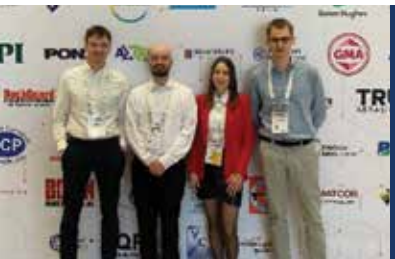
A journal of the Institute of Corrosion

Corrosion Management

Issue 166 March/April 2022

Applying a health and safety managing approach to corrosion risk

INSTITUTE OF CORROSION



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The President Writes


Institute of Corrosion President, Bill Hedges.

Welcome to the spring edition of our magazine and as I write this the sun is shining and has some real warmth to it – I'm sure that, like me you're ready to leave winter behind. There is also real energy within our institute with many programmes moving forward. These include starting our 2022 Young Engineer Programme, which for the first time is being hosted by our Aberdeen branch – I'd like to say a massive thank you to everyone in Aberdeen for making this happen and to everyone who has contributed to this programme.

Also, be sure to mark your calendars for our annual Corrosion Engineering Division (CED) Working Day and Symposium on 'Knowledge Transfer and the Management of Infrastructure Corrosion' which will be held at the National Railway Museum in York on Wednesday 27 April 2022. More details can be found on the ICorr website events calendar. This is a great opportunity for me to thank Nick Smart for chairing the CED for many years and making the annual working day such a success. Nick is stepping down as chair this year and Danny Burkle, currently our Young ICorr chair, has kindly agreed to step into the role. Many thanks to both Nick and Danny for all their support of ICorr.

During February and March we held our quarterly ICorr Council and Correx Board meetings. I'm delighted to report that all is well with both organisations and our finances remain very healthy.

We continue with our training course development and on the 1st April our first foreign language course will go-live in Brazil. This is a conversion course in Portuguese to allow Brazilian Level 1 coating inspectors to attain the ICorr level 2 accreditation. This has taken a few years to put in place with ABRACO – the Brazilian corrosion society – and I'd like to thank Lucia Fullalove, Kevin Harold, David Horrocks, John Fletcher and Chris Kirby, and his staff at IMechE, for their dedicated work on this. We now have an excellent relationship with ABRACO and expect to do more joint projects together.

I'll end with a highlight for me which was to attend the AMPP annual conference in San Antonio, Texas, USA, with six of our YEP programme winners from 2020 *(editor, see later in this issue)*. For those who may have missed this AMPP stands for the Association of Materials Protection and Performance which formed in 2021 as a result of the merger of NACE and SSPC. The conference had 41 symposia, 348 exhibitors and attracted 5,000 attendees. At the Young Engineers award ceremony I was proud to present our Young Engineers with their certificates. I'm extremely grateful to AMPP who provided attendance to our winners for free. We have an excellent relationship with AMPP and both organisations continue to look for opportunities to work together.

As always, I love to hear your comments and questions about ICorr so please keep them coming.

Until next time,

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

From the Editor

I hope you are all looking forward to a 'normal' summer, certainly more and more meetings are being held in person, and physical exhibitions have restarted.

This in another bumper issue, with three technical articles, a lot of Institute news, together with the other usual columns The technical articles cover the application of a health and safety management approach to corrosion and degradation in the oil and gas industry, the defects which can occur with PFP systems over time, and a personal view of what to look for when choosing a consultant.

The "Ask the Expert" column as usual contains a coatings related and a CP related questions, and readers are reminded to send in their technical questions to be answered by our panel of experts.

Finally, I welcome comments from readers as to what topics they would like to see in future.

Brian Goldie, Consulting Editor
Email: brianpce@aol.com

New GOLD Sustaining Company Member

Rysco Corrosion Services

Rysco International, a global provider of corrosion management services, based in Red Deer, Alberta Canada, was formed in 2018 and is a division of the Rysco Group of companies, responsible for the international distribution of Rysco Corrosion and Rysco Integrity's equipment and services.

Rysco Corrosion actively promotes teamwork and expertise within its organisation, and its mission is to provide the best corrosion measurement and monitoring services available to the marketplace, so that clients can make informed decisions related to their infrastructure assets, in the interests of public safety and the environment. Rysco believes its mission to be an honest commitment to all its stakeholders, delivering on that commitment by adhering to its Core Values, throughout its daily operations providing quality, consistency, and accuracy in all its business offerings, treating client's infrastructure monitoring and measurement concerns, as if they were its own.

Rysco's 5 Core values are:

- **Service**
- **Integrity**
- **Innovation**
- **Excellence**
- **Knowledge**

Rysco seeks to change client's perceptions of corrosion measurement and monitoring through innovation, knowledge sharing, and providing a superior customer service experience.

Rysco Corrosion Services and Products include:

- Internal Corrosion Monitoring
- External Corrosion Monitoring
- Engineering & Design
- Pipeline Analysis
- Online Reporting

When it comes to competency, all Rysco Group employees either have AMPP certifications or are diligently working towards the necessary achievements to satisfy these certifications. Rysco believe education, along with applicable experience and competency management, to be the cornerstone of its organisation. As part of its "first in class" culture, Rysco maintains ISO 9001, ISO 14001, and ISO 45001 management systems certifications within an IMS that includes Quality Management, Environmental Management, and Occupational Health and Safety Management. In addition, Rysco maintains an active APEGA permit to practice and participates in the Alberta Quality Programme.

New Sustaining Company Member

Testing climate resistance to the limit

Ascott Analytical Equipment

Ascott have been at the forefront of corrosion and salt spray test cabinets for over 30 years. Their business is totally focused on corrosion test equipment, and today they are one of the leading suppliers of salt spray cabinets and cyclic corrosion cabinets in the world, exporting to over 45 countries.

Everything produced is manufactured in their factory here in the Midlands, with local suppliers very much at the heart of the supply chain.

Their latest range embodies customer led innovation, blending performance and technical excellence. The creation and control of corrosive climates has never been more demanding, and the development of new materials and surface coatings, plus increasing user expectations, has given rise to ever more rigorous testing. This is their forte.

Their expertise is the reassurance that a customer needs to ensure their testing is precise, compliant, and repeatable. Their equipment leads the world technically, but they also pride themselves on offering excellent value for money. Investment in an Ascott chamber offers the customer consistency, reliability, and, with their premium level of after sales support as standard, a high degree of confidence.

Many test standards can be complex and difficult to interpret, and the customers rely on their expertise, experience, and knowledge in this field to guide them to the exact product that will meet their needs. Every chamber is built to individual customer specification, even down to incorporating customer branding and corporate colours if required.

They also supply a comprehensive range of laboratory and field test equipment and consumables via an online shop, offering a convenient and trusted one stop solution for all your testing requirements.

ICATS Up-date

During 2021, and the first quarter of 2022, the ICATS Managers Course (Corrosion and Protective Coatings Management) has proven to be one of most successful of our courses, with presentations to global audiences as well as contractor and engineering organisations in the UK. This one-day course is designed for project managers, engineers, site agents, and any persons wanting more knowledge of the coatings industry.

This course is currently available face to face, or remote via video conference. It will also be available via our ICATS LMS in the near future. Any enquiries should be directed to CORREX Ltd, or Kevin Harold at kevin@paintel.co.uk

New Courses

As mentioned in the previous magazine, work has now begun with the creation of new ICATS courses. The industry has desired these additional modules, and story boards have been created.

We are also working with our industry partners for very specific technical information, this is particularly true of 'Fire Protection', which is expected later this year.

ISO 17024

ISO/IEC 17024 is the International Standard relating to the conformity assessment for bodies operating certification of persons. Certification Bodies that are accredited to this standard have demonstrated an impartial and rigorous quality approach, and their clients can have confidence in certified personnel. We have been busy reworking information and documents to help us conform to this standard and will be introducing new forms that conform to ISO 17024 in the next couple of months. When we do, you will be informed ahead of release to assist with version control.

I am always on the lookout for interesting ICATS projects that you are working on. Please let me know your stories, and let's tell everyone about them and how ICATS is changing the face of Industrial Painting.

Kevin Harold, CORREX Managing Director

ICorr YEP Winners recognised at the AMPP 2022 EMERGing Leaders Event

At the recent AMPP 2022 Corrosion Conference and Exhibition, the first in-person event since the merger of NACE and SSPC, an event was held to celebrate our industry's next generation of talented leaders.

On the evening of the EMERGing Leaders party, a number of different categories were presented during a ceremony at the historic Aztec Theatre near the San Antonio Riverwalk, to recognise the hard work and achievements of the younger professionals of the industry. Among them, our ICorr Young Engineer Programme (YEP) 2020 cohort winners, who were recognised for their achievements and presented with their winners' certificates, by Bill Hedges (ICorr President) and Bob Chalker (AMPP CEO).

The winning team, mentored by Tasos Kostrivas (Mott MacDonald), was Team 4, made up of Ryan Cobbs (Civil Engineer at Mott MacDonald), Izabela Gajewska (Corrosion Engineer at Intertek), Vincent Lemoine (Welding Engineer at Saipem), Praveena Nanthakumaran (Mechanical Engineer at Worley Parsons) and Harry Wright (Corrosion Engineer at Element). The YEP 2020 case study, was a real-life corrosion problem and this particular case was based on an onshore glycol desalination plant failure. The prize for the winning team was a fully expensed trip to the AMPP 2022 Corrosion Conference and Expo.

In addition to the prize for the winning team, the YEP panel and mentors selected 2 participants to join the AMPP Leadership course (also held at the AMPP 2022 conference) for their performance during the programme. The winners for were James McGladdery (National Nuclear Laboratory) and Benjamin Lee (SGN).

Above: Ryan Cobbs (Left), Harry Wright (Left Centre), Izabela Gajweska (Right Centre) and Vincent Lemoine (Right).

Above: James and Benjamin, and at a session of the Leadership course.

Young ICorr

To find out more contact Danny Burkle **(info.youngicorr@gmail.com)**

Follow **Young ICorr** on LinkedIn to ensure you do not miss out on future events:

The Cooperation ICorr and ABRACO

The Journey described by Isaac Catran, Florentina Melo (ABRACO) and Lucia Fullalove (ICorr).

As ABRACO, the Brazilian Association of Corrosion, becomes nearer to getting ICATS, and the ICorr Paint Inspector Conversion course, we would like to take readers on the journey travelled so far.

It was in May 2018, during the INTERCORR (International Corrosion Congress) in São Paulo, Brazil, that ABRACO's technical staff, Florentina (Flor) Melo and Isaac Catran met with Lucia Fullalove. Flor and Isaac were responsible for the training and qualification of corrosion professionals for ABRACO, and Lucia was in Brazil to deliver a 'plenary talk' on the "Application of Lean Principles in Corrosion Protection", as a guest of INTERCORR.

As brief introduction, ABRACO is the Brazilian association which has represented the corrosion professionals in Brazil for over 50 years, it promotes and disseminates knowledge about corrosion and corrosion protection, and qualifies professionals in industrial paint application, industrial paint inspection, and cathodic protection. In addition to the above, ABRACO also delivers courses in the areas of pipeline protection and hot dip galvanising, for those professionals wanting to expand their knowledge.

Following the introductions, we (Lucia, Isaac and Flor) started to discuss the professional courses on corrosion protection from both our organisations, and we identified a great synergy between ourselves and the courses, and the possibility of closer co-operations between the organisations became our main target.

At ABRACO head office in Rio de Janeiro, the three of us made a presentation to the President of ABRACO at the time, Prof Laerce de Paula Nunes. The objective of the presentation was to propose a partnership which would allow for the promotion of ICorr in Brazil, as well as promoting ABRACO internationally. In addition, we wanted to get an agreement and recognition by ICorr for the paint inspectors trained and qualified in Brazil. Thus, providing the ABRACO paint inspectors with an internationally recognised qualification.

The collaboration project, "ICorr-ABRACO", was immediately welcomed by the ABRACO President who under the advice of Lucia Fullalove, sent a message to the then President of ICorr, Sarah Vasey, introducing ABRACO and explaining the intention of creating a partnership between the two organisations. The positive response from ICorr was swift, and 'we' started to outline the co-operation project whilst still in May 2018.

Above: Lucia, Isaac and Florentina

Initially it appeared that the best way to progress would be with a direct comparison between the qualifications of both organisations in the areas of paint Inspection, paint application and cathodic protection. Therefore, a Memorandum of Understanding (MoU) between ABRACO and ICorr to show the intentions was created, the terms agreed, and finally signed by the then current Presidents of the respective organisations in June 202, Dr Olga Ferraz (ABRACO) and Dr Gareth Hinds (ICorr).

This partnership between ICorr and ABRACO was anticipated to go beyond the technical recognition, but also allow for further exposure and recognition of ICorr in Brazil where there is a huge potential for training development due to the country's size, and the recognition by major players across several market sectors that corrosion protection is paramount, and of great benefit to asset owners.

On the other hand, ABRACO is well recognised in Brazil for the high standards of its qualification and quality of the training of corrosion professionals, therefore the partnership with ICorr will keep these high standards, and will give the Brazilian professionals the opportunity to also have international recognition.

As soon as the MoU was signed, we (Isaac, Flor and Lucia) started to work in earnest to focus on the equivalence for the certification of paint inspectors. From the very beginning the difference between the levels of qualifications was identified.

In Brazil, the paint inspectors' certification is divided into 2 levels, whereas in the UK it is in 3 levels. Therefore, the first step was to see how the equivalence could be achieve, and the way forward was chosen to be to analyse and compare the course syllabuses. The idea was these would be assessed and a proposal made as to how this equivalence could be achieved, decided.

In March 2019, the contents of the ABRACO Paint Inspectors levels 1 and 2 courses were sent to be appraised and

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evaluated by ICorr. John Fletcher of ICorr was appointed to carry out this work, and in December 2019 following a GAP Analysis, he identified that the ABRACO Level 1 course content addressed most of the content of the ICorr Paint Inspectors levels 1 and 2, however there was a shortfall in the areas of H&S and the International Maritime Organisation ballast tank coating regulations. In the initial GAP Analysis, John also proposed options for the equivalence and a conversion module for this recognition has been proposed.

In March 2020, on the return to the UK, Lucia made a presentation to ICorr PDTC, which described the excitement and expectation created by the Brazilian paint inspectors for this 'conversion' from ABRACO to ICorr. Isaac, Flor and Lucia then carried out a mapping exercise between the Brazilian and the International Standards, so that ICorr could become acquainted with the Brazilian Standards and understand that the Brazilian paint inspector, although working under local standards, do have the level of work practice equivalent to their international counterparts.

The remaining differences were identified as relating to Brazilian legislation. Unlike in the UK, in Brazil, H&S activities on site are carried out by a Safety Medical professional, and by a Health & Safety qualified engineer. In addition, Brazilian technical standards are supported in law, therefore some of the activities of a corrosion protection professional must follow these. In Brazil, the standard even determines how the paint containers are stacked in storage.

The conversion module and exam questions have been written by Kevin Harold on behalf of ICorr, and the course translated, and reviewed. will be translated into Portuguese to be delivered in Brazil. The conversion course has now been uploaded to the IMechE Learning Management System. It is anticipated that once the Brazilian paint inspector takes the conversion module they will sit and online examination and the successful candidates will have their ABRACO L1 paint inspector certification, confirmed as an ICorr L2 paint inspector.

We would like to point out our certainty regarding the success of this project. This was one of the reasons Lucia was invited to deliver a presentation about the "ABRACO – ICorr" project at the Brazilian seminar of Anti- corrosive painting (SBPA) in Brazil in December 2019. The main attendees to the event were paint Inspectors and the project was well received by the audience.

The conversion module for L1 ABRACO Inspector was launched in Brazil on the 28th March, and the the next natural step is to get a similar process for the recognition of the L2 ABRACO paint inspectors as ICorr L3.

Whilst a lot of training activities came to a halt as consequence of the COVID 19 pandemic, Isaac, Flor and Lucia started to work on the paint applicators course, and how to get the ICATS to Brazil.

ABRACO also wanted to have the ICATS in Brazil 'online' and Lucia has translated the modules and has been working with Isaac Catran to ensure the correct ' site jargon' . as well as the Brazilian working practices are incorporated into the course. The translated ICATS modules have also been uploaded to the IMechE LMS system for 'online' access. This is now being tested , and although no definite date has been agreed for the launch, a trial is due to start soon.

As in the UK, in Brazil the training of paint applicators is carried out in parts. The ICorr Industrial Coating Applicator Scheme (ICATS) starts with a module on understanding the principles of corrosion protection, the importance of a good surface preparation before treatment, and the role of paint. And at this fudamental level the ICA is trained on the use of the paint brush and roller. It is ABRACO's intention to follow thus training sequence. In 2020 this project was also introduced to Kevin Harold (MD of Correx) who was excited about the prospect, and proposed the setting up of the online Industrial Paint Applicators course (ICATS) in Portuguese to provide training to paint applicators in Brazil. The practical part of the course as well as the technical evaluation of the students (candidates) will be done by ABRACO.

The initial course (brush and roller) is currently being translated into Portuguese and the course contents adapted to the Brazilian legal requirements, environment, and work procedures.

For the practical assessment, Flor and Isaac had already developed a form to evaluate the students. which covers all the activities carried out by an industrial painter. This was shared with Kevin Harold to be assessed, and a modified version produced, which will be discussed and agreed by all (Kevin, Isaac and Lucia) as the new evaluation form for the ICATS Brazilian Industrial Paint Applicators.

In December 2020, there was another virtual SBPA (seminar on anticorrosion paints) meeting, which had 130 attendees, and at which Lucia was invited to, and delivered a presentation on the progress of the cooperation between ICorr and ABRACO. At this, there was great interest from both paint inspectors and paint applicators waiting to be able to take the ICATS conversion course.

The ICorr – ABRACO partnership is now being recognised and awaited by several sectors of the Brazilian Industry, such as Oil and Gas, steel producers, mining, petrochemicals, and others. There are still other areas for growth in Brazil where the strength of this partnership will be well received.

Young Engineers Programme (YEP)

Aberdeen held its first YEP session online, on 27 January 2022, chaired by Hooman Takhtechian. There are 24 participants in the scheme selected from over 50 applicants meeting the YEP criteria. These come from a diverse range of disciplines, CP, CUI, FM, Materials, Process Engineering, Reliability / Maintenance, RBI, Subsea and Welding, thus bringing a wide cross-section of experience, cultural and networking opportunities for this year's programme.

The chair congratulated all the successful candidates and encouraged them to also participate also in the branch technical meetings and ICorr events nationally, as far as possible. All YEP participants also have the opportunity to attend the branch ACF – Annual Corrosion Forum on Tuesday 30th August 2022, with this year's theme being the "Role of materials selection, corrosion management and asset integrity/management in the Energy Transition and Net Zero Target industry sectors.

YEP Candidates and Course Organisers.

Steve Paterson, formerly Principal Technical Expert Upstream Materials for Shell Projects & Technology, got things off to an excellent start with a very comprehensive presentation covering corrosion control fundamentals and all aspects of corrosion management including, the impacts of corrosion, deterioration mechanisms, electrochemistry, materials, mitigation, modelling, passivity, kinetics and thermodynamics, along with several examples of corrosion failures. This generated many interesting questions and requests for further reading material.

YEP Session 1 presenter Steve Paterson -YEP Mentor and Case Study Leader.

The branch continued with its YEP on 8 March with an in-person meeting when Stephen Tate (ICorr Vice Chair) presented Integrity Management, and provided many experienced based examples of loss of integrity due to corrosion and erosion in, offshore fixed and floating facilities, oil and gas process systems, land-based structures and pipelines, stressing the need to ensure that all production facilities remain safe and legally compliant. A range of in-service failure specimens were made available to attendees, including removed flowline sections, choke valve sections and other piping specimens.

Subsea 7 have kindly loaned their Westhill training facilities for the YEP in-person events and the Aberdeen committee is extremely grateful to Brian Welsh - Subsea 7 Training Coordinator, for making this possible along with Amir Attarchi who managed all the catering on the night. David Mobbs has also been regularly supporting the Aberdeen YEP for us, which is very much appreciated.

YEP Session 3 – Integrity Management with Stephen Tate at Subsea 7 Training Centre.

Local Branch News

Aberdeen Branch

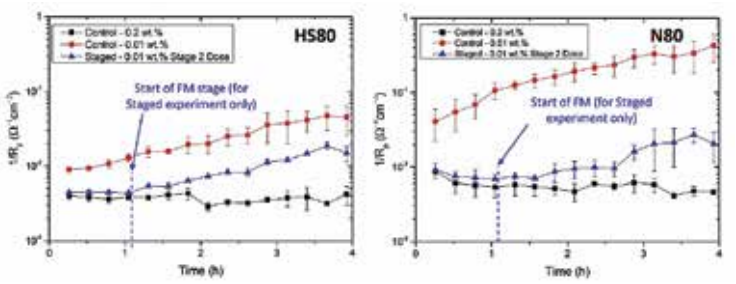
The January technical meeting featured a presentation by Joshua Owen (pictured left), Research Fellow in the Institute of Functional Surfaces, School of Mechanical Engineering, University of Leeds, on "Advanced once-through flow cell methodology for validation of a new 'staged' inhibition approach for matrix acidising treatments" as part of a collaboration between Schlumberger and Leeds to evaluate staged inhibitor approaches prior to industrial application.

Schlumberger recently introduced and patented a new staged acid corrosion inhibitor (ACI) treatment concept for application in matrix acidising treatments. The staged treatment concept recognises that treatments which employ a fixed dosage of corrosion inhibitor may not be optimal in terms of their efficiency. The concept proposes staged pumping of a first fluid composition designed to establish a persistent inhibitor film (Stage 1) and a second fluid composition to maintain the film and its associated inhibited corrosion rate (Stage 2). The staged ACI concept has the potential to provide enhanced corrosion protection of wellbore casing and coiled tubing (CT) materials, whilst using the same total quantity of inhibitor compared to conventional treatments.

Typical Onshore Well Acidising Treatment.

Typically, the corrosion test methods used to evaluate this approach have involved preparing two equivalent pre-heated and conditioned glass reactors, one of which is used for the first film-forming stage and the other for the second film maintenance stage. This procedure is rather inconvenient and involves a short period of time (~1 min) during which the weight loss coupons or working electrode (a rotating cylinder electrode) are in contact with the atmosphere which could change the corrosion potential and could potentially have an influence on the inhibitor film formed during the first stage. Instead, a bespoke, electrochemical, milli-fluidic once-through flow cell was used for validation of the staged ACI concept by exposing a carbon steel coupon, mounted within the flow cell, to 4 M hydrochloric acid (HCl) flow at a temperature of 80 °C and a flow rate of 5 ml/min. A once-through flow cell enables testing in a continuously flowing environment whilst maintaining a fresh acid solution, a controllable supply of inhibitor, and eliminating any contact of the electrode with the atmosphere.

The system was used to quantify changes in corrosion behaviour during continuous flow and during transitions from the first to second stage inhibitor dosages, to find optimal inhibitor concentration for film-forming and film maintenance stages, and to investigate the effect of metal pre-corrosion on inhibitor performance for carbon steel used as wellbore casing and CT materials. In situ linear polarisation resistance measurements confirmed that an acetylenic alcohol-based polymerisable inhibitor, used at a concentration of 0.01 wt.% in Stage 2 after a 0.2 wt.% concentration film forming stage (Stage 1), maintained excellent corrosion protection of N80 (wellbore casing) and HS80 (CT) carbon steel, with corrosion rates of < 5 mm/year measured.



Significant corrosion rate reductions achieved with staged inhibition versus applied controls.

Advantages of the flow cell for application in ACI studies are:

1. Well-defined hydrodynamics: Consistent and predictable flow across metal surface once-through nature:
2. Fresh HCl and ACI are continuously replenished and flow into waste, maintaining consistency in experimental conditions throughout In situ electrochemical measurements:
3. Measurements of corrosion rate in real time seamless condition changes:
4. Composition of fluid can be easily changed prior to inflow during an experiment (no exposure of coupon to air)

For the February presentation, Leo Richards, Principal Engineer and Andrew Duncan, Lead Consultant, both with Intertek Production and Integrity Assurance Group, described the "Implementation of Plan-Do-Check-Act review.

Leo Richards (left) Intertek Principal Engineer Production Chemistry and Andrew Duncan (right) Intertek Lead Consultant, Production and Integrity Assurance.

Corrosion management guidelines were used as the basis for an audit study of a large onshore oil field, the purpose of which was to perform a detailed review of the corrosion monitoring and mitigation systems, and to advise on any required upgrades to ensure world class/excellent asset integrity performance.

The approach taken for the study was to follow the UK Health and Safety Executive's guidance for 'Managing Health and Safety', HSG65 (2013), of PLAN-DO-CHECK-ACT, which considers both Technical and Systems approaches associated with managing assets safely. This is a closed loop planetary model commencing with a high-level corporate policy for health and safety, under which there is a policy and plan for managing corrosion and integrity. The model ends with lessons learned which feed back into the corrosion and integrity policy and plan to ensure risks are managed to 'As Low as Reasonably Practicable'.

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The model ends with lessons learned which feed back into the corrosion and integrity policy and plan to ensure risks are managed to 'As Low as Reasonably Practicable'.

First, a detailed study was carried out to assess and identify the current corrosion management techniques being used and their effectiveness in the operator's fields and process plants. The 'gaps' were identified within the assets, and corrosion management proposals and solutions were then provided to ensure world class asset integrity performance.

A desktop-based document review was conducted in the UK and also at the client's offices. This was followed up by site surveys, which included visits to at least one plant of each of these facility types: gas station, degassing station, gas recycle plant, PWI stations, gas distribution stations and stripping plants.

In order to help delegate and spread some of the responsibilities for the study areas within the operator's corrosion team, Intertek deployed RACI Charts: Responsible - Accountable - Consulted – Informed, which serves to provide structure to the corrosion team as a whole, defining who does which task and allowing the right people to do the right job and move on with it.

The study highlighted a distinct pattern in the working practices of the operator with virtually all sections of the corrosion management system being shown to have some form of PLAN and DO. However, the implementation of the CHECK and ACT stage was missing from almost all aspects.

Some Key Findings

1. Automation and use of a suitable database/Corrosion Management System makes the DO stage easier and quicker.
2. For CHECK and ACT – an automated system requires Specialist assessment, rather than total reliance on the CMS output. Automation may also result in complacency.
3. For CP monitoring, sensors need to be regularly calibrated, and the system checked to ensure full protection.
4. Data requires to be both CHECKED and reviewed.
5. ACT will have double impact – ACT on what the data has shown and ACT on how the data was gathered.

Future Application of P-D-C-A and Corrosion Monitoring

The working world has changed dramatically over the last two years due to Covid and there has been a significant change in Engineers' working patterns and methods of project study and delivery. This has also combined with a move towards remote and automated inspection and monitoring, however, the speakers were keen to stress that if the PLANNING Stage is not implemented correctly, then wholesale automation of integrity systems is not always helpful, as automated systems will follow 'Garbage In Garbage Out' scenarios, Specialist input is always required. *(Editor: Readers should note that a longer technical article on this topic appears later in this issue of the magazine).*

Both these very engaging presentations generated many questions from the audience that were expertly responded to by the speakers, and all Q&A write-ups may be found on the branch webpage.

Slides of technical papers for branch events, along with their respective Q&A's can be found at, ICorr Aberdeen Branch (google.com) under Local Technical Programme, Aberdeen Branch - Institute of Corrosion (icorr.org). A library of event recordings may also be found at: ICorr Aberdeen - YouTube.

It is also with our great pleasure to announce that Rysco International Inc. based in Alberta, Canada, has become the latest new sponsor of the branch, as well as becoming a GOLD sustaining member of ICorr. The branch is very grateful to all its sponsors for their continued support.

Finally, the branch is very sad to report the recent passing of Carol Anne Powell BSc., FIMMM, a long-term consultant to both the Nickel Development Institute and the Copper Development Association. She had written over 40 papers and publications and been a member of our Partner Organisation the Marine Corrosion Forum (MCF), since its inception. During the recent COVID-19 epidemic as we were moving increasingly towards Webinar formats in April 2020, Carol greatly assisted us with an excellent presentation to our ICorr/MCF membership entitled 'An Overview of the Corrosion of Metals in Seawater. In her memory, we would respectfully direct you to: https://marinecorrosionforum.co.uk/free-webinar-30%2F04%2F2020

Aberdeen Branch call for papers – Technical Session 2022 – 2023

The Aberdeen branch would like to invite you (or a colleague) to give a presentation during their 2022/2023 session. The events normally are held at 6 pm on the last Tuesday of the month from September till May 2023, excluding December 2022.

Topics on pressure systems, pipelines, renewables and structural integrity management with regards to the material selection, production chemistry, welding, corrosion/microbiological control and monitoring, inspection techniques and data analytics, are acceptable. Past case studies, project experiences, and emerging technologies have proved popular and interesting to members, and are particularly welcome.

The attendees (members and non-members) include students, technicians, technologists, engineers, scientists, researchers, managers, company directors and other professionals from the oil and gas, power generation, manufacturing and renewables sectors. Subsequently we would publish a report of the presentation in Corrosion Management magazine, and also on the ICorr, and Aberdeen website pages, including the presentation slides and Q&A session write-up. A recording of the event (if conducted online) will be uploaded to our YouTube channel later.

If interested, please supply the following including, speaker's name, role and company, short biography of the speaker(s) (~ 150 words) and the proposed presentation title and an abstract (400 words), to the ICorr Aberdeen Branch Chair, Hooman Takhtechian, via htakhtechian@oceaneering.com and please also copy in icorrabz@gmail.com in your submission.

All the submitted presentations will be subject to a branch committee review and those successful will be scheduled into the 2022/2023 events programme. Please note that the deadline of the submission is 30th April, and the branch will confirm the successful presenters in May, and announce them in June.

London Branch

The branch's February technical meeting was held online, to a large audience including many international attendees, and Mr. Phil Low, presented on "Diversified Approach to Vapor Corrosion Inhibitors (VCIs)."

Philip Low is European/ Middle East/GCC Business Development Manager Zerust Oil & Gas. He has 25+ years' experience in the Global Oil and Gas industry.

Phil (pictured above) started his presentation by explaining that VCIs are a variety of chemical formulations which prevent corrosion of metals. First patented in 1948 by Shell, VCI's have evolved into many applications, from powder and liquid forms, to being infused in plastic, oils and greases, and many other delivery methods. He showed a brief animation illustrating how VCIs work and then described the standards and regulations for VCI Use, including:

- NACE TG543: Standard for External Corrosion Control of On Grade Carbon Steel Storage Tank Bottoms
- API 2610 Design, Construction, Operation, Maintenance, and Inspection of Terminal and Tank Facilities, section 12.5 Volatile Corrosion Inhibitors (VCI)
- API 651 Cathodic Protection of Aboveground Petroleum Storage Tanks
- API TR655 Vapor Corrosion Inhibitors for Storage Tanks

Phil then reviewed the many storage tank foundation designs compatible with the use of VCIs for corrosion protection of the tank bottoms, and went into the details of the various methods for validating the effectiveness of VCIs in the field, such as:

- Coupons
- Electrical Resistance Probes
- Ultrasonic Thickness Probes
- Inhibitor Delivery
- Gas Detection

The many VCI application uses in the Oil & Gas industry, were described, including corrosion protection of metals in static, enclosed environments such as:

- Beneath Tank Floors
- ZIF Tape (Impregnated with VCIs) for corrosion under insulation (CUI), scab repairs, and flange protection
- Preservation/Warehousing/Mothballing
- Pipeline Protection and Preservation
- Pipe Casings
- Rust removal/waxes/greases/RP's

Protection of tank bottoms using Vapor Corrosion Inhibitors (VCIs).

Corrosion Under Insulation (CUI) / scab repair using ZIF tape.

continues on page 14

Phil concluded that:

- Design and materials help mitigate corrosion
- Cathodic Protection is effective in mitigating corrosion
- Standards and Regulations are looking at new tools to combat corrosion
- Vapor Corrosion Inhibitors are one of those tools
- Field experience indicates that VCIs are effective

There was an extensive question and answer session, and Phil was thanked for his presentation.

The branch AGM was held on 10th March, and the chair, Ben Moorhouse described that the last year had been difficult for everyone, and that the technical presentations had been held virtually, however as the country was getting back to a more normal state, in-person meetings were now being held, of which this will the first. As the virtual meetings had been appreciated by many who could not get to London easily, or were based abroad, technical presentations going forward would be hybrid, in person/virtual events. The branch treasurer, Jim Glynn, then presented the accounts, which highlight that approx £6,500 of our allocation had been returned to head office, as there had been few physical meetings. These were accepted by the floor. The branch committee was then elected with no objection, and Ben then welcomed the new members, Polina Zabelina (who will take over the role of chair), Adam Cliff, Xinming Hu, and Anthony Setiade, and thanked the retiring members, Trevor Osborne and Peter Sinclair, for their contributions to the working of the branch. He also explained he was leaving due to a new work posting.

Ben Moorhouse.

After the AGM, Ben then gave the usual chair's presentation, which was on the "Flint Water Crisis – Corrosion, Management and Politics". The town of Flint in Michigan, suffered one of the worst water crisis in the United States of America in 2014, when the tap water supply began to be poisoned with corrosion products and other toxins. Hundreds of thousands of Flint residents were exposed to dangerous levels of lead and outbreaks of Legionnaires disease that caused deaths and many long-term health problems. This talk focused on the decisions that led to this outcome, the corrosion engineering around ensuring safe water sources, and the importance of ensuring a greater understanding of corrosion issues in relation to environmental issues. Approx. 30 people attended this very interesting talk, including members from S. Africa, Canada, and the Middle East online.

Ben was then presented with a branch pen in thanks for his presentation by the incoming chair, Polina.

Obituary, Geoff White (1944-2022)

Geoffrey Edward White (Geoff) started working life as a chemist in the water industry. He was head-hunted by the newly formed Cathodic Protection (CP) team in the Gas Industry to install and monitor CP on the new high-pressure National Grid steel pipelines. This involved much outdoor work, and helicopter surveys of the pipelines, over the south-east of England. He soon became an expert in fault-finding and developing remote monitoring which provided him with the opportunity and time to enlarge on his bird-watching knowledge. He later transferred from Ashford to the Maidstone office, close to where he was born in April 1944.

Geoff was a Fellow of the Institute, a long-term member of London Branch and an active committee member long into his retirement.

He had many and varied hobbies which were lifelong interests actively pursued to the end. He became an acknowledged authority in many of these and was frequently consulted. These included the Inn Sign Society, stamp collecting specialising in Commonwealth stamps of the 1950s, photography, cricket, painting and drawing. He supported the Real Ale movement and disliked what he called "chemical fizz."

He built his own model railway from scratch, including several engines and a magnificent layout, including many model buildings, built to scale. He enjoyed a wide range of music, especially organs, he played guitar and piano, was an excellent male alto and built his own harpsichord. He composed a number of songs for solo voice and choir, some of which

have been published. His greatest love and commitment were for his wife Dawn, whom he considered "Just so fantastic!" and he never wavered from that initial assessment. Geoff was a Gentle Gentleman, dependable, faithful, funny, good company and a true friend. He will be missed, but always remembered.

ICorr Training and Certification for Cathodic Protection Personnel

The Institute of Corrosion Training and Certification Scheme for Cathodic Protection Personnel has been successfully running for many years. In 2006 it was extended from only Buried CP courses to include, firstly Steel in Concrete and then Marine/Offshore to meet the then BS EN 15257: 2006 Standard on 'CP Competence levels and Certification'. This Standard was adopted across Europe and worked as a framework to ensure equivalence and acceptance of rigorous training, assessment and certification in CP.

At an early stage ICorr partnered with the Corrosion Prevention Association (CPA), the UK trade association for CP and other corrosion mitigation measures in concrete. The CPA has members from the client/owner, contractor, material supplier and consultant sectors, and most contractors and designers active in CP of steel in concrete are members. ICorr members have been prominent in the CPA and in their technical activities in the production of guidance notes and in working with clients/owners in ensuring effective and reliable CP systems. Highways England and many other major users of CP in the concrete infrastructure require personnel working on CP to be Certificated to the appropriate level in accordance with the ICorr Scheme. This is applied to their designers, installation and operational surveillance personnel. The CPA has been responsible for marketing and administrating ICorr courses and examinations in the concrete CP sector.

In 2017 the Standard became BS EN ISO 15257:2017; this revised the previous Levels 1-3 to Levels 1-5, with Level 1 being typically for those who either worked part time in CP alongside other responsibilities, or whose role was to collect data. Level 5 is an expert level for those with particularly high levels of knowledge and expertise. During this time, as well as extensive work being undertaken by ICorr CP specialists in meeting the expanded and more rigorous requirements of the new ISO Standard, ICorr was in discussion with National Grid and other major gas distribution network operators who require high levels of expertise and certainty in their safety related CP activities. These gas transmission companies now require their key CP personnel and the CP personnel of their specialist contractors working on CP to be Certificated to the appropriate level in accordance with the ICorr Scheme. Also, during this time ICorr invested in improving the quality of their training packages which are now considered to be world leading. ICorr offers training in

Levels 1-3, examinations in Levels 1-4, and competence assessment and certification to all levels. In 2021 most of the ICorr CP courses and examinations were delivered at an ICorr Approved CP Training and Examination Centre at Freyssinet in Telford. Since 2021 the CPA have been administering all L1-L3 Courses.

During the coming months, CP courses will be held at Telford and other selected locations. For a complete list of L1-L3 courses in all sectors, and to make bookings, go to, https://www.corrosionprevention.org.uk/training-courses-2022

In March 2022 ICorr rolled out its first Level 4 Buried examination. This is intended for those experienced CP Level 3 engineers, who have studied CP literature, have been mentored for some years by experienced Level 4 CP engineers in detailed and complex CP system designs and interpretation of CP performance data from 'complicated' CP systems, and have reached the Competence required at Level 4.

The next Level 4 examinations will be held at Corrosion House, Northampton, on 17 September and 8th December 2022. See https://www.icorr.org/cathodic-protection-training for details.

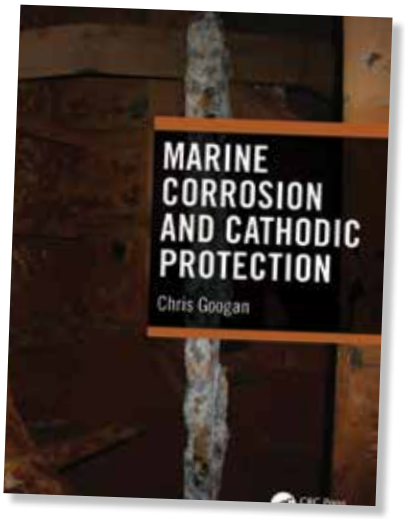
Competence Assessment and Certification

In accordance with ISO 15257 the post examination Assessment and Certification process is undertaken within ICorr's Professional Assessment Committee (PAC), independent of the training and examination activities. All details are on the ICorr web site as above. In addition, there is a list of all ICorr Level 4 Senior CP engineers on this web site.

Industry News

Book Review

Marine Corrosion and Cathodic Protection, Ist Edition By Dr Chris Coogan



Cathodic protection (CP) mitigates the high cost of steel and other alloys corroding in seawater and seabed sediments. *Marine Corrosion and Cathodic Protection* is a comprehensive guide to corrosion issues and presents methodologies to tackle common offshore code-based CP designs. Advanced theory is developed for non-routine CP applications, with and without subsea coating systems.

The interactions between CP and the fatigue and hydrogen embrittlement characteristics of alloys are explained. Sacrificial (or galvanic) anodes and impressed current systems are examined, followed by descriptions of successful and unsuccessful applications on petroleum installations, harbours, jetties, pipelines, windfarm foundations, ships, and floating production storage and offloading (FPSO) structures. Retrofit CP systems for the life extension of assets, together with methods for applying CP internally in both static and flowing systems are evaluated. A critical review of the role of physical and computational modelling in CP design and evaluation addresses the more geometrically complex applications. Techniques for, and limitation of, CP surveying, inspection and monitoring, are explained in the context of system management.

This book is ideal for engineers, designers, manufacturers, equipment suppliers and operators of offshore CP systems.

The author, Dr Chris Googan, is an AMPP International Accredited Corrosion Specialist. After graduating in chemistry, and spending several years in the steel and copper industries, and in the protective coatings industry, he became a freelance corrosion engineering consultant. His experience of corrosion, materials, coatings and cathodic protection has been gained in over 40 countries.

Published by CRC Press, ISBN 9781032105819. Price £13

40 Years of Premier Coatings Ltd

Premier Coatings Ltd are celebrating 40 years of trading this year. Founded in 1982 and operating from Smarden in Kent, Premier Coatings Ltd specialise in the manufacture and supply of a wide range of corrosion prevention and chemical resistant coatings, linings, and waterproofing systems.

The company's products are used in the Oil & Gas sector, utilities sector, and construction industry, and are supplied to a variety of national, ISO, and commercial standards. The Premseal™ range of waterproofing and gasproofing products are CE and UKCA marked, and the company operates under ISO 9001:2015 and ISO 14001:2015 quality and environmental management systems.

In 1997 Premier Coatings Ltd was acquired by Winn & Coales International, where it has continued to prosper, and in 2017 achieved a Queen's Award for Enterprise: International Trade.

According to Steve Crawley, Managing Director of Premier Coatings Ltd., '*This major milestone of 40 years could not have been achieved without the support of our employees, distributors, clients and the continual development of the company and its products. We are proud of our past and look forward to an exciting and successful future together.*

KAEFER Secure Five Ship Deal with Babcock to Provide Surface Protection Marine Coatings for the Type 31 Frigate Programme

Image courtesy of Babcock International Group.

KAEFER UK and Ireland, has announced that it has secured a long-term, £22m contract with Babcock, to provide technical surface protection to the Royal Navy's newest frigate, the Type 31.

The shipbuilding programme which will continue until 2028, brings continuity of work for KAEFER's existing industrial services workforce at Babcock's Rosyth facilities, with new employment opportunities and prosperity for the local economy.

KAEFER will apply over 510,000m^{2}of specialist paint coatings, providing skilled jobs for an additional 70 painters and support staff. With this work forming part of the build programme, KAEFER's expertise, highest quality standards and long history of delivering ship support services safely, on time and on budget, is vital.

Sean Donaldson, Managing Director, Marine Engineering and Systems, Babcock International Group said: *"The contract with KAEFER, to supply the Type 31 programme, builds upon years of collaboration between our organisations. New painting, protection and digitilisation technology will be deployed within a working arrangement, to deliver a successful project for our end customer, the UK Royal Navy."*

Intrinsically safe cathodic protection systems for hazardous environments - how one of Australia's key ports tackled corrosion

According to the press release, over the last decade, it has been established that chlorine-induced corrosion is affecting some of the major structures at NSW Ports, including Sydney Harbour and Port Botany, Australia's largest container port.

As a result, NSW Ports commissioned Infracorr to design a CP system for use at BLB1, which is located at Port Botany and contains hazardous gas pipelines. The project also included the repair of defective concrete structures which were suffering from the effects of corrosion and concrete spalling in the many pre-stressed beams and headstocks of the various bridges and catwalks at the port.

The CP system needed to be designed to allow for tight control of the currents and voltages used across the site, due to the presence of hazardous materials in the environment on an ongoing basis, meaning that any stray sparks caused by excess voltages and currents could become an ignition source for a major fire or explosion, and that as many of the structures present are constructed using pre-stressed concrete, it was extremely important that all electrical currents applied were carefully controlled to avoid structural damage caused by over protection.

One of the big technical challenges for the project was that there was no off-the-shelf CP system available that had certification for use in zone 1 classified hazardous areas, which meant that a bespoke system had to be designed that met the cathodic protection objectives, including dealing with the challenge of prestressed concrete, and that could be certified to meet the necessary requirements under AS60079 regulations.

The system designed for use at BLB1 by Infracorr, was a hybrid CP system that combined the properties of both passive galvanic and impressed current cathodic protection. It works by inserting specially designed anodes directly into the structure in a matrix. A voltage is then applied to force salt migration from the steel to the anode and passivate the zone, and when the zone is sufficiently charged, the power source is disconnected, and the sacrificial anodes are left to operate galvanically, providing passive protection to the structure.

The system relies on remote monitoring technology to provide asset managers with ongoing reassurance that it is operating as intended, and corrosion levels are under control, and to deliver this, Omniflex were asked to advise on the remote monitoring aspects of the design.

Because this was the first large scale implementation of hybrid CP used in a working hazardous area anywhere in the world, some components needed certification for the design to meet the requirements of AS60079 as an intrinsically safe certified system, which was subsequently obtained.

Remote monitoring unit.

System performance and corrosion levels are continuously monitored 24/7 using 24 remote monitoring units situated throughout the site, each with the capacity to monitor 16 structures. This should ensure that the integrity of BLB1 is maintained, and the berth remains reliable and available to handle NSW's growing bulk liquid trade volumes for the next 50 years. For further information, visit www.omniflex.com

Market Study: Paints & Coatings - World (5th edition)

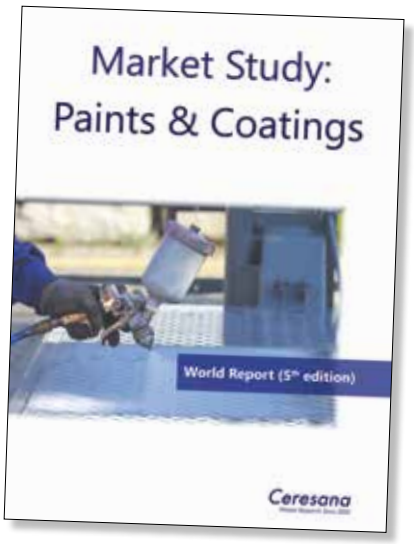
Ceresana has published their latest paints and coatings market survey. Chapter 1 presents and analyses the global market for paints and coatings – including forecasts up to 2030. The development of revenues, demand and production are outlined for each world region, and the market figures on consumption are divided according to applications, product types, and technologies. In addition, the regional markets for paints and coatings are broken downinto, and analysed by, the application, and the demand for each product type is examined separately. In Chapter 2, sixteen countries are analysed in detail according to demand of paints and coatings, export, import, production, and revenues.

The market data on consumption volumes per country are analysed according to the individual paint types, and technologies, e.g.

- Waterborne
- Solvent-borne
- Powder coatings
- Others

Finally, Chapter 3 offers a useful index of 119 major manufacturers of paints and coatings, clearly organised according to contact details, revenues, profits, product range, production sites and a brief company profile.

Further details can be found at, www.ceresana.com



Novosound Belenus-X corrosion monitoring sensor

According to the press release, the Novosound Belenus-X corrosion monitoring sensor has been certified for operation in ATEX, IECEx and UKEX Zone 0 locations. Designed and manufactured in line with international intrinsically safe standards, this latest certification extends the potential application of the Novosound Belenus-X to operate in areas where explosive gas atmosphere is present continuously or for long periods.

The Novosound Belenus-X is a permanently installed ultrasonic sensor enabling in-service corrosion monitoring in the most safety-critical and high-risk environments and capable of continuous operation up to 400°C. Combined with its high-resolution imaging capabilities, the Belenus-X provides process engineers with highly accurate wall thickness measurements.

Enabling continuous corrosion monitoring in hazardous areas, the Belenus-X provides plant operators with granular, high-quality and repeatable corrosion data that cannot be achieved with periodic manual inspections.

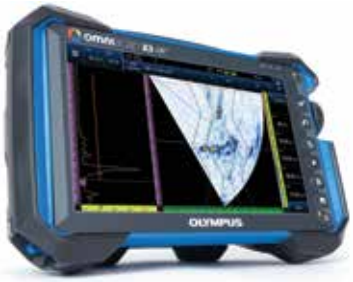
With the sensitivity to detect small changes in wall thickness, the Belenus-X enables the early and reliable detection of corrosion. This facilitates better maintenance planning and allows operators to carry out timely repairs, mitigating potential, costly damages. By enabling the move away from manual inspections, the safety risk to personnel when operating in hazardous locations is also reduced, concluded the company.

New Products: OmniScan™ X3 Flaw Detector

According to a press release, the new OmniScan™ X3 64 flaw detector from Olympus, delivers improved power and performance to their phased array ultrasonic testing (PAUT) product line. This 64-channel instrument has the pulser capacity to drive phased array (PA) probes with a larger number of elements, increasing the data acquisition speed for total focusing method (TFM) imaging. Users can exploit its increased capabilities to expand and diversify their application portfolio.

The high portability and enhanced performance of the OmniScan X3 64 flaw detector increase inspection productivity. It can process TFM images up to four times as fast as its predecessor, yet comes in the same rugged and easily transportable box. On job sites with limited or restricted space, users will appreciate that the unit is compact and less cumbersome than other 64-channel devices. Inspectors can also remain on site longer and perform bigger scanning jobs without transferring data, thanks to the large 1 TB onboard storage.

Smaller defects are easier to distinguish using the flaw detector's high-resolution PA and TFM imaging. Accommodating lower frequency probes, the OmniScan X3 64 unit can increase penetration in attenuative materials while reducing signal saturation. These improved detection capabilities assist monitoring for early-stage flaws, such as high-temperature hydrogen attack (HTHA), concluded the company.



For more details visit www.Olympus-IMS.com/phasedarray/OmniScan-X3.

Latest Literature

Enhanced anticorrosion performance of zinc rich epoxy coatings

In a recently published study, the effect of a partial replacement of spherical zinc particles by stainless steel flakes (SSF) on the corrosion protection performance of a zinc-rich epoxy (ZRE) coating was studied. Salt spray test, open circuit potential, electrochemical impedance spectroscopy and potentiodynamic polarisation tests were utilised to evaluate the anticorrosion performance of the coatings.

The results demonstrated that a partial replacement of zinc particles by SSF enhanced the anticorrosion properties of the ZRE coating, and the enhancement was attributed to the synergistic effects by increasing the coating impedance and extending the cathodic protection duration.

The study was published in Progress in Organic Coatings, Volume 163, February 2022.

Enhanced protection of reinforced concrete structures

The corrosion of steel bars is the main reason for the premature failure of reinforced concrete structures, and coating reinforcement is considered to be an effective method to protect steel bars from chloride attack. A recent publication, describes the development of a graphene oxide (GO) modified silane composite coating (isobutyl triethoxysilane combined with tetraethyl orthosilicate) for the corrosion protection of reinforcement bars. The physicochemical characteristics and corrosion resistance performances of mild steel coated with this composite coating was examined by scanning electron microscopy, Fourier transform infrared spectroscopy, thermogravimetric, Raman analyses, and electrochemical measurements.

The results indicated that the coating with a thickness of about 45 µm exhibits substantial corrosion resistance with a maximum protection efficiency of about 99.36% in chloride media. The superior corrosion protection performance is attributed to the formed covalent bonds between GO and silanol, which strengthens the three-dimensional network structure of the coating. In addition, the uniformly distributed GO immensely slows down the degradation of silane coating structure and improves the stability of the coating, and thus delays the corrosion.

The study was published in Progress in Organic Coatings, Volume 164, March 2022.

Advances in steel surface treatment via green conversion coatings

Replacing the chromate and phosphate conversion coatings (CCs) with nontoxic ones has played a key role in CC research in recent years. Although considerable efforts have been devoted to discovering and modifying the toxic CC alternatives, much of the research has been restricted to a few green CCs.

A new review of the recent attempts that have been made in this area of research to address the toxicity issue of CCs, with a focus on the steel substrate. It includes investigations on different CCs: cerium (CeCC), neodymium (NdCC), lanthanum (LaCC), zirconium (ZrCC), titanium (TiCC), trivalent chromium (TCC), molybdate (MoCC), silicate (SiCC), and silane (SilCC). Surface studies, electrochemical measurements, CCs' comparison, and film formation mechanisms are summarised, and adhesion to the steel surface is discussed.In addition, the influence of several steel substrates (coated and uncoated) and solution parameters (pH, temperature, concentration, stirring, and immersion time) on the CCs properties are also outlined.

The review was published in Journal of Coatings Technology and Research, Volume 19, 2022.

Antifouling properties of epoxy coatings

A recently published review discusses the various types of epoxy-based antifouling coatings as cost-effective and environmentally sustainable solution to biofouling. The need for nontoxic antifouling coatings has encouraged material scientists to develop a new class of epoxy coatings. As a versatile thermosetting resin and well known for various coating applications, antifouling characteristics have been integrated into epoxies along with anticorrosion and adhesive functions. Accordingly, both micro- and macro-biofoulings have been successfully controlled by using epoxy-based antifouling coatings, and epoxy nanocomposites, silicon-grafted epoxy, epoxy-aided conductive polymer blends, and nanocomposites are important antifouling epoxy variants This newly published review discusses the various types of epoxy-based antifouling coatings. The ability of nanomaterials, siloxanes, and conducting polymers to induce antifouling activity into the epoxy and corresponding antifouling mechanisms is also covered. The review concludes with the enormous potential of antifouling epoxy coatings as cost-effective, environmentally sustainable solutions to biofouling in diverse industrial applications.

The study was published in Journal of Coatings Technology and Research, Volume 19, 2022.

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 formal approval.

ISO/FDIS 12696 Cathodic protection of steel in concrete (Revision of 2016 standard)

ISO/FDIS 24656 Cathodic protection of offshore wind structures

New international standards published during the past two months

ISO 9220:2022 Metallic coatings — Measurement of coating thickness — Scanning electron microscope method

ISO 10270:2022 Corrosion of metals and alloys — Aqueous corrosion testing of zirconium alloys for use in nuclear power reactors

ISO 24020:2022 Corrosion of metals and alloys — Standard test method for particle-free erosion corrosion of metallic materials by jet-in-slit

Ask the Expert

The questions in this issue feature pipeline corrosion and how to decide whether a full repaint or sport repair is required for a failed vessel lining.

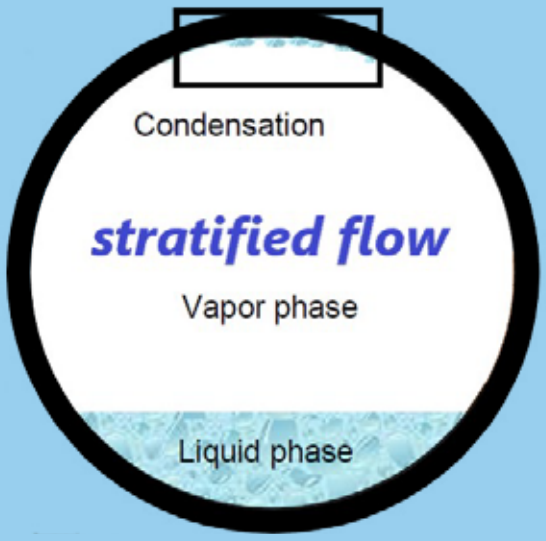
Question:

What is Top of the Line Corrosion? When would you expect this, and how do you mitigate against it? **BK**

Answer:

Top of the line corrosion most commonly occurs in wet gas pipelines. It takes place on the top section inside the pipe (hence the name – top of the line corrosion) due to condensation of water containing corrosive agents, such as CO_2 (''sweet'' corrosion), H_2S (''sour'' corrosion) and acetic acid (HAc).

The flow regime has an impact on this mechanism, as it mostly occurs in pipes with stratified and wavy-stratified flow regimes – these allow for the condensation process to take place uninterrupted, and for that reason makes traditional liquid corrosion inhibitors not very effective in protecting against this type of corrosion, as liquids stay in the bottom area of the pipe and the protective film isn't formed on top area of the pipe inner surface.



The factors impacting top of the line corrosion include:

- CO_2 /H_2S concentration
- Presence of organic acids
- Flow regime and flow velocity
- Temperature
- Pressure
- Water condensation rate

The mechanism of the top of the line corrosion in a 'sweet' environment, caused by the presence of CO_2 is,

(a) Formation of aqueous CO_2:

$$CO_{2(g)} \leftrightarrow CO_{2(aq)}$$

$$CO_{2(aq)} + H_2O_{(l)} \leftrightarrow H_2CO_{3(aq)}$$

(b) Dissociation of H_2CO_3:

$$H_2CO_{3\,(aq)} \leftrightarrow H^+_{(aq)} + HCO^-_{3(aq)}$$

(c) Formation of H^+ and CO_3^{2-}:

$$HCO^-_{3\,(aq)} \leftrightarrow H^+_{(aq)} + CO^{2-}_{3(aq)}$$

The subsequent carbon steel corrosion mechanism involves,

(a) Anodic reaction:

$$Fe_{(s)} \rightarrow Fe^{2+}_{(aq)} + 2e^-$$

(b) Cathodic reaction:

$$2H^+_{(aq)} + 2e^- \leftrightarrow H_{2(g)}$$

$$2H_2CO_{3(aq)} + 2e^- \rightarrow H_{2(g)} + 2HCO^-_{3(aq)}$$

$$2HCO^-_{3(aq)} + 2e^- \rightarrow H_{2(g)} + 2CO^{2-}_{3(aq)}$$

$$2H_2O_{(l)} + 2e^- \leftrightarrow H_{2(g)} + 2OH^-_{(aq)}$$

and the overall reaction is,

$$Fe_{(s)} + CO_{2(aq)} + H_2O_{(l)} \leftrightarrow FeCO_{3(s)} + H_{2(g)}$$

The presence of organic acids exacerbate top of the line corrosion as they lower the pH of the condensed water even further. Top of the line corrosion can manifest itself as pitting, uniform corrosion, or mesa attack, and it depends on the above factors. To prevent top of the line corrosion, gas lines are often treated with a mixture of monoethylene glycol (hydrate inhibitor) and corrosion inhibitor. Monoethylene glycol is also able to reduce corrosion rate as it reduces the vapour pressure of the liquid phase of a wet gas.

The effectiveness of corrosion inhibitors in protecting pipes against top of the line corrosion varies and highly depends on the volatility of the chemical. You can find a variety of papers on this subject in NACE archive.

Suggested reference articles:

Dugstad, A., 2014. Top of line corrosion - Impact of MEG and organic acid in the gas phase. In: NACE International, Corrosion/ 2014, 9–13 March, San Antonio, Texas, USA, NACE2014-4382.

Ojifinni, R.A., Li, C., 2011. A parametric study of sweet top-of-line corrosion in wet gas pipelines. In: NACE International, Corrosion/ 2011, 13–17 March, Houston, Texas, NACE-11331.

Olsen, S., Dugstad, A., 1991. Corrosion under dewing conditions. In: Corrosion/91, Paper No 472, NACE, Houston, Texas

PN

Question:

What criteria should an inspector/owner use to determine whether to specify full removal or sport repair of a tank lining? **PS**

Answer:

There are many thoughts regarding the timing for replacement of vessel linings and whether it should be a total or partial replacement. Lining failures occur due to various mechanisms, the most common, among others, being the following:

- Blister formation due to osmosis through the coating caused by surface contamination on the steel substrate during preparation.
- Solvent entrapment in the coating.
- Adhesive failure of the coating to the steel substrate caused by surface contamination, inadequate profile, material applied outside its pot life or incorrect ambient conditions.
- Explosive decompression where a substance is liquid at the operating pressure, but is gaseous at ambient temperature migrates into the coating during operation but in a rapid shut down situation blow sections of the coating apart, this may take several cycles to effect this result.
- Thermal stress cycling, due to differences in the linear thermal expansion characteristics between the substrate and the coating, thermal cycling sets up a series of stresses which compromise the cohesive and adhesive strengths of the coating system.
- Mechanical damage from either internal or external sources.
- Chemical attack of the lining due to the introduction of liquids into the vessel that destroy the coating integrity.

The above list is not exhaustive, but gives a feel for the problems associated with vessel lining performance. Because of the potential for failures to occur during service, it is a bit of a lottery estimating the life expectancy of a coating system. A vessel operating at ambient temperature and pressure with a non-aggressive liquid will have a greater life expectancy than a similar lining exposed to varying temperatures and pressures with an aggressive mixture of liquids. Coating manufacturers on the whole will quote life expectancies for what they expect an 'average' exposure to involve.

When inspecting a vessel lining that has been in service for a period of time, any breakdown present needs to be carefully analysed to check whether it is a local failure with a driving force that is not uniform throughout the vessel, or whether what is encountered is the first stages of total lining failure. This can be a hard call for the inspector as the decision on whether a total re-line, or a series of spot repairs, could lead to a premature/ catastrophic failure of the lining when put back into service especially when under pressure to get a vessel back in service as fast as possible.

From an inspection point of view, a lot depends on the inspector visually identifying the defects present. This should then be backed up by non-destructive tests to determine if the coating still meets specification - the most useful of these being to check the dry film thickness to look for wastage and coating thinning, and these need to be taken over the entire vessel, concentrating on the areas such as nozzles and edges where thinning of the coating is likely to be prevalent. Spark testing at 4Kv per mm of coating will show up any holidays along with other defects such as porosity and inclusions. Destructive testing such as dolly pull-off adhesion tests will give a good indication of any potential reduction in adhesion/cohesion but the test area requires to be repaired.

Spot repairing a vessel lining tends to be a short term fix as the repair itself can end up creating a weak spot. Preparation is invariably of a lower standard that that used to prepare a full vessel, ie power tool, which does not give a long term life expectancy for the lining. If blasting is used, it is essential to remove all corrosion salts and contamination from the affected area and chase back to a firm feathered edge. Spot repairs result in large amounts of 'free' edges where future breakdown may readily nucleate from. When blasting in a vessel to undertake spot repairs there will inevitably be collateral damage from the blasting operation in the form of overblast and ricochet which can lead to coating weakness and potential failure.

If a coating is reaching the end of its expected life it is not advisable to spot repair except in extenuating circumstances, as the failure rate will become unacceptable and damage to the vessel shell will occur. A new coating system should be used that will give the optimum life expectancy, with consideration also to be given to the life of the vessel. Under most circumstances it is preferable to completely renew a coating system. Changes in the operating parameters need to be taken into account as these may have changed since the original specification was drawn up, it is worth looking at failures and using these to learn from to improve the specification.

Bearing the above comments in mind, the following procedures and systems should be used:

- 100% visual inspection after clean out to identify through coating failures.
- Dry Film Thickness check, all nozzles, edges and welds with at least 3 readings per m^2 to check for thinning/wear on the coating, minimum acceptable is 15% below specified thickness.
- 100% holiday detection to find any pinholing or porosity defects.
- Finally, if deemed necessary, apply dolly pull off adhesion tests to check for reduced adhesion of delamination.
- Report findings to client.

Under normal circumstances, a failure rate in the order of 15 to 20% or greater would be deemed as uneconomical to spot repair as the effort needed would be as great as that to recoat fully, the percentage being based on the percentage area of the vessel shell that will receive new coating, not the percentage area of visible failure or corrosion. What initially appears as a small defect of say nominally 10mm x 10mm will probably end up as a repair of the order 400 to 500mm diameter if done correctly.

Simon Hope, Auquharney Associates ltd

Readers are reminded to send their technical questions, for answer by the panel of experts, to the editor at, brianpce@aol.com

Fellow's Corner

This series of articles is intended to highlight industry-wide engineering experiences, practical opinions and guidance, to provide improved awareness for the wider public, and focussed advice for practicing technologists. The series is prepared by ICorr Fellows who have made significant contributions to the field of corrosion management. This month's articles include, John Boran on measuring hardness in sour service, and Bob Crundwell on sacrificial anodes.

Think about where you measure hardness for sour service applications – weld root hardness.

Great care must be taken in the control of welding processes, as they may introduce significant metallurgical defects and detrimentally alter material performance in the sometimes 'adverse' conditions of Oil and Gas operations.

Hydrogen sulphide in oilfield fluids can cause sulphide stress cracking (SSC) in metals and alloys used in oil and gas production for pipelines, piping, pressure vessels, and other items that may come into contact with the sour fluids. SSC occurs if a material is not sour service rated at design, along with other cracking mechanisms, such as hydrogen induced cracking (HIC), step wise cracking (SWC) and stress-oriented hydrogen induced cracking (SOHIC), but this article will concentrate on SSC aspects.

Oilfield fluids are classified partly on the presence of acid gasses in the fluids. Carbon dioxide (CO_2), when dominant, results in so-called sweet fluids where it is the major integrity threat in the presence of moisture. Trace amounts of hydrogen sulphide (H_2S) are almost always present but when these exceed safe limits, the fluids are termed sour. Acid corrosion of metals and alloys in sour oilfield fluids result in the production of monatomic hydrogen, the hydrogen sulphide present acts as a catalyst to the hydrogen recombination reaction where diffused monatomic hydrogen recombines to form the diatomic hydrogen molecule.

Monatomic hydrogen can diffuse relatively easily into the metal lattice and embrittle the metallic matrix, subsequently causing cracking that can have catastrophic consequences for the integrity of the pressure containment envelope and result in leaks of the well fluids. The hydrogen molecule cannot diffuse into the metallic matrix to embrittle the metal.

The control and assessment of SSC is described in the International Standards Organisation (ISO) and National Association of Corrosion Engineers (NACE) standard ISO 15156 / MR 0175 – Petroleum and Natural Gas Industries – Materials for use in H2S – containing environments in oil and gas production, parts 1 – 3, henceforth referred to as ISO 15156.

One principal method of controlling SSC in low alloy carbon steels is to control the hardness of the base metal, weld, and heat affected zone (HAZ). It has been established over 45 years ago that carbon steels would not suffer SSC if the steel had a hardness less than 250 hardness Vickers (HV) or 22 hardness Rockwell scale C (HRC). Carbon steel can tolerate any partial pressure of H_2S if the steel hardness is sufficiently low and the corrosion rate can be tolerated within the corrosion allowance.

The hardness of a metal is measured and controlled during weld procedure qualification and steel plate production to assure the suitability of the parent material and the weld for service in sour conditions, and ISO 15156 specifies how the hardness should be measured as discussed below.

ISO 15156 specifies a number of configurations for the hardness survey, including for butt welds, fillet welds, weld repairs and weld overlay.

The principal ISO 15156 configurations are for a Vickers hardness survey and a Rockwell hardness survey of a butt weld. The Rockwell test is generally easier to perform but the Vickers test has the advantage of an optical system that enables magnification of the material's target area that allows the tester to pinpoint microelements on the surface for a more accurate and test.

It is important to note that the line of hardness test locations adjacent to the weld root, which is the region of the metal that faces the sour fluid, is 1.5 mm from the inside surface for Vickers hardness surveys and 3 mm for Rockwell hardness surveys. The tip of the root weld will be even further away from the line of the inside surface hardness survey.

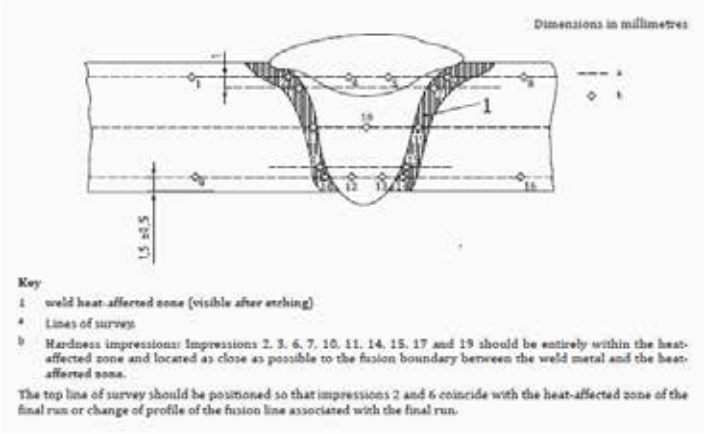


Figure 1: Butt weld survey method for Vickers Hardness measurements. From BS EN ISO 15156.

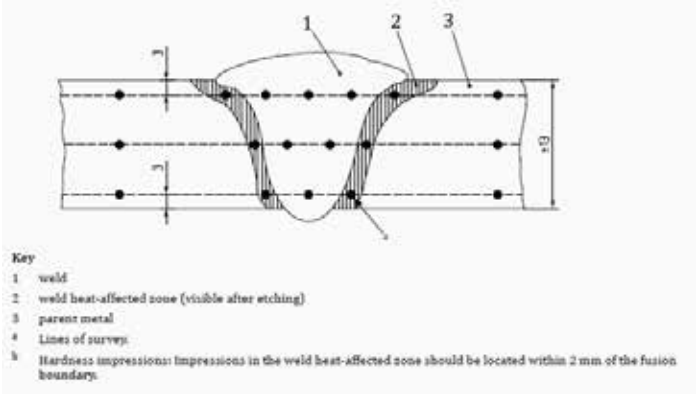


Figure 2: Butt weld survey method for Rockwell Hardness measurements. From BS EN ISO15156.

It is well known that when welding, the quenching action of the base metal and any root weld backing such as the copper backing shoes or other conductive metallic materials, may result in more rapid weld root cooling rates, resulting in higher hardness's in the vicinity of the tip of the weld root due to chilling effects.

In a recent sour service pipeline construction that suffered extensive SSC, hardness values of up to 350 HV were recorded at the tip of the weld root, despite passing the ISO 15156 weld procedure test hardness requirements and values of up to 290 HV on the inside surface of the parent pipe which also suffered SSC. It is clear that the hardness traverses specified in ISO 15516, are not adequate to detect all hardened zones in both weld roots and parent plate.

In another recent highly sour fabrication project, the specified weld hardness traversed significantly closer to the extreme tip of the weld root as shown below.

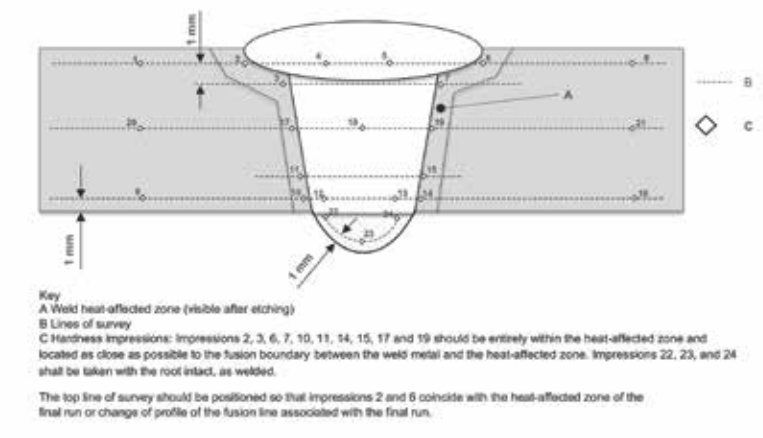


Figure 3: Hardness traverse to extreme tip of weld root.

The experience gained over several pipeline construction projects has identified the need to consider more carefully the purpose of sour service hardness testing and the need to obtain hardness test results more representative of the material hardness in contact with the often 'sour' environments of Oil and Gas operations.

Background Information

- Effect of backing plate material diffusivity on microstructure, B.S Kulkarni · 2018.
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- Complying with NACE hardness requirements, Online Bulletin 2022, R. Shaw and G. Mathers - TWI Ltd, Granta Park, Great Abington, Cambridge, CB21 6AL, UK.

John Boran

Editor : The figures used from BS EN 15156 are reproduced with permission of the BSI.

Sacrificial anodes in the future

The largest consumption of sacrificial anodes is in the protection of energy related structures in seawater.

• Anode Alloys

Zinc was the initial choice for marine protection systems and is now mainly related to shipping applications. Zinc alloys do not perform well at elevated temperatures, loss of driving potential and formation of adherent corrosion products, with some reports of high consumption rates, means that they are not considered at temperatures much above ambient. Zinc anode alloys have the advantage that their current capacity is unaffected by operating current density and are therefore well suited to applications where an anticorrosion coating is present.

Aluminium alloys, based on the addition of 5% of zinc and 0.15% tin give a desirable driving potential but only very low efficiency unless solution heat treated after casting, when better capacity is achieved. Aluminium with 5% zinc, 0.02% indium and 0.2% silicon, is the commonest in general use and has found application at higher temperatures, driving potentials hold up but at the cost of a significant proportion of current capacity. Aluminium anode alloys experience a reduction in current capacity at reduced operating current density, this being significant at very low current density such as may be found with well-coated pipelines.

There are unlikely to be any fundamental advances in anode alloys in the foreseeable future. The use of zinc in offshore applications has been limited by opposition from environmental lobbies leading to banning of their use, and the issue of anode performance at elevated temperatures still has to be resolved. Testing has shown that anode performance is significantly reduced at elevated temperatures, but virtually all that testing has been under isothermal conditions, with little testing under heat transfer conditions, which is much more likely to be the actual service situation.

Future offshore developments are venturing into environments more aggressive than plain seawater. The particular issues surrounding Lake Maracaibo are well documented, less well known are those of the Black Sea, where the seabed is at a great depth and covered with centuries of organic matter. The suitability of existing materials and engineering practices will need to be confirmed and if necessary, adapted to such applications. Seawater having limited access to oxygen replenishment is another design challenge.

• Production of anodes

Most anodes are produced by casting the alloy onto an insert (usually a steel pipe or frame which supports the anode material and facilitates its attachment to the structure to be protected) in a permanent mould usually made of steel. Care must be taken in the casting process to take account of expansion of moulds and inserts, and contraction of anodes. Anode alloys are formulated for their electrochemical properties rather than their structural ones and this has led to problems of cracking of the anode material particularly with aluminium anodes. It is unlikely that production techniques will change significantly.

• Application engineering

The shape of an anode will contribute markedly to its performance in a cathodic protection system.

Fixed production platforms have a life expectancy of 30+ years and are usually only provided with coatings in the tidal areas. Anodes for these applications are generally up to 30cm in section and up to 300cm in length with a trapezoidal or circular cross section. Inserts are now invariably a tube with ends bent to facilitate attachment some 30 cm from the surface to be protected. Inserts are made from steels with a composition compatible with welding direct to the structure or via a doubler plate. A typical production platform may stand in 200 metres or more of water and have 1000 tonnes of anodes providing protection for the life of the structure. Care must be taken in the design to allow for current drain to assorted attachments, including but not limited to, production risers, export pipelines and piling. Failure to make due allowance for such current drain may compromise the protection system life, or in extreme cases prevent protection being achieved at all.

Probably the most interesting application engineering challenge is with anodes for submarine pipelines. These traditionally are segmented or semi cylindrical (half shell) bracelets which are a tight fit to the pipe. A taper may be cast into the leading and trailing edges of the anodes for smaller diameter pipelines. Larger diameter pipes often have a reinforced concrete weight coating several centimetres thick over the anticorrosion coating, and in this case the bracelets are made to a corresponding thickness in order to minimise any 'step' in the surface profile causing impact as the pipe passes over the stinger or boom on the lay-barge during laying.

continues on page 24

Traditional engineering principles for the cathodic protection of pipelines are therefore a compromise between protection requirements and installation requirements. Future developments are likely to focus on the balance of this compromise in favour of the protection requirements ever recognising that the political, environmental and economic results of getting it wrong are usually disastrous.

• Current density for protection

In almost all cases the cathodic current density to initiate polarisation is substantially greater than that required to maintain it, exceptions being where there is a substantial water velocity past the structure or some other depolarising effect such as frequent storms. Protection system specifications are now recognising this and require an initial polarising current density and (much) lower maintenance current density. This will generate considerable rewards and impact substantially on design philosophy in the future. The selective use of coatings on parts of a fixed structure can lead to reduced anode requirements and greatly assist with the initial polarisation current issue. Any reduction in float-out weight can yield significant cost savings and will be relentlessly pursued although the risks make such progress slow.

The design of protection systems for coated structures requires an estimate of the levels of coating break down over the life of the structure to be made. The CP system is then designed to cater for this. In the future this combination of coatings and cathodic protection will merit increased attention, as even a low-grade coating with a relatively short life would address the initial polarisation current.

Offshore pipelines unlike platforms are almost invariably provided with a very heavy-duty anticorrosion coating, and reinforced concrete weight coatings on top are common. Pipeline coating breakdown levels used in CP design are typically 2.5% over the design life of the line or less. The future may well include superior anticorrosion coatings to those used at present. Cathodic protection designs could therefore have fewer unit anode installations, however distribution of protection along the length of the line will be a serious consideration, and anodes may be installed only at the ends of relatively short lines, or even fewer anodes added after the line has been laid in the case of longer lines.

• Quality control and quality assurance

The importance of effective QC & QA cannot be overstressed. Anode producers use instrumented analytical techniques such as infrared spectrophotometry, spark emission spectroscopy, atomic absorption spectroscopy, and plasma emission spectroscopy, to control alloy chemistry. When undertaken by properly trained technicians with access to traceable standards these methods provide rapid and reliable compositional data.

The use of steels with appropriate certification and welding to coded practices can give suitable assurance in respect of inserts.

The use of electrochemical testing as a quality control procedure has become mandatory on alloys, and a whole industry has grown up around such testing both by producing foundries and independent test houses. The testing procedures now used involve small samples of anode alloy often prepared in such a manner as to remove the entire 'as cast' surface. Great store is placed on the absolute values of current capacity per unit weight obtained.

In more than 40 years of practice in the use and manufacture of aluminium alloy sacrificial anodes, the author has never heard of a report of the failure of an anode whose chemical composition was within specified tolerance, to operate as expected. Thousands of electrochemical tests have been undertaken at great expense for no benefit whatsoever. It is to be hoped that the future will see realism and this waste of effort and resource consigned to history.

• System design

The calculation of the weight of anode alloy required to protect a structure is given by a simple calculation using area to be protected, current density, required life, and anode capacity. It is a brave designer that claims to know the true surface area of the structure. Dimensional tolerances of rolled sections of the sizes from which offshore structures are made are known quite accurately but it is surprising what bits get left out of the calculation let alone any correction for surface irregularity. Maintenance current density is variously quoted at figures between 0.140 A/m^2 and 0.040 A/m^2 for the same location, a factor of almost 4 times.

Anode current capacities for Al-Zn-In alloys are variously quoted between 2550 Ahrs/kg and 2750 Ahrs/kg. In general, the lower figure is on the basis of long term field tests, and the higher figure is on the basis of those short term lab tests mentioned previously.

Future design of sacrificial anode systems should focus on true surface areas and the current density required to polarise them, rather than squeezing the last drop of performance out of the anode alloy, and then justifying it with spurious testing.

Dr Bob Crundwell

APPLICATION OF HSG65 TO A LARGE CORROSION MANAGEMENT PLAN

Andrew Duncan, Lead Consultant, and Leo Richards, Principal Engineer, Intertek P&IA.

This article demonstrates how the application of an over-arching health and safety management approach to corrosion and degradation risk assessment, and mitigation, can be applied effectively to identify gaps and achieve improvements in the maintenance and integrity management of large oil and gas production facilities.

Introduction and background

The authors were engaged by an onshore hydrocarbon production company to perform a detailed study of their corrosion monitoring, corrosion mitigation, and production chemistry systems, and to identify improvements to ensure world class asset integrity management performance. The work is used here as a case study of the effectiveness of using the **Plan – Do – Check – Act** approach to assess asset integrity management systems and to deliver the resultant messages directly and clearly to middle and senior management to enable them to take suitable action.

The UK's ***Management of Health and Safety at Work Regulations*** 1999 (MHSWR), requires:

- **Regulation 3, Risk Assessment:** *Every employer shall make a suitable and sufficient assessment of:*
  - *(a) the risks to the health and safety of his employees to which they are exposed whilst at work, and*
  - *(b) the risks to the health and safety of persons not in his employment arising out of or in connection with the conduct by him of his undertaking.*
- **Regulation 4, Principles of Prevention to be Applied:** *Where an employer implements any preventative and protective measures he shall do so on the basis of the principles specified in Schedule 1 to these Regulations.*
- **Regulation 5, Health and Safety Arrangements:** *Every employer shall make and give effect to such arrangements as are appropriate, having regard to the nature of his activities and the size of his undertaking, for the effective planning, organisation, control, monitoring and review of the preventative and protective measures.*

Arising from the requirements of Regulation 5 of MHSWR, the UK's Health and Safety Executive (HSE) developed guidance entitled *Managing for health and safety, HSG65* (third edition, revised 2013) [1], which describes the **Plan – Do – Check – Act** approach to achieving a balance between the systems and behavioural aspects of health and safety management. HSG65 identifies health and safety management as an integral part of overall good management practice. ISO 9001 (2015) Section 0.3.2 describes the **Plan – Do – Check – Act** cycle and states *"The PDCA cycle can be applied to all processes and to the quality management system as a whole."*

HSG65 is pictorially represented as a planetary model (Figure 1).

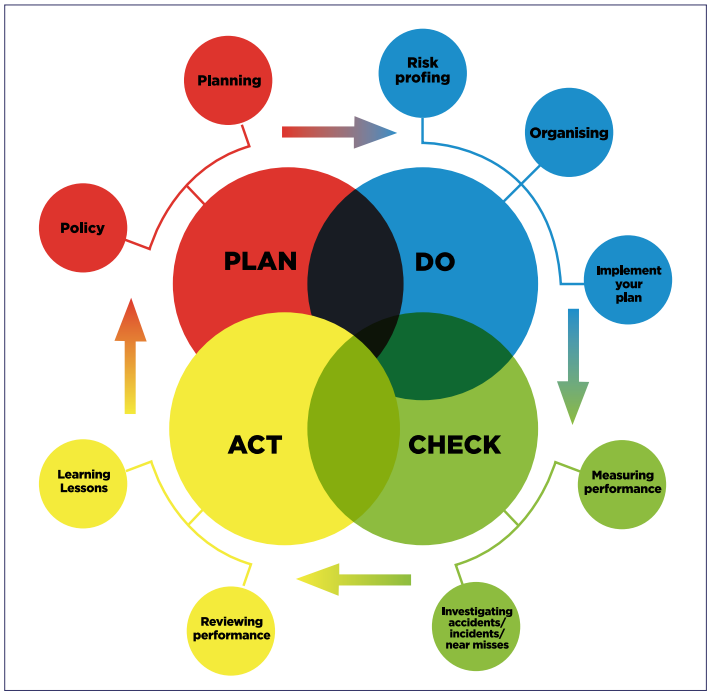

Figure 1 HSG65 Plan – Do – Check – Act

In March 2019 the Energy Institute (EI) [2] published the 383-page, second edition of Guidance for corrosion management in oil and gas production and processing [3], in which the opening sentence of the foreword states:

"Corrosion is first and foremost a safety risk which has to be understood and managed. Once the safety risks associated with corrosion are managed control of the associated economic risks will generally follow".

This statement recognises corrosion as a threat to the health and safety of persons who may come into contact with oil and gas production and processing systems, and which must be managed accordingly; hence, the second revision was updated to align with the latest revision of HSG65, as discussed above.

In the context of the Energy Institute's Guidance, Plan – Do – Check – Act involves:

- **PLAN** – requires operators to consider the corrosion and degradation integrity status of the asset, future aims of corrosion management and how to achieve those aims, responsibilities, KPIs, and legal framework.

- **DO** – requires consideration of the corrosion and degradation risk profile, the organisation and implementation of the plan.
- **CHECK** – measurement of corrosion management performance, corrosion management audits, investigate causes of degradation to learn from incidents.
- **ACT** – review the performance of the corrosion management strategy, learn from the review, and revise and optimise plans as required.

Regulation 5 of MHSWR, and also the EI Guidance, require roles and responsibilities to be identified, to this end in this onshore study we addressed the Organisation using the **RACI Matrix Model**, which identified that improvements could be achieved within the organisation to progress information transfer and speed of responses to integrity findings, where RACI is:

- Responsible
- Accountable
- Consulted
- Informed

An overview example of a RACI matrix is contained in Table 1, and an example of a RACI matrix for intrusive corrosion monitoring (ICM) is given in Table 2:

DESIGNATION	ROLE
Responsible	Person who actually does the action, collects the corrosion measurements, conducts analyses, updates the system.
Accountable	Person whose job it is to ensure the task is completed.
Consulted	Person(s) who can provide input to the task; Technical Specialists, Technicians, Consultants.
Informed	Person who has an overview and checks with the accountable person the task is completed.

Table 1 Overview of a RACI Matrix

ACTIVITY	RESPONSIBLE	ACCOUNTABLE	CONSULTED	INFORMED
Selecting ICM devices	Corrosion Engineer	Head of Corrosion Dept	Optimisation Dept	Asset Management
Selecting locations for ICMs	Corrosion Engineer	Head of Corrosion Dept	Optimisation Dept	Asset Management
Planning and arranging retrievals	Corrosion Engineer	Head of Corrosion Dept	Optimisation Dept	Asset Management
ICM measurements, data recording, reporting	Corrosion Engineer	Head of Corrosion Dept	Optimisation Dept	Asset Management
Acting on ICM findings (e.g. corrosion inhibition, biocide, dehydration, etc)	Head of Corrosion Dept	Optimisation Dept	Asset Management	Corrosion Engineer
Reporting actions taken on ICM findings	Optimisation Dept	Asset Management	Head of Corrosion Dept	Corrosion Engineer

Table 2 Example RACI Matrix.

The example job titles given in the Table 2 are indicative, and likely to be unique to a company and its organisation.

We applied HSG65 to this onshore asset integrity management study in line with Figure 2:

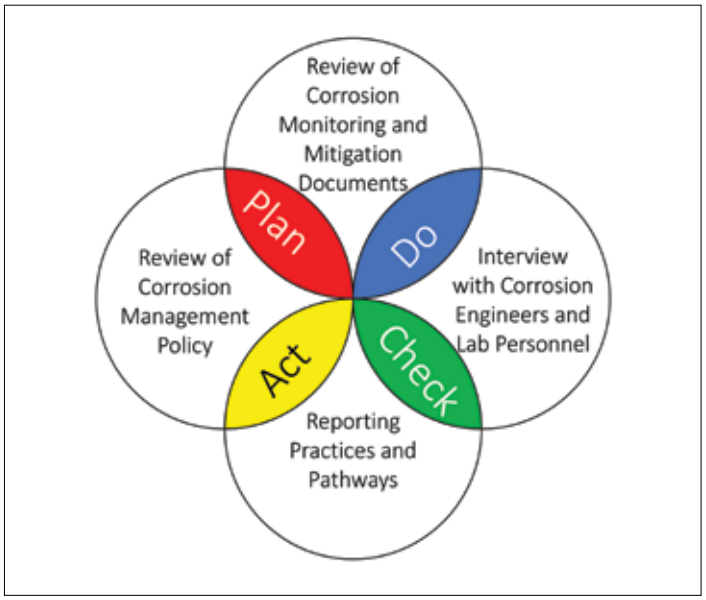

Figure 2 The Study Approach

Annex L of the EI Guidance contains a *Checklist For Assessment Of Corrosion Management In Oil And Gas Production And Processing Facilities*, which provides guidance on undertaking a review of Corrosion Management Plans (CMP); hence, when we were instructed to perform a review of the CMP of a major hydrocarbon production system, the EI Guidance was used as the basis for the study.

Review of the corrosion management plan

This study comprised both a desktop study of the operator's systems/plans in place to manage both internal and external corrosion and degradation, as well as production chemistry, and corrosion mitigation. Extensive site visits were made to the facilities to put the documentation review into context with reality, and enable meetings with field and office personnel.

The purpose of the review was to identify improvements required to the asset's CMPs to ensure alignment with the best of international operators' corrosion and degradation plans.

The EI Guidance contains a section on Human Factors (HF), which recognises that people are responsible for the design and implementation of CMPs, and wherever people are involved the possibility of errors exists; hence, at a basic level the influence of HF was considered in this study. The HSE has stated: *"Human factors refer to environmental, organisation and job factors, and human and individual characteristics, which influence behaviour at work in a way which can affect health and safety"* [4].

Whilst a study on the effectiveness of a CMP requires significant explanatory detail on the findings, and justification for recommendations for change, it also should recognise that senior management do not necessarily have the time to review, distil, and act upon recommendations made in lengthy documents. To this end, the findings of this study were supplemented with a traffic light system (Table 3):

	In our opinion needs significant improvements to achieve international levels of excellence.
	In our opinion needs some improvements to achieve international levels of excellence.
	In our opinion equivalent to international levels of excellence.

Table 3 Traffic Light System.

continues on page 28

This study was extensive, assessing the efficacy of corrosion monitoring and mitigation (Table 4).

CORROSION MONITORING METHODS	CORROSION MITIGATION METHODS
Intrusive corrosion monitoring	Corrosion inhibitors: continuous and batch
Deposit analysis	Scale inhibitors
Scaling tendency	Biocides
Microbiological assessment	Impressed current cathodic protection – pipelines
Cooling water quality assessments	Sacrificial – tank internals and road crossings
Glycol quality	Cooling water chemical treatments
External & internal coatings assessments	Coatings: external & internal
Thermal insulation inspections	Defined life repairs
Review operator laboratory procedures, documentation, reporting	

Table 4 Topics Included in the study.

The study also identified the personnel responsible for managing internal and external corrosion and degradation to be well organised, competent, and motivated, as were the supporting laboratory staff. Competence is defined as:

Qualified + Trained + Experienced.

However, the absence of key supporting software systems were hampering the ability of the staff to carry out their roles efficiently, requiring the use of some 3000 spreadsheets to contain all aspects of corrosion and production chemistry monitoring data, with the potential to contain several million data cells. This inevitably resulted in some human factor failures, although it must be said the number of errors was small considering the complexity of the data being monitored, which is an indication of the competency and motivation of the personnel involved.

The overall traffic lights for the corrosion monitoring system reflects the high competency of the staff, but also takes into account there wasn't a suitable Corrosion Threats Assessment or Risk Based Inspection programme in place, and insufficient software support systems for the integrity staff (Table 5):

PLAN – DO – CHECK - ACT	INDIVIDUAL TRAFFIC LIGHTS	OVERALL TRAFFIC LIGHT
PLAN	Policy	
	Planning	
DO	Risk profiling	
	Organising	
	Implementing the plan	
CHECK	Measuring performance	
	Investigating accidents & incidents	
ACT	Reviewing performance	
	Learning lessons	

Table 5 Plan – Do – Check - Act Traffic Lights for Corrosion Monitoring.

In common with numerous other Operators, the **Plan** and **Do** sections were carried out fairly well; however, **Check** and **Act** needed improving to benchmark against international approaches. By not effectively closing the Plan – Do – Check – Act planetary loop it is difficult to achieve continuous improvements in safety and asset integrity management, and in ageing assets may contribute to lack of understanding of future integrity management requirements including funding and staffing.

When the overall traffic lights were collated for corrosion monitoring activities, it became evident there was a common theme across the corrosion management and asset integrity area, which was that **Plan** and **Do** were either equivalent to international levels of excellence or needed some improvement, whereas **Check** and **Act** needed significant improvements in order to become equivalent to international levels of excellence (Table 6). The findings made it evident that if the preceding part of the planetary model is not implemented it almost guarantees that the following stages will prove deficient. In this case it was impossible for the operator to **Act** and improve the plan, due to there being no **Check** process in place to understand what has occurred.

TOPIC	PLAN	DO	CHECK	ACT
Intrusive corrosion monitoring				
Scale deposit assessments				
Scaling tendency				
Microbiological assessments				
Cooling water quality				
Glycol quality				
Residual corrosion inhibitor concentration				
Deposit / debris corrosion product assessments				
External & internal protective coatings assessments				
Thermal insulation inspections				

Table 6 Overview of corrosion monitoring traffic lights vs HSG65.

When the overall corrosion mitigation programme was reviewed in accordance with HSG65 and traffic lights applied, a more complicated view appeared requiring a range of significant improvements to be made (Table 7):

TOPIC	PLAN	DO	CHECK	ACT
Continuous Corrosion Inhibitor Injection				
Batch Corrosion Inhibitors Gas Pipelines				
Scale Inhibitor Injection for Production & Produced Water				
Biocide Shock Dosing				
Impressed Current Cathodic Protection (ICCP)				
SACP – Road Crossings				
Sacrificial Anodes – Tanks				
Chemical Treatment Cooling Waters				
External & Internal Coatings Specifications Equipment & Structures				
Temporary Repairs (Defined Life)				

Table 7 Overview of corrosion mitigation traffic lights vs HSG65.

The findings of this corrosion mitigation review demonstrated situations where there was comprehensively good application of a Plan – Do – Check - Act type approach, as with the Batch Corrosion Inhibitor mitigation, but also situations where there was a failure to apply any aspect of Plan – Do – Check - Act, such as scale inhibition, biocide application and temporary repairs (defined life repairs).

A key finding of both the well delivered mitigation actions and the poorly delivered mitigation actions was the initial technical understanding of what, and importantly how, the mitigations were aiming to achieve corrosion control. In the case of the batch corrosion inhibitor application there had been technical consultancy with regards to the mitigation, with both internal corrosion experts and external vendors. However, for the scale inhibition, biocide application and temporary repairs aspects of corrosion and integrity management there had been no external discussion. These differences highlighted the requirement for the application of RACI matrices with regards roles involved with the deployment of these corrosion mitigations, which would otherwise have resulted in more focused and properly executed processes.

Conclusions

This study demonstrates that HSG65 can be used to successfully assess the effectiveness of a large and complex corrosion management system. When the HSG65 approach is used in conjunction with Energy Institute guidance on corrosion management, RACI matrices and a traffic light system, it becomes a very effective system to analyse any corrosion management system, identify gaps and weaknesses, and identify the necessary improvements, which will result in more effective corrosion management, and, most importantly, improved asset safety.

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What makes a good consultant?

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As more and more large companies reduce their technical staff, they are looking to consultants to provide advice and other services for specific projects. This article is a personal reflection of one consultant in the marine industry, as to what is needed from these consultants. Based on the authors 30+ years in the consulting business, this article offers some guidance to the next generation.

"My biggest strength as a consultant is to be ignorant and ask a few questions" – Peter Drucker.

There is a well-worn adage that a consultant is someone who borrows your watch to tell you the time. My view is that if you own a watch and you cannot tell the time yourself, then there are bigger issues at stake.

I got my Doctorate researching quality and accuracy techniques in ship production in 1991 and learnt my very first lesson about being a consultant. No one likes a smart Alec!

The second lesson I learnt as a consultant was that if you cannot breakdown a complex problem (coating related or otherwise) into simple steps that your client can understand (who may know nothing about the discipline), then YOU have failed to communicate the key issues to the client well enough. It is time to revisit the issue to ensure you really have understood them.

No one person can be a master or all aspects of corrosion and coatings, and hence the immediate need is to create a team, network, or work with other consultants with complimentary skills, so that you do not have to stray outside your scope of expertise.

Those who want to do everything will never do anything! – Andre Maurois.

I recall being challenged by one of the big 5 management consulting firms with whom I was working as a sector specialist to explain my skill set in one sentence. I failed (but thankfully got the job). It did however force me to consider what it was I was good at and determine that my skill set was looking at how to integrate the coating process into the whole life cycle of an asset from design, though construction and operation, to end of life.

In simple terms I asked myself what does a client want when they buy paint? The short answer is simply "predictability". They want to apply the system, and have it perform as expected. As a result, I became obsessed with functionality of coatings (what they could or could not do, rather than the chemistry – how they did it). That is not to say that you can ignore the chemistry and I was fortunate at my company to work with some of the very best paint chemists about.

Arguably people can become consultants by 3 routes:

- They can have a basic academic qualification and then develop their knowledge over many years (the experience route). There is one thing to be wary of from this approach, that is there are people who end up with 20 years of experience and those who end up with one year's experience twenty times. In the late 1970's this was the sort of person who was usually called in as an expert.

"Good judgement depends mostly on experience and experience usually comes from bad judgement" – Fred Rose.

- They can be academically qualified and so can impress with their theoretical knowledge but do not understand enough of the practical issues to understand that theory may not stand up to the realities of the job at hand and the associated budgetary and time constraints. An example of that would be someone undertaking an analysis of a coating failure without knowing how to formulate a coating and therefore how the various components may interact. By the early 1980's many experts were academically qualified but had little in field experience.

"Everyone has a plan until they get punched in the face" – Mike Tyson.

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- The ideal is to have a mix of suitable field experience and be able to back it up with sound theoretical knowledge and stick to your defined scope of work/skill set, and have the desire to deepen and broaden your knowledge. These seem to be the people who have become successful experts.

"Those who have stopped learning find themselves equipped for a world that no longer exists" – Eric Hoffer.

It does not matter which comes first the practical skills or experience. I lean towards the experience first as it tends to inform your view of much of the theory that you are then taught and allows you to place it into context.

Finally, you must accept that not everyone despite experience and education is suited to the role of consulting.

The key factors in delivering effective consulting are Honesty and Integrity. As a consultant you have a grave responsibility to provide your client with timely, independent, and relevant advice (as outlined in my company's mission statement). Of course, you must be able to make a living from it.

Considering these each of these in turn.

Honesty is critical to gaining the client's trust. Not only must you be able to recommend a course of action, but you should recommend the best course of action, even if that means upsetting the client and/or earning less fees. In the longer term this pays off. The worst thing that can happen is a client works out that you have not been honest with them or worse, when you are in a witness box defending a clients claim.

"Honesty is the first chapter in the book of wisdom" – Thomas Jefferson.

Integrity. Honesty is one thing, but integrity means that you must stick to your principles. Whatever pressures the client, your boss, or lawyers, may place upon you. If the issue is a technical one you must determine what is the correct technical solution, and not be dissuaded by anyone or the potential to gain more income by "being flexible" in your determination of the issue.

"The supreme quality for leadership is unquestionably integrity. Without it, no real success is possible, no matter whether it is on a section gang, a football field, in the army or in an office "– Dwight D Eisenhower.

Experience has shown that honesty and integrity pay considerable dividends in the long run. While that might not solve any short-term cash flow problems for a budding or small consultancy, their importance to the longer-term success of a business cannot be overstated.

Timeliness of advice. While the nature of inspection work can be quite predictable because inspection generally implies a repetitive activity, consulting work tends to be lumpy or less predictable. It usually also implies fine time margins because the clients are probably already well into the development of a project before they start to even consider any issues of coating the structure that is to be built. Or more likely the coating failure has occurred, and revenue is being lost from the asset(s).

"Timelines is best in all matters" - Hesiod.

It is very tempting to bid for work even though the time frame may be fine. However, experience has shown that failure to deliver on time, and to the required quality can have a considerable harmful long-term effect on the business and its ability to retain repeat clients. As a result, a consultant is often required to work long hours to meet those deadlines often under considerable pressure from both client and their managers, so it is very important that a project is sufficiently well resourced and planned out.

Independent (impartial) advice is key. Commercial work often places considerable temptations to earn increased revenue by aligning with one or two clients (even when they may be wrong) at the expense of demonstrating real independence to the marketplace. If any conclusion reached is based on sound technical analysis, then it should not matter who is paying the fees, the conclusion would be the same. Some clients may not like that approach, but in the long term it develops credibility in the marketplace.

"Man is always partial and is quite right to be. Even impartiality is partial" – George Christoph Lichtenberg.

Relevant advice is also important. Providing an overview of the key issues and their magnitude is critical and often requires a multi-disciplinary approach. Relying on your own scope of skills often means that some aspects of the any problem are overlooked, which may prove to be critical to the final solution.

"Great leaders are almost always great simplifiers, who can cut through the argument, debate and doubt, to offer a solution everybody can understand"- Colin Powell.

Finally, a consultant is only as good as the systems that support them in doing their work. It is often surprising to see how little effort is made to develop a suitable proposal to define the required scope of work and deliverables together with resource and time estimates. It is often also surprising as to how poor the reports produced are for clients, in terms of the ease of understanding and their utility to the client. They always seem to be packed with photographs but short on words. As a guide a consultant should address the following key questions [1] when bidding or carrying out an assignment:

- Can I do it OK? Have you properly understood the problem, defined the scope, and properly planned and costed the proposal? This is the process required to determine if you should consider taking on a project.
- Am I doing it OK? During the project progress are you monitoring the quality, time, and output of the project on a regular basis (depends on the length of the assignment of course).
- Have I done it OK? This is the post work analysis and client feedback (good or bad) that informs you on the performance of your systems and approach.
- Could I do it better and if so, how? Just as any report issues encourages clients to learn from their mistakes and put in place systems to prevent the same thing happening again, so must the consultant review their own work and systems to see how they can be improved. Above all you should be passionate about what you do and enjoy it

"The fool who loves giving advice on our garden never tends his own plants" – Paulo Coehlo.

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Fit for purpose of in-service aged Passive Fire Protection

Chris Fyfe, FICorr, SCci.

Passive Fire Protection (PFP) is specified with the aim of mitigating or reducing the impact that a fire event may cause. PFP can be described as a coating that insulates critical structure components and equipment so as to reduce the rate of temperature rise to maintain structural and integrity stability.

Structural stability allows time for facility venting (blow-down), abandonment, or to slow the rate of fire escalation to allow mobilising of emergency services. However, PFP does not mitigate inventory release or subsequent inventory ignition.

There are no National or International standards for assessing the fire performance of "in-service aged" PFP systems. However, there are guidance publications that may be used as supportive information when assessing in-service PFP systems. The interpretation of these documents should remain the responsibility of an engineer with a demonstrable background in asset Integrity and an understanding of the application and inspection of Passive Fire Protection systems.

The following list is not exhaustive but rather a "snapshot" of literature available to support an assessment of these in-service funtional coatings.

a) NACE Standard RP0198-2004 (Item No 21084): The Control of Corrosion Under Thermal Insulation and Fireproofing Materials A System Approach.

b) HSE Offshore Information Sheet No 12/2007: Advice on acceptance criteria for damaged Passive Fire Protection (PFP) Coatings.

c) MMI joint industry goup report, MMU013-P2-R-01: Acceptance Criteria for Damaged Passive Fire Protection Coatings.

d) The Institution of Chemical Engineers: Fire resistance of passive fire protection coatings after long-term weathering.

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Although this article aims to give an understanding of the type of defects and anomalies encountered in ageing oil & gas facilities within the UK, it is still important to understand the type of fire hazard, and potential escalation the PFP has been installed to mitigate against. This information is typically found, for upstream operations, within the facility safety case and down-stream in the facilities COMHH case.

The article will look at defects and anomalies associated with cementitious portland cement and epoxy intumescent PFP systems, it defines an anomaly as something that has degraded to an extent that may not function when required, and a defect as something that requires corrective maintenance or will continue to degrade.

Lightweight vermiculite portland cement (cementitious) systems

Lightweight cementitious PFP systems have been widely specified for both upstream and downstream oil and gas industry facilities, and offer a good level of pre-fire durability and fire protection. However, in many cases, due to a poor understanding of the maintenance requirements, these vermiculite portland cement systems have seen a decline in upstream use.

It could be argued that this poor understanding of the maintenance requirements has resulted in a continual deferral of the remedial work, leading to a continual degrading of the system, and in many cases to a point where a full replacement is required. After all, it can be said, it's easier to maintain a regularly maintained coating than one which has been left to deteriorate.

These cementitious PFP systems were originally specified as a relatively cheap material that satisfied some of the most onerous fire scenarios. It was further believed that due to the alkalinity of the system that the substrate would be pacified offering good anti-corrosion protection, however, what was not understood was the need for the systems to be maintained. This lack of maintenance knowledge resulted in a continually degrading system which allowed for moisture penetration resulting in carbonation of the free lime in the portland cement that reduced the alkalinity. This reduced alkalinity subsequently made a more favourable environment for corrosion to take place.

Having said this, lightweight cementitious systems are still of value as a PFP system, and are still widely specified due to being a cost-effective solution for downstream projects. Downstream projects generally use lighter grade construction materials, such as smaller steel section profile sizes. These small profile sizes (or HP/A values) can drive up the film thickness of some PFP systems such as epoxies. In addition, in maintenance situations, it is sometimes more practical to repair like for like rather than look for design deviations. The original design of PFP systems specified would have been accepted/approved by a certifying authority such as Lloyds or DNV . This acceptance would be based on pre- fire and fire test certification and a number of other considerations. Therefore, should a repair be made to the original, let's say cementitious PFP system, using an epoxy PFP material, the original design acceptance has now been changed. Therefore, a design deviation should be sought as part of a management of change process (MOC).

Additionally, in an ageing infrastructure where the facility has a known end of life, a cementitious system repaired like-for-like will be the most cost-effective solution, and may offer sufficient durability for the reamining assest or conponent life.

There are numerous reports and situations of corrosion under fire protection (CUF) attributed to cementitious systems, however, it needs to be taken into consideration that in the early years of oil & gas production, these cementitious systems were widely specified. It should also be considered that it's possible that a high volume of reported CUF issues are attributed to ageing infrastructure, and in many cases, to those assets still operating well beyond their original design life. Therefore, given the poor understanding of the maintenance requirements, combined with the volume of cementitious systems in service, this may have contributed to the perception that the system is susceptible to CUF.

It's not suggested that cementitious systems should be specified over new more environmentally suited systems but only that these original systems, in many cases, offered a good level of PFP and pre-fire durability over and beyond the facilities original design life.

Examples of defects and anomalies (the severity description is in the spirit of the HSE 12/2007 document of assessing in-service PFP systems).

- Priority 1 Anomaly (see paragraph 4) WILL NOT PERFORM IN A FIRE EVENT.

The PFP has deteriorated (missing, omitted) and will not perform as intended. Will cause gross failure of PFP, when subjected to a fire threat leading to a significant element of the protected component becoming exposed to the fire.

Catastrophic failure: A compromised reinforcement system, corrosion swelling (CUFP), expansion and contraction of steelwork, vibration or movement, general degradation due to lack of maintenance, or failed achorage and disbonded from substate.

- Priority 2 Anomaly (see paragraph 4) WILL NOT PERFORM IN A FIRE EVENT.

Degraded PFP possibly from erosion due to prevailing winds, equipment service consideration, hot surfaces, moisture run-off, lack of maintenance or poor application.

- Priority 1 Defect (see paragraph 4) the defect, if not maintained will develop into an Anomaly.

Minor damage will worsen if not repaired but does not immediately reduce the fire resistance performance. It will lead to further deterioration if not corrected.

The PFP is exhibiting various levels of degradation, failing top-coat, silicon mastic failing/missing, erosion/flaking of the outer PFP surface. Impact damage, weather cycling whichwill accelerate the degradation mechanisms and the systems will progressively worsen.

Thick Film epoxy Passive Fire Protection

Thick film epoxy PFP systems are widely specified for both upstream and downstream projects and can arguably be considered maintenance-free. However, epoxy PFP systems are not void of problems and can be susceptible to a number of degradation mechanisms. However, these degradation mechanisms are normally the result of external factors.

Typical issues associated with epoxy PFP are mainly the result of mechanical modification where the impact of maintenance activities causes a weakening of the bond strength of the adhering systems causing a bond fracture at the PFP primer steel interface. Once the bond strength has been compromised delamination can propagate.

Epoxy PFP can be susceptible to cracking however, maintenance cracks differ from cracks associated with the fabrication stage and should not be confused. Maintenance cracks are typically found near high heat locations where radiant or conductive heat raises the substrate temperature above the recommended operating temperature of the material which results in small fissures developing which propagate overtime.

Other problematic areas can be attributed to water-uptake of the epoxy PFP. Epoxy resins are formulated to be off-ratio, this gives a degree of flexibility to the material allowing the system to move. However, the more flexible the material, the higher potential for water uptake. There are issues with moisture or water in the system, unlike a cementitious system where moisture can improve fire performance.

(note: cementitious PFP works twofold, as a barrier, and by the release of moisture. The barrier properties physically block heat from reaching the area being protected. Moisture or vapour release act as a cooling agent on the outer surface).

Most if not all epoxy PFP systems have water-soluble pigments, therefore, any moisture /water movement may allow these pigments to leach from the system resulting in a reduced functional ability i.e. reduced fire performance . The PFP type(s) of curing agents can also contribute to a more susceptible system to water uptake. These water uptake issues can be managed by way of applying topcoat paint systems, however, should a PFP system be known to be susceptible to high water uptake then maintaining the topcoat adds to the maintenance burden.

Examples of defects and anomalies (severity description as before)

- Priority 1 Anomaly (see paragraph 4) WILL NOT PERFORM IN A FIRE EVENT.

The PFP has deteriorated (missing, omitted) and will not perform as intended. Will cause gross failure of PFP, when subjected to a fire threat leading to a significant element of the protected component becoming exposed to the fire.

Catastrophic failure, lack or incorrect reinforcement system, general degradation due to lack of maintenance applicator malpractice, high water uptake impact damage.

- Priority 1 Defect (see paragraph 4) the defect, if not maintained will develop into an Anomaly.

Minor damage will worsen if not repaired but does not immediately reduce the fire resistance performance. It will lead to further deterioration if not corrected.

The PFP is exhibiting various levels of degradation, failing top-coat, Silicon mastic failing/missing, erosion/flaking of the outer PFP surface. Impact damage, weather cycling will accelerate the degradation mechanisms and the systems will progressively worsen.

Further considerations during PFP in service assessemnt

1. Is an Operational Risk Assessment (ORA) required?
2. Technical safety review of the Safety Case for offshore and COMAH regulations for onshore.
3. Review the need for PFP e.g. reinstate or remove.MOC
4. Repair in accordance with the manufacturer's repair instructions or design devations?

Thin Film epoxy fire protection

Although this article mainly deals with the maintenance of hydrocarbon PFP systems, for completeness, the use of thin film epoxy PFP systems are described briefly. These are designed for use in the non-hydrocarbon industry, such as in commercial buildings, stadiums, airports, hospitals etc, with the fire being described as cellulosic e.g paper/wood and furnishings etc.Whereas the over application of a hydrocarbon PFP coating (thickness) is not detrimental to fire performance,over applicartion of a cellulosic PFP system can result in a reduced level of protection.

With hydrocarbon PFP systems, the formation of char is a fire event is robust and able to support itself, in cellulosic PFP, the formation of char is a fire event is fine, like cigarette ash and can not support itself. Therefore, if over applied may fail (drop off), reducing the level of protection. Another issue with the long term use of cellulosic PFP can be, in addition to the thicknesses, the application of decorative topcoats. A cellulosic fire is less onerous than a hydrocarbon fire, therefore, type and thickness can be restrictive to the char formation of a thin film system during a fire.

Recommendations from Inspections of thin film systems

1. Primer: Does the PFP system require a pre-approved primer?
2. Will active pigments settle to the bottom of the can during storage?
3. Can the PFP be thinned with solvents to help with application?
4. Have the filters been removemend from the spray equipment [filters can remove active pigments from the coating)?
5. What is the maximum thickness before fire performance becomes compromised?
6. How long before application of a top coat, to allow for solvent release?
7. What type and thickness of topcoats can be used?
8. Enviromental consideration, during application and in service?

Conclusions

Given the complexity of fabric maintenance and specifically in-service PFP, "fit for service" verification engineers should be seen as individuals who can demonstrate an in-depth knowledge of PFP application processes and procedures. They should have expert knowledge of degradation mechanisms and understand the potential impact a PFP anomaly or defect may have on long term service, and more importantly, fire performance. They should be proficient in reporting and offer guidance on coating degradation rates allowing for effective repair scheduling.

It should also be understood that a PFP Inspection qualification dIffers to that of a PFP in- service verifcation engineer, in that, a coating (PFP) inspector is typically a progressive activity at the original application stage and should not be seen as a standalone qualification suitable to offer guidance for verification of fit for service of PFP sstems.

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DYER & BUTLER LTD
Tel: 02380 742222 www.dyerandbutler.co.uk

F A CLOVER & SON LTD
Tel: 020 89486321 Email: ian@cloverpainting.com

FIRESAFE SERVICES (NE) LIMITED
Tel: 01670 351666 Email: info@firesafelimited.com

FORWARD PROTECTIVE COATINGS LTD
Tel: 01623 748323 Email Pete@forwardpc.co.uk
www.forwardpc.co.uk

FOUNTAINS (PART OF THE OCS GROUP)
Tel: 07876 556197
Email: Donovan.gosher@fountainsgroup.co.uk

HANKINSON PAINTING GROUP
Tel: 0870 7892020
Email: Stephen.hankinson@hankinson.co.uk

HDM TUBES LTD
Tel: 07710080845 www.hdmtubes.co.uk

HERRINGTON INDUSTRIAL SERVICES LTD
Tel: 0191 516 0634 www.herringtonltd.co.uk

HRS RAIL LTD
Tel: 01797 329421 www.hrsrail.co.uk

JACK TIGHE LTD
Tel: 01652 640003 Email: sales@jacktighe.com

JPV (PAINTERS) LTD
Tel: 01277 201515 Email: enquiries @jpvpainters.co.uk

KUE GROUP LIMITED
Tel: +44 (0)1274 721188 www.kuegroup.com

NUSTEEL STRUCTURES
Email: scott.arnold@nusteelstructures.com
www.nusteelstructures.com

OAG INTERNATIONAL UK LTD
Tel: +44 (0) 151 318 6999 www.oag-group.com

ORRMAC COATINGS LTD
Tel: 0114 2461237 www.orrmac.co.uk

PAINTEL LIMITED
Tel: 01752 719701 www.paintel.co.uk

PIPERCREST LTD T/A HALLS SPECIALISED SERVICES
Tel: 01375 361408 www.hallsspecialisedservices.co.uk

Q A COATINGS LTD
Tel: 01752 813260 www.qacoatings.co.uk

RailX UK LTD
Tel: 07961764943 www.railxuk.com

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

SCA GROUP LIMITED
Tel: 01202 820820 www.sca-group.com

SOLENT PROTECTIVE COATINGS LTD
Tel: 02380221480 Email: info@solentpc.co.uk
www.solentpc.co.uk

SPECIALIST PAINTING GROUP LTD
Tel: 01733 309500 www.specialistpaintinggroup.co.uk

SHUTDOWN MAINTENANCE SERVICES LIMITED
Tel: 01634 256969
www.shutdownmaintenanceservices.co.uk

STANDISH METAL TREATMENT LTD
Tel: 01695 455977 Email: stuart.croft@standishmetal.co.uk

SURFACE TECHNIK DUDLEY LIMITED
Tel: 1384 457610 www.surfacetechnik.co.uk

TAZIKER INDUSTRIAL
Tel: 0844 8800 385 www.ti.uk.com

WEDGE GROUP GALVANIZING LTD
Tel: 0845 271 6082 www.wedge-galv.co.uk

WESCOTT INDUSTRIAL SERVICES LTD
Tel: 0191 497 5550 www.wescottis.com

W G BEAUMONT & SON LTD
Tel: 01708 749202
Email: tom.costello@wgbeaumont.co.uk

CONSULTING TESTING AND INSPECTION

AW CORROSION SOLUTIONS LTD
Tel: 01732 700924
Email: enquiries@awcorrosion.co.uk

CAN
Tel: 01224 870100 Fax: 01224 870101 www.cangroup.net

EQUILIBRANT LTD
Tel: 02890 767227 www.equilibrant.co.uk

ERIMUS INSULATION
Tel: 07968828825 www.erimusi.com

HYDROCOMM LTD
Tel: 07779333781 Email: hydrocomm@btinternet.com

HYDROSAVE UK LTD
Tel: +44 (0) 1536 515110 www.hydrosave.co.uk

INTECSEA
Tel: 01483 795300 Email: amanda.murray@intecsea.com

LBBC BASKERVILLE
Tel: 0113 2057423 www.bbcbaskerville.com

L & T CHIYODA LIMITED
Tel: +91 02652442000 Email: urvesh.vala@lntchiyoda.com

PAINT INSPECTION LIMITED
Tel: 0845 4638680 www.paint-inspection.co.uk

PLANT INTEGRITY MANAGEMENT LTD
Tel: 01224 798870
Email: info@pim-ltd.com www.pim-ltd.com

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

SUPPLIERS COATINGS

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

ASCOTT ANALYTICAL EQUIPMENT LIMITED
Tel: 01827 318040 Email: hmorley@ascott-analytical.com

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: stuart.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

TRAINING AND COATING INSPECTORS

CORRODERE ACADEMY
Tel: 01252 732220 www.corrodere.com

Institute Events
DIARY DATES 2022

INSTITUTE OF CORROSION

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BRANCH DATES

26th April 2022
Aberdeen Branch
"Reducing the environmental footprint for surface preparation and coating application for onshore and offshore assets"
Dinko Cudic, Presserv
In person, venue to be confirmed.

31st May 2022
Aberdeen Branch
"SECEs: It's time for a rethink
Martin Worth (PIM).

30th August 2022
Aberdeen Branch
Annual Corrosion Forum.

ADDITIONAL DIARY DATES

28th August – 1st September 2022
EUROCORR, Berlin Germany

IMechE courses at the Sheffield Training Centre

16th – 20th May 2022
Paint Inspector Level 11

23rd – 27th May 2022
Paint Inspector Level 2

6th - 10th June 2022
Paint Inspector, Level 1

4th - 8th July 2022
Paint Inspector, Level 1

11th – 15th July 2022
Paint Inspector, Level 2

CP courses at the ICorr Training Centre, Telford

2 - 6th May 2022
Marine, Level 3

9 - 11th May 2022
Buried, Level 1

16 - 18th May 2022
Reinforced concrete, Level 1

23 - 26th May 2022
Buried, Level 1

23 - 26th May 2022
Marine, Level 1

6 - 10th June 2022
Marine, Level 3

6 - 10th June 2022
Buried, Level 2

Online Corrodere courses plus online assessments and practical workshops

10th - 11th May 2022
Icorr Coating Inspector level 1&2, practical workshop and assessment

18th - 19th May 2022
Icorr Coating Inspector level 3, mandatory workshop and assessment