchers, students, early-career professionals, and industry representatives to exchange the latest developments in corrosion science and engineering. With technical presentations from both universities alongside an industrial perspective, the event provided an excellent platform for knowledge sharing and networking. I believe this new seminar series, which will alternate between Leeds and Manchester, will become an important initiative for strengthening regional collaboration, fostering closer links between academia and industry, and encouraging greater engagement with ICorr's technical community.

Looking ahead, I would also like to highlight several important forthcoming ICorr activities. Our annual Aberdeen Corrosion Forum and corrosion awareness event will take place on 28th August 2026, with preparations well underway in collaboration with Lloyd's Register Aberdeen. This long-established event remains one of the highlights of the ICorr calendar, bringing together professionals from across the energy sector to exchange experience, promote corrosion awareness, and strengthen professional networks. I look forward to seeing many members there.

Beyond this, I strongly encourage members to register for EUROCORR 2026, which will be held in Dublin, Ireland, from 6–10th September 2026. Under the theme "Investing in our Future: Corrosion Challenges for Green Technologies", the conference will showcase how corrosion engineering is supporting the transition towards more sustainable energy systems and resilient infrastructure. ICorr is proud to play a leading role in organising this prestigious international event in partnership with the Institute of Materials, Minerals and Mining (IOM3), the European Federation of Corrosion, and many other international partners. I very much hope to welcome many ICorr members to Dublin for what promises to be one of the most significant corrosion conferences of the year.

Finally, I would like to thank everyone who took the time to complete the recent ICorr all-member survey on the Corrosion Management Journal (CMJ) and the ICorr website. Member feedback is invaluable in helping us continuously improve the services we provide and ensuring that both our publications and digital platforms continue to meet the evolving needs of our members. The survey closed on 30th June 2026, and I would like to express my sincere appreciation to everyone who shared their views. Listening to our members is fundamental to the Institute's continued development, and the feedback received will help inform future improvements to our publications, digital platforms, and member services as we continue to strengthen ICorr for the benefit of the global corrosion community.

As always, I warmly welcome your thoughts, insights, and aspirations for the Institute. Please feel free to contact me directly at **president@icorr.org** Your continued support, enthusiasm, and engagement are fundamental to ICorr's success. I look forward to seeing many of you at our forthcoming activities and events.

With best regards,

Dr Yunnan Gao
President, Institute of Corrosion **president@icorr.org**

From the Editor

Dear Members,

Protective coatings remain one of the most effective and widely used methods of controlling corrosion. From offshore platforms and storage tanks to pipelines, bridges, industrial plants, and buildings, coating technologies play a vital role in extending asset life, improving reliability, reducing maintenance costs, and supporting safe operation. At the same time, passive fire protection systems provide an additional layer of defence by preserving the structural integrity of critical assets during fire incidents. Selecting the right coating system, applying it correctly, and maintaining it throughout its service life are essential to achieving long-term performance.

The theme of this issue, Coating Technologies for Corrosion Prevention and Fire Proofing, brings together three technical articles that examine different aspects of coating technology, from fire protection and coating failure to advanced materials designed for demanding service environments.

Baptiste Rozé of AkzoNobel - International Paint (an ICorr Corporate Member) has contributed the first technical article, 'Fire Integrity Assessment of Damaged Passive Fire Protection Systems and the Impact of Substrate Corrosion'. The article explains how corrosion beneath passive fire protection (PFP) systems can affect their performance during a fire. It discusses how corrosion can reduce the effectiveness of PFP systems and outlines practical methods for assessing damaged areas. The article provides useful guidance to help engineers make informed decisions about inspection, maintenance, and repair. Dominic Marshall and Steven Slack, an ICorr member, from Corrous Industrial Group have contributed the second article, 'Top 10 Reasons Internal Tank Linings Fail — and How to Prevent Them'. The article looks at one of the most common challenges in protective coatings. Internal tank linings are used in harsh conditions, where chemical exposure, poor surface preparation, incorrect product selection, and poor quality control can cause early failure. Based on their extensive industry experience, the authors explain the main reasons why tank linings fail and provide practical advice to improve project quality and extend the service life of tank linings.

The final technical article, 'High-Temperature Degradation in Chlorine and Sulphur-Rich Environments: Mechanisms and Mitigation Using Arc-Sprayed Coatings', is written by Ahmad Usman, Group Innovation R&D Engineer at Welding Alloys Group UK. The article looks at the challenges of protecting components that operate at high temperatures. It explains how chlorine- and sulphur-rich environments cause high-temperature degradation and shows how advanced arc-sprayed coating technologies can improve resistance to corrosion and high-temperature attack.



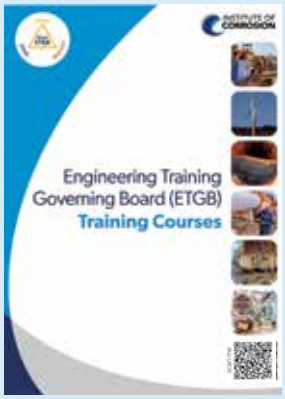
Alongside these technical contributions, this issue includes several new and regular features that continue to strengthen the journal. Our new **Standards in Focus** feature introduces important developments in corrosion-related standards, while the new **HSE Alert** highlights lessons that can be learned from recent industrial incidents.

I would like to thank all our authors, reviewers, ICorr leaders, and contributors for their continued support of *Corrosion Management Journal*. Their willingness to share their knowledge and experience helps make the journal a valuable resource for corrosion professionals in industry, academia, and research. I hope you enjoy this issue and find the technical articles and Institute updates both interesting and useful. As always, I welcome your feedback and future contributions. If you have any questions or would like to propose an article, please contact me at **editor@icorr.org**

Dr Shagufta Khan, FICorr, Consulting Editor, *Corrosion Management Journal*

Announcement

Introducing the New ICorr ETGB Brochure and Training Portfolio



ICorr reaffirms its long standing commitment to sharing knowledge honed through decades of hands on experience, and to delivering **best in class training** to the international corrosion community through the work of the Institute's Engineering Training Governing Board (ETGB). We are delighted to introduce our new e brochure, showcasing a **strong and expanding portfolio** of classroom-based corrosion, materials, and asset integrity training programmes designed to meet the evolving needs of industry and to raise corrosion awareness across civic communities.

Developed and delivered globally by **high achievers with internationally recognised expertise** in their specialist areas, our courses draw on extensive practical experience and leadership in professional qualification. Several programmes were originally developed and/or approved by major international operators for staff development, underscoring the depth, relevance, and industry credibility of the content. The portfolio serves managers, professionals, researchers, stakeholders, students, and senior technicians, offering everything from foundational corrosion principles and management to advanced specialist modules aligned with ICorr recognised industry standards. A number of courses also provide the opportunity to obtain **highly regarded ICorr certification and assist ICorr professional membership**, upon successful completion of the after course examination.

The brochure brings together all current and upcoming courses planned for the next twelve months, along with tutor biographies, ETGB committee members, our values, Chartered Engineer (CEng) competency mapping, and flexible delivery options, all presented in one clear and accessible guide. Whether your goal is to build organisational capability or pursue individual professional accreditation, ETGB programmes deliver **practical, immediately applicable knowledge** that strengthens competence, confidence, and long term career progression with excellent networking / knowledge sharing opportunities.

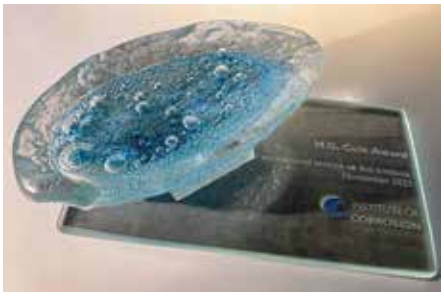
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To explore the full digital version and register your interest, whether as a participant, international training partner, or course developer[1], simply scan the QR code on the brochure's front page. Course fees are carefully aligned with ICorr charitable status, and programmes are regularly delivered in the UK, with options for delivery at company premises or partner offices worldwide.

[1] Partnership and tutorship opportunities are subject to meeting ICorr criteria. All courses undergo peer review and approval to ensure quality and consistency.

Pre-learning materials are supplied to all registrants and courses may be attended consecutively. We would be pleased to discuss how ETGB can support your individual or company training objectives for 2026 and beyond. You can reach the ETGB Chair at **ETGBchair@icorr.org**

H G Cole Award 2026: Recipient Has Been Selected



The H G Cole Award 2026 recipient has been selected! Please join us in congratulating David Harvey on being selected as the recipient of the 2026 H G Cole Award.

The H G Cole Award is the Institute of Corrosion's most prestigious honour, presented on an occasional basis in recognition of outstanding service to the Institute. It is reserved for individuals Photo: Unique Engraved Artwork of the H G Cole Award whose exceptional contributions have played a significant role in the development and wellbeing of the Institute.

David's Impact in ICorr

David has been an active member of ICorr since the 1980s and is an Honorary Fellow of the Institute. Before his retirement in 2025, he was involved in a wide range of activities within the Institute, most notably advancing the development and certification of ICorr's technical activities, including course approvals, documentation and procedures, professional assessment, and professional development and training. David's involvement and contribution were invaluable in helping the Institute achieve its first ISO 9001 certification in 2005. He acted as a quality assurance adviser and established a quality management system to maintain the certification. Furthermore, he developed ICorr's Cathodic Protection course documentation and procedures for the training and certification of CP personnel in accordance with ISO 15257.



Photo: David Harvey (right) with Past President Gareth Hinds for His Earlier Honorary Life Fellowship Award.

As Chair of the Professional Assessment Committee (PAC), David also spearheaded ICorr's registration as a Professional Affiliate of the Engineering Council in 2006. Having become the first member to be registered as a Chartered Engineer through ICorr's Professional Affiliate agreement, David's dedication and commitment in this area helped ICorr progress towards becoming a fully licensed member of the Science Council in 2009 and, subsequently, a fully licensed member of the Engineering Council in 2025.

Through his contributions, ICorr is able to directly assess and support its members in attaining Chartered Scientist and Chartered Engineer status, positioning the Institute alongside other leading UK professional bodies and further strengthening its standing within the corrosion community.

Comment from David:

"After 40+ years of working on Council and various committees, I will be honoured to accept this highly respected H.G Cole Award. I would like to give my heartfelt appreciation to those Members who have supported, advised and guided me in the various committees, processes and procedures for enhancing the science, engineering and practice of corrosion control and prevention."
David's long-standing impact on the Institute is unparalleled, as demonstrated by his many years of passion, dedication and commitment to the advancement of ICorr. The H. G. Cole Award is a well-deserved recognition of his distinguished and enduring contributions to the Institute.

The award will be presented at ICorr's 2026 Annual General Meeting (AGM), which will be held in London on 18th November 2026.

The H G Cole Award is named after Henry George Cole, who was Chief Materials Engineer at the UK Ministry of Defence and a former ICorr President. For more information on the award, including previous recipients, please click **https://www.icorr.org/?s=cole**

A Fraudulent Website Impersonating Corrosion Management Journal

The Institute of Corrosion (ICorr) has become aware of a fraudulent website impersonating our official publication, Corrosion Management Journal.

This website is not affiliated with ICorr and should not be trusted.

We advise all members, subscribers, partners and visitors not to visit or interact with the site and not to provide any personal or financial information. Please remember that the only official source for *Corrosion Management Journal is via our Members Area*, and all other ICorr resource(s) can be found on **www.icorr.org**

If you receive any suspicious communications claiming to represent ICorr or *Corrosion Management Journal,* or if you are unsure whether a website, email or request is genuine, please contact the ICorr Editor at **editor@icorr.org** before taking any action. We are taking appropriate steps to address this matter and appreciate your vigilance in helping protect the integrity of ICorr's communications.



Thank you for your continued support.
Institute of Corrosion (ICorr)

CORREX Updates Summer – The Peak Season for Industrial Coatings and the Importance of ICATS Training

During the summer months, the coatings and corrosion protection industry enters its busiest period of the year. Asset owners across the UK and internationally take advantage of the warmer temperatures, longer daylight hours, and generally more stable weather conditions to undertake maintenance painting programmes on critical infrastructure. From bridges and pipelines to storage tanks, marine structures, power stations, and industrial facilities, summer provides the optimum window for coating application and asset preservation activities.

While favourable weather creates opportunities for increased productivity, successful coating application is about far more than simply applying paint on a warm day. Modern protective coating systems are highly engineered products that require strict adherence to manufacturer's specifications and industry standards to achieve their intended service life. This is where the ICATS (Industrial Coating Applicator Training Scheme) plays a vital role in ensuring that coating applicators possess the knowledge, skills and competency required to deliver quality work safely and efficiently.

Environmental conditions remain one of the most critical factors affecting coating performance. Applicators must continually monitor air temperature, surface temperature, relative humidity, and dew point throughout the working day. Even during summer, rapid changes in weather conditions can create circumstances where condensation forms on the steel surface. Industry best practice generally requires the substrate temperature to remain at least 3°C above the dew point temperature before surface preparation or coating application can commence. Failure to comply with these requirements can result in flash rusting, poor adhesion, blistering, and premature coating failure. Relative humidity also plays a significant role in coating performance. Excessive humidity can adversely affect curing and drying times, while certain coating systems may be particularly sensitive to moisture contamination. Trained applicators must understand the limitations of the products they are using and be capable of interpreting environmental monitoring data accurately.

Surface preparation remains equally important. Abrasive blast cleaning operations must achieve the specified cleanliness standard and surface profile to ensure optimum coating adhesion. Operators must understand the impact of blast media selection, nozzle size, compressor performance, air cleanliness, and flow rates on productivity and coating performance. Adequate compressed air volume and pressure are essential for achieving consistent blast quality, while contaminated air systems can introduce oil or moisture that compromise the integrity of the coating system. Health and Safety considerations become increasingly important during the summer period when workloads are at their highest. Applicators may be working in confined spaces, at height, or in areas exposed to direct sunlight and elevated temperatures. Heat stress, dehydration, fatigue, and reduced concentration can all increase the likelihood of accidents and quality defects. Proper planning, hydration, welfare arrangements, personal protective equipment, ventilation systems, and safe systems of work are therefore essential components of any successful coating project.

Quality control throughout the coating process is equally critical. Wet film thickness measurements, dry film thickness verification, environmental monitoring records, surface cleanliness checks, and coating inspection activities all contribute to ensuring that the specified coating system performs as intended. Trained ICATS operatives understand not only how to apply coatings correctly but also why these quality control measures are necessary to protect valuable assets from corrosion. As demand for maintenance painting continues to increase throughout the summer months, the importance of competent, qualified personnel cannot be overstated. ICATS provides the industry with a recognised benchmark for applicator competence, helping contractors, asset owners, and clients maintain the highest standards of workmanship, safety, and quality. By combining practical skills with an understanding of environmental controls, coating technology, surface preparation requirements, and health and safety responsibilities, ICATS-trained operatives contribute significantly to the long-term protection and reliability of critical infrastructure assets.

ICATS training is part of Correx.
Find out more at: https://www.icats-training.org/

Paul Brooks, Managing Director, Correx Ltd
PBrooksMD@correx.org

INSTITUTE OF CORROSION

Visit the ICorr website for all the latest news
www.icorr.org

Highlights from the CEOCOR 2026 Congress

Chris Lynch CEng, FICorr, Senior Engineering Manager, Corrpro Companies Europe Limited

The CEOCOR 2026 Congress was held aboard the permanently moored former cruise ship SS Rotterdam in Rotterdam, the Netherlands and was hosted by Van Der Heide.



Photo 1: *SS Rotterdam*, the Venue for the CEOCOR 2026 Congress, Permanently Moored in Maashaven Harbour on the River Maas, Rotterdam, the Netherlands.

The event was a great success, attracting more than 100 delegates from around the world.

Participants engaged in excellent technical and informal discussions in the Commission Working Groups, the congress was underpinned with excellent technical presentations delivered by over 25 international experts in their fields of corrosion, cathodic protection and coatings. The event once again had a strong UK presence and contribution. There was a well-supported partner's programme and Van der Heide hosts Evelien, Rene and Gonda were exceptional in ensuring everything went without a hitch.

Attendees were welcomed by René Swart who is the Business Unit Manager for Van der Heide and the event was opened by the President of CEOCOR, Markus Buchler. René's message was his pride in "facilitating connecting people to share knowledge". Markus reminded attendees that, the industry is operating in a time of rapid change with the presence of AI, e-tools, financial constraints, and emerging understanding of the impacts of power infrastructure in AC and DC interference phenomena.



Photo 2: René Swart, Business Unit Manager at Van Der Heide, the Netherlands, and Host of CEOCOR 2026, Delivers the Welcome Address to Delegates.

Commission 1 presentations from Germany and The Netherlands respectively, included regulatory requirements and consideration and testing of lead and asbestos and their contribution to internal corrosion of asbestos cement drinking water pipelines and MIC control and internal corrosion prevention in sprinkler and fire prevention piping systems.

Commission 2 presentations included Cathodic Protection and CP applications in hazardous areas by Dr. Pat Lydon, coatings, renewable energy source AC and DC interference and microbial influenced corrosion. Keynote presentations were given by Rob Polder of RPCP on Cathodic Protection of Reinforcement in Concrete and by Ken Lax on Renewable Energy Sources and Electrical Interference Risk to Pipelines.



Photo 3: Ken Lax (Corroconsult UK Ltd) Delivering the Keynote Presentation, "Renewable Energy Sources and Electrical Interface Risk to Pipelines".

All papers are now available to CEOCOR members on the CEOCOR website (https://ceocor.lu/) . For membership details, visit the website. Annual membership fees are only 150 Euros per person.

The Working Group activities were conducted either side of the 2-day presentations and good progress has been made in several groups including:

WG J - Overline survey techniques including CIPS, DCVG and PCM (Neil Webb)

WG O - New backfill materials for anodes. Specifically coke breezes. (Bill Whittaker)

New working group projects were considered for the assessment of DC influences on metallic structures, remote monitoring, and (microbiologically influenced corrosion) MIC corrosion assessment.

The CEOCOR Governing Board and the Annual General Meeting (AGM) were held during the congress. ICorr currently has 2 active board members. It is hoped that the organisation of the annual congress in 2029 will be held in the UK and provide us the opportunity to significantly contribute to the ongoing success and popularity of CEOCOR.

The next CEOCOR event will be the Autumn Days Working Group activities held every year in Brussels.

ICorr will be putting together a planning team to host the 2029 CEOCOR Congress in Dublin, Ireland. If you are interested in helping, please contact ICorr directly.

Please do consider attending the next CEOCOR Congress which will be hosted during May 2027 in Bonn, Germany.

ICorr President Visits the University of Manchester to Inspire the Next Generation of Corrosion Professionals

Dr Yunnan Gao, president of the Institute of Corrosion (ICorr), visited the University of Manchester on 26th June 2026 to engage with engineering students and introduce the opportunities available through ICorr membership, professional development, and involvement in the global corrosion community.

Following the successful collaboration between ICorr and the University of Manchester, Dr Gao was invited to deliver a presentation entitled: "Meet the ICorr President – How the Institute of Corrosion Can Help UoM Students Develop Their Careers".

The event was hosted at the Engineering Building, University of Manchester, and was attended by students with an interest in corrosion, materials engineering, and related disciplines. The session provided an opportunity for students to learn more about the role of ICorr, its activities, and how involvement with the professional body can support their academic journey and future careers. The visit followed Dr Gao's earlier engagement with the University of Manchester, where he met with ICorr Scholarship recipient students and discussed the importance of supporting young engineers entering the corrosion profession. The combined activities reflect ICorr's ongoing commitment to encouraging student participation, developing future corrosion specialists, and strengthening links between academia and industry.

During the presentation, Dr Gao introduced ICorr's mission and role in advancing corrosion prevention, management, and engineering excellence. Key topics covered included:

- The role of ICorr in supporting the corrosion profession in the UK and internationally.
- The benefits and opportunities available through free ICorr student membership.
- Career development pathways, Continuing Professional Development (CPD), and routes towards professional registration.
- Young engineer initiatives, mentoring opportunities and professional networking.
- ICorr's engagement with international corrosion organisations and global activities, including collaboration with partners in China.
- The importance of building professional networks and engaging with the wider corrosion community at an early stage of career development.

The presentation was followed by an interactive discussion with students, allowing attendees to explore career opportunities in corrosion engineering, current industry trends, and the skills required to develop successful careers in this important field.

Dr Gao said:

"It was a great pleasure to return to the University of Manchester and meet with students who are interested in corrosion and materials engineering. Developing the next generation of corrosion professionals is a key priority for ICorr. Through student membership, professional networking, mentoring, and engagement with the wider corrosion community, we hope to provide students with the support and opportunities they need to build successful careers."

The session received very positive feedback, with strong student engagement and interest in becoming involved with ICorr. Students were encouraged to take advantage of ICorr's free student membership scheme, which provides access to professional networks, technical knowledge, events, and opportunities to connect with corrosion professionals across industry and academia. The University of Manchester has a long-standing reputation for excellence in engineering, materials science, and corrosion research. Through continued collaboration with universities such as Manchester, ICorr aims to strengthen the connection between education, research, and industrial practice, ensuring that future engineers are equipped with the knowledge and professional networks needed to address corrosion challenges worldwide.

ICorr would like to thank Dr Beatriz Mingo, Professor Dirk Engelberg, and colleagues at the University of Manchester for their support in organising the event and for their continued engagement in promoting corrosion awareness and professional development among students.



Photo: Dr Yunnan Gao, President of the Institute of Corrosion (ICorr), with University of Manchester Students Following His Presentation "Meet the ICorr President – How the Institute of Corrosion Can Help UoM Students Develop Their Careers" on 26th June 2026.

ICorr Aberdeen Updates

On Thursday 21st May, members of the Aberdeen Committee and Guests attended the Energy Institute Highlands and Islands Dinner, Held at the Norwood Hall Hotel in Aberdeen.



Photo: (From Left to Right), Dotimi Egbuson, Stephen Tate, Emanuel Okoye and Stephanie Okoye (Aberdeen Chair), Steve Paterson and Eugene Ogosi.

On **Tuesday, 26th May 2026**, the Aberdeen Branch held a technical event, entitled 'Vapour Corrosion Inhibitor (VCI) technology, providing advanced, non-toxic, and cost-effective corrosion protection for metal assets during shipping, storage, and operation' presented by Alexander Tweddle of Zerust (Excor).

About the Presenter



Photo: Alexander Tweddle, Business Development Manager, ZERUST® UK.

Alexander (Sandy) Tweddle, Business Development Manager for ZERUST® UK, is an industrial chemist with long experience in corrosion control in the UK O&G sector. His experience includes coatings development, manufacture, technical service, coating inspection (onshore and offshore), blast and paint, corrosion inhibition and business development.

ZERUST® are specialist in VCI technologies company and invented the world's first volatile VCI film product for corrosion prevention and now have multiple international laboratories offering technical support globally.

Presentation Details

Sandy discussed the many potential applications of VCI products. VCI Emitters (also known as VCI diffusers) provide targeted corrosion protection in hard-to-reach enclosed spaces.

There are 3 main stages to successful VCI application:

- **Sublimations** - the scientific process where the embedded inhibitor compound transitions directly from a solid to a gas, completely bypassing the liquid phase.
- **Diffusion** - mobile diffusers that enhance VCI anti-corrosive action during transport and prolonged storage.
- Adsorption – a process by which Volatile Corrosion Inhibitor (VCI) molecules vaporise, diffuse through the air inside a sealed package, and chemically attach (adsorb) onto metal surfaces. This forms a microscopic, protective nano-coating that blocks moisture and oxygen from triggering corrosion.

Apart from protective VCI packaging, other key applications (particularly for the energy sector) include CUI prevention, flange Joint protection and prevention of corrosion following hydrotesting. Also, for preserving drilling rigs in various states of readiness.



Photo: ZERUST® Inhibitor Fusion (ZIF) Tape.

According to local conditions/environmental constraints, pre-cleaners are used prior to application e.g. Phosphoric Acid (pH 1) , Citric Acid (pH 2.5).

VCI systems are available that are effective for 4-5 years but most commonly VCI protection is only required for shorter periods for around 2 years, prior to plant commissioning.

ZERUST® Zerust UK work in partnership with Taylor Packaging Limited (Durham), UK, VCI Emitters & VCI Diffusers - Taylor Packaging.



Photo: Palm Court Audience of 26th May 2026.

Sandy presented a wealth of potential applications for deploying corrosion inhibitors, leading to an extended Q&A session with some excellent audience contributions.





Photos from the Presentation by Alexander Tweddle: Use of Vapour Inhibitors (VCI's) for Protection of Operating Plant and Equipment Prior to Start-Up.

The June Aberdeen Webinar event was held on Tuesday, 30th June 2026, to a global ICorr Audience with 84 registrants and skilfully managed by our retiring Vice Chair and YEP Graduate – Eilidh MacDonald.

Presentation Details



Photo: Tony Rizk, ICorr ETGB Chair.

This presentation was delivered by Tony Rizk our Engineering Training Board (ETGB) Chair and entitled Corrosion at Home, this being a pilot of our new 'Corrosion at Home' course, intended for non-corrosion specialists.

The Engineering Training Governing Board (ETGB) is a bold initiative by ICorr, dedicated to shaping the future of professional development in corrosion engineering. It complements ICorr Professional Engineering Institution (PEI) licence, awarded to ICorr in 2025 by the Engineering Council (EngC PEI), reinforcing ICorr's commitment to delivering internationally recognised, best-in-class training and certification. ETGB has a further remit to help raise general public awareness of everyday corrosion issues and the cost to society in particular, to individual families on limited budgets.

Covering a wide range of domestic systems and materials, the presentation examined corrosion risks in:

- Batteries - electronics and leakage issues.
- Electrical systems - wiring, sockets, circuit boards.
- Garage and shed - tools, storage units, exposed surfaces.
- Garden furniture and outdoor fixtures - moisture and pollutant exposure.
- House components - windows, doors, roofing, structural metals.
- Kitchen - cookware, cutlery, appliances, food contact materials.
- Vehicles - bodywork, undercarriage, battery terminals.
- Water systems - pipes, taps, boilers, heating units.

The online audience learnt how corrosion affects safety, reliability, cost, and appearance, and how simple preventive actions can extend asset life, preserve value, and avoid preventable incidents.





Photo: Images from the Presentation by Tony Rizk: Various Forms of Domestic Corrosion and Remedies.



An online survey was issued to every attendee following the webinar and the Institute will now be taking this course forward based on attendee feedback, incorporating various suggested additions and improvements and will now offer it on a wider basis, to targeted community groups.

All Aberdeen presentations are now uploaded at: **https://www.icorr.org/aberdeen/** and may be found under 'local technical programme'.

Please contact: **icorrabz@gmail.com** if you wish to join the Aberdeen Branch mailing list, or contact: **ABZchair@icorr.org** if you wish to join the Branch committee or deliver a technical presentation.

ICorr India Updates

The ICorr India Branch recently organised a technical presentation on 17th August 2026 by Mr Salil Gadgil of Krishna Conchem Products Pvt. Ltd., Mumbai, India.

Mr Gadgil is a Civil Engineer with over 23 years of experience in the building materials and construction industry, specialising in corrosion mitigation, structural repair and rehabilitation, and protective coating systems. He currently leads marketing support, specification development, certification, and techno-commercial business development for advanced infrastructure protection solutions. A Life Member of ISSE, ICI, IIBE, and ASTR, he has co-authored several technical publications on corrosion protection and structural rehabilitation. His professional interests include concrete durability, FRP systems, structural strengthening, protective coatings and life-cycle performance optimisation.

Mr Gadgil presentation, **"Overview of Vapour Phase Corrosion Inhibitors for Reinforced Concrete Structures: Mechanisms, Applications, Testing, and Case Studies"**, provided a comprehensive overview of Vapour Phase Corrosion Inhibitor (VCI) technology for mitigating reinforcement corrosion in reinforced concrete structures. The presentation explained the fundamentals of steel corrosion, the mechanism by which VCIs protect embedded reinforcement, and their application in both new construction and rehabilitation of existing structures. Drawing on practical field experience and case studies, Mr Gadgil discussed internationally accepted testing methodologies, performance evaluation techniques, selection criteria, advantages and limitations of VCI systems, and their long-term effectiveness under chloride-exposed environments. He also highlighted recent developments, ongoing research, and the need for standardised specifications to support wider adoption of VCI technology in the construction industry. The presentation generated good discussion. Members appreciated the practical insights and real-world examples presented during the session. The ICorr India Branch thanks Mr Salil Gadgil for delivering an informative and engaging presentation and thanks all members and guests who attended and contributed to the event.



Photo: Salil Gadgil.

Members interested in Continuing Professional Development (CPD) opportunities or wishing to join the ICorr India Branch mailing list are encouraged to contact the Branch at **INDIAchair@icorr.org**

ICorr London Updates



The first technical meeting of the 2026/27 season will be held on 8th October 2026 at 18:30. This will be a joint meeting with the London Materials Society (LMS), a local society of IOM3. Guus Coolegem, founder and CTO of C-Cube, will present "How can you measure quality of protective coatings and predict the remaining lifetime" in this joint meeting. Full details of this presentation can be found on the ICorr website, events page.

As Founder and CTO of C-Cube Guus has scaled it from a consultancy into a pioneering technology provider. He remains the architect of C-Cube's core technologies, now applied to major global infrastructure including and the Eastern Scheldt Barrier.

The 37th Annual London Branch, Christmas Luncheon will be sponsored by , ICorr Gold Member, "Interprovincial Corrosion Control Company" **(www.Rustrol.com)** and held on 3rd December at the usual venue, The Royal Overseas League in Mayfair.

Full details of all branch events can be found on the events page in due course.

Please contact at **londonchair@icorr.org** if you would like to join the Branch Committee, deliver a technical presentation or have any other queries.

ICorr Midlands Updates

The ICorr Midlands Branch continues to deliver its programme of webinars and training activities, alongside progressing key initiatives aimed at strengthening engagement with industry and academia.

Webinar Featuring ICorr President, Dr Yunnan Gao

Recently, the branch hosted a webinar featuring ICorr President, Dr Yunnan Gao. The session provided an overview of the Institute of Corrosion, including its structure, services, publications, and collaborative activities, followed by an interactive Q&A session. The event attracted significant engagement, with a high number of registrations and active participation from attendees.

Technical Webinar on Microbiologically Influenced Corrosion

A highly successful webinar on Microbiologically Influenced Corrosion (MIC) in dry gas pipelines was delivered in late May by our ICorr member, Dr Ali Morshed. The session highlighted mechanisms of MIC in nominally dry systems and demonstrated how deficiencies in construction and operation can lead to failures, supported by case histories. This event achieved record attendance, with approximately 240 registrants from 23 countries. A recording is available via the ICorr Midlands YouTube channel.

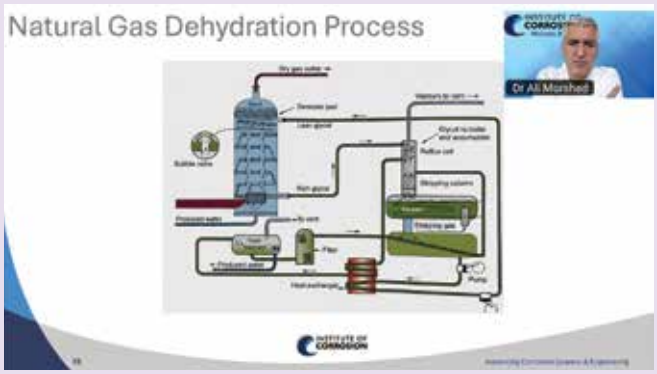


Photo: Snapshot from the Webinar: Dr Ali Morshed (Senior Consultant, AMPP/NACE Trainer and Author) Presenting on Microbiologically Influenced Corrosion (MIC) in Dry Gas Pipelines.

Technical Webinar: Validation of CMI for Pipeline Corrosion Assessment – From a New Method to Proven Practice

On 23rd July, the Midlands Branch hosted a well-attended technical webinar on Current Magnetometry Inspection (CMI) for Pipeline Corrosion Assessment, presented by Mark Glinka, Founder of EMPIT.



Photo: Mark Glinka.

Mark provided an engaging overview of CMI, explaining the scientific principles behind this innovative, contactless above-ground inspection technique for assessing buried pipeline corrosion without excavation or the use of in-line inspection tools. He demonstrated how CMI can be used to identify coating defects and quantify metal loss, highlighting its potential to improve the efficiency and reliability of pipeline integrity assessments.

The presentation also compared CMI with established inspection methods, including In-Line Inspection (ILI), Direct Current Voltage Gradient (DCVG) and Close Interval Potential Survey (CIPS), outlining the advantages and appropriate applications of each technique.

A key focus of the webinar was the validation of CMI through independent research and field applications. Mark shared findings from the German DVGW NEMEK research project, which benchmarked CMI against conventional inspection methods, as well as the results of a blind trial conducted with a major North American pipeline operator using a pipe spool containing artificial defects. The webinar was highly informative and generated considerable interest among participants. The presentation was followed by an interactive Q&A session, with attendees actively engaging in discussions on the capabilities and future applications of CMI technology.

Committee Meeting and Branch Initiatives

The branch held its regular committee meeting on 29 May, during which recent activities were reviewed and priorities for the coming period were discussed. A key initiative underway is the development of a regional database of companies and academic institutions across the Midlands. This activity is intended to enhance outreach to industry, support student engagement, and facilitate sponsorship opportunities for future in-person events.

Training Activities

In early June, the Corrosion Training Programme was successfully delivered as part of its regular biannual schedule by Cranfield University (https://www.cranfield.ac.uk/). The three-day programme provides both theoretical and practical training to professionals in the corrosion and asset integrity field.

ICorr Midlands contributed through delivery of training sessions on Risk-Based Inspection (RBI) and Corrosion Under Insulation (CUI), supporting the branch's objective of promoting corrosion knowledge and engagement with academia and industry.



Photo: Participants in the Corrosion Training Programme at Cranfield University (9th–11th June), including ICorr Midlands Branch Chair Ali Oskuie (right), Dr Stefano Mori (Programme Lead, Cranfield University, centre), and Dr Susanne Impey (Programme Co-Lead, Cranfield University, left).

Please contact Aliakbar Oskuie, Midlands Branch Chair, at **midlandschair@icorr.org** if you would like to join the Midlands Branch mailing list, become a member, deliver a technical presentation or have any other enquiries.

ICorr North-East Updates

The inaugural Engineering NE Golf Day was a resounding success in every respect, marking the start of an exciting new chapter for the tournament.

Hosted by The North of England Institute of Mining and Mechanical Engineering (NEIMME) and supported by the Institute of Corrosion NE Branch, the event has evolved from the Institute of Mining Golf Competition, a tradition dating back more than 150 years.

Held at the City of Newcastle Golf Club on Friday 5TH June, the event benefited from the support of the club's staff, as participants enjoyed a great day of golf, valuable networking opportunities, and even favourable weather throughout the event. The success of the day would not have been possible without the tremendous support of the Institute of Corrosion NE Branch, with special thanks to NE Branch members, Josie Watson and Kevin Dempsey.

"On behalf of our party, I would like to thank you for a very well organised golf day which worked out perfectly," said participant Alan Vasey. "We really enjoyed the day and are already looking forward to next year."

Kevin, Josie, and the event host David Mobbs set the room up with the trophies, refreshments, raffle prizes and banner, before the contestants arrived at 10.00 am for breakfast.

Kevin and David went off in one of the three buggies supplied by the club to set up the Tuck Shop, while Josie started selling raffle tickets. The organisers are extremely grateful to Northern Monk who supplied the refreshments, Thank you to Ross for ensuring no one went thirsty.

The Tuck Shop was situated perfectly on the 9th which is bang in the centre of the course. First Tee-Off was 11.00 am.

The beat the Pro Challenge was on the 2nd, which everybody really enjoyed.



Photo: The Golf Professional Driving at the Beat the Professional Tee.

Then, after 18 holes of the City Golf Club everyone retired to the bar for refreshments and dinner, which was served at 5pm and included pie and chips with sticky toffee pudding.

The trophies were accompanied by a bottle of champagne. On the day, the award for the most golf played would have been won by the Hon Secretary, but as the organiser they were ineligible for the trophy, so it went to Adam Ovington from PPG, which he received with grace. Thank you for the great sportsmanship, Adam.



Photo: The Competition Winners.

NE Engineering Golf Competition			
Trophies			
	Cup	Category	Winner
1	Presidents Cup	Best Stableford Score + 1 bottle champagne	Graham French
2	The Engineers Cup	2nd Best Stableford Score + 1 bottle champagne	Stephen Herron
3	NCB Cup	3rd Best Stableford Score + 1 bottle champagne	Ryan Simmons
4	The Schwarz Hollywell Cup	Longest Drive + 1 bottle champagne (18th)	Richard Graham
5	Garmonsway Trophy	Nearest the Pin (18th)	Richard Betteridge
6	Grace Cup	The Most Golf Played + 1 bottle champagne	Adam Ovington
7	Tyne Tubes Cup	Beat the Pro (2nd)	Ryan Simmons

Financially, the event overachieved its target by £81 and £50 was donated to Maggie's the Cancer Care organisation in Newcastle.

Plans are already in place to hold the competition at the same venue next year on the first Friday in June – Friday 4th June 2027. The event will be larger with 14 x 4 ball teams, and we would ask the Engineering community of the NE to make a note in their diary.


MAGGIE'S

Thank you David

Please contact **nechair@icorr.org** if you would like to join the North East Branch mailing list, become a member of the Branch Committee or deliver a technical presentation.

ICorr North-West Updates

Inaugural Regional Research Exchange Launched in Manchester



Photo: Lunch and Networking Before the Event at the University of Manchester.

The ICorr North West Branch was pleased to co-organise and host the **inaugural ICorr Regional Research Exchange on 26th June 2026 at the University of Manchester**, marking the launch of a new collaborative seminar series connecting academia, early-career researchers, and industry across the North West and Yorkshire and Humber regions.

The event was delivered in partnership with the ICorr Yorkshire and Humber Branch, Young ICorr, and colleagues from the University of Manchester and the University of Leeds. Running from 12:00 to 17:00, the Exchange brought together students, researchers, and industry professionals for an afternoon of technical presentations and networking.

The programme opened with registration, lunch, and introductions from the organisers: **Robert Lindsay (University of Manchester), Joshua Owen (ICorr Yorkshire & Humber Branch Chair), and Izabela Gajewska (ICorr North West Branch Chair).**

In her introduction, Izabela outlined the background to the event, emphasising the importance of strengthening collaboration between ICorr branches, universities and Young ICorr, while also highlighting the need to bring greater industry context into academic discussion. This set the tone for the day, reinforcing the



Photo: Izabela Gajewska (ICorr North West Branch Chair) Outlining the Aims and Context of the Exchange.

Exchange's aim of bridging research and real-world application The technical content was delivered across two sessions, separated by a networking break, encouraging discussion and engagement throughout the afternoon.

A central feature of the Exchange was the strong contribution from early-career researchers, with eight research talks delivered by postgraduate, postdoctoral, and Master's students from the University of Manchester and the University of Leeds. These speakers showcased a broad range of corrosion science and engineering topics, reflecting both fundamental research and applied challenges. The event provided an important platform for emerging researchers to present their work and engage with the wider corrosion community.

The research programme was complemented by invited talks offering both academic and industrial insight. Freda Akwah (Amentum) delivered a presentation on Primary Water Stress Corrosion Cracking, drawing on her experience working within the nuclear industry while Ali Kosari (University of Manchester) examined the role of molybdenum in passivation and localised corrosion. Joshua Owen (University of Leeds) also contributed, presenting on corrosion challenges in carbon capture and storage.



Photo: Freda Akwah (Amentum) Presenting her Talk Titled "Primary Water Stress Corrosion Cracking".

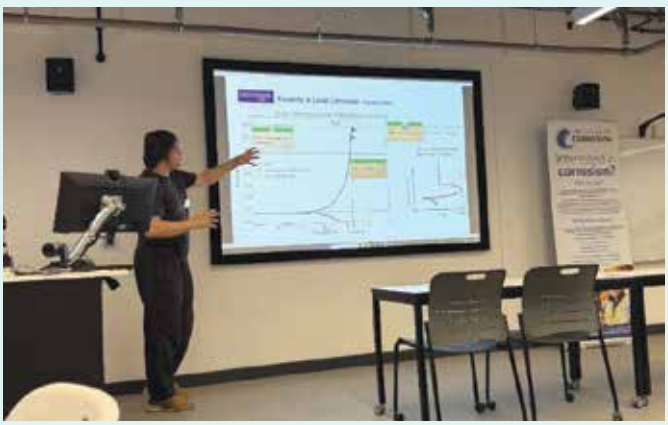


Photo: Ali Kosari (University of Manchester) Presenting His Talk Titled "The Role of Molybdenum in Passivation and Localised Corrosion of Stainless Steels: Atomistic Insights".

Attendees also benefited from a thought provoking presentation by Dr Michael Jones (Deepwater Corrosion Services, Inc.). His comparative insights into academic and industrial research highlighted key differences in priorities and timescales, prompting discussion on better aligning research with industry needs.

continues on page 16



Photo: Dr Michael Jones (Deepwater Corrosion Services, Inc.) Presenting His Talk Titled "Electrochemical Modelling: From Academia to Industry".

The Exchange provided an important opportunity for researchers to present their work, while also reinforcing a key theme: bridging the gap between research and real-world application. Academic insights help shape the questions, while industry ensures they remain relevant and impactful.

The event concluded with a Young ICorr social gathering, providing further opportunity for informal networking and strengthening connections between attendees from both regions.

The Regional Research Exchange will now run on a biannual basis, alternating between Manchester and Leeds. The strong attendance and engagement at this inaugural event have established a solid foundation for what is expected to become a key fixture in the ICorr calendar.

The ICorr North West Branch extends its thanks to all speakers, attendees, and organisers who contributed to the success of the day, with particular recognition to co-organisers Joshua Owen and Robert Lindsay for their significant efforts.

North West Branch Welcomes New Members

The North West Branch is pleased to welcome three new members to the committee: **Fatima Mehnoune, David Hutchinson** and **Kaivalya Borwankar**. Their diverse expertise across industry and academia further strengthens the branch's ability to support and engage the corrosion community.

Dave is the ENI UK Asset Integrity Coordinator, where he leads a team of integrity engineers responsible for the integrity management of pipelines, pipework, and pressure vessels across Liverpool Bay and the Southern North Sea. His role also encompasses work associated with decommissioning and the repurposing of infrastructure for carbon capture and storage (CCS).



Photo: David Hutchinson

He has a strong background in mechanical and pipeline integrity within the onshore chemical and oil and gas sectors, with extensive experience in inspection, repair, modification, and regulatory compliance of major accident hazard assets. His current focus is on supporting the safe transition of existing infrastructure into CCS service while ensuring continued compliance with the Pipeline Safety Regulations during this critical phase.



Photo: Fatima Mehnoune

Fatima is a Corrosion Engineer and Project Lead at Intertek CAPCIS, specialising in materials qualification and environmentally assisted cracking mechanisms, including hydrogen embrittlement (HE), hydrogen-induced cracking (HIC), and stress corrosion cracking (SCC). She has a background in Chemical and Process Engineering and holds an MSc in Advanced Process Integration and Design from The University of Manchester.

Over recent years, she has led complex testing programmes within UKAS-accredited environments, generating critical data to support materials qualification, integrity assessments, and client-specific qualification requirements across the energy sector. Fatima joined ICorr to further develop her expertise within the corrosion and integrity community, expand her professional network, and contribute to the advancement of corrosion engineering. She is keen to engage with fellow members of the North West Branch.



Photo: Kaivalya Borwankar

Kai is a Corrosion Engineer at Baker Hughes. He previously completed his PhD at The University of Manchester, where his research focused on imaging organic anti-corrosion coatings across multiple length scales to better understand the mechanisms of coating degradation and failure. Kai is also an active member of the Young ICorr Committee, serving as Awards Co-ordinator. He is keen to use his involvement with ICorr to connect with experts from both industry and academia, while contributing to outreach activities that promote corrosion science. Outside of his professional and academic commitments, Kai enjoys travelling, reading, video games, and exploring spicy cuisine.

Please contact at **nwchair@icorr.org** if you would like to join the North West Branch mailing list, become a member of the Branch Committee or deliver a technical presentation.

ICorr Wales and South West Updates

The branch successfully hosted a social event in collaboration with NCMS, part of IOM3's Newport and Cardiff Branch, at the Holland Hotel, Cardiff, on 12th February 2026. The evening featured a three-course dinner and provided an opportunity to celebrate the branch's activities, engage with colleagues from the wider materials and engineering community, and foster collaboration between IOM3 and ICorr members.



Photo: ICorr Leaders and Members at the Social Event.

The branch also held an in-person event on Thursday 19th March 2026 at Mott MacDonald's offices in Bristol. The session featured two technical presentations: Dr John Edwards (Kent PLC) presented on "How Corrosion Engineering Has Evolved to Support the Green Energy. Transition, Particularly in Offshore Wind, Building on Experience from the Oil and Gas and Petrochemical Industries." Dr Rene Brueckner gave a presentation on corrosion in reinforced concrete and potential protection methods.

A total of 11 delegates attended, with lots of engagement and interaction. Before the event, the committee held the AGM and appointed Rene Brueckner as Branch Chair and Maryam Bonyadi as Vice Chair after Sarah Bagnell stepped down from the position following two years of doing a fantastic job in getting the branch started, organising many events, and putting a great succession plan in place. Many thanks to Sarah.

2026/2027 Session Executive Committee

The ICorr Wales & South West 2026/2027 executive committee is as follows:

1. Chair: Dr Rene Brueckner
2. Vice Chair: Dr Maryam Bonyadi
3. Secretary (External): Sarah Bagnall 4. Secretary (Internal): Dr Chris Weirman 5. Finance & Sponsorship Officer: Sian Hill
6. Event Co-ordinator: Syed Umair Niaz Bukhari
7. University Liaison & CPD Officer: Barrie Goode

Please contact Rene Brueckner, Branch Chair, at **swchair@icorr.org** if you are interested in joining the Branch Committee, delivering a technical presentation or have any other enquiries.

ICorr Yorkshire and the Humber Updates

The Yorkshire and Humber Branch has been busy this month, organising a new ICorr Regional Research Exchange in partnership with the ICorr North West Branch, the University of Manchester and the University of Leeds.

The inaugural event, held on 26th June, attracted an impressive turnout of students and professionals from across both regions. Building on this momentum, the Branch is now preparing for the second Research Exchange, scheduled for later in 2026 (date to be confirmed). This upcoming event will be hosted at the University of Leeds.

If you wish to join the Branch Committee, deliver a technical presentation or have any other enquiries, please contact Branch chair at yorkshirechair@icorr.org.

Visit the ICorr website for all the latest news www.icorr.org

Young ICorr Updates

It has been a fantastic year so far for Young ICorr, with strong engagement across all our activities and a growing number of students and early-career professionals taking advantage of the opportunities available through the Institute.

Young Engineers Programme Reaches New Heights

The Young Engineers Programme (YEP) has continued to flourish, attracting excellent attendance and delivering a series of high-quality technical sessions that have been both informative and engaging. The positive feedback received throughout the programme has been a testament to the enthusiasm of participants and the calibre of the speakers involved.

Our sincere thanks go to **Jane Lomas, Paul Lambert, Alan Denney and George Winning**, whose presentations were exceptionally well received and provided valuable insights drawn from their extensive industry experience. We would also like to thank **Michael Kuhn** for delivering an excellent session on coatings, which proved particularly popular with attendees. One of the most exciting developments this year has been the launch of the **YEP Case Study Challenge**. The case study caused a tremendous level of excitement among attendees and teams quickly gathered to begin tackling the challenge. Feedback from attendees has been overwhelmingly positive, with many highlighting the opportunity to work collaboratively on a real-world industry problem as one of the programme's most valuable experiences.



Photo: YEP Case Study Reveals Participants.



Photo: Participants Listening to a Presentation Delivered by the YEP Committee During the Session.

A special thanks goes to **Intertek** for providing the case study and helping to bring this initiative to life. We are also grateful to **Andy Piercy** for leading the case study and introducing participants to the challenge. The continued support of **BP** and **Mott MacDonald** has also been invaluable in helping the programme grow and succeed.

Mentoring the Next Generation

Interest in the YICorr Mentorship Programme continues to increase, with a growing number of early career professionals expressing an interest in being paired with experienced industry mentors.

Mentorship remains one of the most rewarding ways for members to contribute to the future of the profession, providing guidance, encouragement and practical career advice to those just starting their corrosion journey. We would encourage any interested parties – mentors or mentees to apply on the website at https://www.icorr.org/young-icorr-mentorship-scheme/

Graduate Membership Tier Moves Forward

We are delighted that the proposed **Graduate Membership Tier** has now been approved by the ICorr Board and is currently in development. The new membership category is expected to launch later this year and will provide additional support for members transitioning from education into professional careers.

This initiative represents an important step in strengthening the pathway from student membership to full professional membership, helping young professionals remain supported by the Institute during the early stages of their careers.

Student Lecture Series Success in Manchester

Collaboration continues to be at the heart of Young ICorr activities, and this was clearly demonstrated by the highly successful **Student Lecture Series event held in Manchester** in partnership with the **Yorkshire and North west Branches.**

The event attracted strong attendance and provided students with an excellent opportunity to learn more about corrosion engineering, hear from industry experts and connect with professionals from across the sector. The enthusiasm shown by attendees highlighted the importance of these events in inspiring the next generation of corrosion specialists.

Looking Ahead

Plans are already underway for the next phases of our activities, including continued collaboration with **YEFC** and the **Midlands Branch** on the popular **Skills for Corrosionists** series. An upcoming session focusing on personal branding and networking skills will help participants develop the broader professional capabilities needed for a successful career.

With a thriving Young Engineers Programme, growing mentorship opportunities, an exciting new Graduate Membership Tier on the horizon and continued engagement with students across the UK, the future looks exceptionally bright for Young ICorr. We would like to thank everyone who has contributed their time, expertise and enthusiasm in supporting our activities and helping to develop the next generation of corrosion professionals.

If you have any enquiries, please contact young ICorr chair at youngicorrchair@icorr.org

Applying for Upgrades - Helping Us to Help You

We have a healthy stream of corrosion professionals applying for the Technical, Professional and Fellow grades of the Institute and long may that continue. Every application for the professional grades is peer reviewed by members of the Professional Assessment Committee, all of whom are volunteers.

The predominantly voluntary nature of many of the roles within the Institute not only keeps the cost of membership as low as possible but also ensures that every applicant is truly assessed by a group of their peers who consider each request on the merits of the applicant. We are very proud to be able to maintain this model which differentiates us from many other professional bodies.

To allow this to function efficiently we rely on the applicants to follow the guidance in the Membership Regulations and also ensure that their referees are aware of the requirements. When an application form and its accompanying referee forms are filled in accordance with this guidance, the assessment of the application can be carried out quickly and a recommendation made and passed onto for final approval by the ICorr Council in the shortest time possible. But where corners are cut or the regulations largely ignored, assessment becomes difficult and the whole process slows down or stalls completely as the opinions of other Assessors are sought and additional information is requested from the Applicant and their referees. So, I send out a heartfelt plea to anyone considering applying for an upgrade to any level of Professional Membership – help us to help you by carefully reading the Membership Regulations and Guidance Notes and ensure your referees do the same. Next spend a little time filling in the forms as directed and if there is any uncertainty about what is required contact the Institute and ask for assistance. While it is tempting to simply state 'see attached CV' under as many headings as possible, it is far more effective (and compliant with the requirements) to make sure the relevant information is extracted and included in each of the sections.

If you do it that way (also known as the correct way, as stated in the regulations and in the forms themselves) the assessors can quickly see how the stated requirements are satisfied, identify and apparent shortfalls that may require a quick follow up to clarify (a phone call is often all that is needed) and together we can ensure that applications are dealt with promptly and the Professional Assessors are able to retain what little hair (and/or sanity) they have left. I thank you all in advance.

Paul Lambert, Chair – Professional Assessment Committee, Email pac.chair@icorr.org



Engineering Intelligence: Creating Impact Through Knowledge, Leadership and Mentoring

To celebrate International Women in Engineering Day on the 23rd June, I wanted to share reflections on this year's theme – *Engineering Intelligence* – which resonates strongly with me. While often associated with technical expertise and problem-solving, it also reflects curiosity, adaptability, communication, and a commitment to continuous learning and supporting others.

My journey into corrosion and integrity engineering has not been entirely conventional. I began by studying Chemical Technology in Poland, specialising in composites and nanomaterials, before moving to the UK to continue developing my career. Early experiences across laboratory work, logistics, and supply chain roles helped me build strong organisational and communication skills-foundations that continue to shape how I approach engineering challenges. In 2019, I transitioned into corrosion consultancy and found a field that combines science, engineering, and real-world impact.



Photo: Discussion with ICorr Young Engineer Programme 2024-2025 Participants at the Final Event, London, 2024.

More recently, I have also been involved in laboratory-based work within a sour service department environment, preparing metal samples for testing and carrying out post-test assessment. This hands-on experience has provided valuable insight into material behaviour, failure mechanisms, and the practical side of testing–further strengthening my understanding of corrosion processes and integrity performance.



Photo: Site Visit to UK Energy Operations Site, 2023.

Corrosion engineering is often unseen, yet it plays a vital role in maintaining the safety, reliability, and performance of safety-critical systems. It requires detailed analysis, critical thinking, and the ability to make informed decisions that stand the test of time. This is where engineering intelligence comes to life-combining knowledge with judgement and foresight to ensure long-term integrity and reduce risk.



Photo: Awaiting Presentation Delivery at the CEOCOR International Congress, Bratislava, Slovakia, 2023.

Beyond my technical work, mentoring and knowledge-sharing are central to my professional journey. Through my involvement with Young ICorr and the Institute of Corrosion, I am passionate about supporting early-career engineers. Having completed the ICorr Young Engineer Programme myself, I now contribute to initiatives that help others build confidence, develop expertise, and form valuable connections. More recently, taking on the role of North West ICorr Branch Chair has been an important milestone, allowing me to strengthen regional engagement and support collaboration within the corrosion community.

I also strongly believe in the importance of visibility and representation. By sharing experiences and engaging in professional activities, I hope to inspire others–especially women– to see engineering as a space where they can thrive and contribute meaningfully.



Photo: Parliamentary and Scientific Committee discussion meeting 'Reuse, Renew or Replace?', Portcullis House, Westminster, London, 15th October 2024. Above (left to right): Prof. Dr. Gareth Hinds (Past ICorr President/Speaker), Christian Stone (ICorr Speaker), Stephen Tate (ICorr Immediate Past President/Speaker), Stephen Benn (3rd Viscount Stansgate), Izabela Gajewska (ICorr Speaker), David Parker (ICorr Speaker), David Mobbs (Coatings Specialist). Photo credit: The Parliamentary & Scientific Committee.

International Women in Engineering Day is both a celebration and a reminder of the importance of inclusion. Engineering intelligence grows through collaboration, shared experience, and diverse perspectives and I am proud to be part of a profession that continues to evolve and make a difference worldwide.

Company Fined £350,000 After Chemical Tank Collapse Left Worker with Life-Changing Injuries

- A 700-tonne tank containing calcium chloride was more than 30 years old and corrosion was first identified a decade before incident.
- 62-year-old left with life-changing injuries and not been able to work since.
- Peterhead base handles thousands of ship movements each year.

A company has been fined £350,000 after the catastrophic collapse of a storage tank at its Peterhead premises which left a self-employed worker with life-changing injuries.

The Health and Safety Executive (HSE) investigated the incident, which occurred on 21st June 2023 at Tetra Technologies UK Limited's offshore supply base. The base handles around two thousand ship movements per year, supplying North Sea oil and gas installations with deck cargos and quantities of fluids.



Photo: A Still of Drone Footage Captures the Aftermath

Philip Moir, a 62-year-old self-employed rope access technician, was on site conducting surveys of storage tanks when Tank 7 — a bolted steel tank holding approximately 480,776 litres of calcium chloride solution weighing around 700 tonnes — catastrophically ruptured without warning.

Mr Moir was almost immediately immersed to chest height in the released fluid. He was subsequently found slumped over the wheel of a nearby cherry picker, which itself, along with a Ford Transit pickup, a small skip and the cherry picker — weighing twelve and a half tonnes — had all been displaced by the force of the escaping fluid.



Photo: The 700-Tonne Tank Was More Than 30 Years Old.

Mr Moir sustained a double fracture of his spine and pelvis, lacerated liver, punctured lung, multiple rib fractures, fractured sternum, a fractured wrist, and extensive chemical burns requiring skin grafts. He has not worked since the incident and is unable to climb ladders or work at height, injuries described as life-changing.



Photo: HSE Inspectors Arrived on Site and Took This Photo of the Scene.

HSE's investigation, conducted by both regulatory and specialist inspectors, identified that the structural failure occurred around halfway up the tank shell, where the third row of plates split vertically along a bolted seam. Approximately 4.5 mm of the original 5.5 mm steel plate had been lost through corrosion over time, leaving just 1 mm of steel unable to withstand the outward forces of the fluid within. Investigators found that the loss of any protective coating had left the steel surfaces exposed to aggressive coastal air, accelerating external degradation. The density of calcium chloride — more than one third denser than water — further increased the forces applied to the already weakened structure.

The tank was more than 30 years old and the manufacturer's maintenance manual required six-monthly checks of seams and bolts, and annual external inspections for corrosion. An inspection in 2013 had already identified extensive outer surface corrosion over the lower section of the tank and corrosion at bolted connections, yet no remedial work was carried out on Tank 7. The company was unable to provide evidence of any regular inspection regime being followed in the years that followed.

HSE concluded that the failure of the tank was wholly foreseeable and preventable.

Source: https://www.hse.gov.uk/

ETGB Corner

ETGB Corner

Chair Introduction

Welcome to this issue of ETGB Corner, highlighting recent developments from the ICorr Engineering Training Governing Board and our continued progress toward a comprehensive, globally accessible training portfolio.

The past period has been notably productive. Three new business cases have been submitted to ICorr Council for development approval, reflecting our commitment to expanding high-quality, relevant training for both professional and civic audiences, and to further establishing ICorr as a global direct provider of corrosion-related courses. ICorr tutors continue to deliver the ETGB portfolio across the UK and internationally, both directly and through our network of global partners. If you work in the training sector and meet ICorr qualification criteria, we invite you to enquire about collaboration opportunities in your region.

This issue features two new courses developed in direct response to member and industry feedback: Galvanic Corrosion and Production Chemistry for Corrosion Engineers. We are also pleased to report the successful pilot of Corrosion at Home and Its Prevention, held at the end of last month. The session attracted strong engagement (96 registered and 63 participated) demonstrating the public's growing interest in understanding and addressing everyday corrosion challenges, and providing valuable insights to support wider rollout.

We welcome your comments on ETGB Corner.
For further information, please contact Dr Tony Rizk at ETGBchair@icorr.org, and for registration enquiries, please reach out to ICorr Administration at **admin@icorr.org**

Training Course 1: Galvanic Corrosion

Galvanic corrosion continues to be a cause of service failures despite there being information on how to avoid it. The galvanic corrosion course is designed to describe the factors that both cause it and exacerbate it, and to recommend ways of preventing or combatting it.

The half-day course is split into four short modules. The first addresses the causes of galvanic corrosion and the importance of each in typical failures. The second module discusses galvanic corrosion in both seawater and fresh waters and what materials may be safely connected together. The third module discussed galvanic corrosion in the atmosphere, and the final module discusses the various ways of preventing or minimising galvanic corrosion.





Photo: Course Tutor, Roger Francis, CENG, FNACE, MIMMM.

Training Course 2: Production Chemistry for Corrosion Engineers

The course is designed to provide specialised knowledge at the intersection of production chemistry and corrosion management. Originally developed within industry and kindly donated by BP. It brings a strong foundation of practical, real-world knowledge rooted in decades of operational experience. At its core, production chemistry focuses on the behaviour of reservoir fluids, and the impact this has on flow, separation, and long-term asset integrity. It is structured around three key pillars:

- **Separation** – Ensuring produced fluids (oil, gas, and water) are efficiently separated to maximise product value and meet export specifications.
- **Flow Assurance** – Identifying and mitigating restrictions that prevent hydrocarbons from moving from the reservoir to the customer, including chemical and physical blockages.
- **Integrity Management** – Protecting infrastructure from corrosion and degradation, ensuring long-term operability and safety.



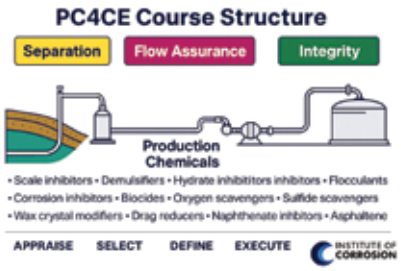


Photo: Course Tutor, George Winning, FICorr, Hon. FAMPP.

All course fees are carefully aligned with ICorr non profit ethos, ensuring excellent value for organisations investing in staff development. We also offer an attractive package for group bookings, whether for scheduled UK deliveries or on site training at company premises worldwide.

For further information, registration, or to express interest in developing a corrosion related training course, please contact Dr Tony Rizk, ETGB Chair, at **ETGBchair@icorr.org**

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Introducing Our ICorr CP Training Tutors - Ashokan Gopal

Welcome back to our *Meet the ICorr Trainers* series, where we introduce the expert trainers behind our ICorr Coating Inspection courses.

This month, we're pleased to feature Ashokan Gopal, ICorr Level 4 - Cathodic Protection Specialist



Ashokan Gopal, MSc, CEng, FICorr

- **ICorr Level 4 - Cathodic Protection Specialist**
- **NACE CP4 - Cathodic Protection Specialist, Senior Corrosion Technologist, Internal Corrosion Technologist**

Ashokan is a Chartered Engineer with a Master's in Corrosion Control Engineering from the University of Manchester. Further, he is accredited with reputable industry certifications such as ISO 15257 level 4 Cathodic Protection Specialist and AMPP (formerly NACE) CP-4 Cathodic Protection Specialist, Senior Corrosion Technologist and Internal Corrosion Technologist. He is proficient in advanced diagnostic tools used in cathodic protection testing methodologies, remote monitoring systems, and providing integrated approaches owing to the changing trends and new challenges evolving in the cathodic protection industry.

With over 18 years of experience in the field of corrosion mitigation and cathodic protection, Ashokan Gopal is an electrochemical engineer and an industry-recognised cathodic protection expert in the UK. He is currently the chairman for the London ICorr Branch and an active member of the ICorr CPGB, working closely with the industry's best minds.

He has rich hands-on experience in corrosion engineering and cathodic protection, working with various industries in the oil and gas sector across five continents. and is well versed in standards and regulations such as ISO, NACE, and ASTM.

As a practising CP specialist, he also has wide experience in design & engineering for various facilities ranging from simple to complex configurations, including offshore structures and subsea pipelines. His strength is in approaching challenges pragmatically and getting to a win-win situation, and this is evident in all of his CP solutions developed.

He has been tutoring ICorr's BS EN ISO 15257 cathodic protection buried on-land metallic sector courses since 2023. His insights on the way the courses are developed are remarkable, and it guides step-by-step progress starting from Level 1 to Level 3 to achieve astounding technical proficiency.

Ashokan approaches technical tutoring with interactive lessons, breaking complex concepts with case study examples, visual aids, and real-life experience and showing how that has evolved. As an established ICorr tutor, he has mentored many trainees who are now successful cathodic protection engineers in various organisations.



Photo: Ashokan Gopal at the CP Themed ICorr Aberdeen Corrosion Awareness Day in August 2025.

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Industry News

The Architecture, Mechanical Performance and Atmospheric Durability of a Triple Resin DTM Coating System

Jeremy Pasatta, Vice President of Technology, Advanced Polymer Coatings, Avon, OH, USA

Introduction

Industrial coatings face extreme and varied stressors: chemical exposure in processing facilities, ultraviolet light and weathering in outdoor service, vibration and impact in transport, and high humidity or temperature fluctuations in storage. Traditional solutions rely on multi-layer systems, each designed for a separate performance role. While technically effective, such systems introduce practical drawbacks: long cure times, complex application requirements, sensitivity to environmental variables, and risks of inter-coat adhesion failure.

Asset owners demand coatings that can perform multiple functions under real-world conditions across sectors such as rail transport, chemical processing, and heavy industry. Coatings must resist corrosion and chemical attack, remain flexible under vibration or thermal cycling, retain gloss and colour under UV light, and be applied efficiently in environments that may be less than ideal.

Advanced Polymer Coatings (APC) have developed a triple resin DTM (direct-to-metal) system to meet these evolving needs. This system merges the performance benefits of multi-coat structures into a single, co-cured architecture.

The triple resin coating system represents a deliberate shift away from this paradigm, integrating three distinct resin chemistries into a single film seeks to balance chemical resistance, mechanical toughness, UV durability, and rapid cure in one step. Co-curing ensures compatibility between components and creates a uniform polymer network with balanced properties. The result is a formulation designed not only for laboratory excellence but also for field reliability.

This paper integrates three complementary investigations of the system:

1. **Atmospheric Durability** – assessment of UV stability, corrosion protection, chemical spot testing, and heat ageing.
2. **Mechanical Performance** – using ASTM standards to evaluate adhesion, flexibility, and impact resistance.
3. **Performance Architecture** – an in-depth look at resin selection, formulation strategy, and co-curing integration.

Atmospheric Durability of a Triple Resin DTM Coating

Materials and Test Methods

QUV Accelerated Weathering (ASTM D4587)

12" x 12" (30 x 30 cm) steel panels were sprayed with the triple resin coating system, along with three competitive epoxies. Each panel was partially masked to preserve an unexposed control area. Panels were subjected to 750 hours of UV exposure using UVA-340 bulbs. Colour stability was measured using Lab* colour space and Delta E calculations to quantify change.

Dry Heat Ageing (120°C, 720 Hours)

Performed by GPI Laboratories Project ID: N102301.B. The triple resin coating system panels were exposed to 120°C for 720 hours to simulate continuous high-temperature service. The post-exposure evaluation included visual assessment per ASTM D660 and D772 and adhesion testing per ASTM D4541.

Corrosion Testing (ISO 12944-6:2018)

Performed by KTA-Tator, INC. Project No. 66075853-R2. Panels coated at 6.0-8.0 mils (150-200 microns) were subjected to salt spray (ISO 9227), humidity (ISO 6270-1), and cyclic ageing. Each test included multiple durability classifications from C3 to C4 (Low through Very High). The assessment included rusting, blistering, cracking, and scribe creep.



Figure 1: KTA-Tator, INC. Project No. 66075853-R2.

Chemical Spot and Humidity Testing (ASTM D1308, D2247)

Panels were exposed to ten aggressive chemicals for 72 hours at 23°C. The post-exposure evaluation included blistering (ASTM D714), rusting (ASTM D610), and visual degradation. Separate humidity exposure was performed at 38°C in 100% humidity for 1000 hours.

Spot and Spill Acid Resistance

Panels were exposed to concentrated acids, including nitric, phosphoric, sulphuric, acetic, and hydrochloric, for up to 72 hours. Gloss loss, discolouration and film integrity were evaluated.

Results and Discussion

QUV Accelerated Weathering (ASTM D4587)

After 750 hours of UVA-340 exposure, the triple resin panels showed only minor discolouration and gloss loss compared to epoxies. Delta E measurements confirmed superior colour stability, highlighting its enhanced UV resistance. Masked panels directly compared exposed vs. unexposed areas, demonstrating long-term aesthetic retention. This enhanced performance is considered due to UV-stable polyaspartic and polyurethane resins that absorb and dissipate radiation without the chain scission typical of conventional epoxies.

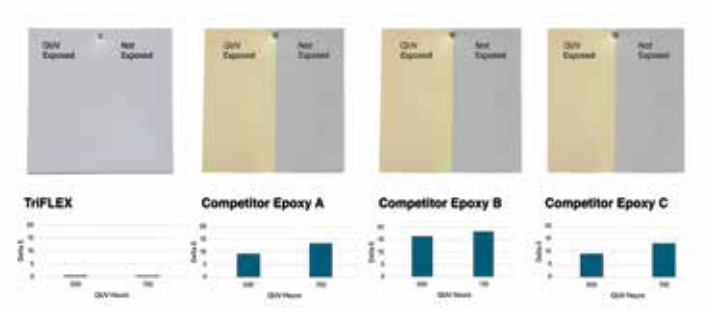


Figure 2: Results of QUV Accelerated Weathering (ASTM D4587) Testing at 500 and 750 Hours, Showing that TriFLEX Maintains Colour Stability with Minimal Change, While Competitor Epoxies A, B, and C Exhibit Significant Yellowing and Higher Values After Exposure.

Dry Heat Ageing Performance (120°C for 720 hours)

After prolonged exposure at 120°C, the triple resin system maintained structural and adhesive integrity, with no cracking, flaking or blistering. Adhesion exceeded 3600 psi, with cohesive rather than interfacial failure, suggesting strong thermal stability and possible cross-linking benefits. Minor discolouration and gloss loss were superficial, confirming suitability for continuous dry heat service up to 120°C.

Corrosion Resistance (ISO 12944-6:2018)

Corrosion testing by KTA-Tator, including salt spray, humidity, and cyclic aging per ISO 12944-6, showed the triple resin system met or exceeded C4 durability requirements. Panels exhibited no rusting, blistering, flaking, or cracking, and adhesion remained intact. Scribe creep was minimal and within limits, with only the most extreme accelerated regime causing higher creep than allowed. Overall, the results confirm the system as a reliable corrosion barrier for demanding coastal and industrial environments.

$$M = \frac{C - W}{2}$$

Where: M = Corrosion of the substrate from the scribe
W = Width of original scribe
C = Average of nine corrosion width measurements

Table 4 - Results Following Neutral Salt Spray Exposure

Panel ID	Durability	Exposure Time	Dates of Exposure	Blistering Rating	Rusting Rating	Cracking Rating	Flaking Rating	Corrosion from the Scribe (M)	Individual Adhesion Ratings	Average Adhesion Rating
27B	C4 Low	240 Hours	12/08/23 to 12/18/23	0 (S0)	Ri 0	0 (S0)	0 (S0)	0.1 mm	0, 0, 0	0
35F				0 (S0)	Ri 0	0 (S0)	0 (S0)	0.3 mm	0, 0, 0	0
27B	C4 Low	240 Hours	12/08/23 to 12/18/23	0 (S0)	Ri 0	0 (S0)	0 (S0)	0.3 mm	0, 0, 0	0
32F				0 (S0)	Ri 0	0 (S0)	0 (S0)	0.4 mm	0, 0, 0	0
39F				0 (S0)	Ri 0	0 (S0)	0 (S0)	0.3 mm	0, 0, 0	0
21B	C4 Medium	480 Hours	12/08/23 to 12/28/23	0 (S0)	Ri 0	0 (S0)	0 (S0)	0.3 mm	0, 0, 0	0
32F				0 (S0)	Ri 0	0 (S0)	0 (S0)	0.4 mm	0, 0, 0	0
34F				0 (S0)	Ri 0	0 (S0)	0 (S0)	0.6 mm	0, 0, 0	0
3B	C4 High	720 Hours	12/06/23 to 1/05/24	0 (S0)	Ri 0	0 (S0)	0 (S0)	0.4 mm	0, 0, 0	0
9F				0 (S0)	Ri 0	0 (S0)	0 (S0)	0.4 mm	0, 0, 0	0
31F				0 (S0)	Ri 0	0 (S0)	0 (S0)	0.6 mm	0, 0, 0	0
11B	C4 Very High	1440 Hours	12/08/23 to 2/06/24	0 (S0)	Ri 0	0 (S0)	0 (S0)	0.6 mm	0, 0, 0	0
17F				0 (S0)	Ri 0	0 (S0)	0 (S0)	1.4 mm	0, 0, 0	0
28F				0 (S0)	Ri 0	0 (S0)	0 (S0)	2.4 mm	0, 0, 0	0

Chemical Spot and Humidity Resistance (ASTM D1308 and D2247)

The triple resin coating system strongly resisted aggressive chemicals, including concentrated acids and bases. After 72 hours of exposure, only minor gloss loss or surface yellowing was observed, with better retention of appearance and integrity than a leading epoxy. In 1000 hours of humidity testing at 38°C, panels exhibited minimal blistering, reduced underfilm corrosion, and superior adhesion.

These results confirm the system's suitability for environments with frequent chemical contact and sustained moisture.

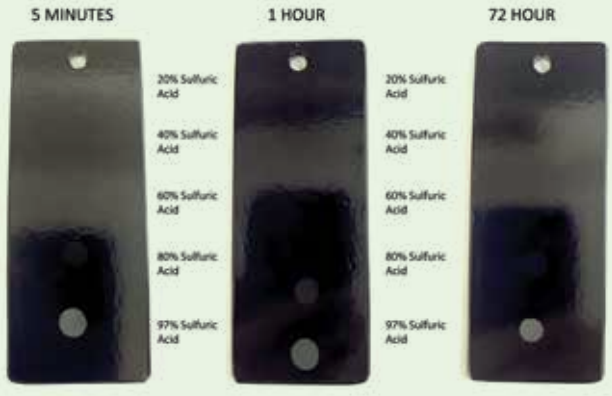


Figure 3: Results of Spot and Spill Acid Resistance Testing for TriFLEX™ Panels.

Formulation Strategy and Resin Components

The foundation of this approach lies in the deliberate selection and chemical compatibility of three primary resins:

- a Cyclic polyolefin-based polymer,
- a Cycloaliphatic polyurethane, and
- an Aliphatic polyaspartic (fast-curing, durable resin).

continues on page 26

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Each resin contributes to a specific performance domain, and together, they co-react to form a single crosslinked polymer network during cure.

Cyclic Polyolefin-Based Polymer

Serving as the primary barrier resin, the cyclic polyolefin-based polymer provides the dense, inert matrix necessary for chemical resistance and moisture impermeability. Unlike traditional epoxies, which often embrittle over time or under cyclic loading, this polymer retains its flexibility and integrity. Its molecular structure is characterised by tightly packed chains and minimal free volume, which translates into low water vapour transmission rates and high resistance to underfilm corrosion.

Cycloaliphatic Polyurethane

The second resin in the formulation is a cycloaliphatic polyurethane, chosen for its resistance to ultraviolet degradation and weathering. Derived from sterically hindered aliphatic isocyanates and UV-stable polyols, this polyurethane is chemically engineered to avoid the common pitfalls of aromatic variants, which degrade quickly under UV exposure.

Aliphatic Polyaspartic Resin

Completing the resin triad is an aliphatic polyaspartic resin formed by reacting a polyaspartic ester with an aliphatic isocyanate. This component offers several key benefits. First, it enables a rapid cure profile, reducing overall project timelines. Second, it is highly tolerant to humidity and temperature variations during application. These properties are particularly useful in real-world environments where conditions are rarely ideal.

Resin Integration Through Co-Curing

While each resin in the system offers unique attributes, the formulation's performance depends on more than just its individual properties. Central to the system's effectiveness is its co-curing behavior. Unlike traditional multi-coat systems, where each resin is applied and cured in isolation, the triple resin formulation is designed for simultaneous chemical reactions.

This co-curing strategy addresses several critical challenges. First, it prevents phase separation, a common issue when combining chemically dissimilar polymers. The resins in this system are selected for their function and compatibility in terms of reactivity, polarity, and molecular weight distribution. Second, simultaneous cure minimises differential shrinkage and stress accumulation within the film. These unmitigated stresses can lead to cracking or delamination over time.

The result is a coating with a uniform modulus profile across the film thickness. This uniformity enhances both mechanical toughness and resistance to environmental degradation.

Furthermore, the system achieves a high crosslink density, improving chemical resistance and moisture impermeability. The balance of hardness and flexibility achieved through co-curing is especially significant, as most conventional coatings tend to favour one of these properties at the expense of the other.

Application and Performance Considerations

From a practical standpoint, this triple resin coating system is designed to perform in varied and unpredictable environments. Its moisture-tolerant cure behaviour, primarily driven by the polyaspartic component, allows for application under high-humidity or low-temperature conditions without introducing common defects such as amine blush or incomplete film coalescence.

The barrier properties of the cyclic polyolefin base bolster the formulation's chemical resistance. At the same time, the cycloaliphatic polyurethane ensures surface durability in the presence of UV light, cleaning agents, and temperature fluctuations. The three resins contribute to a versatile performance profile that addresses the full range of chemical, mechanical, and aesthetic challenges commonly encountered in protective coatings.

In addition, the single-coat approach simplifies logistics. It reduces labour requirements, eliminates inter-coat inspection steps, and shortens turnaround time. This streamlined process is particularly advantageous in fast-paced project environments or settings where consistent environmental control is difficult.

Mechanical Performance of a Triple Resin DTM Coating

Materials and Test Methods

Adhesion Testing with Surface Conditioner

To evaluate the system's adhesion to steel substrates under realistic surface conditions, carbon steel panels were prepared via dry abrasive blasting to a near-white metal finish (SSPC-SP10 / NACE No. 2). Panels were then exposed to three different pre-coating treatments:

- No submersion (control)
- Submersion in distilled water
- Submersion in a 50:1 water dilution of HoldTight® 102

HoldTight® 102 is a biodegradable, non-flammable surface preparation additive that removes soluble salts and prevents flash rusting post-blasting. Although widely used in field settings, its compatibility with high-performance coatings must be verified to ensure no adverse impact on adhesion.

After treatment, panels were coated with the triple resin coating system Grey at an average dry film thickness (DFT) of 8 mils (203 microns) and cured under ambient laboratory conditions (23 ± 2°C, 50 ± 5% RH) for seven days. Pull-off adhesion was tested per ASTM D4541 using an Elcometer 510 hydraulic adhesion tester with 20 mm aluminium dollies. Failure modes were classified as adhesive (at the substrate), cohesive (within the coating), or interfacial (between coating and dolly).

Flexibility Testing

Flexural properties were assessed using the ASTM D522 Method A test for cylindrical mandrel bend. Coated panels were conditioned for 7 days post-application and then bent 180 degrees over mandrels of decreasing diameter, ranging from 1 inch (25.4 mm) to 1/8 inch (3.2 mm). The smallest mandrel diameter with no observed cracking was recorded. In parallel, a qualitative assessment of the coating's crack resistance was performed by manually flexing fully cured panels back and forth to evaluate performance under repetitive bending stress, simulating flexural fatigue.



Figure 4: Mandrel Bend Test Performed on a TriFLEX™ Coated Panel.

Impact Resistance Testing

Impact resistance was evaluated by ASTM D2794, using a falling weight impact tester capable of delivering both direct and reverse impact. A hemispherical indenter was dropped from a fixed height to apply a known energy load (measured in inch-pounds) to the coated surface. For direct impact, the indenter contacted the coating directly. For reverse impact, force was applied to the uncoated backside of

the panel. Failure was defined by visible cracking, delamination, or complete rupture of the coating film. The system's results were compared to reference data from standard epoxy coatings.

Results and Discussion

Adhesion Performance

The average adhesion strength across all test conditions remained consistent. The control panel exhibited a pull-off strength of 1802 psi, while the distilled water-treated and HoldTight® 102-treated panels measured 1814 psi and 1796 psi, respectively. These differences are statistically negligible and fall within the expected variability of field-blasted substrates. More importantly, all tests exhibited cohesive failure within the system's film, indicating that the failure occurred in the bulk material rather than at the substrate interface. This suggests that a triple resin coating system establishes a robust bond to carbon steel surfaces and maintains interfacial strength even in salt removal agents or residual moisture films. Field use of HoldTight® 102 as part of the surface preparation process does not compromise adhesion and may be confidently included in standard surface treatment protocols.

Flexibility Results

The triple resin coating system demonstrated high flexibility, withstanding 180-degree bending over a 1/8-inch mandrel without cracking, delamination, or visible film degradation. This performance equates to an elongation threshold exceeding 30%, which surpasses the flexibility range typically observed in conventional epoxies (6% to 12%).

The triple resin matrix appears to distribute mechanical stress across the film, reducing localised strain concentrations that would otherwise initiate cracks. When manually flexed in both directions, panels retained film integrity, supporting that the system possessed static flexibility and dynamic strain tolerance. These attributes make the coating advantageous for mechanical vibration, thermal cycling or structural movement environments.

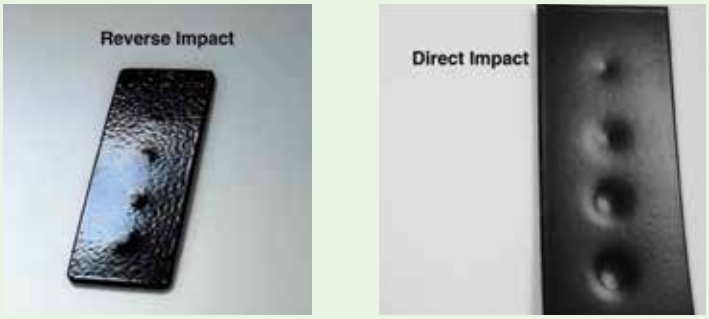


Results of Mandrel Bend Test Performed on a TriFLEX™ Coated Panel.

Impact Resistance

Results from ASTM D2794 testing showed that the triple resin coating system provides impact resistance values exceeding 160 in-lb for both direct and reverse impacts. Conventional epoxy coatings typically register direct impact resistance in the 70 to 90 in-lb range and show significantly diminished resistance in reverse impact due to their brittleness.

The coating's ability to absorb and dissipate mechanical energy from both directions without cracking or film failure reflects the synergistic effect of its resin composition. This makes it well-suited for highwear environments where equipment may be subjected to dropped tools or shifting loads. The dual-mode impact resistance also suggests that the coating can provide reliable protection during service, fabrication, transport and installation.



Figures 6: Results of Revers Impact and Direct Impact ASTM D2794 Testing of TriFLEX™ Panels.

Conclusion

This research indicates significantly improved performance traditionally reserved for multi-coat architectures through uniting three distinct resin chemistries into a co-cured single-coat system. The performance architecture study established the scientific rationale for resin selection and integration. The mechanical study confirmed that adhesion, flexibility, and impact resistance exceed conventional epoxy benchmarks. The atmospheric research validated resilience against UV, corrosion, humidity, heat, and chemical exposure.

Together, these results confirm the developed triple resin coating system as a durable, versatile, and efficient solution for industrial and transportation applications, offering asset owners the ability to reduce downtime, simplify coating application, and extend protection cycles.

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Reducing Detection Time for Sulphate-Reducing Bacteria in Industrial Water Systems

Les Merrill, CEO, Retego Labs

Bacterial contamination does not always lead to material degradation, however, microbiologically influenced corrosion (MIC) continues to present a significant operational and economic challenge across a wide range of industrial sectors, including oil and gas systems, water treatment, and process industries. A substantial proportion of corrosion-related failures are associated with MIC [1], a complex process in which microbial activity alters localised chemical conditions at metal surfaces, accelerating degradation.

Among the microbial groups implicated in MIC, sulphate-reducing bacteria (SRB) are widely regarded as one of the most significant contributors [2]. These anaerobic microorganisms reduce sulphate to hydrogen sulphide (H_2S), a corrosive species that can promote pitting, contribute to sulphide stress cracking, and interfere with corrosion inhibition strategies. The presence of SRB is also associated with oilfield reservoir souring and operational inefficiencies in industrial systems. Despite the well-established role of SRB in corrosion processes, effective monitoring of these organisms remains challenging. Traditional detection methods often involve extended incubation periods or sophisticated laboratory-based analysis, limiting the ability of operators to respond rapidly to changing microbial conditions. As industrial systems increasingly move toward predictive and proactive maintenance strategies, there is a growing need for faster, field-applicable methods of detecting microbial activity.

Limitations of Conventional Detection Techniques

Table 1. Comparison of Conventional and Rapid SRB Detection Methods.

Method	Cost	Portable	Expertise Required	Analysis Speed	Accuracy	Bacteria Selective	False Positive Risk
Rapid SRB detection method	Low	Yes	Low	1-24 hours	High	Yes	No
ATP testing	Low	Yes	Low	30 minutes	Low	No	Yes
Serial dilution	Low	No	Low	7-28 days	Low	Yes	Yes
Quantitative polymerase Chain reaction (qPCR)	High	No	High	48 hours	High	No*	No*

**Note: qPCR selectivity depends on the DNA target primers; however, it cannot distinguish between viable and non-viable microorganisms without propidium monoazide (PMA) sample optimization.*

A range of analytical methods has been developed to detect and quantify sulphate-reducing bacteria in industrial water systems. These include culture-based techniques, serial dilution methods, and molecular approaches such as qPCR.

Another commonly used approach utilises adenosine triphosphate (ATP) testing, which measures total microbial activity by quantifying cellular energy present in a sample. While ATP testing provides rapid results and is useful for assessing overall biological activity, it does not distinguish between specific microbial groups such as SRB, limiting its ability to directly assess SRB-related corrosion risk. ATP testing is additionally susceptible to false positives, as it can have difficulty distinguishing between viable and non-viable bacteria [4].

Culture-Based and Serial Dilution Methods

Culture-based methods, including the serial dilution most probable number (MPN) technique, remain widely used due to their relative simplicity, ease of on-site use and historical acceptance [3]. These approaches rely on the growth of microorganisms under controlled conditions to estimate bacterial populations.

However, a key limitation of these methods is the time required to obtain results. Incubation periods may extend up to 28 days before observable changes occur, particularly in samples with low bacterial concentrations. During this time, environmental changes such as oxygen exposure, temperature variation and sample handling can influence microbial activity and affect accuracy.

In addition, culture-based methods may underestimate microbial populations due to the inability to cultivate all organisms present in a sample, leading to incomplete assessment of microbial activity.

Molecular Techniques

Molecular approaches, including qPCR, offer faster detection compared to culture-based methods and can provide highly sensitive identification of microbial DNA, often within hours to days depending on sample logistics.

Despite these advantages, molecular methods require specialised laboratory infrastructure and trained personnel. Additionally, DNA-based detection does not necessarily indicate active metabolism, as genetic material from non-viable organisms may still be present [5], unless both propidium monoazide (PMA) and photoactivation protocols are optimized for each sample. This limitation can complicate interpretation when assessing current corrosion risk through overestimation of bacterial content.

Operational Implications

The extended timelines and logistical requirements associated with traditional detection methods can delay decision-making in corrosion management. In dynamic industrial environments, a delay of several weeks between sampling and results may result in missed opportunities for early intervention.

Emerging Approaches to Rapid Detection

Alternatives to traditional microbiological detection protocols have led to the development of methods that focus on measuring microbial activity rather than microbial growth. These approaches aim to provide faster and more relevant insights into the presence of metabolically active organisms.

A new method uses two key indicators of SRB activity:

- Enzymatic activity associated with microbial metabolism
- Production of hydrogen sulfide (H_2S)

By targeting these indicators, it is possible to detect active SRB populations without prolonged incubation.

[1]If one chose to use an ATP assay on anaerobic samples in an attempt to obtain viable SRB activity it would produce results that would significantly underestimate viable SRB levels.

Case Example: Rapid Detection of SRB Activity

A field-deployable detection approach has been recently developed and evaluated that combines biological and chemical indicators to assess the presence of sulphate-reducing bacteria in water samples. The method employs two complementary detection pathways:

- **Biological detection:** Enzymatic activity from SRB produces a fluorescent signal through reaction with a substrate.
- **Chemical detection:** Hydrogen sulfide (H_2S) from the sample reacts with a reagent to generate a visible color change.

These combined mechanisms allow for detection of active SRB without requiring propagation of the organism.

Rapid SRB Detection Workflow

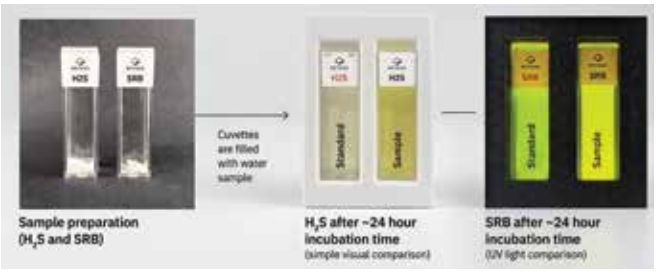


Figure 1. Workflow for rapid detection of sulphate-reducing bacteria (SRB) and associated hydrogen sulfide (H_2S) in water samples. Following sample preparation, results are obtained between 1 and 24 hours, with visual indicators distinguishing microbial activity through colorimetric and fluorescent responses. This workflow illustrates how rapid detection enables earlier identification of microbial activity compared to traditional incubation-based methods.

Detection Time and Sensitivity

Field evaluations have demonstrated that this method can produce detectable results within approximately 1 to 24 hours, depending on bacterial concentration. Detection sensitivity has been observed at levels as low as 1,000 colony-forming units per milliliter of water (CFU/mL).

Field Application

The new method can be applied directly in the field and is effective across a wide range of water conditions, including variations in salinity and pH. Field-based testing reduces the need for sample transport and minimizes environmental impact on microbial activity prior to analysis.

Validation and Comparative Performance

The new rapid SRB detection methods have been evaluated against established techniques, such as serial dilution and ATP-based testing across diverse environments, including Arctic, desert and tropical conditions. These evaluations demonstrate that rapid detection methods can provide results consistent with traditional techniques while significantly reducing time to result [6]. Faster turnaround enables more frequent monitoring and improved responsiveness.

Performance Characteristics

Key performance characteristics include:

- Detection sensitivity down to 1,000 CFU/mL
- Effective across a wide range of salinity and pH conditions
- Reduced likelihood of false-positive results
- Suitable for field-based application without laboratory infrastructure
- Time to result typically between 1 and 24 hours

Limitations and Considerations

While the new rapid detection method provides significant advantages, several limitations should be considered. The method is specific to sulphate-reducing bacteria and does not detect other microbial groups, such as acid-producing bacteria. Additional testing may be required for comprehensive microbial analysis. Sample conditions are also critical. Fresh samples provide the most reliable results, while aged or oxygen-exposed samples may exhibit slower reaction times due to reduced microbial activity. Rapid detection methods should be used as part of a broader corrosion monitoring strategy that includes chemical analysis and system inspection.

Implications for Corrosion Management

The ability to detect SRB activity within hours rather than weeks has important implications for corrosion management.

Operators can use rapid results to:

- Adjust treatment strategies, including biocide dosing
- Assess corrosion risk more quickly
- Identify microbial activity earlier
- Monitor effectiveness of bacteria mitigation programs
- Provide early indication of reservoir souring

This supports a shift from reactive maintenance toward more proactive corrosion management.

Conclusion

Sulphate-reducing bacteria play a critical role in microbiologically influenced corrosion, yet traditional detection methods often fail to provide timely insight into their activity. Rapid detection approaches that target metabolic indicators offer a significant advancement in corrosion diagnostics. By reducing detection timelines from weeks to hours, these methods enable faster, more informed decision-making. As these technologies continue to evolve, they are likely to become an increasingly important component of modern corrosion management strategies and associated treatments. Regardless of the technique used, regular microbial monitoring is essential to evaluate whether preventative treatments are effective over time, as trend analysis provides the clearest insight into system conditions .

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NCIMB is a microbiology services company and custodian of the UK's National Collection of Industrial, Food and Marine Bacteria.

Case Study: Assessing Microbiologically Influenced Corrosion (MIC) Threat in Oil and Gas Well Tubing

The Requirement

Retrieved tubing from three North Sea oil and gas field wells showed signs of degradation. Following tubing inspection, the client requested samples to be taken for microbial analysis. MIC is often associated with deep, localised pitting. Analysing populations of bacteria and archaea allows assessment of MIC risk and mitigating action to be planned.

Analysis Undertaken

NCIMB partnered with CIU, an SES Energy company, to assess the risk of microbiologically influenced corrosion for the client. CIU microbiologists undertook a site visit to take samples from the tubing.



Figure 1: CIU Microbiologists Took Samples from the Tubing.

Two samples for each well were delivered to NCIMB's Aberdeen laboratory for testing. This included:

- 16S rRNA gene sequencing for analysis of bacteria and archaea community composition.
- qPCR and most probable number analyses to provide data about microbial load.
- Sulphide analysis: high sulphide levels are often associated with MIC.

Results

The results, summarised in Table 1, were used to assess MIC threat, which is a product of microbial load and microbial community composition. Figure 2 shows, as an example, community analysis results for one of the samples. In this sample, the proportion of the microbial population associated with MIC was high at 79.9%. However, qPCR and MPN results found the microbial load to be low, and so the overall MIC threat was assessed as moderate. It can be seen that while there was variation in the results obtained for each sample from each well, in all cases the microbial load was assessed as moderate.

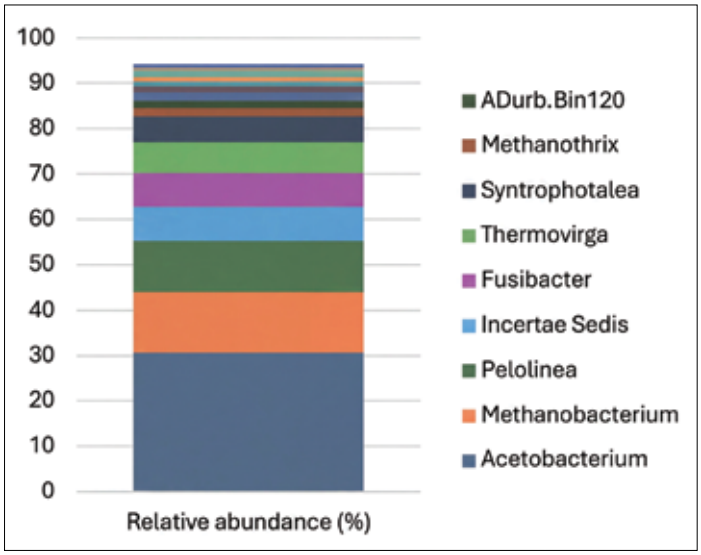


Figure 2: Relative Abundance of Top 20 Genera Present.

Table 1.

Sample	Sulphide	Relative abundance of MIC Associated Genera	Microbial load	MIC threat
1	L	H	L	M
2	M	H	M	M
3	M	M	L	M
4	M	M	L	M
5	L	M	L	M
6	L	L	M	M

The results illustrate the value of combining different analytical approaches to gain a deeper insight into MIC threat – basing mitigation strategies on a single analysis could lead to unnecessary biocides treatments or unchecked proliferation of MIC-associated organisms.

Combining quantitative and qualitative microbial analysis along with chemical testing provides greater insight and better-informed corrosion management strategies.

For more information contact us at enquiries@ncimb.com, +44 (0) 1224 009333 or visit https://www.ncimb.com/microbiologically-influenced-corrosion/

Standards in Focus

Inside ISO 18796-2: Why This New Standard Matters for Internal Vessel Coatings

Simon Daly, MICorr, Senior Consultant – Energy & Infrastructure, Safinah

Thanks for sitting down with us today! This new ISO 18796-2 standard has been getting quite a bit of attention in the coating world—especially from the oil & gas and petrochemical communities. Before we get into the nuts and bolts, can you give us a sense of why this standard needed to exist in the first place? Absolutely. The short version?

Internal coatings for process vessels were being selected with too much variability and not nearly enough standardised evidence. Before ISO 18796-2, people relied heavily on vendor literature that wasn't always comparable— different test liquids, different test conditions, different definitions of failure. The standard now sets out key factors influencing coating selection and principal test methods used as evidence, so everything is aligned and defensible. And honestly, the industry needed it. When you're dealing with high-temperature, high-pressure, multi-phase fluids, the consequences of a wrong coating decision can be high impact—unplanned or extended shutdowns, disbondment failures, blistering, and expensive weld repairs in severe cases.

Let's rewind a bit. What sparked the earliest conversations about creating this? Was there a "this is getting out of hand" moment?

Definitely. One big driver was the inconsistency in how asset owners were evaluating coating systems. Some specified very aggressive test regimes, while others accepted minimal supporting evidence. Additionally, they could only assess based on the test evidence presented to them, often generated for other conditions and then extended. Meanwhile, vendors were offering "high-temperature linings" or "chemical-resistant systems", but the data behind each claim could be wildly different. At the same time, we kept observing that temperature, pressure, gas composition, decompression rate and fluid chemistry were being considered inconsistently across projects. ISO 18796-2 explicitly organises these into the framework we use today. So, the industry wasn't lacking knowledge—it was lacking a shared language. The sharing of knowledge and failure histories between operators has always been a problem.

I want to ask about one of the key features of the standard: its emphasis on the variables—temperature, pressure, fluid composition, and so on. Your group really structured the document around these. Why?

Because those variables fundamentally define the service environment. And if you don't understand the service environment, you can't select the right coating. Many coating specifications are focused on specifying a coating response to a specific environment. But that's very hard to do as the number of variables increases, so we were very keen to ensure that this standard could be used as a design guide rather than simply a general specification.

Take temperature, for example. Thermoset polymers change dramatically with temperature—their permeation resistance, glass-transition behaviour, softening points, and their ability to handle thermal gradients are all influenced by the temperature at which they are cured and operate. Yet we still refer to temperature as a single entity, and often it's not even clear which temperature is being referred to—minimum, maximum design, etc. This standard tries to standardise that and also to explain why these variables are so important to consider.

There are of course, in-service operational upsets where there might be sudden changes in temperature and pressure and the linings must be capable of tolerating these for short periods.

And fluid composition—whether acidic, aqueous, hydrocarbon, drilling fluids, or ad-hoc mixtures—is arguably the first question you should ask. It affects permeation, chemical degradation, swelling, osmotic blistering—everything. Again, in oil and gas operations, it is not uncommon to have a change of service proposed as part of plant modification, but this normally goes through a management of change (MOC) procedure and peer review.

Pressure and decompression, on the other hand, are often misunderstood, and there is often a focus on simply the maximum pressure and occasionally the decompression rate. However, the solubility of different gases in different polymers is a key consideration also, making it really important to understand gas composition in the same way that we do with liquids.

I noticed ISO 18796-2 excludes metallic coatings and weld overlays. Why draw that boundary?

Because metallic coatings belong to a completely different world—different failure mechanisms, different testing regimes, different qualification logic. The standard explicitly says it doesn't cover metallic coatings. We wanted ISO 18796-2 to be highly focused on organic linings applied directly to the substrate. If we tried to cover everything from epoxy novolacs to Inconel overlays, the document would become unusably broad.

Let's talk about testing—specifically the push for pre-qualification. Asset owners often complain about inconsistent or a lack of test data. Was that a major motivator?

One hundred percent. We can't avoid the fact that pre-qualification testing for these types of applications is complex and expensive. That was probably the main push back during the development of the standard. But once people understood this was not about testing every combination of environments in the standard but simply using it as a consistent framework for the selection of relevant tests and then consistently executing them, its usefulness became clearer.

The industry already recognised the importance of key tests—adhesion, immersion resistance, permeation resistance, steam-out resistance, explosive decompression, cold wall testing, thermal shock, and so on.

But they weren't done consistently. With ISO 18796-2, you now have:

- Reference test liquids,
- Principal test methods, and
- Minimum evidence requirements

…so, specifiers can actually compare like-for-like. It's not about making life more difficult—it's about ensuring the data means something.

continues on page 32

What was the hardest part of getting consensus among the working group?

Everyone agreed on the problem, but not everyone agreed on the level of prescription we should include. Some wanted very specific test conditions, generally the operators; others wanted flexibility so manufacturers could innovate. No surprise, this was generally the manufacturers group.

The compromise was:

- Define the criteria and minimum requirements (non-negotiable).
- Define the types of test methods expected (clear guidance).
- But allow flexibility in the exact test conditions as long as they are justified and relevant.

This is why the standard describes the principles and fundamental requirements without dictating every lab setting. Let me give you a couple of examples of how this could be used:

A vessel operator has a potentially high-risk requirement in organic coating terms. The variables are outside of what are typically considered suitable for a coating, and there is a fundamental requirement to understand a coating's performance in this environment before it can even be considered. They can either commission testing themselves or by using the standard outline the clear test evidence they require from any coating manufacturer for their products to be considered.

On the other hand, perhaps a coating manufacturer has an innovative solution for a specific part of the pressure vessel market where fluid composition is relatively consistent. By selecting the limits of the coating in terms of the other key variables such as, temperature, they can provide not only clear evidence of its performance to support introduction, but the testing can also help to clearly define the limits of use of the product.

One is a very specific example, and one is much more general, but the key point is that by having consistent testing and presentation of evidence, a coating's suitability is much easier to determine.

So, what are the key takeaways from this?

I hope that people appreciate that the standard doesn't add bureaucracy—it adds clarity by bringing structured decision-making and reducing both over-engineering and under-specification. It moves the burden solely from individual judgement to a shared, internationally vetted framework, making it a true design-led process which was always the ambition. It will of course take time but, hopefully it's a positive start.

So, what's next for this standard series?

Whilst we always intended this standard to be used for process vessels, its relevance to other equipment, such as storage tanks, heat exchangers etc. is hopefully clear to see, so we will see where that takes us. But for now, our focus is ensuring that the historic ISO 18796-1 document is improved and revised to fully align with this new Part 2 document. That work is ongoing, and we hope to conclude with a draft standard in the coming months.

One Final question—if you could give one piece of advice to someone new to specifying process-vessel linings, what would it be?

If you understand the temperature, pressure, fluid composition and mechanical factors, the right lining type usually becomes obvious, and then you can focus on the specific benefits of individual products and brands. If you start with the product rather than the problem—you're already off track.

And once you've arrived at a solution, make sure that your vessel design is optimised for efficient and effective coating application, but that's another discussion, and standard!

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Fire Integrity Assessment of Damaged PFP Systems and Impact of Substrate Corrosion

Baptiste Rozé, Materials/Structural Engineer – Fire Protection, AkzoNobel

INSTITUTE OF CORROSION

Meet the Author



Baptiste Rozé

Baptiste Rozé graduated with an engineering degree from the University of Grenoble, France, in 2023. He joined AkzoNobel (ICorr Corporate Member) as a student placement during his university studies. He has worked there full-time since graduating as a Structural Engineer in the Fire Engineering Leadership Team, specialising in heat transfer modelling.

Baptiste has extensive experience in using heat transfer modelling to assess the effects of fire on structures where passive fire protection (PFP) has been damaged. His work combines advanced modelling with extensive fire testing of damaged PFP systems. He has also played a key role in developing a range of test methods for new PFP repair materials.

Background

Within the Oil & Gas (O&G) industry, a significant proportion of operational assets are now ageing, with some installations having exceeded their typical 25 years design life by a considerable margin. As a result, damage (sometimes hidden) to Passive Fire Protection (PFP) systems can be widespread across such assets. This situation often arises where maintenance and repair activities are deprioritised in favour of other operationally critical interventions, particularly in contexts of shortened planned outages, constrained resources and limited maintenance budgets.

Defects observed in PFP systems may arise from a range of interacting mechanisms, which should be considered collectively when assessing their significance. Mechanical damage (most easily detectable) is among the most commonly reported forms of degradation and may result from impact from dropped objects (e.g. scaffold fittings) during routine operations, material handling, or maintenance activities. In addition, defects can be associated with historic deficiencies at the application stage, including inadequate surface preparation, suboptimal installation practices, or improper curing conditions, all of which may affect the long-term integrity of the system. Over time, the natural ageing of the asset, combined with exposure to environmental conditions such as thermal cycling, elevated humidity, and marine or otherwise aggressive atmospheres, may further contribute to material degradation.

The resulting defects can manifest in different forms, with cracking and localised voids or small cavities being among the most frequently identified during specialist PFP inspection campaigns. While some of these defects may initially appear superficial in nature, their presence may still be of concern depending on their extent and location. In particular, cracks may act as preferential pathways for moisture ingress, thereby facilitating progressive deterioration within the PFP material. Under certain conditions, this may lead to more advanced forms of degradation, including the development of corrosion under fire protection (CUF). Where such corrosion initiates and propagates beneath the protective layer, the underlying steel substrate may be adversely affected, especially where PFP is applied to pressurised pipeline risers. This is also of concern for configurations involving encased structural steel, or where lightweight cementitious PFP systems are applied. It should be noted that these degradation mechanisms are not always immediately visible and may evolve gradually over time, potentially affecting both the durability of the PFP system and the condition of the underlying steelwork. Consequently, careful consideration should be given to the nature, extent, and location of observed defects when evaluating their potential impact.

PFP defects will require immediate repair where they are deemed to compromise structural integrity under fire exposure conditions. In recent years, a number of repair-specific products and methodologies have been developed to address such defects in a cost-effective manner, while aiming to minimise disruption to ongoing operations. However, the presence of damage within a PFP system does not necessarily imply a loss of fire protection performance. In some instances, the system may still be capable of meeting the required fire protection performance criteria despite the presence of localised defects. PFP damage will however, initiate water ingress leading to loss of steel section and in some cases loss of pressure retention capabilities. A Fire Integrity Assessment (FIA) can therefore be employed to determine whether the presence of such defects is likely to affect the structural performance under fire conditions, and to support decisions regarding whether repair is required in the short to medium term, or whether it may reasonably be deferred until further degradation occurs. As part of this assessment, consideration should also be given to the potential presence of corrosion, which may influence both the effectiveness of the PFP system and the load-bearing capacity of the structure and may therefore necessitate more immediate intervention. The overall assessment process will likely involve both structural engineers and pressure systems engineers according to location. This article presents the methodology used to assess damaged PFP systems applied to structural steelwork only, including beams and columns, and proposes an approach to differentiate cases based on both the severity of defects and their location on the structural member. The proposed FIA framework considers what may reasonably be regarded as acceptable levels of degradation, including the potential impact of corrosion, with the aim of providing facility operators with a technically justified basis to demonstrate continued fire performance up to the point at which repair becomes unavoidable.

Fire Integrity Assessment (FIA)

O&G facilities are typically subject to periodic risk-based inspections aimed at verifying the general condition of installations, including PFP systems. While budgets are allocated to cover maintenance and repair activities, they may not always allow all identified issues to be addressed, for which there can be many. It is therefore essential to exercise sound engineering judgement when assessing the criticality of each defect and determining both the urgency and the appropriate remedial strategy. This is the purpose of a Fire Integrity Assessment (FIA).

FIA involves establishing a detailed diagnosis of each defect through a condition survey,with several important parameters considered. Firstly,

continues on page 34

those relating to the PFP system itself, including the type of material (e.g. lightweight cementitious materials or concrete), its condition, its extent (e.g. profiled, box, top flange unprotected), and the original fire resistance rating of the product. PFP defects must then be characterised in terms of their size and position. In parallel, the geometry and conditions of the protected steel member(s) need to be clearly defined. All these parameters contribute to determining whether, despite one or more defects, the PFP system may still meet the required level of fire performance. To support the development of FIA, many fire tests have been conducted to better understand the thermal impact of a variety of defects in common PFP systems applied to representative steel members. However, it is important to note that, at time of writing, there is no fire test standard dedicated to damaged and/or corroded PFP configurations. As such, an ad hoc fire testing set-up was deployed by the Fire Protection Division of International Paint utilising the UL 1709-time-temperature curve [1].

Two examples of test specimens subjected to fire testing are presented below. *Figure 1* presents a steel Universal Column [UC] box-encased in concrete, this time with defect introduced as a square omission to expose the flange outstand. *Figure 2* illustrates a steel column UC protected with profiled lightweight cementitious material (LWC), in which a crack has been artificially introduced. In both scenarios control specimens were also tested. The PFP thickness throughout ensured 2 hours of fire performance was afforded to the control, according to *UL 1709* [1] performance criteria.





Figure 1: Deliberate Omission on Concrete Encased Steel Beam.

Figure 2: Crack on LWC PFP.

Test data analysis will inform on the temperature evolution of the defected specimens relative to the associated control, and ultimately whether the performance criteria from the applicable fire test standard has been met. For those minor defects which do not negatively affect fire performance, it is possible to generate guidance without further effort. However, for defects causing adverse temperature effects, subsequent analysis is required through Structural Fire Engineering. Specifically, activities within the scope of Structural Fire Engineering include heat transfer modelling (that is validated against the fire test data) and structural calculations. Such heat transfer modelling permits an extension of the approach beyond tested limits (section size, defect size, defect position), which is necessary since fire testing alone cannot provide sufficient data. Temperatures derived from heat transfer modelling are then fed into structural calculations that ultimately define performance associated with a given PFP defect in terms of simple pass / fail criteria. Having representative fire test data is critical to ensuring FIA approaches are robust, as it provides the foundation to develop the guidance under this approach. FIA will not be suitable for all scenarios of damaged PFP and there remains a strong need for specialist repair materials. FIA has been developed to support those designated as lower severity defects to demonstrate performance and reduce criticality / delay repair activities. The following discussion will focus on the dedicated products that have been developed specifically for PFP repair applications.

PFP Repair Design Products

In this section, Product A and Product B refer to the same repair materials previously introduced in the technical article *"Asset Operating Integrity and Repair of Damaged or Aged PFP"*, authored by Chris Fyfe and David Wickham and published in the September/October 2023 issue of the *Corrosion Management Journal* [2]. In the article, Product A is described as a 1-component, mouldable, fire-rated putty specifically tested for the repair of small defects and cracks. It is also hydrophobic and has been fire tested after immersion conditions in accordance with ISO 2812-2 [3], without any adverse effect on its fire resistance performance. Product B is a fibre-reinforced, fire-rated mortar designed for the repair of larger areas. It demonstrates durability performance in accordance with EN 13687-1 [4] and EN 13057 [5], which are among the key requirements for meeting EN 1504-3:2005 [6], with which Product B complies. Both materials are suitable for use on LWC and concrete and have been tested under both pool fire and jet fire conditions.

It is important to note that these materials are so-called defined-life products intended for the repair of damaged PFP systems and are typically subject to at least annual inspection. Their main purpose is to restore the initial fire resistance of the asset where the original PFP has been compromised. However, they are not intended to improve the inherent fire performance of an aged PFP system and neither to enhance corrosion protection or integrity of the parent PFP system. Other proprietary monitoring systems may assist in these cases for ongoing risk assessment. Both materials A and B have been designed for ease and speed of manual application, particularly in areas with restricted access which are commonplace across typical O&G facilities. Since the publication of the article, Product A has been further tested and qualified as a repair material for damaged intumescent epoxy PFP systems, again under both pool fire and jet fire conditions. *Figure 3* below provides an example of one such jet fire test. On the right-hand side, a defect was introduced into an LWC substrate and subsequently repaired using an intumescent epoxy PFP system. A crack was then simulated within the repaired area, to which Product A was applied.



Figure 3: Repaired Crack in Epoxy PFP Using Product A.

Further developments to Product A came in 2025, when the material underwent high heat flux (HHF) jet fire testing in accordance with ISO 22899-3 [7], which defines the release as "severe jet fire associated with significant confinement or other severe release scenarios that can generate sustained heat fluxes of 350 kW/m²". An image of the tested specimen before the test is shown in Figure 4, while an image taken during the test is shown in Figure 5. The left-hand side back-face of the jet fire test box comprised three repaired defects within LWC (one crack and two voids of different sizes). The right-hand side, along with the flange of the jet fire box, was protected with an intumescent epoxy PFP system. In this area, one crack was present in the flange whereas two cracks and a void were present in the back-face.



Figure 4: Jet Fire Box Repaired with Product A.



Figure 5: ISO22899-3 HHF JF Test.

This testing supports Product A as a repair solution for cracks and minor defects within LWC, concrete, and epoxy-based PFP for pool fire and jet fire conditions as well as high heat flux jet fire (HHF JF) scenarios in epoxy PFP. While Products A and B are well suited for the repair of small to medium-sized defects, larger defects (e.g. cases where the PFP must be partially or fully removed), may require the use of an epoxy-based PFP system, referred to here as Product C.

Product C is also a mesh-free material, which has been extensively fire tested under pool, jet and HHF fire conditions both as a primary PFP system and as a repair material. An example of this application can be seen in *Figure 3* in which the epoxy material is Product C. In addition to confirming its excellent fire resistance properties, these tests have demonstrated good adhesion between Product C and the LWC substrate, creating a robust interface, which is often a critical aspect of PFP repair performance.

Products A, B and C form a comprehensive range of PFP repair solutions capable of addressing a wide variety of defects, regardless of their size, location or the nature of the original PFP system. It is essential to note that these repairs are intended to reinstate the fire resistance originally provided by the existing PFP, rather than to enhance its performance. Again, it should also be noted that where repairs are carried out on aged and moisture-affected PFP, the resulting performance cannot be expected to exceed that of the degraded substrate itself.

Impact of Corrosion on PFP Performance

Corrosion condition is an important aspect of any defect survey and so it is critical to understand any implication that might present. Signs or risk of corrosion may be obvious such as staining and flaking, due to for example direct exposure of steel substrate due to PFP omission. However, corrosion may often be hidden, resulting in significant corrosion under fireproofing (CUF) not being identified. As such, both FIA and repair schemes must be carried out with corrosion impact considerations baked into the decision-making process. Also, there may be some defects that on first glance may not compromise fire performance but present an increased risk in terms of corrosion or falling hazard (dropped object impact to personnel) in the immediate term.

The fire testing discussed previously for development of FIA approaches was carried out using 'fresh' materials. As such, durability or corrosion effects were not accounted for in subsequent analysis, meaning results only apply to defects where corrosion is not of concern. However, this does not mean to say that corrosion cannot be incorporated into FIA, if corrosion conditions are clearly defined.

ISO 12944-2 [8] provides steel loss rates as an upper and a lower limit (upper bound reproduced in *Figure 6*) based on the corrosivity category of the environment and this guidance may be utilised to predict effective steel geometry where direct measurement is not possible. Even the most extreme CX environment experiences only 0.7 mm steel thickness loss after one year, maximum, according to this standard. On this basis, it may be conceivable that the effective fire performance of the member having defective PFP, even with some level of corrosion, may be sufficient on a temporary basis but corrosion is of course ongoing (7 mm wall loss after 10 yrs). This is especially true for new defective anomalies or defects within lower corrosivity categories.

Figure 6 Table of Steel Thickness Loss Rate (Corrosion) by Corrosivity Category.

Corrosivity category	Year 1 thickness loss (mm)
C1	0.0013
C2	0.025
C3	0.05
C4	0.08
C5	0.2
CX	0.7

Any debonding of the PFP over an area extending beyond the initial defect may result in the need for partial, or in some cases full, removal of the affected PFP, followed by treatment of the underlying steel and reapplication of a new PFP system. Therefore, PFP defects that do not present a significant risk to fire resistance may require further investigations to determine if the application of an anti-corrosion protection system (and / or automated monitoring system) is required resulting in more extensive repair.

Conclusion

FIA can play a central role in defining the most appropriate response to damaged PFP systems: not all defects have the same impact on fire performance. By providing a Structural Fire Engineering approach, it enables a robust and consistent evaluation of defects, taking into account both PFP condition and the characteristics of the protected steel members. Importantly, FIA may buy asset operators valuable time in effectively managing their maintenance programmes to ensure the most urgent defects are prioritised, while those determined as part of an FIA can be left, monitored and addressed at a later stage when conditions have deteriorated. The overall process comprises a detailed risk assessment during which, several discipline engineers may work together – corrosion. pressure systems and structural according to exact situation.

The development and qualification of dedicated repair materials, such as Product A, Product B and Product C, further enhance this approach. These solutions allow targeted and efficient remediation of defects across a range of PFP systems, including LWC, concrete and epoxy-based coatings, under both pool fire and jet fire conditions. However, their use remains focused on restoring the intended fire performance, rather than enhancing the original design capability. In parallel, the potential impact of corrosion must be explicitly considered for either FIA or a given repair scheme. Even where defects do not initially affect fire resistance, moisture ingress and CUF may lead to progressive degradation and weakening of both the PFP system and the underlying steel. Integrating corrosion considerations effects within the assessment is therefore essential to ensure the long-term reliability of the protection system.

Overall, FIA provides a practical framework to balance safety, technical requirements and maintenance constraints. By prioritising interventions based on risk and performance, it enables operators to optimise repair strategies, manage ageing assets effectively, and maintain confidence in the fire resistance of critical structures over time.

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Top 10 Reasons Internal Tank Linings Fail — and How to Prevent Them

Dominic Marshall and Steven Slack, Corrous Industrial Group

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Meet the Author



Dominic Marshall

Dominic Marshall, BA, MCMI, is Group Managing Director of Corrous Industrial Group, which delivers integrated protective coating, industrial cleaning, asset inspection and scaffolding services to heavy industries and regulated sites. Dominic specialises in bulk liquid storage and energy infrastructure and supports asset owners with specification development, estimating, project delivery and commercial control. His focus is on improving the reliability and repeatability of corrosion protection programmes through risk-based planning, robust QA and disciplined execution. He is an ICorr Level 2 Protective Coatings Inspector.

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Meet the Author



Steven Slack

Steven Slack is Group Technical Director of Corrous Industrial Group, where he holds technical ownership of the group's coating, lining and inspection delivery. Steven has extensive field and leadership experience in protective coatings, with specialist expertise in surface preparation, application control, inspection hold points and the delivery of complex tank lining projects. He supports clients and project teams with technical governance, troubleshooting, and the development of practical, fit-for-purpose specifications. He is an ICorr Level 3 Protective Coatings Inspector and an AMPP (formerly NACE) Senior Corrosion Technologist.

Introduction

Internal tank linings are widely used to protect steel and concrete assets from corrosion and chemical attack, extend service life, and reduce life-cycle costs. Despite this, premature lining breakdown remains common across industries including fuels, chemicals, water, wastewater and process storage.

While failure is sometimes attributed to 'bad luck', many breakdowns can be traced to recurring and identifiable weaknesses in specification, preparation, application control, commissioning, and operating discipline. The objective of this article is to summarise the ten most frequent causes of failure based on the authors' practical field experience and to provide practical, engineering-led prevention measures that asset owners, specifiers, contractors, and inspectors can apply to significantly reduce risk.

Why Linings Fail: A Short Note on Mechanisms

Many lining defects present as blisters, pinholes, delamination, cracking, or rapid underfilm corrosion. These symptoms often have different root causes but are frequently linked by the same main underlying mechanisms:

- **Cure inhibition or solvent entrapment** caused by low temperatures, poor ventilation, excessive film build or incompatible overcoating windows.
- **Incompatibility** with internal cathodic protection (where fitted).
- **Osmotic blistering** where soluble contaminants (for example, chlorides or sulphates) draw water through the coating and form blisters.
- Permeation and chemical attack when a lining is not selected for the actual service conditions (including temperature and vapour phase exposure).
- Poor surface preparation and uneven weld profiles.
- Deterioration of the cleanliness standard between blasting and coating application.
- Underfilm corrosion driven by retained salts, moisture, or poor surface preparation that leaves active corrosion sites.



Photo 1 (Left): Lining Blisters.



Photo 2 (Right): Showing Weld Defects, Substrate Contamination, Gingering on Tank Floor Plates.



Photo 3: Removal of the Lining and Preparation of the Steel Surface to ISO 8501-1 Sa2½.



Photo 4: Inspection of the Substrate Being Carried Out to Determine Soluble Salt Contamination (ISO 8502-6/9) and Surface Profile (ISO 8503).

Understanding these mechanisms helps teams focus on controllable parameters and hold points rather than treating defects as isolated events.

Additional Considerations for Specification and Risk Ownership

Beyond workmanship, the lining system is influenced by decisions made at the project design stage: specification, preparation philosophy, access and ventilation design, inspection scope, and commissioning constraints. High-performing projects treat lining installation as a managed engineering activity with defined acceptance criteria, rather than a "paint job" executed at the end of a shutdown.

A useful way to think about internal linings is to regard them as a barrier system with known limits. If the service environment, application conditions, or commissioning regime exceed those limits, failure becomes a matter of time rather than chance. The prevention measures that follow are therefore centred on controlling the few variables that matter most: service fit, cleanliness (including salts), environment, thickness, cure, and verification.

Two practical habits consistently separate reliable outcomes from repeat failures. Firstly, teams agree on the acceptance criteria before mobilisation — including where measurements will be taken, how many will be taken, and what constitutes a pass or fail. Secondly, they treat deviations as decisions, not inconveniences. If salt levels exceed the agreed threshold, the response is defined: re-clean, retest, and do not coat. If the dew point margin is not maintained, work stops. This clarity removes ''on-the-day' debate and prevents schedule pressure from quietly overriding engineering controls.

Where possible, owners should also align lining work with a simple quality assurance risk register. For each major risk (contamination, condensation, over-build, incomplete cure, discontinuities), define the prevention control, the verification method, and the evidence required for sign-off. This approach makes lining projects easier to manage and far easier to defend when incidents, disputes, or warranty discussions arise.

Vapour Space Versus Immersion Exposure

A frequent source of surprise is vapour phase corrosion and attack. Condensation cycles, oxygen availability, and elevated temperatures can create a more aggressive environment in the vapour space than in the liquid phase. Where tanks store fuels, solvents, or chemicals with fluctuating levels, the splash zone and vapour space should be assessed explicitly. In some cases, a dual-system specification (or additional stripe coats / reinforcement in the vapour space) provides better reliability than a single uniform build.

It is also important to consider operational transients: hot fills, cold ambient periods, steam cleaning, or CIP chemicals. Lining selection should account for credible upset conditions, not only normal operation.

Acceptance Criteria and Measurement Methods

To reduce ambiguity, projects should define how compliance will be measured.

Common controls include:

- Dust rating assessment in accordance with ISO 8502-3.
- Environmental readings recorded at set intervals and whenever conditions change.
- Holiday testing with documented voltage, coverage, defect log, repair and re-testing.
- Soluble salt levels measured using the Bresle method (ISO 8502-6/9).
- Surface profile measured with replica tape or needle gauge.
- Wet film thickness (WFT) checks during application and dry film thickness (DFT) verification after cure.

While accurate and timeline reporting can be deprioritised by programme pressure, it ensures that issues are discovered early, while correction is still practical. It also provides auditable and defensible evidence to demonstrate compliance and protect the parties involved in the event of any future claim.

Typical Failure Signatures

Inspectors often encounter repeatable "signatures" that point to root cause:

- Cracking, which can result from over-build, thermal cycling or substrate movement.
- Large blisters or broad delamination may indicate condensation, poor adhesion or incompatibility.
- Pinholes and rust spots are commonly linked to inadequate stripe coating, air entrapment or ineffective holiday testing.
- Small, high-density blisters often correlate with soluble salt contamination.
- A soft or easily damaged film suggests incomplete cure or incorrect mixing ratios.

Capturing these observations during inspection supports faster diagnosis and more targeted corrective action.

Prevention Measures

1. Incorrect Lining Selection for the Service Environment

Selecting a lining based on price, familiarity, or generic data rather than on verified resistance to the specific stored product, contaminants, temperature range, and operating regime (including vapour space exposure) is a leading cause of premature failure.

Prevention Measures

- Assess both immersion and vapour phase exposure as the vapour space can be more aggressive than immersion.
- Confirm the stored media, concentration, operating temperature, cleaning chemicals, and any process upset conditions.
- Specify system build (primer/intermediate/topcoat), DFT range and cure requirements for the service.
- Use manufacturer chemical resistance data for the exact product and temperature, and verify it with independent guidance where appropriate.

2. Inadequate Surface Preparation (Profile, Cleanliness, and Degree of Preparation)

Even high-performance linings cannot compensate for inadequate surface preparation. Insufficient cleaning or an incorrect profile reduces adhesion and increases the likelihood of underfilm corrosion and delamination.

Prevention Measures

- Confirm that sharp edges are treated and that all weld spatter is removed.
- Ensure all critical areas receive a thorough stripe coat, ensuring sufficient coverage.
- Define the required preparation standard (e.g., Sa 2½ / SSPC-SP10) and the target profile range appropriate to the system.
- Hold point: do not proceed to coating until preparation has been verified and recorded.

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- Inspect for shadows, tight corners, and complex welds that may need additional preparation.

3. Soluble Salt Contamination (Chlorides, Sulphates, Nitrates)

Soluble salts are a common hidden contributor to osmotic blistering and rapid underfilm corrosion. Salts can originate from stored product residues, marine environments, process contamination, or abrasive and water sources.

Prevention Measures

- Control abrasive quality and avoid the use of recycled abrasive that can introduce contaminants.
- Document test locations and results as part of the QA dossier.
- Include salt testing in the inspection plan (e.g., Bresle method) with acceptance criteria agreed pre-job.
- Use effective decontamination (fresh-water washing, steam cleaning, detergents) and re-test to confirm removal.

4. Poor Environmental Control During Application (Dew Point, Humidity, Temperature)

Applying linings outside specified environmental limits can cause condensation, amine blush, pinholing, poor cure, and reduced adhesion. Small excursions are often enough to create defects that only appear after commissioning.

Prevention Measures

- Maintain the specified surface temperature margin above the dew point (commonly ≥3°C, unless stated otherwise).
- Monitor steel temperature, air temperature, relative humidity, and the dew point throughout the shift.
- Stop work when limits are exceeded and resume only once conditions are stable and recorded.
- Use dehumidification, heating, and forced ventilation where necessary — especially in enclosed tanks. This includes during overnight cure where required.

5. Incorrect Film Thickness (Under-Build or Over-Build)

Film thickness is a controlled parameter. Under-build reduces barrier performance, while over-build increases the risk of solvent entrapment, cracking, and cure issues — particularly in high build epoxies.

Prevention Measures

- Investigate and correct systematic thickness deviations rather than "averaging them out".
- Specify minimum and maximum DFT per coat and for the total system; align with manufacturer guidance.
- Treat complex geometry as higher risk and plan additional stripe coats.
- Use WFT gauges during application and DFT measurements after cure; record results by area.

6. Poor Workmanship at Critical Details (Edges, Welds, Terminations, Nozzles)

Edges, welds, and terminations are stress concentrators and common initiation points for coating breakdown due to thin film build and mechanical damage.

Prevention Measures

- Inspect details at hold points before full coat application.
- Protect terminations and consider reinforcement where appropriate (e.g glass flake or fabric reinforcement).
- Specify edge grinding/radius requirements and stripe coats on all edges, welds and cut-outs.
- Use appropriate application methods to achieve target build on details (brush/roller stripe coats).

7. Inadequate Cure and Commissioning Control

Many failures are linked to lining systems being placed into service before they have achieved adequate cure. This is particularly prevalent in cold climates, under time pressure, or where ventilation is poor.

Prevention Measures

- Define cure criteria (time/temperature, hardness, solvent resistance) before the job starts.
- Do not introduce product, water, or cleaning chemicals until cure acceptance is formally signed off.
- Ensure ventilation is adequate to remove solvents and support cure, especially in deep tanks.
- Verify cure using appropriate methods (e.g., solvent rub/MEK where applicable, hardness checks) in line with manufacturer guidance.

8. Holiday Testing Gaps and Ineffective Defect Repair

Pinholes and discontinuities allow rapid underfilm corrosion. Holiday testing is only effective when voltage selection, inspection coverage and repair methods are correct.

Prevention Measures

- Ensure testing covers welds, terminations, and complex areas where discontinuities are more likely.
- Include holiday testing as a formal hold point with correct equipment calibration and voltage selection.
- Maintain a defect log with locations, repair details, and re-test results.
- Mark defects clearly, repair in accordance with manufacturer guidance, and re-test repaired areas.

9. Inadequate QA/Inspection Hold Points and Documentation

It is essential that Quality Assurance (QA) hold points are enforced, otherwise defects are often 'built in' and only discovered late — when correction is costly or impractical.

Prevention Measures

- Define acceptance criteria for preparation, salts, environmental conditions, WFT/DFT, cure, and holiday testing.
- Ensure responsibilities are clear for all parties (asset owner, inspector, contractor) and records are retained.
- Implement a documented Inspection and Test Plan (ITP) with clear hold/witness points.
- Treat the QA dossier as part of the asset record, supporting future inspections and repairs.

10. Post-Handover Operational Factors (Mechanical Damage, Cleaning, Temperature Excursions and Water Bottoms)

Even a well-installed lining can fail early if operating conditions exceed design assumptions. Common issues include aggressive cleaning, unexpected chemical exposure, thermal cycling, prolonged water bottoms, and poor housekeeping leading to microbiological activity.

Prevention measures

- Document operating limits, cleaning restrictions, and compatible repair materials.
- Ensure repairs are compatible, controlled, and re-tested (including holiday testing).
- Monitor for water bottoms, sludge accumulation and microbial activity where relevant.
- Plan routine internal inspections and address minor defects early.

Table 1: Typical QA Hold Points for Internal Lining Projects

Stage	Typical Checks / Measurements	Record / Evidence
Pre-clean / isolation	Confined space controls, isolation, access, waste plan	Permits, RAMS, isolation certificates
Decontamination	Wash/steam clean, detergent, dry-out, salt test plan	Cleaning report, salt test results
Post-blast acceptance (hold point)	Preparation standard, profile; dust, cleanliness, edge treatment	Inspection report, photos, measurements
Environmental monitoring (continuous)	Air/surface temp, RH, dew point, ventilation	Logged readings, instrument calibration
Application control	Stripe coats, mixing ratios, pot life, WFT checks	Batch logs, WFT records
Cure verification (hold point)	Time/temperature, hardness/solvent rub (as applicable)	Cure records, sign-off
DFT verification	DFT by area, min/max compliance	DFT map, gauge calibration
Holiday testing (hold point)	Correct voltage, 100% coverage, repairs & re-test	Defect log, re-test records
Handover	As-built dossier, repair materials, operating limits	QA dossier, O&M guidance

A Practical Vignette: Avoiding a "Perfect Storm" Failure

Consider a shutdown where the tank is cleaned and blasted late in the programme. The abrasive quality is acceptable, but soluble salts are not verified and environmental readings are taken only at the start of the shift. Overnight temperatures drop and the steel temperature approaches the dew point. The next morning, coating proceeds to maintain the schedule, resulting in intermittent condensation in shadowed areas. Film thickness is locally high on welds due to repeated stripe coats, and cure is assumed to be complete after a nominal time period.

The lining initially appears satisfactory, but blisters and rust spots develop within months of commissioning. In many cases, the root cause is not a single major error, but a chain of small misses: no salt verification, inadequate environmental control, over-build at edgework, and insufficient cure verification. Breaking any one link — for example, enforcing a hold point for salt testing or maintaining a strict dew point margin — can prevent the failure entirely. This illustrates why systematic hold points and evidence-based acceptance criteria are more reliable than relying on experience and good intentions alone.

Key lessons from this type of scenario are straightforward: establish measurable hold points early, keep environmental control equipment available and properly sized, avoid exceeding maximum film build on details, and verify cure with an agreed method rather than relying on time alone. When these controls are in place, the project team can move quickly with confidence — and when they are not, the apparent time saved is usually paid back many times over in rework and premature failure.

Asset Owner Risk Control

A lining should be treated as part of the wider asset management system — not as a one-off project. Owners can significantly reduce risk by ensuring that the specification is fit for purpose, enforcing hold points, and maintaining operational discipline after handover.

Practically, this means budgeting for the controls that prevent rework: time for decontamination and re-testing, provision for dehumidification and ventilation, access that allows proper inspection coverage, and a commissioning plan that does not force early immersion. The cost of these controls is typically small compared with the cost of early failure, product contamination, unplanned shutdowns, and repeat lining campaigns.

The Asset Owner's Risk Management Checklist

- Correct lining selection for service (immersion and vapour)
- Surface preparation and salt control embedded in the ITP
- Environmental control during application (dew point margin maintained)
- Film thickness controlled within stated min/max limits
- Cure verification before exposure to service
- Defined hold points and documented QA dossier
- Holiday testing completed, defects repaired and re-tested
- Post-handover operating limits and cleaning restrictions documented
- Planned inspection intervals and compatible repair strategy.

Conclusions

Many internal lining failures are considered avoidable. When teams manage risk deliberately — by controlling preparation, contamination, environment, thickness, cure, and post-handover operation — service life becomes far more predictable and total cost of ownership reduces. Ultimately, the difference between a lining that lasts and one that fails early is rarely the coating brand. It is the discipline of specification, verification, and decision-making at hold points. If the project team can answer "yes" to the key questions — Is the system proven for service? Is the steel clean (including salts)? Are conditions controlled? Is the thickness within limits? Is cure verified? Is the lining continuous? — then failure risk drops dramatically. Where QA hold points are not enforced, defects are often "built in" and only discovered when it is too late.

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High-Temperature Degradation in Chlorine and Sulphur-Rich Environments:

Mechanisms and Mitigation Using ArcSprayed Coatings

Ahmad Usman, Group Innovation R&D Engineer, Welding Alloys Group UK

INSTITUTE OF CORROSION

Meet the Author



Ahmad Usman

Ahmad Usman is a Group Innovation R&D Engineer at Welding Alloys Group UK, specialising in high-temperature material degradation in demanding industrial environments. He works with a multidisciplinary team to design alloys that resist corrosion and wear in heavy industry applications. His expertise in thermal spray coatings enables him to address complex challenges through practical, performance-driven solutions. His work focuses on real-world case studies to develop materials that protect critical components and extend service life under extreme conditions.

Ahmad is part of a global research and innovation team committed to technical excellence and supporting industrial partners in advancing their products and services. His research interests focus on the future performance of materials in increasingly aggressive operating environments.

Introduction

Material degradation at high temperature remains a critical challenge across a wide range of industrial sectors, including chemical processing, aerospace, gas turbines, energy generation, refining and petrochemical processing, and metallurgical operations (Spiegel, Zahs, and Grabke 2003). Components operating under such conditions are exposed to reactive gaseous and condensed species, leading to reduced operational efficiency, increased maintenance demands, and ultimately premature component failure. These challenges carry significant economic and operational consequences, underscoring the importance of understanding and mitigating high-temperature degradation processes (Khantisopon et al. 2022).

The nature and severity of degradation are strongly influenced by the local chemical environment, which is governed by factors such as process conditions, feedstock composition, and deposit chemistry (Corrosion Basics Understanding the Basic Principles and Causes of Corrosion n.d.). In oxygen-rich environments, protective oxide scales may form and provide a degree of resistance; however, under oxygen-deficient conditions, the stability of such layers is compromised, increasing susceptibility to accelerated attack. The presence of sulphur- and chlorine-containing species further complicates these processes by introducing additional degradation pathways (Floreen and Kane n.d.). Sulphur-rich environments typically promote sulphide formation, while chlorine-containing species can induce active oxidation through the formation and volatilisation of metal chlorides, resulting in rapid material loss (Sadeghimeresht et al. 2018; Usman et al. 2025).

In practical systems, these mechanisms rarely occur in isolation. Instead, they evolve dynamically in response to local variation in temperature, gas composition, and deposit accumulation, as shown in Figure 1 (Usman et al. 202 As a result, degradation behaviour is often highly heterogeneous, even within a single system, making material selection and lifetime prediction particularly challenging.

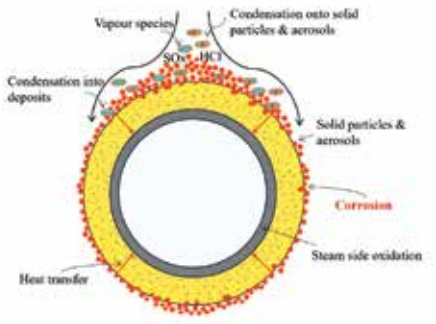


Figure 1: Schematic Representation of Corrosion Attack on a Metal Surface.

Although considerable research has been conducted in this field, many studies are based on simplified or controlled environments that do not fully capture the complexity of real operating conditions. Industrial systems exhibit significant spatial and temporal variability, leading to differences in dominant corrosion mechanisms across components. Addressing this gap requires studies that integrate realworld observations with controlled experimental validation.

The present study adopts this approach by examining three industrial case studies representing distinct chemical environments. The objective is to identify the dominant degradation mechanisms under different conditions and to establish a mechanistic understanding based on post-exposure characterisation of materials and deposits. Alongside this analysis, the study evaluates the performance of thermally sprayed coatings as a mitigation strategy. These coatings offer a flexible and cost-efficient solution for protecting large components, particularly where in situ application is required (Usman et al. 2025). Among the available techniques, arc-sprayed coatings provide a practical balance between performance and deployability. This work therefore investigates the relationship between environmental conditions, degradation behaviour, and coating performance, with the aim of informing the design and selection of protective systems for high-temperature applications.

Industrial Case Studies

Three industrial case studies were selected to examine material degradation under distinct high temperature operating environments. Each case represents a different chemical regime, characterised by variations in deposit composition and gas-phase species, resulting in differences in dominant degradation mechanisms. Material samples were obtained from components exposed to high temperature service conditions. Post-exposure characterisation was carried out to assess both substrate degradation and deposit chemistry. Elemental analysis using scanning electron microscopy coupled with energy-dispersive X-ray spectroscopy (SEM-EDX) enabled identification of key reactive species and their distribution within the deposits and affected material regions.

Case Study 1: Chlorine-Dominated Environment

This environment is characterised by solid-fuel combustion conditions operating at relatively low temperatures (500-600 °C), which favour the condensation and accumulation of highly corrosive molten salt deposits on exposed component surfaces, as shown in Figure 2. Under these conditions, deposited species remain stable in the condensed phase, enabling sustained interaction with the underlying material.

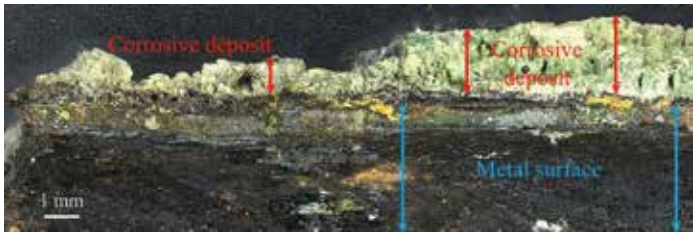


Figure 2: Deposit and Accumulation of Corrosive Deposits on the Exposed Component Surface.

Elemental analysis of surface deposits, as shown in Figure 3, revealed elevated concentrations of chlorine in combination with alkali metals (K, Na), along with iron and oxygen. The presence of alkali chlorides indicates a chemical environment conducive to active oxidation. In this mechanism, chlorine participates in cyclic reactions involving the formation of volatile metal chlorides at the metal-deposit interface. These metal chlorides subsequently migrate outward and re-oxidise in regions of higher oxygen partial pressure, regenerating chlorine species and sustaining the degradation process. This cyclic mechanism disrupts the formation of stable protective oxide layers, leading to accelerated material loss.

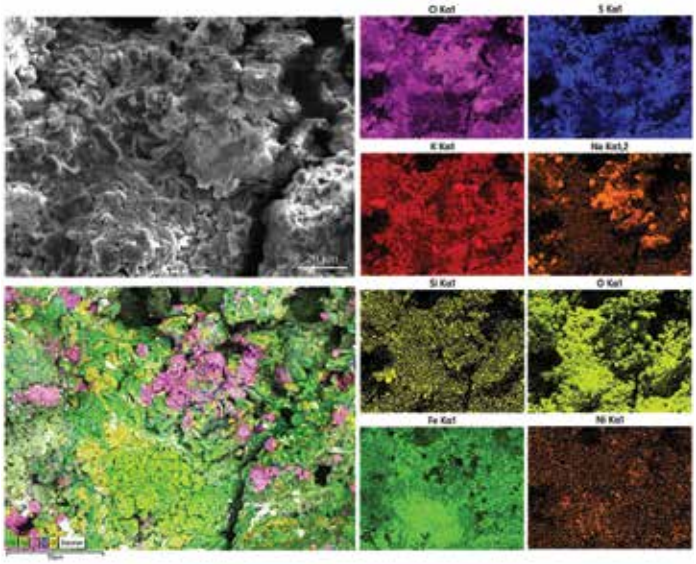
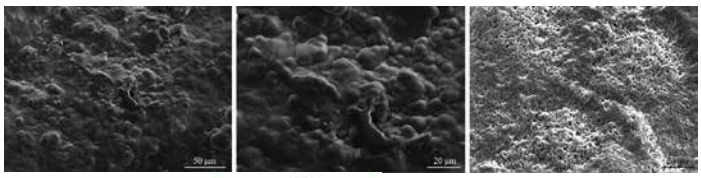
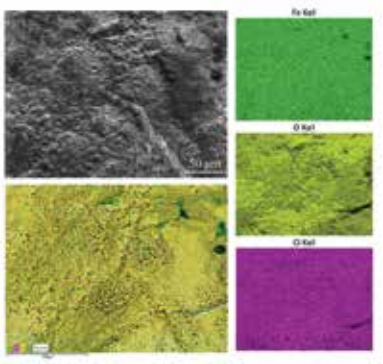


Figure 3: SEM-EDX Elemental Analysis of Surface Deposit from the Exposed Material Showing High Concentrations of Chlorine and Alkali Metals (K, Na).

Microstructural observations from the degraded surface (Figure 4) show a porous morphology associated with outward-growing corrosion products. This porous structure is indicative of volatilisation-driven material transport, in which the formation and outward diffusion of metal chlorides result in a non-protective and mechanically weak scale. Elemental distribution maps obtained via EDX analysis (Figure 5) further confirm the localisation of chlorine within these regions, supporting the proposed mechanism of chlorine-driven degradation.



Above: Figure 4: Surface Morphology of Degraded Material Showing a Porous and Outward-Growing Corrosion Product Layer.



Left: Figure 5: SEM-BSE and EDX Maps of Degraded Region Highlighting the Localisation of Chlorine within the Corrosion Products.

Case Study 2: Sulphur-Dominated Environment

In this study, a 310H stainless-steel component operated at approximately 800 °C under a low oxygen atmosphere with high moisture content. The environment contained sulphur-bearing species, including hydrogen sulphide, carbon disulphide, sulphur dioxide, and sulphur trioxide, along with other process-related compounds. Post-exposure analysis revealed significant sulphur enrichment within the degraded regions, accompanied by redistribution of alloying elements such as chromium, iron and nickel.

Microstructural examination (Figure 6) shows the formation of a layered surface scale, with evidence of cracking and localised breakdown. The outer region is enriched in chromium and oxygen, including the formation of a chromium-rich oxide layer; however, this layer appears discontinuous and mechanically unstable, exhibiting fracture and partial spallation.

Elemental distribution maps (Figure 7) further demonstrate that while chromium and oxygen are predominantly concentrated within the outer oxide layer, sulphur has penetrated beneath this layer into the underlying material.

Within these sulphur-enriched regions, iron and nickel remain present, suggesting the formation of sulphide phases within the substrate. This indicates that the protective oxide layer has been compromised, allowing inward diffusion of sulphur species.

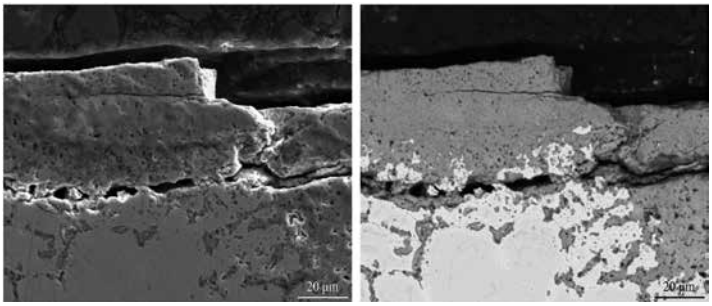


Figure 6: Cross-Sectional SEM Micrograph Showing the Layered Oxide Scale Formed on the Exposed Material.

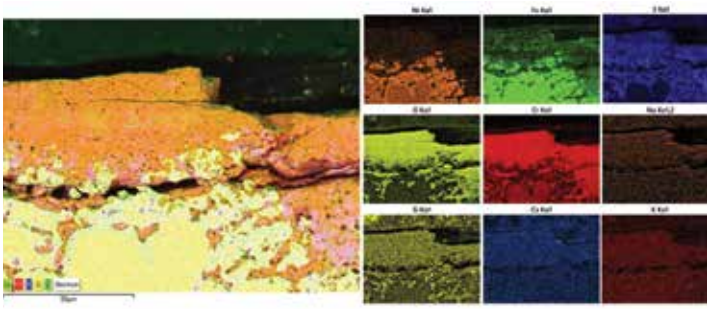


Figure 7: SEM-EDX Maps Illustrating Chromium and Oxygen Enrichment within the Outer Oxide Scale, Alongside Sulphur Penetration into the Underlying Material. The Co-Location of Iron and Nickel within Sulphur-Rich Regions Suggests Internal Sulphide.

Case study 3: Mixed Chemical Environment

This case study exhibited the simultaneous presence of both sulphur - and chlorine-containing species, along with alkali metals, indicating a mixed degradation regime.

Such environments are associated with competing and interacting mechanisms, including sulphide formation and chlorine-induced active oxidation, resulting in complex and often accelerated material degradation behaviour.

Elemental maps (Figure 8) from the degraded metal surface indicate the co-presence of chlorine and potassium within the same regions, suggesting the formation of KCl within the deposited salts. In contrast, sulphur is more widely distributed and associated with iron and oxygen.

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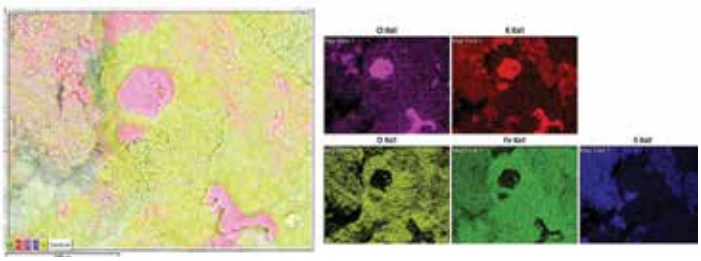


Figure 8: SEM-EDX Maps of the Degraded Surface Showing Co-Localisation of Cl and K, Indicating the Presence of KCl within the Deposits. Sulphur is More Broadly Distributed and Associated with Fe-Rich Regions.

Cross-sectional SEM micrograph (Figure 9) reveals breakdown of the outer oxide scale, accompanied by intergranular attack within the underlying material. The oxide layer appears discontinuous and locally disrupted, reducing its protective capability. Further insight from elemental maps (Figure 10) shows that sulphur, chromium, and potassium are concentrated along the grain boundaries, indicating preferential penetration along these paths. This behaviour suggests that grain boundaries act as fast diffusion pathways, facilitating the ingress of aggressive species and accelerating localised degradation within the material.

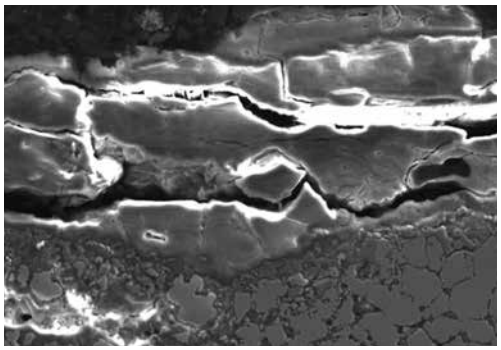


Figure 9: Cross-Sectional SEM Micrograph Showing the Presence of Intergranular Attack within the Underlaying Material.

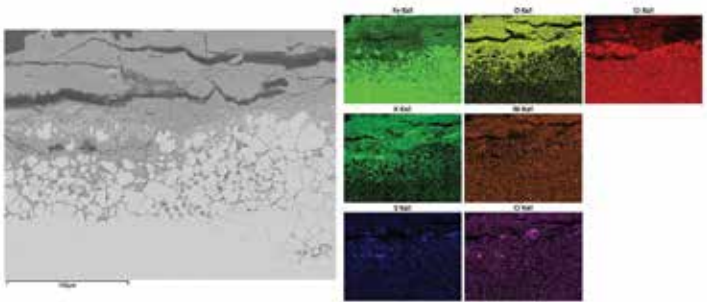


Figure 10: Elemental Distribution Maps Showing the Concentration of Sulphur, Chlorine, and Potassium Along Grain Boundaries, Indicating Preferential Ingress of Reactive Species and Localised Degradation Along These Pathways.

Experimental Procedure and Material

Given the complexity of the three operating conditions identified in the above case studies across different environments, controlled laboratory-scale high-temperature corrosion tests were designed and conducted. This approach was developed to systematically investigate the influence of key variables such as, temperature, exposure time, gas phase composition, and deposit chemistry on the corrosion process.

Arc-Spray Coating

Two cored wire feedstocks were used to deposit coatings via the twin wire arc spraying (TWAS) process (details are reported in a previous study) (Usman et al. 2025). The Ni-based coatings, designated CS-1 and CS-2 (details provided in Table 1), were applied onto 310 H stainless-steel substrate. The coatings were deposited to a thickness of approximately 700 µm.

High-Temperature Corrosion Testing

Corrosion tests were conducted under highly aggressive simulated environments containing CO_2, SO_2, H_2O, O_2, HCl, and N_2 at temperatures of 550 and 800 ± 5 °C, with exposure durations of 200 h and 300 h. A vertically oriented alumina-lined tube furnace (Figure 11) was used to carry out the high temperature corrosion tests under a controlled atmosphere (Waeytens et al. 2023). Coating samples were evaluated under deposited salt conditions comprising KCl and K_2SO_4. Before testing, coupon samples and crucibles were ultrasonically cleaned in acetone, followed by drying on a hot plate at 100 °C for 1 h before initial weighing. The combined mass of the crucibles, samples, and deposited salts was recorded to determine the applied deposit quantity.

Table 1: Samples Identification Codes and Experimental Conditions.

Coating Code	Exposure Time	Coating Type	Salt Deposit	Temperature
CS-1-2	200 h	NI-22Cr	KCl + K_4SO_4 (50:50 wt.%)	550°C and 800°C
CS-1-3	300 h			
C2-2-2	200 h	NI-25Cr		
CS-2-3	300 h			

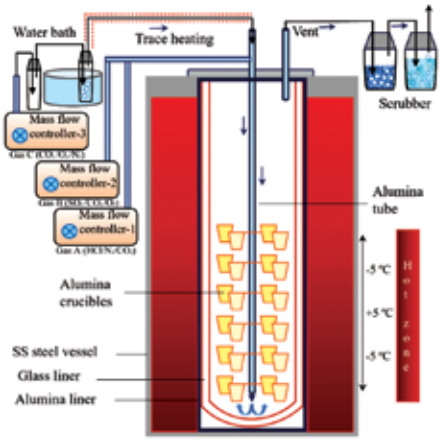


Figure 11: Schematic Representation of High Temperature Corrosion Rig.

Post-Exposure Analysis

Following 200 h and 300 h of exposure, coating samples were assessed through cross-sectional microstructural analysis. Samples were sectioned, cold-mounted in low-shrinkage epoxy resin, and prepared using standard metallographic procedures, followed by polishing to a 1 µm diamond finish using an oil-based system. The cross-sectional microstructures were examined using digital microscopy to evaluate coating integrity, thickness variation, and degradation features.

Dimensional Metrology

Coating performance was further quantified using dimensional metrology to assess material loss and degradation (Waeytens et al. 2023). Thickness measurements were obtained along the perimeter of the exposed coatings. Multiple measurements were collected to ensure statistical relevance, and the data were compared with pre-exposure thickness values. These measurements were used to develop probability models describing coating degradation and to estimate coating lifetime under the tested conditions.

Results and Discussion

Microscopy Image Analysis

Cross-sectional optical microscopy was performed on all eight coatings following high-temperature corrosion exposure. The micrographs presented in Figure 12 and Figure 13 indicate that all coatings experienced varying degrees of surface degradation. However, the CS-2 coatings exhibited comparatively lower damage than the CS-1 coatings at

continues on page 44

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both temperatures. At 550 °C (200 h and 300 h), the CS-1 coatings showed pronounced localised attack, leading to the formation of a porous and non-adherent oxide scale. At 800 °C, the degradation was significantly more severe, as evidenced by the development of a highly porous surface morphology and coating delamination after 300 h of exposure.

In contrast, the CS-2 coatings formed a relatively uniform and more adherent oxide layer at 550 °C, with only limited pitting observed at isolated locations. At 800 °C, although the severity of attack increased, the coatings continued to exhibit protective behaviour, with no significant spallation or deep interfacial corrosion observed.

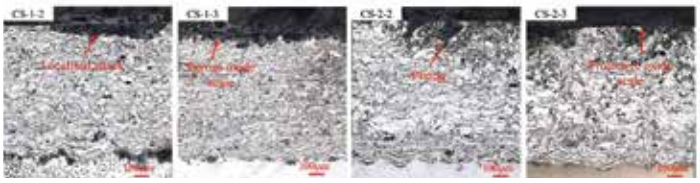


Figure 12: Cross-Sectional Optical Microscopy Images of Samples After Exposure at 550 °C for 200 h (CS-1-2, CS-2-2) and 300 h (CS-1-3, CS-2-3).

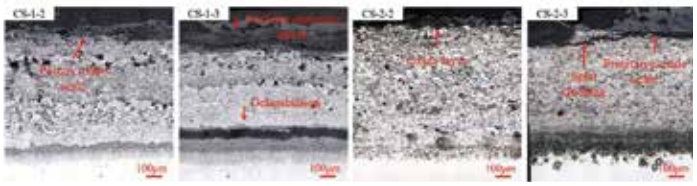


Figure 13: Cross-Sectional Optical Microscopy Images of Samples After Exposure at 800 °C for 200 h (CS-1-2, CS-2-2) and 300 h (CS-1-3, CS-2-3).

Dimensional Metrology

Dimensional metrology analysis was used to evaluate the corrosion performance of coating systems by generating statistical distributions of material loss. The median coating loss values (Figure 14) represent the extent of degradation in the exposed specimens. Figure 14 summarises the corrosion performance of coatings CS-1 and CS-2 exposed to simulated environments at 550 and 800 °C. Across all conditions, CS-2 consistently exhibited lower material loss compared to CS-1, indicating superior resistance to high-temperature degradation. For CS-2-2, the median coating loss was approximately 0.4 mm after 200 h at 550 °C, increasing to 1.0 mm after 300 h. At 800 °C, the corresponding values increased to 0.8 mm and 1.5 mm after 200 h and 300 h, respectively. In contrast, CS-1-2 showed significantly higher degradation, with median coating loss values reaching 5.0 mm after 200 h and 7.9 mm after 300 h at 800 °C.

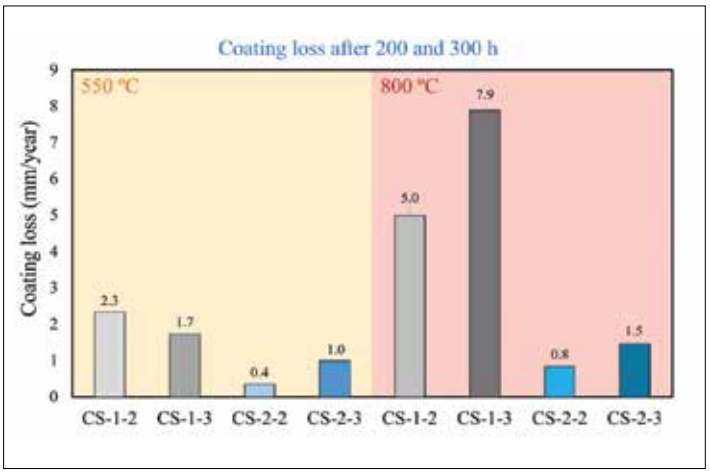


Figure 14: Median Coating Loss of KCl + K2SO4 Deposited Coating Samples Exposed to Aggressive Environments at 550 °C and 800 °C for 200 h and 300 h.

Conclusion

This study investigated high-temperature degradation mechanisms across three industrial environments characterised by chlorine-dominated, sulphur-dominated, and mixed chemical conditions and evaluated the performance of twin-wire arc-sprayed Ni-based coatings under simulated laboratory conditions.

- Chlorine-rich conditions led to the formation of porous, non-protective oxide scales, while sulphur rich environments promoted sulphide formation and internal degradation. Mixed environments resulted in complex attack, including oxide breakdown and intergranular corrosion.
- TWAS coating performance varied significantly between the two systems, with CS-2 consistently outperforming CS-1 under all test conditions. Lifetime modelling confirmed lower material loss for CS-2, demonstrating its superior protective performance at both 550 °C and 800 °C.
- The results highlight the importance of coating composition and microstructure in controlling oxide stability and limiting the ingress of corrosive species. Crucially, a detailed understanding of the underlying degradation mechanisms provides a foundation for the rational design of improved coating materials with enhanced performance in aggressive environments.

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17th September, Midlands Branch
Technical Event: "Risk Assessment of AC Interference on Onshore Pipelines"
Contact: midlandschair@icorr.org

24th September, North East Branch
Technical Event: "From Manual to Robotics: Rethinking Industrial Coating Application" – Presented by Qlayers
Contact: nechair@icorr.org

29th September 2026, Aberdeen Branch
In-Person Joint Meeting with TWI North Scottish Branch, Palm Court Hotel on Additive Manufacturing
Contact: ABZchair@icorr.org

8th October, London Branch
Joint Meeting with the London Materials Society (LMS): "How Can You Measure the Quality of Protective Coatings and Predict Their Remaining Service Life?" – Speaker: Guus Coolegem, Founder and CTO, C-Cube
Contact: londonchair@icorr.org

22nd October, Midlands Branch
Technical Event: "From Soil Resistivity to Interface Mechanisms: Improving Predictions of Buried Metal Corrosion"
Contact: midlandschair@icorr.org

27th October, Aberdeen Branch
Online Webinar: "Assessment, Corrosion Control, and Life Extension of Reinforced Concrete Structures" – Presented by Dr Mohsen Mazraeh, SIMCO Technologies Inc.
Contact: ABZchair@icorr.org

24th November, Aberdeen Branch
In-Person Joint Meeting with IOM3/MIS, Palm Court Hotel: "The Use of Metallographic Replication as a Corrosion Investigation Technique" – Presented by Dr Nkem Nwosu, Element Materials Technology
Contact: ABZchair@icorr.org

YICORR/YEP

24th September, YEP
YEP Session 7
Contact: youngicorrchair@icorr.org

COURSES AND EXAMS

Cathodic Protection (CP) Training Scheme

Buried Level 1
7th–9th September 2026,
Argyll Ruane Ltd., Sheffield
19th–21st October 2026,
Argyll Ruane Ltd., Sheffield
30th November–2nd December 2026,
Argyll Ruane Ltd., Sheffield

Buried Level 2
28thSeptember – 2nd October 2026,
Argyll Ruane Ltd., Sheffield
26th– 30th October 2026,
Argyll Ruane Ltd., Sheffield
21st Sept–25th Sept 2026,
Argyll Ruane Ltd., Sheffield
12th–16th October 2026,
ICORR Training and Examination Centre
2nd–6th November 2026,
ICORR Training and Examination Centre

Concrete Level 2
14th–18th September 2026,
ICORR Training and Examination Centre

Concrete Level 3
16th–20th November 2026,
ICORR Training and Examination Centre

STGB

Other than final certification, these courses are operated and administered by our two approved Training Partners – Argyll Ruane and Corrodere.

ARGYLL RUANE

Argyll Ruane Training Courses

Hot Dip Galvanising Inspector Level 2
Online, sign up anytime

Protective Coatings Inspector Level 1
14th–21st September 2026, Sheffield
12th–19th October 2026, Sheffield
2nd–9th November 2026, Sheffield
7th–14th December 2026, Sheffield

Protective Coatings Inspector Level 2
7th–14th September 2026, Dunfermline
5th–112th October 2026, Sheffield
16th–23rd November 2026, Sheffield

Insulation Inspector Level 2
Online, sign up anytime

Passive Fire Protection (PFP) Coating Inspector (Cementitious) Level 2
Online, sign up anytime

Passive Fire Protection (PFP) Coating Inspector (Epoxy) Level 2
Online, sign up anytime

ICorr Recertification Programme Available for all core methods
Online, sign up anytime

Transition to ICorr Programme
Online, sign up anytime

corrodere academy

Training and Practical Workshops

- **Inspection Level 1**
- **Coating Inspection Level 2**
- **Coating Inspection Level 3**
- **Insulation Inspection Level 2**
- **Pipeline Coating Inspection Level 2**
- **Hot Dip Galvanising Inspection Level 2**
- **Thermal Metal Spraying Inspection Level 2**
- **Transition to ICorr Level 1**
- **Transition to ICorr Level 2**

All above available Online. Sign up anytime. Refer: Corrodere Academy | Accredited Coatings & Corrosion Training Corrodere Academy and Coating Inspection Courses | Corrodere Academy and Corrodere Events Calendar - Corrodere Academy

BRANCH CONTACT DIRECTORY

ABERDEEN:
ABERDEEN: Stephanie Okoye (Chair)
Email: ABZchair@icorr.org

SCOTLAND:
Philip Enegela (Chair)
Email: cschair@icorr.org

LONDON:
Ashokan Gopal (Chair)
Email: londonchair@icorr.org

MIDLANDS BRANCH:
Aliakbar Oskuie (Chair)
Email: midlandschair@icorr.org

NORTH EAST:
Matt Fletcher (Chair)
Email: nechair@icorr.org

NORTH WEST:
Izabela Gajewska (Chair)
Email: nwchair@icorr.org

WALES and SOUTH WEST:
Rene Brueckner (Chair)
Email: swchair@icorr.org

YORKSHIRE and HUMBER:
Joshua Owen (Chair)
Email: yorkshirechair@icorr.org

OVERSEAS CONTACTS:

INDIA
Arpit Goyal (Chair)
Email: INDIAchair@icorr.org

UAE
Dr Muhammad Ejaz (Chair)
Email: UAEchair@icorr.org

DIVISIONAL CONTACTS:

CSD DIVISION:
Julian Wharton (Chair)
Email: csdchair@icorr.org

CED DIVISION:
Danny Burkle (Chair)
Email: cedchair@icorr.org

YICORR:
Kathy Purnell (Chair)
Email: youngicorrchair@icorr.org

ENGC REGISTRATION:
Anthony Setiadi (Chair)
Email: ECReg@icorr.org

SCI.C REGISTRATION:
Brenda Peters (Chair)
Email: Hon.Sec@icorr.org

PAC REGISTRATION:
Paul Lambert (Chair)
Email: pac.chair@icorr.org

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www.icorr.org