A journal of the Institute of Corrosion

Corrosion Management

Issue 163 September/October 2021

Non-Intrusive Inspection.

INSTITUTE OF CORROSION

Stay up to date with all the latest in Institute news

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Our Informative Technical Article series continues

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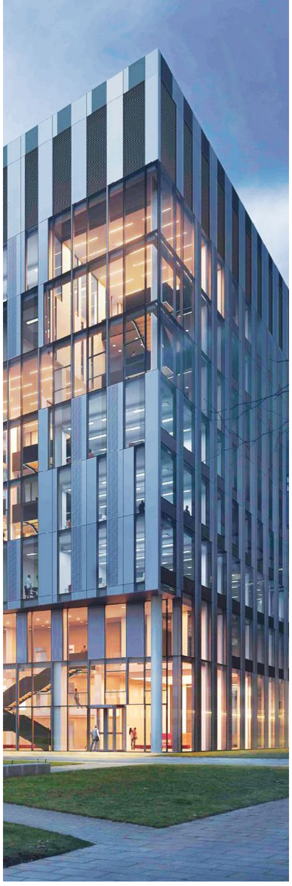



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The President Writes

Welcome to this autumn edition of your magazine – I do hope you managed to enjoy the summer and got some vacation time.

Although the ICorr year runs from the 1st July to the 31st June each year it is at this time that our activities start to pick up again with branch meetings and other events. It's exciting to see our Aberdeen and London branches re-starting in person meetings and exploring how we might be able to live-stream them as well for those who cannot attend. On the subject of branches, I'd like to thank everyone in the Northeast area who responded to our call for help with re-energising our branch there. We had numerous great offers and thanks to David Mobbs for coordinating the way forward – I look forward to attending one of the meetings.

On the 11th August we had our quarterly Council Meeting and I'm delighted to say our Institute remains in great shape. Our new cathodic protection courses are proving very popular and our new coatings courses are about to come on-stream.

With the easing of Covid restrictions I've been really pleased to attend two in-person events and meet some of our members. At the end of August I attended the opening of a new technology centre dedicated to pipeline pigging at Cokebusters in Chester, and in September I attended the second day of the Corrosion Science Symposium at the University of Manchester. All the talks were excellent, and I was impressed by the progress being made in surface imaging at the nanoscale and the advances in modelling corrosion mechanisms at the atomic level. Whilst there, it was my privilege to give our UR Evans award in person to Professor Bob Cottis, University of Manchester for 2020 and to Professor Mary Ryan, Imperial College, London, for 2021. I'd like to thank Professor Stuart Lyon for organising a great event and you will be able to read more about the conference in the next edition.

Finally, I'd like to mention our approach to email communications with you. We work very hard to avoid sending you too many emails as we all understand the problem of email overload. Historically we have only sent you emails about events related to your branch activities as they were in-person events. However, since the arrival of Covid we have moved into the world of on-line presentations and live-streaming which means anyone can attend from anywhere in the world – albeit on UK time ! This has proved very popular and, as a result, we have agreed that if a meeting is exclusively an in-person meeting we will continue to send emails only to the relevant branch members. However, if it is an on-line meeting, we will send to all our membership as it may be of interest to a wider audience. We still believe this will be a relatively small number of emails and expect no more than a few each month.

As ever I'd love to hear from you on this or any ICorr topic you have thoughts on.

Until next time,

Bill Hedges, Institute of Corrosion President
Email: president@icorr.org

From the Editor

Welcome to this issue of your magazine. In the summer I asked the Fellows of the Institute for topics to be covered in the "Fellow's Corner" column. I must say that the response has been fantastic, and I would like to thank the Fellows for their ideas. Due to the response, I have included three articles covering different aspects of our industry, and intend to publish at least two in each of the up-coming issues of the magazine.

There are also two technical articles in this issue, covering inspection and testing. Neil Wilson and Simon Hurst from ENGTEQ discus the use of non-intrusive inspection from a corrosion engineer's point of view, which complements the article in the last issue. Richard Holliday of PPG describes a new method for the assessment of epoxy PFP coatings intended for use on modular and lighter steel components and to meet the increasing construction in colder climates.

Finally, there are some questions to test your knowledge of our industry, and if this is of interest to readers, I can expand this theme for future issues.

Remember, this is your magazine, and I welcome feedback on the contents and other topics you would like covered. You can contact me at, brianpce@aol.com

Brian Goldie, Consulting Editor

ICATS/CORREX

In July of this year, ICorr/CORREX had a very successful audit with LRQA and passed with no recommendations for action or non-conformances.

In the build-up to the audit, ISO 17024 was added to the audit schedule, and also added to the ICorr/CORREX Quality Manual. This meant that our forms and documents had to be changed to comply with this standard. All students being registered for ICATS training will now have to sign any application and ensure address and other details are correct. The forms also contain essential information for guidance to students and trainers. It is hoped to introduce the new forms during October.

The ICATS reqDoc containing all the guidance for ICATS training is also being updated to reflect ISO 17024 and other changes. Remote training and guidance as well as other information is being added. And it is hoped to have this document approved in the near future.

As the UK slowly returns to some normality, we are now beginning to consider ICATS training in Northampton in the Autumn. The proposed dates will be put on the ICATS website during September for Supervisor, Trainer and Manager courses.

Kevin Harold, CORREX Managing Director

Corrosion Engineering Division (CED)

Videos of the presentations given at the CED working day, April 28th 2021, on the theme of "Managing Corrosion in Low-Carbon Energy Technologies", can be found in the members section of the website, under Corrosion Engineering Division (CED), https://www.icorr.org/corrosion-engineering-division/.

Institute AGM

Dear Member,

The Trustees and Council of the Institute would like to invite you all to the 2021 Annual General Meeting (AGM) to be held on Thursday 22nd of November 2021 at the **National Conference Centre & The National Motorcycle Museum** in conjunction with the Midlands Branch meeting, including technical presentations by corrosion experts from across UK.

National Conference Centre & The National Motorcycle Museum
Coventry Road, Bickenhill, Solihull, West Midlands B92 0EJ
http://www.nationalmotorcyclemuseum.co.uk/ http://www.nationalconferencecentre.co.uk/

09h00-10h00	**Arrive and registration**
09h00-10h00	**Midland Branch Meeting** Institute of Corrosion presentations of current ICorr training courses Chris Spence – CP Richard Edwards - CP certification Kevin Harold – ICATS and certification John Fletcher – ICorr Surface Treatment Courses
10h45-11h00	**Comfort break**
11h00 – 12h00	**Communication and Digitisation in the Corrosion Industry** **Speakers** Ian Sotherton - Omniflex – Dr Prafull Sharma – CorrosionRADAR Jack Cornes - HausBots
12h00-13h30	**Lunch and access to the museum**
13h30-14h45	**AGM Agenda** Apologies for absence Minutes of the previous AGM November 2020 President's report Treasurer's report Elections Any other business The Trustees and members of Council will be available before the meeting to answer any questions you may have regarding the Institute and its future. Again, as in the case of 2020, the Institute's accounts, and the minutes for the previous AGM, will be available via the ICorr website (www.icorr.org). Please examine them, and the website in general, as we would appreciate your feedback. This year the AGM will also be live streamed via Zoom or Teams meeting, please confirm your attendance as detailed below to receive further instruct ions for remote access on the day.
14h45-15h00	**Comfort break tea coffee**
15h00-16h00	**ICorr Awards and presentations**
16h00-17h30	**Access to the museum – site closes at 17h30**

Please confirm attendance (for lunch numbers and remote access to the AGM) or apology for absence by e-mail to admin@icorr.org

We look forward to seeing you there.

Yours faithfully,

J Lomas.

Dr Jane Lomas, Institute of Corrosion Honorary Secretary

Advertise in Corrosion Management a leading industry organisation publication

Key Facts

Corrosion Management

- Circulation of 1500 subscribers
- Published bimonthly – 6 issues a year
- 75% of subscribers UK Based
- Majority of readers employed at senior level as decision makers and specifiers in their field
- The main focus of each issue is a themed technical article
- Editorial also includes: Institute News, Industry News, Innovative Products, Diary of Events, Recruitment and currently the Sustaining Members Directory

Don't delay

We have a range of advertising opportunities in Corrosion Management Magazine. However because this is a technical journal, space is limited and is booked on a first come first served basis.

Display Advertising

Full page from £400.00

Recruitment advertising full pages from £600.00

To help you target your advertising effectively we have developed a features list

2021 Features List

November/December Issue – Oil and Gas

Young ICorr

The intent of Young ICorr is to develop a network of younger professionals, who are either working or interested in the field of corrosion, and to assist in their career development as a member of the Institute.

The vision of "Young ICorr" is to Recruit, Train, Retain, the younger generations of engineers and scientists, and to assist in increasing their experience, their corrosion network, and to improve their career opportunities.

In recent years, the Young ICorr community and network has rapidly grown under the leadership of Caroline Allanach who chaired the committee after participating in the 2018 Young Engineers Programme (YEP). Fellow participant, and team member of the 2018 YEP, Danny Burkle, worked closely with Caroline, as vice-chair, to help drive membership growth and assist in bridging the gap between the senior ICorr members, and the engineers, scientists, technicians and researchers in the earlier stages of their career.

Caroline, has recently completed 2 years as the chair and Danny is taking over the chair of the committee. Danny will continue to help continue the growth of Young ICorr and to assist the younger generation with the next steps in their career path. As chair, Danny's first task has been to recruit a new vice-chair and to confirm the Young ICorr committee structure.

James McGladdery, who participated in the 2019 YEP and joined the committee after the programme had finished, has assisted greatly in the growth of the network and will become the next vice-chair. One of the first major tasks for the Danny and James will be to restructure and build the committee to assist with further membership development and growth and to plan the next 12 months of events. The new committee will be made up of professionals in both academia and industry related positions, and widely spread across the UK and beyond.

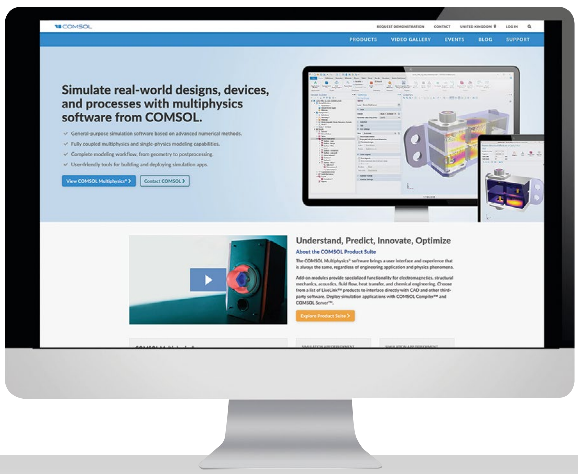
Young ICorr are currently looking for enthusiastic, motivated people to join the advisory committee, and if you are interested in joining, or interesting in learning more about our vision and future events. then please contact Danny for more information on info.youngicorr@gmail.com.

The chair looks look forward to hearing from you and to welcome you to a network of like- minded peers.

New Gold Sustaining Member Company

COMSOL is a global provider of simulation software for product design, engineering, and research in technical enterprises, labs, and universities. COMSOL Multiphysics® is a software environment for the modelling and simulation of any physics-based system with the ability to account for multi-physics phenomena. Optional add-on modules add discipline-specific tools for mechanical, fluid, electromagnetics, and chemical simulations, as well as CAD interoperability. Simulation experts can use COMSOL Server™ and COMSOL Compiler™ to deploy simulation applications to design teams, manufacturing departments, test laboratories, and customers worldwide.

Most corrosion occurs due to electrochemical reaction processes taking place underwater and in wet or humid environments. Modelling corrosion allows engineers and scientists to investigate these processes, gain an understanding of the extent to which corrosion could occur over the lifetime of a structure, and implement preventative measures to inhibit electrochemical corrosion, in order to protect their structures. The Corrosion Module, an add-on to COMSOL Multiphysics®, can be used to simulate corrosion at the microscale in order to investigate the fundamental mechanisms, and at larger scales to determine how to protect massive or long-ranging structures from corroding.



Test Your Knowledge

How good is your knowledge of corrosion protection?
Can you answer the following two questions?

1) What links an aeroplane, a sacrificial anode and a beer can?

2) What links concrete, a paint blister and a heating/cooling system?

Answers on page 29.

ICorr Fellow Receives Prestigious EFC Award

Dr Richard Barker, FiCorr, is the latest in a line of notable Corrosion Scientists to receive the prestigious Kurt Schwabe Award on behalf of the European Federation of Corrosion Committee.

The Kurt Schwabe Prize, established in 2000, honours the late Professor Kurt Schwabe and was initiated by the Hungarian Corrosion Society with support from the 'Kurt Schwabe Foundation'. Presented once every 3 years, the award, consisting of a certificate and 500 Euros, recognises the scientific and technical contribution of young scientists below the age of 35 in the field of corrosion science. The last UK recipient of the award prior to Dr Barker was Professor Mary Ryan of Imperial College in 2003.

This year, the ICorr committee nominated Dr Barker based on his significant contribution and demonstrable impact, predominantly in the oil and gas industry. Dr Barker is an Associate Professor in Corrosion Science and Engineering in the Institute of Functional Surfaces at the University of Leeds. His research interests lie in the areas of electrochemistry, corrosion science and corrosion engineering, particularly in the context of asset integrity and flow assurance in the energy and low carbon abatement sectors. His expertise encompasses numerical modelling, unique/custom system design for the observation of corrosion phenomena, development of in-situ methods for real-time interface characterisation during corrosion processes, and understanding corrosion behaviour in extreme environments (high temperature/pressure, strong acids and toxic gases).

Dr Barker received the award at the opening ceremony of the Eurocorr conference on the 20th September and delivered the plenary talk on the 24th September.

Local Branch News

London Branch

The November technical talk will be on "Lessons Learned from 40 years in Corrosion Protection", by Alex Garner, Corrosion Services Ltd. This is planned to be held on the 11th at the Lancaster House Hotel, Bayswater, London, with the meeting starting at 18.00.

The presentation will focus will be on the highs, with brief mentions of the lows, of a 40-year career in corrosion protection, including CP, material selection, coatings and insulation, for a wide variety of onshore and offshore facilities. The journey will start in 1980 and cover technical and social challenges in office and site -based work in Europe, Middle East, Asia, Canada, South America, and Australia. as well as the corrosion protection peers encountered over the years, many of which are now friends. The anecdotal guidance delivered in the presentation will highlight the pleasures and technical excellence that can be achieved in this industry and hopefully will not scare too many people away from it.

The branch has decided to go ahead with their annual Christmas luncheon this year. This will take place on 2nd December at the usual venue, The Royal Oversees League, Piccadilly, London, for further information, or to book a table, please contact, sjbarke55@gmail.com.

Midland

The branch will be holding a technical meeting to coincide with the Institute AGM. Please see the programme on page 6.

Aberdeen Branch

The branch was extremely pleased to be able to hold their first post-covid 'Face to Face' event on 24th August 2021 at the premises of hosts TRAC Oil & Gas Ltd, which included a range of technology demonstrations, kindly compiled by Mike Dixon (NDT Technical Manager) and Ian Somers (TRAC Compliance Manager - Executive Director of IRATA International), with the proceedings chaired by 2021-2022 branch chair Hooman Takhtechian. This Annual Corrosion Forum also comprised eight presentations by speakers from various companies, all very active in the integrity management field.

New branch chair Hooman Takhtechian, opening the proceedings.

The event attracted over 30 delegates who enjoyed an interesting programme themed on 'External Corrosion Management' which remains a major issue in North Sea Oil and Gas operations.

For most, this was their first public meeting in nearly 18 months of home-working, and the relaxed atmosphere and relief was clearly evident after 3 covid waves, numerous covid tests, and long queues for vaccinations.

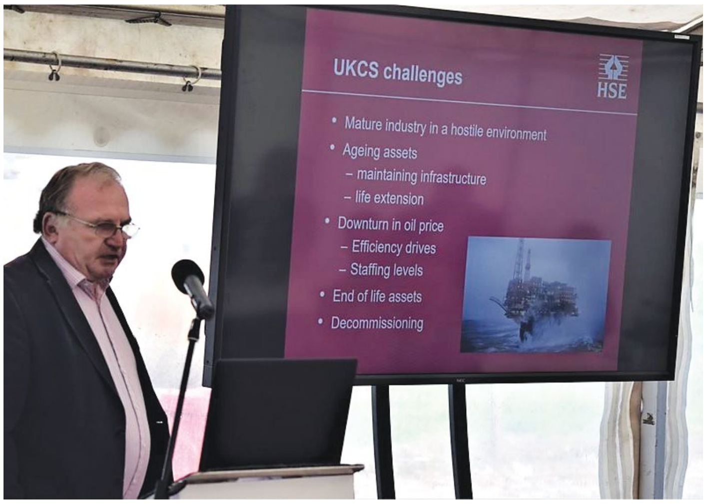
Branch Annual Corrosion Forum event attendees

Dr Mehdi Monir, Senior Corrosion Engineer (Oceaneering), commenced the proceedings with a very comprehensive introduction to the principles of external corrosion, and the key deterioration mechanisms found within the Oil and Gas industries, together with common mitigation strategies. The environmental factors that drive corrosion pitting and cracking were clearly explained, along with how these influence corrosion rates in various regions of the world, with the UK marine environment being particularly aggressive.

Walt Doxford, Specialist Inspector for the Offshore Division of HSE, followed on with an explanation of the HSE regulatory requirements and recent experiences from their viewpoint for a mature industry operating in a hostile environment, key issues being:

- Atmospheric external corrosion
- Bolting corrosion
- Corrosion of / at pipe supports, (in particular trunnion supports).
- CUI, (corrosion under insulation)
- Deck penetrations
- FM (fabric maintenance) in later life assets

This was in the context of many ageing assets approaching COP (cessation of production) and the drives by operators to reduce staffing levels and vendor visits to site.



Walt Doxford, Specialist Inspector Offshore Division HID (Materials/Corrosion/NDT) · Health and Safety Executive

Mike Adams, Director of Eden Asset Integrity Ltd, then considered this all from the Inspector / NDT Technician's point of view (at the front line and often forgotten), and emphasised the need for corrosion engineers to correctly direct the industry workforce, so that NDT inspections are relevant to the likely corrosion and erosion mechanisms occurring, and which may be due to:

- Changes in process corrosivity.
- Local increases in fluid velocity or changes in direction.
- Wherever a microbe just happens to settle down.
- Where surface wetting occurs.
- Where mineral or corrosion scale builds up or breaks down.

The NDT technician needs to know the expected form of damage, so that they can select the right technique, and because most NDT is just a sample of the total surface area, where to look, as without such information serious damage may be missed with consequential in-service failures.

Colin Fowlis (Operations Manager) and Stuart Rennie (Commercial Manager) – Presserv (UK) Ltd, gave a great introduction to external mitigation by coatings covering all aspects of surface preparation technologies and available coating types on the theme 'Coatings – The 1st line of defence against corrosion' and highlighted that 50% of external corrosion costs are preventable (through regular fabric maintenance programmes).

The critical considerations for coating material selection were discussed including:

- Climatic conditions.
- Ease of application.
- HSE considerations.
- Mechanical characteristics.
- Overall lifetime cost (including future maintenance).
- Suitability to environment.
- Supply logistics.
- Tolerance to surface.

Stuart Rennie of Presserv (UK) Ltd.

Frances Chalmers, Technical Consultant of Plant Integrity Management Ltd, continued the proceedings with a 'Whistle-stop tour of CUI Management" including CUPS (corrosion under pipe supports), and reviewed the key regulator recommendations of the HSE-led CUI forum held on 31st May, which were:

Regulator Viewpoint, point 1

- Establish an effective CUI management scheme.
- Meeting good practice alone may not be sufficient to comply with the law (avoidance of prosecution in the event of an incident and/or issue of HSE improvement notice). i.e. The installation must remain safe in all respects.

Regulator Viewpoint, point 2

- Do what you say you're going to do.
- Be clear about progress and CUI priorities.

Regulator Viewpoint, point 3

- Conduct suitable inspection at a frequency to permit detection and remediation of deterioration in good time.

Frances went on to describe CUI management strategies in great detail for asset early life, mid-life, and late-life situations, and RBI approaches, in consideration of all key factors and noting that CUI corrosion rate data can vary significantly for individual plants and locations (operating environments). A traffic light system was proposed for insulation anomalies and for assessing the degree of damage and risk. The manner in which a CUI defect finally fails being most usually related to its operating pressure, i.e. sudden burst (at high pressure) or weep/seep (at low pressure).

Frode Wiggen, Snr. Principal Engineer DNV, closed the morning session with a "virtual' presentation and outlined the new DNV ***CUI Manager*** software, for managing the significant threats posed by CUI, developed under a joint industry project, resulting in DNVGL-RP-G109 methodology that facilitates structured continuous assessment and documentation of present and future CUI risk. This new project was first outlined at the SPE Corrosion Conference in June 2021, and may be found at https://www.spe-aberdeen.org/wp-content/uploads/2020/11/Thurs_DNVGL-RP-G109-presentation-rev-1.pdf

TRAC Demonstration of SAFE Composite Wrap Inspection (specialist NDT for Pipe Repairs).

In the afternoon and after catering courtesy of our hosts, delegates were treated to an excellent series of NDT demonstrations highlighting the very latest technologies deployed in the energy and other sectors by TRAC, who are long-time supporters of the branch and its technical programme.

TRAC Demonstration of External Corrosion NDT Inspection.

The event went off successfully and the branch are extremely grateful to TRAC for their hard work in making it possible for everyone.

The successful Corrosion Forum approach of blended learning, (virtual, plus face-to-face teaching), will surely continue in the years ahead, as we all seek to avoid unnecessary travel, in the desire by all to meet ever stricter environmental targets and avoid further pandemics.

All the technical papers for the event can be found at, https://sites.google.com/site/icorrabz/ and also at Aberdeen Branch - Institute of Corrosion (icorr.org) under "Local Technical Programme, August 2021".

A reminder that the branch is inviting applications for the 2022 ICorr Young Engineer Programme (YEP), which it is pleased to support, following in the footsteps of the highly successful and extremely popular London Branch programmes. For its Aberdeen rotation, the YEP course will reflect the extensive locally based Oil and Gas related Industries, and of course also the rapidly growing Renewables Energy Sector. Please contact Hooman Takhtechian, HTakhtechian@oceaneering.com, if you are interested in participating in this.

Industry News

Henry Royce Institute calls for Technology Roadmap to help co-ordinate action to address degradation issues

The Henry Royce Institute for Advanced Materials has called for co-ordinated action to address the significant degradation challenges presented by the transition to net zero through a 'Technology Roadmap for Net Zero'. Such a roadmap would select which technologies should be prioritised for investment and also be attached to key dates linked to when they're expected to come online. It could also define the most cost-effective investment pathway to net zero, allowing industry and academia to develop Research, Development and Innovation (RD&I) programmes in alignment with clear timescales for delivery.

For many sustainable and low carbon technologies, the degradation of structural materials presents significant and ongoing challenges which can limit the performance, operational life, and sustainability of assets. For example, the financial impact of corrosion, which represents just one of the mechanisms under the umbrella term of degradation, has been estimated at 3.4% of the world's GDP, thus significant savings could be achieved through better understanding and effective management of materials degradation.

To explore these issues in more depth, Royce commissioned a major landscaping exercise which examined the impact of degradation on wind power generation, carbon capture use and storage (CCS), nuclear fission power generation, transportation technologies (air, road, rail and sea), and hydrogen production and usage, with the overall aim of identifying the materials-related issues affecting the lifetime of structural components, and prioritise the research needed to improve the lifetime of these components.

The report identified a need for high-level strategic direction to guide R&D efforts towards these degradation challenges, but stated that in order for such a strategy to have authority and credibility, it is imperative that it should be developed as a collaborative effort between senior policymakers, along with a broad range of cross-sectoral academic and industrial stakeholders. Bill Hedges, ICorr President, and project champion for the Royce landscape study said: "Significant savings and societal benefits can be achieved through better understanding and effective management of degradation issues. Yet at the moment funding calls continue to encourage an isolated approach to investigating degradation mechanisms and this report recommends that only with a significant change in leadership and policy will the obvious opportunities for transformational change be grasped and ultimately realised. While the report confirms that there were no 'show-stopping' issues associated with materials degradation that will block the path to net zero, there are however many opportunities to reduce the costs associated with this."

As a consequence of this study, the research, development and innovation programmes required to support net zero and tackle the degradation challenge, need to be a collaboration between governing bodies, UK Research and Innovation, major industry players, the supply chain, the Department for Business, Energy and Industrial Strategy, and academia.

The full report can be found at, https://www.royce.ac.uk/collaborate/roadmapping-landscaping/degradation/

For further information, contact Dr Andrew Bowfield, Business Development Manager, Henry Royce Institute, E: andrew.bowfield@manchester.ac.uk, and the report can be found at, https://www.royce.ac.uk/collaborate/roadmapping-landscaping/degradation/

Editor's Note : The Henry Royce Institute is the UK national institute for advanced materials research and innovation, with the aim of growing, and supporting, world-wide recognition of the excellence of UK materials research, accelerating commercial exploitation and delivering positive economic and societal impact for the UK. With its base in Manchester, it is funded by the Engineering & Physical Sciences Research Council, part of UK Research & Innovation.

The Sir Henry Royce Institute, Manchester

Opening of the new Henry Royce Institute hub building

Professor Dame Ottoline Leyser CEO of UK Research and Innovation opened the new Henry Royce Institute Hub Building at the University of Manchester, on 7th September

Professor Dame Nancy Rothwell, President and Vice-Chancellor at The University of Manchester and Dame Julia King, the Baroness Brown of Cambridge and Chair of the Henry Royce Institute, welcomed guests to Royce's flagship building at the university and set out the capabilities of the new UK centre for materials research and meeting place for the advanced materials community.

Following a tour of the building's laboratories and meeting researchers, Dame Ottoline unveiled a plaque marking the official opening of the Royce Hub Building, which will be the hub to 400 researchers, PhD Students and professional services staff driving research and innovation in advanced materials.

The event also saw an important keynote video message from The Rt Hon Kwasi Kwarteng MP, Secretary of State for Business Energy and Industrial Strategy, who highlighted the importance of Government investment in innovation and technology translation. The Business Secretary noted that Advanced Materials & Manufacturing is a key technology family of "UK strength and opportunity", as highlighted in the Government's recently announced UK Innovation Strategy: Leading the future by creating it

The building hosts £45 million of new state-of-the-art equipment alongside existing facilities in Manchester for biomedical materials, metals processing, digital fabrication, and sustainable materials research, including the new Sustainable Materials Innovation Hub part-funded by the European Regional Development Fund (ERDF). In addition, there is a variety of collaboration spaces for industry engagement, helping to accelerate the development and commercialisation of advanced materials.

During the event, Carol Holden OBE, from the Northern Automotive Alliance presented on the Royce role in industrial innovation and Mia Maric, winner of IOM3 Young Person's Lecture Competition talked about her Manchester PhD experience and the benefits of using Royce's equipment and expertise in her research.

Royce's presence in Manchester extends well beyond this new building it also has substantial space and equipment in the Alan Turing Building, together with facilities in the National Graphene Institute, Manchester Institute of Biotechnology and at the Dalton Nuclear Institute. It will soon also extend its reach into the new Manchester Engineering Campus Development – the MECD – which is the single largest home for engineering in any UK university.

Winoa celebrates its 60th Anniversary

The Winoa group, a worldwide supplier of abrasive media for shot blasting operations, has announced the group's 60th anniversary, as well as the largest steel media factory in the world, the Cheylas factory in Isère, France.

The company, formerly known as Wheelabrator Allevard, currently has more than 800 employees, is established on four continents, with a total of nine factories, four test centres; and three research centres.

According to the company, for this 60th anniversary, they are taking the opportunity to implement a renewed and improved growth plan, as well as the development and marketing of new services and products.

The steel shot produced by Winoa under the name "W Abrasives®" is used in the manufacturing and processing of thousands of metal products and articles.

For more details on WAbrasives, see, www.wabrasives.com

Sika to divest European industrial coatings business

Sika has agreed to sell its European industrial coatings business, based in Germany, to The Sherwin-Williams Company. The transaction is expected to be completed at the beginning of 2022.

The transaction includes the European industrial coatings business with the main location and manufacturing facility in Vaihingen, Germany. The product range encompasses anticorrosive and fire protection coatings which are mainly sold in Germany, Switzerland, Poland, and Austria.

Latest Literature

Improved wear resistance and anticorrosion properties

A series of environmental-friendly polyvinyl butyral/phenol formaldehyde resin (PVB/PF) composite coatings with various PF contents were prepared by a solution blending method. The tribological and anticorrosion properties of the composite coatings as well as the influence of PF content were studied. The results showed that the addition of PF can significantly improve the wear resistance of the PVB coating, and electrochemical impedance spectroscopy (EIS) results showed that the corrosion resistance of the composite coatings can also be significantly improved after immersing in 3.5 wt% NaCl aqueous solution for 30 days. The researchers, claim that the good tribological and anticorrosion properties of composite coating are due to the uniform and dense structure formed by PVB and PF, which has good flexibility, high mechanical strength and excellent barrier properties. The study was published in Progress in Organic Coatings, Volume 158, September 2021.

Double layer powder coating to enhance corrosion protection

A novel epoxy resin modified PVC powder coating was used as a primer and pure PVC powder coating as a topcoat, for the corrosion protection of steel in a marine environment. Test results revealed that the material obtained the highest adhesion and salt spray resistance when the epoxy content in the primer was 50 wt%. In contrast to the pure epoxy coating and the pure PVC coating, the EP-PVC coating exhibited an excellent corrosion resistance, owning to the good adhesion of the composite primer and the good barrier and corrosion resistance of the topcoat.
The study was published in Progress in Organic Coatings, Volume 158, September 2021.

STANDARDS UP-DATE

ISO

The following documents have obtained substantial support during the past two months and have been submitted to the ISO member bodies for voting, or formal approval.

ISO/DIS 4215 Corrosion of metals and alloys — Test method for high-temperature corrosion testing of metallic materials by thermogravimetry under isothermal or cyclic conditions

ISO/DIS 11997-3 Paints and varnishes — Determination of resistance to cyclic corrosion conditions — Part 3: Testing of coating systems on materials and components in automotive construction

ISO/DIS 22553-10 Paints and varnishes — Electro-deposition coatings — Part 10: Edge protection

New International standards published during the past two months.

ISO 7539-9:2021 Corrosion of metals and alloys — Stress corrosion testing — Part 9: Preparation and use of pre-cracked specimens for tests under rising load or rising displacement

ISO 11125-9:2021 Preparation of steel substrates before application of paints and related products — Test methods for metallic blast-cleaning abrasives — Part 9: Wear testing and performance.

Ask the Expert

Question:

At a recent meeting with a client a question was raised – How does my company find a corrosion engineer who has a broad background over a range of disciplines? They reported that they have tried to recruit, but can only find people with specialist training in limited areas. To cover all our corrosion needs, we would need to hire a paint inspector, a welding inspector, a CP engineer, a metallurgist, a concrete specialist and a water treatment engineer. Surely there must be people who have a basic knowledge of these disciplines who could carry out day to day work and be able to call in specialist experts when needed? **AN**

Answer:

The question is not unusual in the current economic situation. Many companies know that they need experts for some jobs but require a more generalised approach to everyday situations. At one time, larger companies ran training programmes for new engineers, to enable them to become familiar with the company's products and processes, and to provide them with a broad experience of the various corrosion challenges that they would meet during their working lives. Often this was an informal apprenticeship, with the new starter shadowing an experienced engineer and gaining knowledge and expertise over time, perhaps a couple of years. A similar situation may be like that of a junior doctor, who has the opportunity to work in many different healthcare situations before deciding on a specialism.

The result of the informal apprenticeship type process would be an engineer who understood the corrosion aspects of the operation of multiple areas of that plant and who was able to use that knowledge for the benefit of the company at other sites and with other processes. Unfortunately, the need for greater productivity and profits, in combination with the drive towards minimal workforce numbers, has significantly reduced the opportunity for the "grow your own corrosion engineer" approach in all but the largest or most determined companies.

In parallel, there has been an increased requirement for new starters being able to show "paperwork" which demonstrates training and competence in specific areas. Whilst this has reduced the number of "corrosion cowboys" in the industry, it has also resulted in many good corrosion engineers with long term general experience, being unable to "prove" their knowledge. People who went through the on-the-job multi-discipline corrosion training were not provided with a certificate, and after a number of years of experience when they may be looking to change company or diversify out of a career limited industry, are finding it difficult to convince potential employers (who now need certificates as proof of knowledge) to hire them.

In turn, these companies are finding that most of the potential new employees are often qualified only in one specific discipline and therefore they may need to hire several people to cover the range of job requirements – the problem of the client at the start of this article.

One option for the company, is to hire specialist corrosion expertise when it is needed, but again this can be a challenge. How does the company know what sort of expert they need and what happens if the problem covers too many aspects for the expert? What if they need a person with a general corrosion knowledge? Of course, there are large consultancy companies which employ several specialists and can match the enquirer with a person in the right specialism. But again, what happens if a more lateral approach to the corrosion problem is needed?

As one semi-retired senior corrosion engineer, with a lifetime of broad experience, said, people like us are literally dying out. I need to recruit my replacement but how?

To meet the needs of individuals who want to increase their general corrosion knowledge or have their experience recognised in a paper format, and companies who want to take on a corrosion engineer with a certificate demonstrating a broader background knowledge, the Institute of Corrosion has developed a Fundamentals of Corrosion for Engineers (FOCE) course. This course aims to be a solution to fill both the general corrosion engineer's certificate gap and an employers need to find a general corrosion engineer with a relevant certificate of knowledge.

Starting with the very basics of the corrosion reactions, the course builds up over an intensive week to cover a wide range of corrosion situations and industries. The classroom based FOCE course aims to provide the attendees with a general understanding of the common corrosion factors which link apparently different industries. Whilst not a substitute for several years of hands-on training, it gives the participants an awareness of a range of corrosion challenges and solutions across common industries, thus providing a background knowledge of fields that people may wish to investigate further, and work in, as part of their career journey.

In addition, passing the examination at the end of the course provides the successful candidate with a 'Certificate of Achievement' from a globally recognised Corrosion Institute. The certificate demonstrates the broader corrosion knowledge that some employers are seeking when recruiting a general corrosion engineer and provides confidence for the employer that the new engineer does have a wider understanding of corrosion situations. The experienced corrosion engineer will also gain relevant paperwork which both backs up their knowledge and fits company recruitment policies.

FOCE courses are held regularly (covid restrictions permitting) with dates and locations being listed on the ICorr website at www.icorr.org/training-qualifications-2-2. The next course is on 15 – 19th November 2021.

Jane Lomas, Amtec Consultants Ltd

Fellow's Corner

In this issue, we have three articles from experienced Fellows who have made a significant contribution to the understanding of corrosion and its prevention. The first follows on from the topic in the last issue, where Brenda Peters discusses the application of protective coatings, and what needs to be done beforehand. Secondly, Joseph Itodo Emmanuel describes the corrosion protection of buried structures, and finally James McLaurin explains how the design of a steel structure can influence its protection, specifically from bi-metallic corrosion problems

Corrosion protection by protective coatings

The institute of Corrosion is split about 50:50 between Engineers and Scientists, and across several different disciplines, the common ground is in Corrosion Prevention, and there are many overlaps within the fields of expertise. Following on from the Fellow's Corner column in last issue of Corrosion Management, the emphasis of this article is on paint as a means of corrosion protection. Paints generally falls into two categories, decorative and industrial (protective), and paint manufacturers have tended to split their manufacturing and R&D, specialising in one or the other. However, decorative paint can be protective and industrial paint can be decorative. When we talk about "Industrial" or protective paints, we are usually referring to the prevention of steel from rusting. These paints are the most sophisticated technically engineered paints, but they tend to be applied by the least qualified painters. This is why the Correx ICATS (Industrial Coating Applicator Training Scheme) programme was developed to improve the quality and longevity of the finished product. In addition, many manufacturers will run their own training schemes on how their particular product should be mixed and applied and the limitations of the ambient conditions. Paint inspectors are also employed to ensure that the paint is stored and applied correctly, and the surface preparation is to the specified standard. These paint inspectors are normally trained by ICorr or NACE or both, so what can go wrong?

When applying paint to new steel a primer coat is applied to promote adhesion and protect the surface against corrosion, however preparation of the steel prior to painting is paramount. When investigating paint failure, it is a bit "chicken and egg", did the steel corrode and push off the paint or did the paint fail allowing the steel to corrode.

When the steel leaves the mill, it will have some level of millscale on the surface which is blue/black in colour, although this surface can look nice and smooth and suitable for painting, this millscale is however only loosely adhered to the underlying steel, and will scale off after painting. This can often be seen on hand rails and post made from tubular steel which has not been blast cleaned.

To prepare steel for painting, several methods can be used, which depend to an extent on the end use of the material, for example, steel can be pre-treated to inhibit rust and passivate the surface: examples of which are in hot dip galvanising, where the steel is "pickled" in acid to remove rust and millscale then immersed in a vat of molten zinc, which forms layers of zinc alloys at the interface with the steel, culminating in a layer of pure zinc on the surface, and this can be difficult to paint as it is smooth and can result in poor adhesion. It can be left to weather so that zinc oxides form on the surface resulting in roughening which provides a key for the paint to adhere to, or alternatively a variety of primers are available which etch into the surface. These include, acid etch epoxy primers and more the commonly used "T Wash", a mordant solution originally developed by British Rail, which is a phosphoric acid solution containing alcohol and copper carbonate as an indicator. The solution reacts with the surface of the zinc and a black coloration is formed, anywhere it doesn't react and show this colour change can indicate previous contamination on the galvanising and these areas need to be washed, degreased and retreated.

Steel can be treated with hot metal spray (Thermal Spray) as an alternative to hot dip galvanising creating an anti-corrosive layer with a profiled surface to which paint can be applied. This is normally zinc or aluminium and is often used for high temperature conditions.

Similarly, steel can be "phosphated" by dipping in a bath containing a solution of zinc in phosphoric acid forming a thin layer of zinc phosphate on the surface, and which is commonly used in the automotive industry. This can then be undercoated and a decorative finish coat applied on top. The paint can be applied electrostatically in a powder or liquid form then heat cured or applied by spray, roller or brush.

However, in the heavy duty protective coatings field, steel supplied from the factory has to be blast cleaned to remove all millscale and rust, and then primed within a short period of time to prevent flash rusting from forming on the surface. Epoxy primers are commonly used, but these need a good steel surface profile to form a key to ensure good adhesion, so the profile of the blasted steel needs to be checked before application of the paint. As epoxies cure by chemical reaction, they will continue to cure over time until they become fully cross linked, and at this stage they become unsuitable for overcoating, so the manufacturers' overcoating times must be adhered to enable the following coats to adequately bond with the surface of the epoxy. If the overcoating time is exceeded, these coats will eventually lose adhesion at the interface with the epoxy, and detach. Epoxies, like most protective coatings, are also sensitive to ambient conditions, they won't normally cure if it is too cold, and if there is any condensation on the steel, or if they get wet before they cure can prevent them from curing properly. For example, with amine cured epoxies, the amine can react preferentially with moisture resulting in undercure, and if moisture gets on the surface before they are fully cured, amine bloom can occur resulting a dull and chalky surface. Therefore, attention to temperature and dewpoint are very important. Epoxy coatings have been developed which are moisture tolerant and some can even be applied underwater and are utilised for subsea repairs.

When epoxy primers are used then these need to be finished with a decorative acrylic or polyurethane top coat as these are UV resistant – epoxies yellow with sunlight and colours fade through chalking. Acrylics retain their colour longer. Similarly, for alkyd based systems, urethane alkyd top coats are used as these are tougher and have greater longevity.

Historically red lead primers were used, although these were phased out in the late 1960s due to toxicity and leaching they can still be found on many steel structures, and cause problems when it comes to maintenance (full containment and special disposal are necessary). These have been replaced by zinc rich or other anticorrosive primers

Similarly, some steel structures have existing coats of chlororubber or acrylated rubber, which have good corrosion resistance and longevity. However, these can also pose problems during maintenance painting, as they are incompatible with solvent based coating like epoxies, and cannot be refurbished with anything else.

Whichever paint system is chosen it is advisable to use material supplied by the same manufacturer as these are developed to be compatible with each other, and if a failure should occur then there is less anomalies to be considered. Manufacturers will offer a full paint system with primers undercoats and finish coats, for a specific end use.

Brenda Peters

Galvanic Corrosion - the importance of designing-out corrosion hotspot

Galvanic Series of Metals and Alloys in Sea Water

Active End

Magnesium
Magnesium alloys
Zinc
Aluminium alloys
Cadmium
Mild Steel
Wrought Iron
Cast Iron
Stainless Steel (Active)
Lead
Tin
Manganese
Nickel (Active)
Yellow Brass
Red Brass
Copper
Nickel (Passive)
Stainless Steel (Passive)
Silver
Graphite
Gold
Platinum

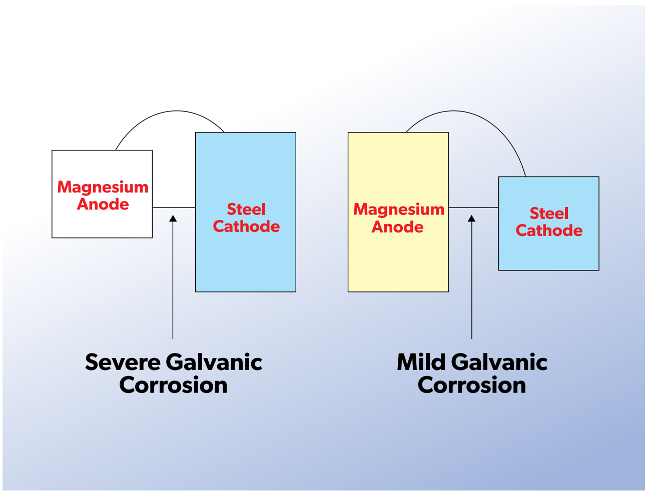
Passive End

Protecting metallic structures from corrosive attack is not just about using coatings or cathodic protection, the design of the structure also plays an important part. There maybe situations which call for two different metals, or alloys, to be joined. If these metals are electrically connected under conditions permitting the formation of a "corrosion battery", then in this situation, one metal can corrode preferentially in relation to the other metal to which it is physically and electrically connected. This is termed "galvanic corrosion".

Galvanic corrosion is an extremely important corrosion process, and one that is frequently encountered. The principles of galvanic corrosion are used to advantage in the cathodic protection of surfaces by using sacrificial metal anodes or inorganic protective coatings. The Galvanic Series lists the activity of metals in order, from the most active (magnesium) to the least active (platinum). When two metals are connected, the metal located higher up the scale will corrode preferentially, and thereby protect the metal lower down the scale from corrosion attack. As an example, if copper and zinc are connected together, the zinc will dissolve, or be corroded preferentially, thus protecting the copper. The metal attacked is defined as the anode, thus the zinc will serve as an anodic area, and the copper will form the cathodic, or the protected area. The function of each will be identical to that found in the typical corrosion cell, as in the set up for rusting of iron. The intensity with which the two metals react in this preferential manner can be measured by the distance between the two metals in the Galvanic Scale. As magnesium is at the top of the scale it will have a tendency to corrode in preference to any other metal shown on the Galvanic Scale, conversely, platinum, which is extremely inert, never corrodes preferentially. While the tendency to corrode depends on the kinds of metal coupled together, the rate at which the corroding anode is attacked depends on the relative area of the anodes and cathodes joined together.

If a small magnesium anode is coupled to a large area of steel (as in protection of a ship's hull), the anode area (being small as compared to the cathode area) will corrode very rapidly. This is due to the entire galvanic current being concentrated on a small area of active metal. Conversely, if the cathode area is small compared to the anode area the corrosion of the anode will be relatively slow, since the demand on the anode is spread evenly across the whole surface of the metal. It must be kept in mind that the areas of each metal involved are those in electrical contact and not just the areas of metal in physical contact. The area of metals in electrical contact will be determined by those areas which are in contact with an external conductive circuit (electrolyte).

For example, in the use of rivets of one metal to fasten together plates of different metal, we find an excellent example of possible effects of galvanic corrosion. If steel plates (anodes) were joined with copper rivets (cathodes) only a very slow corrosion of steel would occur, since the galvanic corrosive effect is spread out over a large area of steel. On the other hand, if copper plates (cathodes) were joined with steel rivets (anodes), a rapid rusting of the rivets would occur. The small area of rivets would be attacked by all the galvanic current generated by large copper plates and would corrode rapidly.



James McLaurin, Altrad Services

External corrosion of buried metallic static structures (piping, pipeline, tanks, and vessels)

Buried metallic structures are common in the oil and gas, petrochemical, and chemical industries. These structures are exposed to a corrosive underground environment which results in their degradation and eventual failure in the form of loss of primary containment. The preferred fabrication materials for the construction of buried assets are carbon and low-alloy steels. Carbon and low alloy steels with some means of mitigation have low capital and operating cost (Opex and Capex) over the asset life cycle when compared to other engineering materials (e.g., polymeric and corrosion resistant alloys). Other notable reasons are, better environment management, safety and security concerns, and long-term strategic objectives. Whilst most buried assets are made of carbon and low-alloy steels with some means of external corrosion control (e.g., protective coating and cathodic protection system), in specific cases where historic data indicate severe corrosion that cannot be acceptably reduced with some means of mitigation in the exposed environment, the other option is to utilise stainless steel or other corrosion resistant alloys (CRA) to reduce corrosion to as low as reasonably practicable. Despite of the superiority of stainless steel to carbon steel in terms of its resistance to corrosion and environmental assisted cracking, it is not immune to localised corrosion damage in the form of pitting, crevice corrosion, stress corrosion cracking (SCC) and intergranular corrosion. Hence, when CRAs are used, there is a need for monitoring, mitigation and management to achieve asset design life during its operation.

Buried metallic assets are exposed to soil, atmospheric gases, ground water and corrosion activating bacteria such as sulphate reducing bacteria (SRB), and others. External corrosion of buried assets is directly influenced by oxygen as it promotes the cathodic reaction, other parameters that accelerate external corrosion are, soil type (e.g., clay, marshy etc.), pH, presence of chlorides, stray current, and induced alternating current. Stray currents can be direct current from a cathodic protection system (CP) or alternating current, e.g., from powered transit systems, electrical welding operations, and mining operations. Also, buried metallic structures that are less than 500 m from power lines rated at 312kV and above, are at risk from induced ac corrosion, plus pose an induced ac hazard to maintenance personnel, and an adverse effect on the cathodic protection system. Although, industry statistics for buried metallic structure show that failures due to induced ac are rare, best engineering practice and codes (e.g., NACE SP 0169, 2013; NACE SP0285, 2011 and API RP 1632, 1996) recommend effective mitigation based on powerline rating, separation distance. angle of overhead, soil resistivity, coating conductance, type of powerline support pole (e.g., metal/wood etc.), and other factors. It is best to carry out computer modelling to assess the effect of ac interference on a buried structure prior to implementing mitigation measures. Due to the complex variables that influence corrosion of buried metallic structures, atmospheric, soil, microbiological influenced corrosion (MIC), and stress corrosion cracking (SCC) are all possible.

The corrosion rates in different soil types vary with soil chemistry, mineralogy and permeability. Soils with poor drainage like clay are more corrosive than soils with excellent drainage like sand. Soil contains base and acid forming elements. Base forming metals that influence corrosion are sodium, calcium, potassium, and magnesium. Acid formers are chloride, carbonate, nitrate, sulphate and bicarbonate. Chloride ion concentration in water can be determined using the ASTM D 512-12 method (withdrawn 2021) and sulphate ion concentration in water is determined using ASTM D516-16 (2016).

The electrical resistivity of the soil greatly influences corrosion, as resistivity increases, the conductivity decreases, and vice versa. Soil resistivity less than 1000 ohm-cm is severely corrosive, and resistivity greater than 10,000 ohm-cm is considered progressively less corrosive. The ASTM G 57-20 (2020), method is recommended, using the Four-Pin method or the Soil Box (Nelson meter), for determination of soil resistivity, and for greater depths, the Geonic EM 37 can be used.

Soil pH influences soil corrosivity. At a pH value less than 4, the soil is extremely corrosive to carbon steel and at a value greater than 10 soil corrosion is controlled except in the presence of strong alkaline solutions. Field operating data for carbon steel, indicates it is unaffected by pH except at a value less than 4, or greater than 10, with the cathodic reaction driven by oxygen reduction. As the moisture content reduces, even at higher soluble ion concentration (very dry soil), the soil corrosivity reduces.

At the pH range found in most soil, oxygen would usually be present for corrosion to take place. This is because most soils have either a neutral or slightly alkaline pH which does not accelerate corrosion except when there is poor aeration or differences in oxygen concentration in the soil creating an anaerobic condition that promotes galvanic (differential concentration) corrosion cells.

Sulphate reducing bacteria (desulfovibrio desulfuricans) can be found in soil with anerobic conditions containing organic matter like clay soil. This results in MIC of metallic structures. Details on the characteristics of soil can be found in ASTM STP 1013. For a better understanding of soil corrosion behaviour, it is advisable to collect soil samples at the installation depth for a detailed soil analysis prior to installation of asset.

The predominant damage modes for buried metallic structures are progressively, wall thinning, pitting and cracking. Common failure modes are pin hole leak, small to moderate leak, large leak, rupture and fracture. Because of the adverse effect on people, environment, asset, and company reputation in the event of loss of primary containment, the integrity of buried assets should be considered a priority.

To ensure effective mitigation of external corrosion, during backfill the soil should be carefully selected to ensure it is dry and free from gravel, clay, rocks, marshy soil, and other harmful corrosion activating materials. The buried structure should be coated with a protective coating (often high build epoxy, vinyl ester etc.) and inspected at hold points to ensure conformance to specification. The coating should have high dielectric strength, superior resistance to water ingress, good mechanical properties (adhesion and abrasion resistance), good flexibility, compatible with CP, withstand degradation due bacteria, excellent performance, long service life, and ideally have low application cost. The asset should also be protected with impressed current CP or sacrificial anode CP with a design life greater than that of the structure.

A CP interference survey should also be conducted to rule out stray current, and if found, should be mitigated to prevent sudden loss of containment. Company standards and codes should be enforced during the engineering, procurement, construction, installation, pre-commissioning and commissioning phases of any buried metallic asset. Because of the criticality of buried assets, it is vital to develop and implement an integrity management programme that is risk-based (API 580, 2016). For pipelines, a risk-based assessment (RBA) should be conducted to determine the remaining asset life. Finally, I would advise the use of ISO 55000 (2014) and 9001 (2015) to develop the asset management plan to increase top leadership commitment to integrity whilst ensuring continual improvement.

Joseph Itodo Emmanuel, Consultant, Joiegloe Global Synergy

Non-Intrusive Inspection, a corrosion engineer's perspective

Neil Wilson and Simon Hurst, ENGTEQ

The traditional approach to determine the internal condition of pressure vessels is by Intrusive Visual Inspection (IVI). This involves the removal of the vessel from service, isolation, cleaning, purging before man entry is possible. There are significant safety risks associated with this approach as well as the costs associated with loss of plant availability.

Non-Intrusive Inspection (NII) allows the effective inspection of pressure vessels from the outside, whilst the vessel remains in service therefore eliminating the loss of plant down time. Effective NII offers confidence in the current condition of the vessel to a degree that is at least equivalent to IVI and generates quantifiable data which may be used for comparison in future inspections.

Typical pressure vessel for NII

HOIS-RP-103 Recommended Practice for Non-Intrusive Inspection of Pressure Vessels [1] offers a consistent, structured approach to NII where the object of the inspection is to be able to justify the continued operation of the equipment until the next inspection interval as specified in the Risk Based Assessment (RBA). NII is becoming used increasingly in place of IVI as experience and confidence in its application grows.

In the July/August issue of Corrosion Management, Susan Osbeck and Mark Stone described NII and the HOIS guidelines in detail, and this article covers the use of this technique from an engineer's point of view.

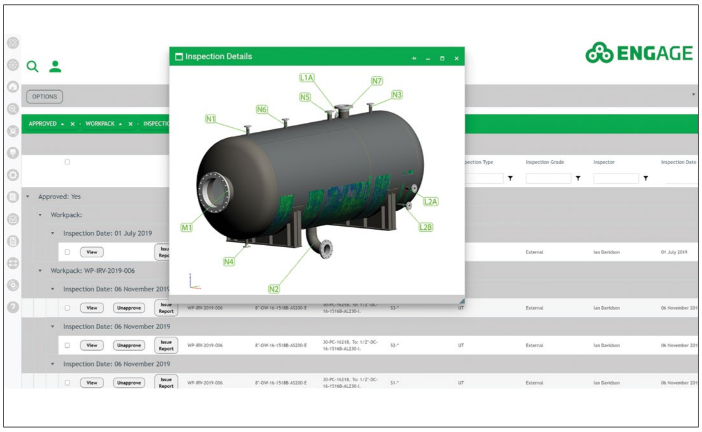


Figure 1 – Integrity Management of a pressure vessel

NII is similar to RBA in that it is a team based, multi-disciplinary activity which requires input from corrosion, integrity and inspection engineers mainly but might require information from chemistry, process and operations. Corrosion engineers often play a central role in NII and may prepare most of the documentation including the key Assessment, Workscope and Evaluation reports. Even if not directly involved in the NII process, a corrosion engineer will usually see the output of the NII when reviewing the equipment for the Operator when updating the RBA or Corrosion Risk Assessment (CRA).

NII and RBI Process

Non-Intrusive Inspection is not a standalone process and is not a substitute for Risk Based Inspection (RBI). It is, in the context of RBI, simply an inspection and doesn't aim to replicate the full RBI process. Figure 2 is an example of a complete RBI process based on API 580 [2]. In this case the NII fits in the "Inspection plan" box and all the other parts of the process are driven by the RBI. NII is therefore reliant on the information currently available in the Integrity Management System (IMS), and the RBI and does not seek to duplicate what has already been assessed. For example, the Consequence of Failure and Risk ranking are very important outputs of the RBI but are not re-evaluated for NII.

The initial step in the preparation of an NII is to conduct an integrity review to identify and evaluate what information is available. For example, vessel General Arrangement drawings and design details, inspection history, CRAs, RBAs, process descriptions, and process histories.

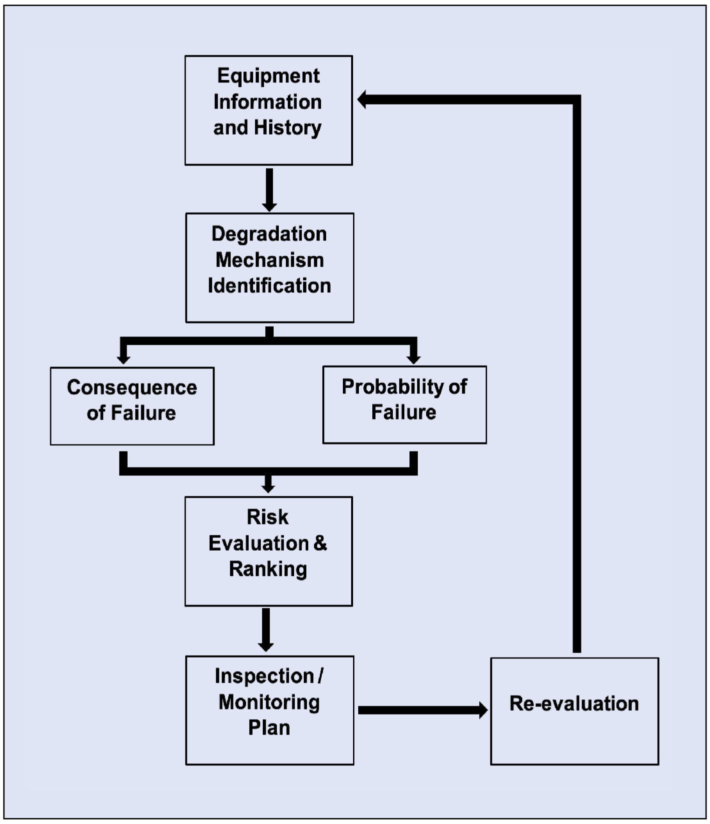


Figure 2 – Risk-Based Inspection Planning Process [2]

If the relevant information is readily available it makes it much easier to make a case for NII. Most of the inputs for the NII are the same as are required for an RBI process so this should be a relatively straightforward exercise. The information should be critically reviewed for the purpose of NII to ensure it meets the required level of detail and accuracy. So, for example, do the damage mechanisms in the RBA and corrosion rates in the history correspond with those you might expect for the vessel in question? Upon completion of NII the findings detailed in the outputs (the Inspection report and the Evaluation report) should then be fed back into the RBI.

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Where companies have an existing RBI process these may need to be amended to integrate NII into the IMS, so for example a specific NII procedure may need to be developed and other existing procedures should be updated to include reference to NII as a suitable method of inspection.

Inspection strategy type

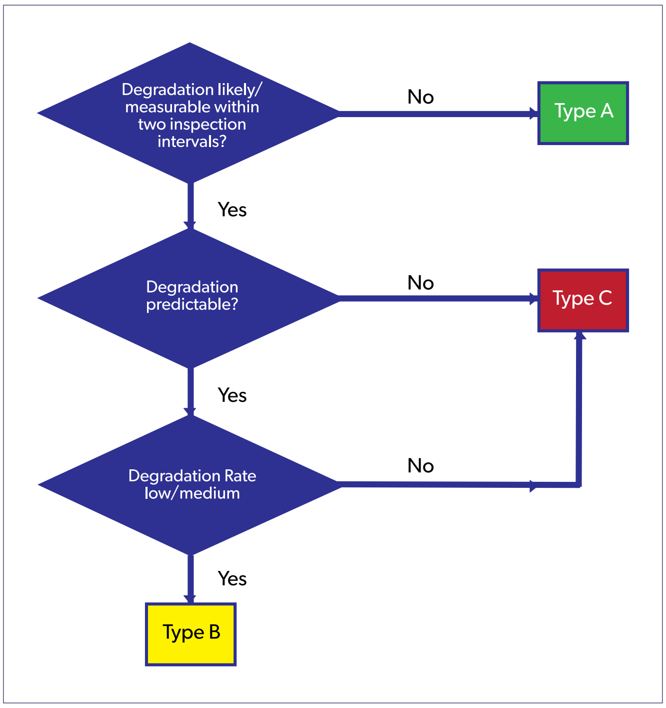

Figure 3 – Selection of Inspection Type [1] Figure published with permission of HIOS

There are 3 main inspection strategy types for NII: A, B & C

Inspection strategy Type A

The first of these is Type A and is applied when no degradation is expected. This usually applies to Corrosion Resistant Alloy vessels, and the recent update to HOIS-RP-103 also allows for carbon steel with a very low internal degradation rate (e.g. vessels in dry gas service). Type A also usually applies to carbon steel vessels which are internally clad with a layer of corrosion resistant alloy. One exception to this is when the cladding is of the weld overlay type as there are limitations in the detection of degradation in the cladding layer. This becomes a Type A+ inspection type in accordance with HOIS-G-026 HOIS Guidance on NII of clad vessels [3].

For a Type A NII, typically 5 – 10% surface area coverage is inspected. The areas selected for inspection are spread throughout the vessel. Remember that no degradation is expected in this case, so we are looking to confirm the absence of degradation throughout the vessel.

Coverage is usually higher at vessel nozzle barrels and each main process nozzle (i.e. the process inlet, various outlets etc) would typically be inspected because they may experience different process conditions than the rest of the vessel. Where multiple nozzles are considered to be "similar" it may not be necessary to inspect each one individually and a sampling approach may be used.

Inspection strategy Type A+

Most internally clad vessels are hot roll bonded where the corrosion resistant alloy layer is fused to the carbon steel substrate by rolling together at temperature in the mill. The clad plate produced is then used to fabricate vessels. This results in a plate with a fine grain structure in both the substrate and the cladding, and means that ultrasonic (UT) angle beam shear waves are often possible to be used for detection of stress corrosion cracking in the vessel cladding layer. Inspection techniques should be sensitive to low-level degradation in the corrosion resistant alloy clad layer and extensive in-service SCC is likely to be detected in most cases. However, detection of localised finer-scale SCC is more difficult to conclusively identify with the risk of false results due to back-scatter from the clad layer. There is also no method with a capability to detect fine hairline pitting on the internal surface of the cladding.

In image (Figure 4) taken from HOIS-G-026 [3], the different types of cladding are clearly visible. The main shell has been fabricated from hot roll bonded plate and results in a uniform, smooth appearance.

Figure 4 – Weld-overlay cladding [3] Image published with permission of HIOS

The area around the nozzle and inside the nozzle bore are weld-overlay clad as these areas have more complex geometrically and are more complicated to fabricate. Some vessels may be fully weld-overlay clad and these are the most relevant to a Type A+ inspection. Weld-overlay cladding results in a much coarser grain structure than hot-rolled cladding and also an uneven interface and internal surface. The coarse grain structure can limit the effectiveness of angled beam ultrasonic methods as it tends to strongly scatter and attenuate the beam therefore the detection and sizing of cracking at the cladding inner surface is not straightforward. In addition, the uneven internal surface due to the individual weld beads can cause increased reflections when using angled-beam methods. The use of angled beam, compression wave DMA probes gives lower levels of backscatter than angled beam shear wave probes, but Stress Corrosion Cracking (SCC) detection is still unlikely to be reliable, given the very low amplitude of signals obtained from the more localised form of SCC. The higher level of signals from the more extensive form of SCC would be more likely to be detectable, but there is currently no published evidence to confirm this. Therefore we must come to the conclusion that it may be not possible to detect fine pitting or cracking (SCC) in weld overlay cladding but unfortunately these are often the morphologies of concern in stainless steels.

Where there is a reasonable likelihood of failure of the cladding, the inspection should aim to identify any delaminations between the corrosion resistant alloy cladding and the vessel shell. These can occur immediately after manufacture but may also be caused by service induced degradation of the corrosion resistant alloy cladding. If cracks develop in the cladding and grow to reach the interface it is most likely they will lead to delamination or disbonding at the interface, since the mechanism for continuation of crack growth in the carbon steel base material will be different to that in the cladding material. Although if conditions are right then there is the possibility of cracks from the cladding progressing through the interface into the carbon steel base material or under cyclic loading conditions by fatigue. If corrosive fluids reach the interface due to cracking or local failure of the cladding, then this is likely to lead to corrosion of the carbon steel starting at the interface. This is the most likely occurrence and inspection of the carbon steel and the interface is the current focus for NII carried out on clad vessels.

The purpose of a Type A+ inspection is still to confirm the absence of degradation but due to the challenges associated with detecting low level degradation a significantly higher coverage is required than for a conventional Type A inspection.

Inspection strategy Type B

The second main type of inspection strategy is Type B which applies when degradation is at a low to medium rate and is predictable in:

- Degradation Likelihood
- Degradation Location
- Degradation Rate

Coverage is typically higher than for a type A inspection and is usually approximately 25%, although this may vary significantly from vessel to vessel. Coverage is determined using the equations which have been added to the recent version of HOIS-RP-103 and is focussed on the areas where degradation is expected / predicted to happen. This is most often the bottom of the vessel where a liquid layer will collect and perhaps solids may gather. The inspection coverage for nozzle barrels should be greater than the main shell and the main process nozzles should be selected.

The rest of the vessel may be subject to a sampling inspection with coverage spread throughout the vessel. The results of the inspection may be then be used to estimate the worst- case flaw for the areas not inspected (provided that the area inspected is representative of the remaining area) by extreme value statistical analysis.

Inspection strategy Type C

The third and final inspection strategy type is Type C which is applicable when degradation is expected to be at a medium to high rate but the location cannot be predicted. The aim of a Type C inspection is to directly measure the worst degradation. This is typically applied to carbon steel vessels with an internal organic polymer-based coating.

All organic coatings have a finite in-service lifetime which may be hard to predict. Once the protective coating fails the carbon steel is exposed, and may corrode quickly. It is not possible to inspect for coating condition by NII, so we must inspect for wall loss in the carbon steel. The location of coating breakdown is considered random and is impossible to predict, therefore it is not possible to estimate what is happening in one location based on another, unlike in a Type B inspection. So, if we inspect 50% and find no corrosion there is no confidence that there is no corrosion in the other 50%. Therefore. we must inspect as close to 100% as possible. This is a potential disadvantage of NII as it is time consuming and expensive, especially in the case of large vessels.

NII Evaluation

Completion of the inspection does not constitute completion of an NII. The conformance and analysis of the inspection results are very important and it is this output which should be used to feed back into the RBA. The analysis and evaluation of the data collected in the inspection is much more involved than would be the case with inspection of, for example, pipework. In the case of pipework the aim of the inspection is to quantify wall thickness and the inspection report would constitute the final deliverable of the inspection. In the case of NII the task is only fully compete once the evaluation report has been issued.

The inspection results should be compared to the requested work scope and non-conformances in the inspection techniques used, surface area coverage and locations inspected (versus requested) should be identified. The findings of the NII should be clearly identified and conclusions drawn as to their meaning, for example were the locations of predicted degradation correct? Are there new previously unidentified damage mechanisms or are there identified DMs which aren't active?

Most of the advanced NDT inspection results are quantitative and allow us to calculate accurate corrosion rates and estimates of remaining life. It also increases the confidence in the ability to predict types and locations of damage for future inspections as well as providing information about spatial distribution (i.e. density and homogeneity) of corrosion. These things may not be possible using Intrusive Inspection and therefore is a major advantage of NII over IVI.

This information should then be fed back into the RBI cycle and the information for the vessel updated.

Summary

NII in accordance with HOIS-RP-103 is used increasingly to fulfil the inspection needs of pressure vessels. It can be used as part of an RBI process to determine the overall integrity of the equipment. There is currently much interest in the best practice for the inspection of internally clad vessels (especially weld overlay clad) which is addressed in the recent publication HOIS-G-026.

References

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3. HOIS-G-026, HOIS Guidance on NII of clad vessels, HOIS, 2020.
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Editor: This article is based on a presentation to Aberdeen Branch, and this can be accessed on the branch web page.

A New Method for Testing Passive Fire Protection (PFP) Coatings Performance

Richard Holliday, PPG Protective and Marine Coatings

Modular construction, extreme operating environments and long-distance transportation require a new approach to testing and specifying passive fire protection coatings, Richard Holliday, Global Director - Hydrocarbon PFP, PPG Protective and Marine Coatings

The hydrocarbon industry has strict international testing standards related to the performance of passive fire protective (PFP) coatings for oil and gas platforms, terminals, refineries and other petrochemical facilities.

In recent years, several high-profile PFP coatings failures in cold-weather climates, such as a well-documented case at the oil sands in Alberta, Canada, have demonstrated the need for more rigorous testing of intumescent epoxy coatings for application in such environments.

This article highlights a comprehensive test regimen sponsored by a major coatings manufacturer and developed and executed by a leading international university, which compared five intumescent epoxy passive fire protection (EPFP) products commonly specified for hydrocarbon industry steel structures.

The testing served not only to quantify the potential performance of the five EPFP coatings in less-temperate climates but may also provide a template for industrywide adoption of more comprehensive testing standards for PFP coatings in general, particularly as their use continues to expand in northern locales and on lighter, pre-coated, modular steel structures.

When evaluating PFP coatings for any application, it is important for specifiers to look beyond the fire-rating. This is true for all PFP coatings types, but especially so for intumescent EPFPs, which are increasingly preferred over traditional cement- and fibre-based PFP materials due to their lightness, flexibility, performance, and ease of application.

While any PFP material will have fire certification, EPFP intumescent epoxy coatings should be selected for their ability to meet all the demands associated with their end use, including their ability to survive transportation to a jobsite, as well as the installation and construction methods employed at the job site, without cracking or delamination.

Flexibility of EPFP coating

With the growing popularity of stick-built and modular off-site construction techniques, steel beams, columns and other components are increasingly prefabricated and finished with EPFP coatings before they are delivered to the jobsite. In many cases, these fire-protected components are shipped across oceans and continents, through changing weather conditions. This, in turn, can cause some coatings to crack or delaminate and compromise their performance before they are ever placed into service.

This trend, combined with the increasing prevalence of hydrocarbon projects being constructed in extremely cold environments, makes expanding the scope of industry standard testing of PFP coatings beyond their existing parameters more critical than ever.

Application of an EPFP coating

While EPFP has been used for many years in the offshore oil and gas industry it is typically installed in temperate and tropical environments on heavy structures. However, due to their rigid formulation, some of these products have proved not to be well-suited for colder climates where thermal cycling extremes can cause steelwork to expand and contract dimensionally and frequently, which can lead to delamination, cracking and loss of fire integrity.

A New Testing Regimen

In 2018, a global coatings manufacturer developed a new EPFP coating that was designed to be thinner, lighter and more flexible than alternate PFP coatings, yet offer the same high levels of impact, jet- and pool-fire resistance as other field-proven counterparts. To investigate the viability of its new formulation, the company engaged independent researchers at a leading university who are recognised industry experts in the fields of structural dynamics and PFP material science.
Together, they developed a test methodology to quantify the mechanical performance of the new coating compared with one of the same manufacturer's existing and well-proven EPFP coatings, together with three commonly specified alternative EPFP coatings.

The five materials tested were:

1. Product P – Serving as the benchmark material, this product has a proven 35-year track record of cracking resistance in extreme and cold environments. It was developed by the manufacturer of the new coating

2. Product N – The next-generation flexible and extremely lightweight epoxy intumescent coating, it was engineered by the above manufacturer to accommodate weather extremes and the lighter steel structures now being constructed for many hydrocarbon applications;

3. Product C1 – A rigid epoxy-based PFP coating with a 15-year track record developed for the onshore UL 1709 fire-test-standard market;

4. Product C2 – A relatively rigid, mesh-free EPFP coating that had previously exhibited failure in cold climates and in hydrocarbon structures built using modular and stick construction techniques;

5. Product C3 – A newly launched novel epoxy-based EPFP intumescent coating described as a "low-temperature-cure modified epoxy with a more rigid network."

The test regimen was as follows.

Test Calibration of Surface Strain

A calibration test of an uncoated mild steel specimen at ambient temperature (25 C) was carried out to establish a benchmark of the load displacement-surface strain relationship.

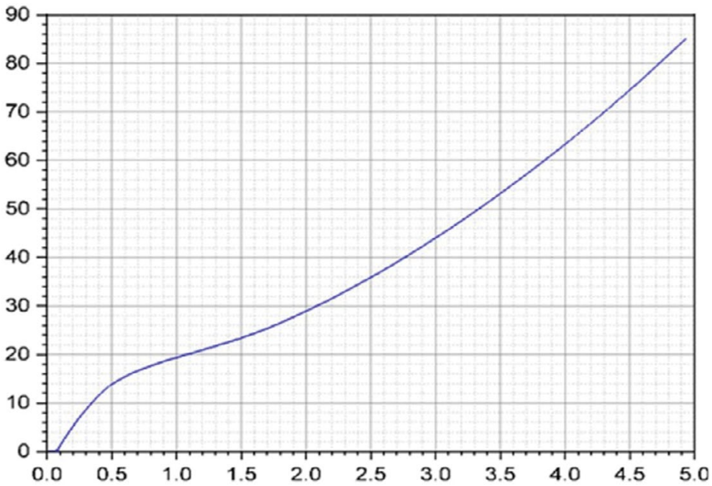

Figure 1: Displacement - Surface Strain Curve

Temperature Calibration

A calibration test was then carried out with coated EPFP specimens to establish a common through-thickness temperature profile. This was done by cooling the specimens to -50C for 24 hours, then inserting a needle thermocouple into the midpoint of the EPFP. This temperature was then compared against the surface temperature of the steel and the EPFP coating using an infrared gun thermometer, which showed that the temperatures were consistent throughout the thickness of the coating. Changes in temperature of approximately 5.5C were noted to occur after being outside the freezer for one minute, and 10C after two minutes outside the freezer.

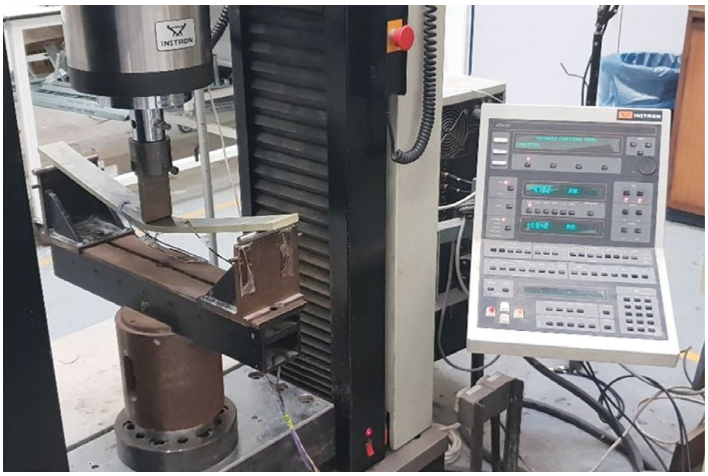

Figure 2: Three-point bend test on uncoated steel specimen with strain gauges

continues on page 26

Main Testing

75 tests were performed, consisting of combinations of specimen type and temperature as shown in the table below. For each test, all specimens were held at the specified temperatures for 24 hours before being subject to bend testing.

During the tests, visual observations were made of the onset of the following:

- First surface cracking or tearing
- First through-thickness (down-to-steel) cracking
- Delamination or dis-bonding

When a crack, tear or delamnation, was observed the amount of displacement at that point was noted - this could then be looked up on the graph in Figure 1 to determine the corresponding strain at that point. A minimum of two specimens of each material were tested at each of the temperatures specified in the table.

Material	Temperature (^{0}C)
P	25,5,-10,-30,-50
N	25,15,5,-10,-30,-50
C1	25,15,5,-10,-30,-40,-50
C2	25,15,5,-10,-30,-40,-50
C3	25,15,5,-10,-30,-50

Extra tests were performed on products C1 & C2 to establish the failure point because these samples did not provide a positive outcome at -50C. In essence, the study was trying to identify a transition point, and in some instances, there was need to include a test specimen at -40C as the difference between -30C and -50C was too big to establish the point of interest.

Photographs 1 and 2 show that flexible products are able to withstand large deflections before the onset of surface tearing at room temperature. Photograph 3 shows that below 0C for product N, the tearing transitions into a cracking, but the product remains adhered to substrate.

Photo 1: Product P exhibiting ductile tearing at room temperature

Photo 2: Product N exhibiting ductile tearing at room temperature

Photo 3: Product N ductile-brittle transition <0°C (32°F) temperature

Photographs 4 and 5 show that the more rigid products, C1 and C3, already exhibit cracking at room temperature, and at below 0 C, the failure mode is delamination from the substrate (photograph 6).

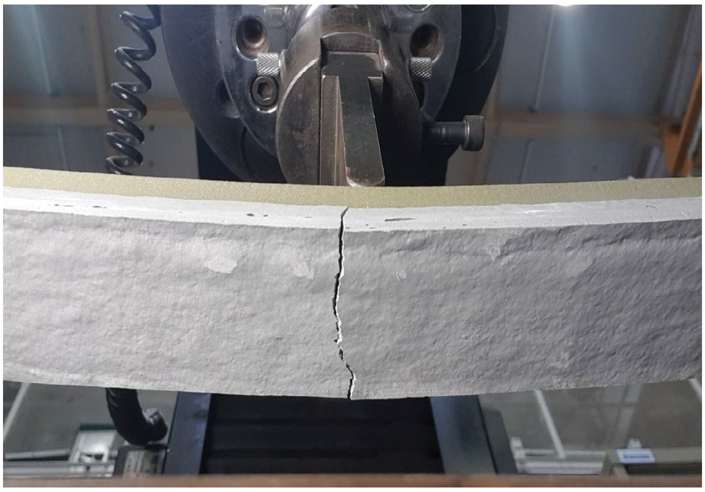

Photo 4: Product C3 exhibiting brittle failure at room temperature

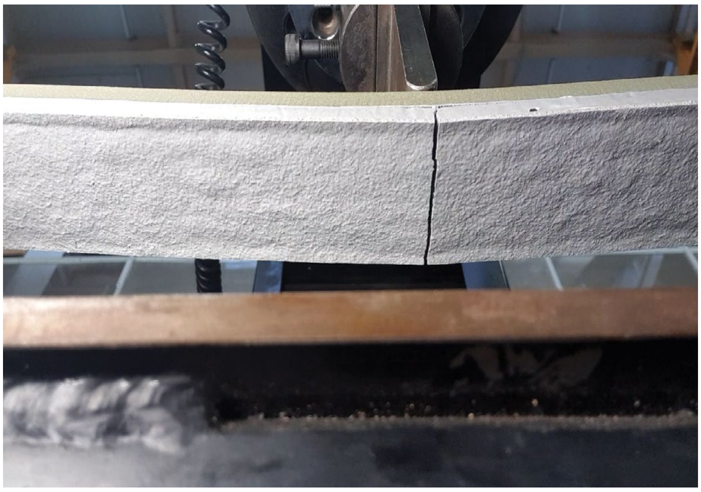

Photo 5: Product C1 exhibiting brittle failure at room temperature

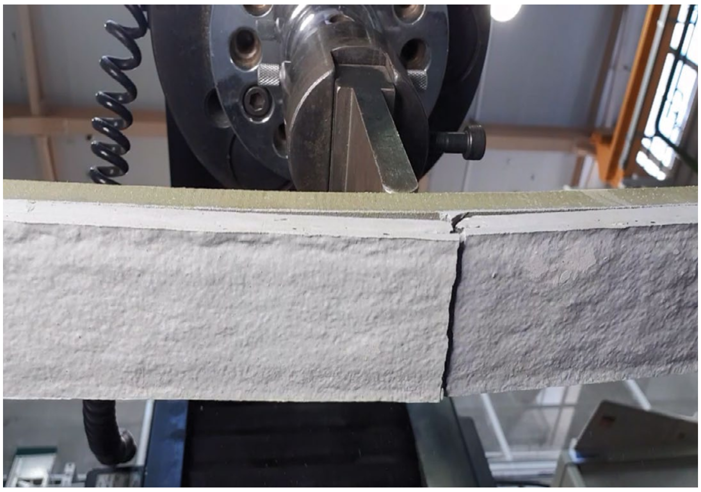

Photo 6: Product C1 exhibiting delamination at 0C

Photograph 7 shows that product C2, the most rigid material, exhibits delamination from the substrate even at room temperature.

Photo 7: Product C2 exhibiting delamination at room temperature

Test Results

The failure-strain test results for each product were plotted to illustrate their trends of transition between ductile (tearing) and brittle (cracking) failure, as well as to establish if the products exhibited delamination.

This is shown in Figure 3 which plots the steel surface strain where the product tears or cracks against key temperatures of interest. The red and amber lines on the graph represent proposed design limits; first at 0.2% strain (end of elastic limit) and second at 0.5% strain (limit for plastic strain), and these values are taken from established structural steel design codes. These limits can be used to help establish at which temperature these products can be safely used (above the amber line) and when more detailed analysis of strains and material properties is required to demonstrate the suitability of the products (between amber and red lines) and where the products are probably unsuitable (below red line).

As the graph illustrates, there is a correlation between temperature and load failure with two of the products remaining undamaged at strains greater that 0.5% across the critical temperature range. When the ductile-brittle transition curve crosses the 0.5% value there is a risk damage to the PFP material in its design state.

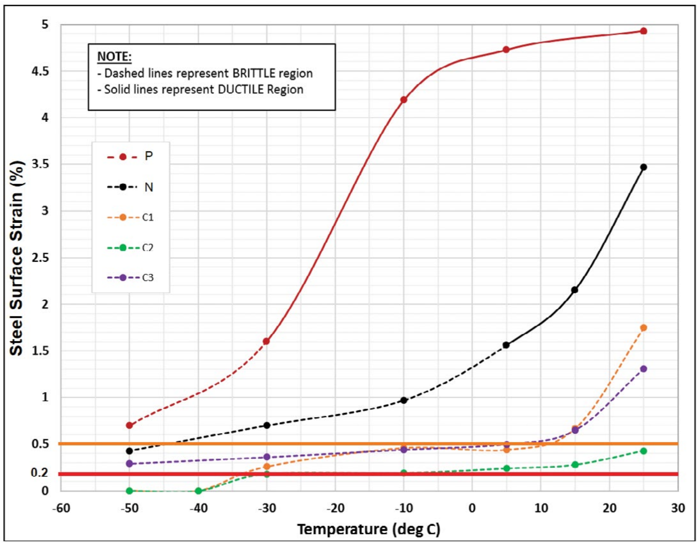

Figure 3: Strain-temperature plots at first crack for tested EPFP materials

Key Observations

As expected, the three rigid intumescent EPFP coatings (products C1, C2 and C3) performed the least well, exhibiting brittle failure modes at relatively low strain levels and, in some cases, delaminating extensively from the steel test specimens even before the application of load at low temperatures (for example, the 2 plot points at -40C and -50C on specimen C2, showing failure at 0% - in other words the coating had already delaminated before any bending load was applied).

Product P, the benchmark EPFP coating with the 35-year track record, performed the best at low temperatures, exceeding the yield-point strain limit of 0.2% for steel structures at temperatures of -50 C. (as did C3).

Product N, although slightly less flexible than Product P, also performed very well at low temperatures, again exceeding the industry-standard strain limit of 0.2% at a temperature of -50 C. The 0.2% is a universally accepted limit for yield point of steel and is used in multiple standards for steel design, but these differ from country to country.

Conclusions

Until recently, the hydrocarbon industry has operated under the belief that, when it comes to EPFP coatings "harder is tougher." But with the prevalence of modular construction and its demands for lighter steel components—as well as the increasing level of industry construction in cold weather climates—that truism no longer applies. It is now essential that designers understand how steel behaves in various conditions and why it can require more flexible PFP coatings.

Just as PFP coatings must be formulated to accommodate these new realities, the scope of industry-standard testing must expand to meet them as well.

The design of safe, affordable and effective EPFP coating systems, tailored to the specific requirements of the facility it is meant to serve, can be a complex undertaking. The development of new EPFP coatings solutions to meet the changing demands of the industry has the potential to complicate matters further. For all these reasons, the need for more robust testing standards and protocols for the next generation of EPFP coatings, including cold-weather testing is more critical than ever.

EPFP coated structure exposed to winter temperatures of almost -50C

Test Your Knowledge

The answers to the quiz questions on page 9.

Whilst there could potentially be many answers, the fundamental links are:

1) Aeroplane parts, beer cans and sacrificial anodes can all be made from aluminium alloys;
2) An alkaline pH can link concrete, the fluid in a paint blister and treated water in some heating/cooling systems.

Did you get these correct? If not, maybe you would benefit from the Fundaments of Corrosion for Engineers course.

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Email: info@pim-ltd.com www.pim-ltd.com

SAFINAH LTD
Tel: 01670 519900 Email: enquiries@safinah.co.uk

SCALED SOLUTIONS LTD
Email: enquiries@scaledsolutions.co.uk www.scaledsolutions.co.uk

SONOMATIC LTD
Tel: 01925 414000 www.sonomatic.com

STEEL PROTECTION CONSULTANCY LTD
Email: Wil.deacon@steel-protection.co.uk
www.steel-protection.co.uk

SPECIFIERS

SSE LTD
Tel: 01738 456000

SUPPLIERS COATINGS

CARBOLINE
Tel: +44 (0) 116 2697777 www.carboline.com

CHEMCO INTERNATIONAL LTD
Tel: 01236 606060 www.chemcoint.com

CORROCOAT
Tel: +44 (0) 113 2760 760 www.corrocoat.com

HEXIGONE INHIBITORS LTD
Tel: 01792 606494 www.hexigone.com

INDESTRUCTIBLE PAINT LTD
Tel: 0121 7022485 www.indestructible.co.uk

SUPPLIERS GENERAL

CORRODERE ACADEMY
Tel: 01252 732220 www.protectivecoatingseurope.com

FISCHER INSTRUMENTATION (GB) LTD
Tel: 01590 684100 Email: mail@fischergb.co.uk

FUTURE PIPE LIMITED
Tel: 0207 8388660 www.futurepipe.com

GMA GARNET (EUROPE) GMBH
Tel: 01606 836223

INFRASTRUCTURE ANALYTICS LTD
Tel: 028 9532 0131 Email: info@ infrastructureanalytics.co.uk

LAKE CHEMICALS & MATERIALS LTD
Tel: 01527 594630 Email: philip.collier@lakecm.co.uk

LBBC BASKERVILLE
Tel: 0113 2057423 www.bbcbaskerville.com

LLEWELLYN RYLAND LTD
Tel: 0121 4402284 Email: research@llewellyn-ryland.co.uk

PRESSERV LTD
Tel: 01224 772694 Email: Rennie@presserv.com

RENTAJET GROUP LIMITED
Tel: 02380 817160 Email: sales@rglservices.co.uk

SCANGRIT
Tel: 01469 574715
Email: sales@scangrit.co.uk www.scangrit.co.uk

RECIPROCAL ORGANISATIONS

ELSEVIER SCIENCE LTD
Tel: 01865 843000

INSTITUTE OF METAL FINISHING
Tel: 0121 6227387 www.uk-finishing.org.uk

QUALITY CONTROL

ELCOMETER
Tel: +44 (0) 161 371 6000 www.elcometer.com

DEV4 ONLINE LTD
Tel: 0795 2203531 https://condi.online

TRAINING AND COATING INSPECTORS

CORRODERE ACADEMY
Tel: 01252 732220 www.corrodere.com

IMECHE ARGYLL RUANE
Tel: 0114 245 0600 www.hodgeclemco.co.uk

Institute Events
DIARY DATES 2021

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Due to the ongoing restrictions, ICorr meetings are being held online. At the time of going to press, the following branch meetings are expected to be held.

BRANCH DATES

14th October 2021
London Branch
Joint meeting with LMS "Meeting Todays Materials Challenges to Enable Low Carbon Hydrogen Production at Scale",
Stephen Shapcott, Johnson Matthey

26th October 2021
Aberdeen Branch
"Internal Corrosion of Pipelines, Mechanisms, Modelling and Management"
Prof. Y. Frank Cheng, University of Calgary

11th November 2021
London Branch
"Coating Developments"
Alex Garner

30th November 2021
Aberdeen Branch
Joint meeting with IOM3/MIS
"The Development and Application of Inconel Bar and Tubular Nickel Alloys for Sour O&G Environments"
Dr Steve McCoy, PCC Metals Group

ADDITIONAL DIARY DATES

4th November 2021
PDA Europe Conference

IMechE courses at the Sheffield Training Centre

14th October 2021
Hot dip galvanising

25th October 2021
Paint Inspector, Level 2

1st November 2021
Paint Inspector, Level 1

8th November 2021
Insulation Inspector, Level 2

15th November 2021
Paint Inspector, Level 2

6th December 2021
Paint Inspector, Level 1

13th December 2021
Pipeline Inspector, Level 2

CP courses at the ICorr Training Centre, Telford

25-27 October 2021
Buried Level 1

16-18 November 2021
Buried Level 1

Online Corrodere courses plus online assessments and practical workshops via Zoom

18 - 19th November 2021
ICorr Coating Inspector Level 3, Mandatory Workshop and Theoretical Assessment

23-24th November 2021
ICorr Coating Inspector Level 1&2, Workshop and Assessment

7-8Th December 2021
ICorr Coating Inspector Level 1&2, Workshop and Assessment