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Contents

Issue 152 November/December 2019

4 The President Writes

4 Institute News

11 Industry News

14 Innovative Products

16 Technical Article
Field testing for Soluble salts – A problem to be aware of

19 Technical Article
Correct Cladding Systems are the Key to Reducing Corrosion under Insulation

22 Technical Article
Failure Investigation of Internal Anodic Protection of Sulphuric Acid Tank

26 Sustaining Members

32 Diary Dates
The President Writes

I am now officially halfway through my term as President and I have to say the time has really flown by! I have nothing but good things to say about the role – I get to see and do some very interesting things and meet some amazing people along the way. Above all, I have been continually impressed by the dedication, pride and professionalism of our members. ICorr is a very special institution and I feel a strong sense of responsibility to maintain and enhance this wherever possible.

It was a pleasure to attend the AGM at the end of October in the rather grand surroundings of the Birmingham Council Chamber, to which we have become accustomed in recent years. The meeting was hosted by the Midlands Branch and was preceded by an impressive talks on cathodic protection from Markus Büchler, Trevor Osborne, Brian Wyatt and Chris Wozencroft. This very distinguished list of speakers was undoubtedly a major factor in the large turnout of over 80 people, which was great to see. Many thanks are due to Bill Whittaker and the Midlands Branch committee for their organisation of the event.

A number of important changes to our categories of membership were ratified at the AGM. The first was to introduce a new category of Honorary Life Membership. From July next year, all members over the age of 70 with at least 35 years of membership will be automatically entitled to Honorary Life Membership via a one-off payment of twice the annual subscription fee (for members over the age of 70) or three times the annual subscription fee (for members over the age of 65).

All of these new options will be laid out in detail in your subscription renewal letter next year and will apply to all categories of membership. We hope that this will make it much easier for members to retain links with the Institute after retirement, when membership subscription fees may understandably drop down the list of priorities. Honorary Life Membership is also a fitting recognition of the contribution to the Institute made by our members over their entire career.

The second change was to rename Individual Members (formerly Ordinary Members) as Affiliates, which was deemed necessary in order to resolve the perennial confusion with Professional Membership. Affiliate is an important entry-level category of membership for the Institute, comprising almost one third of all members, and it is vital that we continue to highlight the opportunities for career development and progression that the Institute offers. Networking, training and accreditation rank highly among these, and we are working hard to enhance these benefits. We are particularly keen to increase the number of Affiliates progressing to Professional Membership, which can be achieved after 15 years of field experience, together with additional training and accreditation.

If you know someone in this position, please do not hesitate to give them a nudge in this direction; more details can be found on the Membership section of the ICorr website.

The AGM also saw the election of our Officers and Council members for 2019-20 and I would like to congratulate all concerned and thank them again for their valuable contribution to the Institute. In particular, we are pleased to welcome Caroline Allanach as a newly co-opted member of Council. Caroline has been doing a great job in supporting the activities of our Young ICorr Chair, Simon Bowcock, and we are looking forward to the fresh perspective she will bring to Council. I also had the pleasure to present David Harvey with Honorary Life Fellowship in recognition of all the hard work he has done for the Institute.

May I take this opportunity to wish you and your loved ones a very happy Christmas and a prosperous New Year.

ICorr President, Gareth Hinds

Institute AGM

The AGM was held in the Birmingham Council Chamber at the end of October, and at which David Harvey was presented with Honorary Life Fellowship by the President in recognition of all the work all the work he has undertaken for the Institute as chair of PAC, managing the ISO 9001 process and supporting CP training, for many years.

From the Editor

Welcome to the last issue of the magazine for 2019. Again there are three technical articles covering different aspects of our industry. Firstly, Simon Hope describes a problem to be aware of when carrying out field testing for soluble salts on steel surfaces prior to painting. Next, James Meier discusses Corrosion Under Insulation and how the correct choice of protective cladding can help to prevent this problem, and finally, Ahmed Mahgoub explains how anodic can be used to protect sulphuric acid tanks, and highlights how getting it wrong can lead to failure.

Next year, as well as the re-branding of the Institute, as described in Gareth’s presentation to Aberdeen branch, there will be some exciting changes to the magazine, starting with a new Q&A column.

Finally, I would just like to add my good wishes for the festive season to those of the President.

Brian Goldie, Consulting Editor
Industrial Coating Applicator Training Scheme (ICATS)

ICATS NEWS

ICATS is moving rapidly towards its 15th anniversary in March next year and continues to grow exponentially with such prestigious organisation supporting the programme as; Highways England, Network Rail, Transport for London, London Boroughs, Sellafield, Workplace Solutions and Devonport Dockyard to name a few.

The business is packed with great stories where companies have been able to demonstrate improved workmanship and cost saving through the ICATS training programme;

K&M Group (London) have used the ICATS training programme as the basis to build the skills necessary to develop their industrial coatings division. They have been incredibly successful in winning work in this sector around London including; Battersea Power Station and Southwark Council. They will be holding seminars in the New Year at Aberdeen Football Club and inviting potential customers from the London area. Customers will be able to see the benefits of the ICATS programme and have the opportunity to talk to people who have benefited from the scheme.

Survivex (Aberdeen) have installed some of the best training equipment in the country and have started the task of training applicators in the north-east of Scotland. They have won support from the Altrad Group and Bilfinger who they bring into the ICATS family. They will also be holding seminars in the New Year at their facilities in Aberdeen, and inviting customers from both the offshore and onshore industries.

Paintel (Plymouth) continue to drive the excellent training programme, Work Place Solutions, at Babcock, and to the applicator community across the South West. Rob Hurley has become a Senior Specialist Trainer allowing Kevin Harold more time to develop the ICATS programme even further; new modules will be introduced in the New Year which will assist specialist activity in our industry.

Livingstone Surface Treatments (Cumbria) continues to offer the ICATS programme with the Managers Course held at Sellafield in October being a great success and ICorr are planning a joint evening with the Materials Society of Cumbria in March next year. There will be further ICATS training delivered by Livingstone Surface Treatments, for the engineering community in Cumbria throughout 2020.

The Managers Course programme gives the specification writer and planning engineer a knowledge of protective coatings, standards, specifications and the complexity of their application. In addition to Sellafield the course has also been given at Babcocks.

There are two new Approved Training Centres in Aberdeen and London and additional companies to join the growing group in Birmingham and Southampton are being sought.

SMART Card - the work is virtually complete on the new SMART card which will be launched in the New Year. This complies with the CSCS requirement for the Partner Card scheme of which ICATS is proud to be a member.

The first apprenticeship programme, run by DN Colleges and driven by Jack Tighe Ltd, will be coming to a conclusion in mid2020 and the second apprenticeship cohort has recently started. It’s a great credit to JTL who have driven the whole programme and somewhat surprising other major applicators in the UK haven’t taken up the programme. Martin Hillyard at JTL said that it offers young people a new opportunity, improves skills and capabilities, and starts to redress the industry issue of an aging workforce who are retiring with those skills. Kevin Harold and John Whittaker have worked tirelessly to develop these ICATS apprenticeship modules.

We are pleased to announce that Skills Training UK will be adding the Industrial Coating Applicator training programme to its already successful NDT apprenticeship which is a perfect fit with the BINDT and IMechE in Sheffield.

ICATS training powers McLoughlin’s work at iconic London landmark

K&M McLoughlin has credited the ICATS training programme - which has trained 66% of its workforce - for not only the successful application of the high solids surface tolerant epoxy to girders in the turbine hall at the old Battersea Power Station, but also the smooth running of the project and the quality of the service. A few of the employees were doing the course whilst working on the application at Battersea, which allowed them to learn practical skills on site to back up the theory being taught.

The London-based company has spent six months working in collaboration with tradesmen and scaffolders on Phase 2 of the £9bn project at the instantly recognisable landmark that will be transformed into housing, shops, offices, and over 18 acres of public space. The scale of this phase of the project at the Grade-II listed building, was something that had to be closely managed by K&M McLoughlin on site with a vast network of birdcage scaffolding needed to accommodate the variety of trades.

Continues on page 6
Institute Awards – call for nominations

Each year the Institute of Corrosion bestows a range of internationally-renowned awards in recognition of excellence in corrosion science and engineering and to reward outstanding service to the Institute and the wider corrosion community. Many of these awards are open to nomination by members of the Institute. Below is a brief description of each award together with details of how to nominate potential candidates.

U.R. Evans Award
The U.R. Evans Award is the premier scientific award of the Institute of Corrosion and is presented annually for outstanding international achievements in pure or applied corrosion science. The recipient is selected by a Corrosion Science Division panel and presented with a sword at the annual Corrosion Science Symposium. The symposium is one which seeks to encourage the participation of the junior members of the corrosion community who would appreciate the visit of, and address by, a corrosion scientist of international repute. The form of the award symbolizes the fight in which we are all engaged. The recipient is also granted Honorary Life Fellowship of the Institute. Nominations may be submitted at any time via email to the CSD Chair, Julian Wharton (J.A.Wharton@soton.ac.uk).

T.P. Hoar Award
The T.P. Hoar Award is presented to the authors of the best paper published in the scientific journal Corrosion Science during the previous calendar year. The winning paper is selected by a sub-committee of the Corrosion Science Division and the authors receive a certificate and a cash sum of £400. The recipient of the award in 2019 will be announced by the end of the year.

Lionel Shreir Award
The Lionel Shreir Award is made to the best student presenter at the annual Corrosion Science Symposium. Selection of the recipient is carried out by a sub-committee of the Corrosion Science Division. The award consists of a certificate and a cash prize of £125.

H.G. Cole Award
The H.G. Cole award is in the form of a poignard and is made in recognition of exceptional services to the development of the Institute. It is only awarded on an occasional basis, typically every 5 to 10 years, reflecting the highest possible level of commitment of the recipient to the activities of the Institute. Nomination and selection for this award is administered by the ICorr Awards Committee. Nominations may be made at any time to the Awards Committee Chair, Gareth Hinds (gareth.hinds@npl.co.uk).

Honorary Fellowship
Honorary Fellowship is awarded in recognition of outstanding service to the Institute over many years. The recipient is bestowed the suffix FICorr (Hon) and all future membership fees are waived. Nominations for Honorary Fellowship must be submitted via Council.

Galloway Award
The Galloway Award is presented to a student author for the winning paper published in the scientific journal Corrosion Science during the previous calendar year. The winning paper is selected by a sub-committee of the Corrosion Science Division and the authors receive a certificate and a cash sum of £300. The recipient of the award in 2019 will be announced by the end of the year.

Continued from page 5
Young ICorr held a joint meeting with the Greater London region IMechE Young members network on the 21st of November. The talk was held in the Council room of the IMechE on Birdcage walk followed by networking in a nearby hostelry. The evening brought together young engineers, professionals and students from across the country who are interested in corrosion, materials, metallurgy and welding. It was a great opportunity to meet like-minded peers from other industries and also provided many of the attendees enrolled on the 2020 Young Engineering Programme (YEP) to meet prior to the programme starting in January.

Guest speaker Roger Francis (RF Materials) gave a fascinating talk on "Corrosion Engineers (& Metallurgists) can save you money". This covered a whirlwind tour of case studies from fertiliser production to deep sea diving, highlighting poor materials selection and the importance of working together to understand the operating environment for the mechanical equipment. Often mistakes are repeated without learning, emphasising the need to engage a corrosion engineer. Roger’s extensive knowledge on duplex and superduplex stainless steels, in conjunction with correct heat treatments, demonstrated how the corrosion problems could be solved, often with cost savings. He then emphasised the importance of corrosion engineers’ involvements in QA/QC activities to ensure the correct testing and support regimes were put in place at the procurement stage. The talk was very well received and definatly got people thinking about the importance of materials selection.

Sponsorship was kindly provided by the Institute of Corrosion and IMechE. To stay informed about future Young ICorr events please join the LinkedIn group by searching for ‘Young ICorr’ or alternatively email Caroline.Allanach@gmail.com

New Sustaining Member
Paintel Ltd

Paintel Ltd has been specialising in industrial painting and maintenance of structures since 1999. They are privileged to have partnered with clients, and cared for some of the most iconic bridges and structures in the South West UK.

Paintel applicators are fully ICATS trained, including Specialist and Supervisor modules. Their team have numerous years of experience between them and hold a raft of industry qualifications including; Rope Access (IRATA), MEWP (IPAF), Towers (PASMA) & Confined Spaces.

The trainers, both ICA & specialist, operate from the Paintel office & ICATS Approved Training Centre in Lee Mill, Devon. They are proud to support Correx and be part of the ICorr/ICATS development team for creating courses. Kevin Harold is the lead ICATS trainer, delivering the ICATS Company Trainer, Supervisor and Technical Manger courses. Kevin is also involved with writing courses for ICorr, ICATS, and the ICATS Apprenticeship scheme.

There is an experienced team of ICorr Painting Inspectors covering all three levels. Paint investigation work is carried out for various clients, including Highways, where the investigation is used to determine the existing paint system(s) and how best to prepare and re-paint with a new system.

Paintel are accredited to ISO 9000 and NHSS 19A, ISO 14001 and ISO 45001, which demonstrates to customers that they are willing and able to take the extra steps to prove that they will be held accountable for what advice they give and work they do.
The annual ICorr corrosion induction presentation was given on September 26 at Aberdeen University by Zahra Lotfi, the branch University Liaison and CPD Officer. This event was excellently organised with the support of Dr. M. Amir Siddiq of the School of Engineering, Aberdeen University, which resulted in a brilliant turn out of new MSc students, as well as many returning students (35 in total).

The presentation included an introduction to corrosion, corrosion costs, the importance of corrosion control/mitigation monitoring, and the consequences of corrosion with several real life examples of catastrophic failure due to corrosion in oil and gas and transportation sectors. Common corrosion degradation mechanisms in the oil and gas industry and how the co-operation of different engineering disciplines can help protect the integrity of an asset, were also covered.

As a finale, questions on ICorr membership, chartered and qualifications provided, the many benefits of membership (e.g. ICorr mentoring programme to assist its members to achieve their Chartered Status) and how to apply for this. In addition, the students were familiarised with the work of the branch, its activities calendar and website, and how the Institute can assist students greatly in their continuous Professional Development (CPD).

As a finale, questions on ICorr membership, chartered engineering requirements and local events were discussed in detail and Yunnan Gao (Immediate Past Chair) told the students how they can involve themselves in ICorr activities e.g. by way of a poster presentation, or presenting their research project in greater detail, at upcoming branch events.

The branch held its first technical meeting of the 2019-2020 session at its usual venue, Robert Gordons University, on 24 September. This was the annual joint event with TWI (The Welding Institute – Northern Scottish Branch) at which a topic relevant to both welding and corrosion communities is presented. This year it was “Environmentally Assisted Cracking in Offshore Assets – A Review of Mechanisms & Mitigations” presented by Dr Daniel Sandana of Rosen.

Dr Sandana explained what environmentally assisted cracking is, its causes, and the conditions under which it occurs and to which materials. He discussed the well known ‘bathtub’ model for crack initiation, propagation and final fracture, and highlighted a number of key facts for stress corrosion cracking initiation, propagation and mechanisms, including the Staehle Diagram and the Parkins Spectrum.

The effect of hydrogen embrittlement on steel and how hydrogen is absorbed into steel during corrosion was discussed and he touched on the various theories of how hydrogen may act to embrittle steel and showed the observable effects of embrittlement.

Daniel also discussed sulphide stress corrosion (SSC) cracking which occurs in the presence of hydrogen sulphide, and showed the associated mechanisms of hydrogen induced cracking and stepwise cracking, and recalled failure examples of duplex stainless steels (DSS) by hydrogen induced stress cracking (HISC) in subsea pipelines in the late nineties and more recently in 2003. He detailed the requirement for HISC to occur in DSS and how this was countered by the requirements of DNV-RP-F112. Lastly, he talked about external chloride stress corrosion cracking which is a relatively common failure mechanism of stainless steels in an offshore environment.

Daniel fielded many questions from the large audience and was assisted in responding by Craig Cooper (TWI, North Scottish Branch chair).

At the end of the meeting, the branch chairman, presented the speaker with a Certificate of Appreciation from the branch.

The attendees at Robert Gordons University for the joint TWI/ICorr event.
He went through the different types of ICorr membership touching on the plans to change individual membership to “Affiliate” and other planned changes. He also touched on the challenge to get student members to stay, and by empowering younger members, for example to take part in the young engineers programme which has as a prize a free trip to the NACE conference in the USA, and free ICorr and NACE memberships. Gareth continued by highlighting membership benefits which he stated were networking, career development, visibility and financial rewards. He also gave the audience an update on the situation with the Engineering Council caused by the sudden failure of the Society of Environmental Engineers (SEE) in that the Institute hopes to combine with the Society of Operational Engineers (SOE) to continue to award Chartership status through the Engineering Council. It is expected that an agreement will be signed in January next year and ICorr head office will be in touch with all those chartered engineers affected to confirm this.

He described the brand refresh which will be taking place at the start of next year when the ICorr website and all paperwork etc. will be revised to make the image of the Institute more modern. Pictures of rust and corrosion will be replaced by pictures of gleaming new infrastructure and similar modern hardware. He told how the Institute had undergone digital modernisation and members can now pay their subscription online on the website. He said that the Institute of Corrosion was once again looking to influence governing bodies as they had in the 70s when they had been influential in getting Capcis in Manchester and the National physical laboratory setup.

Gareth’s comprehensive presentation was enlightening and uplifting showing his clear vision for the future of the Institute of Corrosion under his leadership.

In the second presentation of the evening Matt Streets of Rawwater discussed how, as all oilfield reservoirs have different souring propensities, operators must view all injector/producer (I/P) pairs as unique in regard to H₂S gas production, as well as control and mitigation strategies. Matt’s presentation described how a predictive oilfield souring model can be used to help forecast if, when, and to what extent, an oilfield will sour. He explained how the model describes the cooling of an oilfield due to water-flooding and the subsequent growth of sulphate-reducing microorganisms, resulting in sulphide production at the topsides facilities. Outputs from the model can be used to inform and influence key operational decisions and have provided huge cost savings for operators through cost-effective material selection and chemical dosing.

Matt’s presentation included a detailed review of the science that was used to produce the model and how the output from it can be used by Oil and Gas operators to plan to minimising costly problems caused by reservoir souring and thereby maximise their operating profits.

At the end of his presentation Matt answered questions on where the model input data came from, how critical seawater breakthrough was to the modelling, how many core samples were required to confirm that they had not been contaminated, the viability of injecting alternative food stock to the reservoir and about re-educating operational personnel.

At the close of the meeting, the branch chairman, presented both of the speakers with a Certificate of Appreciation.

Matt Streets receives his Certificate of Appreciation.

Full details of future branch events can be found on the diary page of this magazine and on the website, or by contacting: ICorrABZ@gmail.com. Copies of the majority of past branch presentations can be found at: https://sites.google.com/site/icorrabz/resource-center, and a photo gallery for these events is at: https://sites.google.com/site/icorrabz/event-gallery
London Branch

A joint meeting with the Society of Chemical Industry (SCI) was held at their newly refurbished auditorium in their Belgravia HQ, on 26 September. The audience of over 70, included Professor Ken Grattan, OBE, FREng, who is the Dean of the graduate school at City University, London, and who agreed to give the vote of thanks.

The evening Chairman, John O’Shea, introduced Dr Fred Parrett, John Treasurer of the SCI London Group, who gave the first presentation on the laying of the first Transatlantic Telegraph Cables.

The electric telegraph was first developed by Samuel F. B. Morse in 1832 who also developed Morse Code. Land based cables to connect the telegraph were introduced, and within a decade, more than 20,000 miles of telegraph cable criss-crossed the USA, the UK and Europe. Trials of underwater cable were undertaken by Samuel Morse across New York Harbour in 1842 and Charles Wheatstone across Swansea Bay in 1844. In 1851 a cable crossed the English Channel.

The problems of laying a cable across the Atlantic were a greater challenge, not just the technical and logistical problems, but financing such a great undertaking. The first attempt in 1857 failed when the cable broke, and could not be recovered. New finance was arranged and in August 1858 they succeeded, when the first transatlantic telegraph message was transmitted. Unfortunately the cable failed after only three weeks, which was thought to be due to breakdown of the cable insulation when voltages of a few thousand volts were used to try and speed up transmission speed. It took another 7 years before new finance was arranged and improved cable designs were developed for the next attempt. For this Brunel's ship the Great Eastern was acquired, the largest ship in the world at that time. In 1865 it almost succeeded, starting in Valienta Bay, Ireland it reached 600 miles from Newfoundland, when the cable again broke. The final success came one year later in August 1866 when the cable finally crossed the Atlantic and permanent telegraph communication established.

The 1866 transatlantic cable could transfer 8 words a minute, Atlantic and permanent telegraph communication established. By the year later in August 1866 when the cable again broke. The final success came one year later in August 1866 when the cable finally crossed the Atlantic and permanent telegraph communication established. The evening Chairman, John O’Shea, introduced Dr Fred Parrett, John Treasurer of the SCI London Group, who gave the first presentation on the laying of the first Transatlantic Telegraph Cables.

The presentation walked the audience through the period of time from early offshore structure design and construction for the oil and gas markets to the painful transition to wind energy, including the attendant problems that have occurred along the way and what should have been an easy transformation but often times was not.

The first meeting at the branch’s new venue, the Lancaster Hall hotel in Bayswater, was held on 10 October. Kevin Harold of Paintel Ltd gave a fascinating insight into the world of an Industrial Coating Applicator, taking a look at past, present and future practices in the industry. Kevin explained how the Industrial Coating Applicator Scheme (ICATS) has changed the view of Health and Safety and the concept of "slap it on and get out of here", to ensure the work is compliant to the specification. He began his presentation by describing his journey as a painter from the era when PPE was non-existent, how he moved into industrial painting, became a painting inspector, and after joined the Tamar Bridge strengthening and widening project, found the painters could not apply coatings properly, so he began teaching them.

Kevin could see the enormous benefits of ICATS, notably the evidence that the training results in major savings from less repeat work and the advantages gained by the asset owners and operators, so he became an ICATS senior specialist trainer, and the current ICATS course material, launched in 2018, was written by him and his wife Jo. He has also written the ICATS Supervisor course and the new Managers Coating Awareness course which provides an insight into coatings for specifiers and engineers.

Kevin finished his presentation by saying that a lot of asset owner operators are happier with the final product they get from ICATS accredited applications, and ICATS is now mandated by many companies. The enormous impact of ICATS on the whole industry has yet to be completely realised and it’s now going global.

The January meeting will be held on Wednesday 8th at the Lancaster Hall hotel (note change from usual second Thursday for this month), when there will be a panel discussion on “Linings for Extreme Duty” with Dr N Miskin, DuraPol, and Michael Harrison, Sherwin Williams.
A new system for predictive Corrosion under Insulation (CUI) management

CorrosionRADAR, a Cranfield University spin-out company, has developed a novel automated system for monitoring and predicting Corrosion under Insulation (CUI). This patented system supports a move away from reactive risk-based inspections to predictive corrosion management.

The system uses a distributed sensor system, with long, thin sensors (<3mm diameter) permanently embedded in the insulation around the asset. The core technology is called Electromagnetic Guided Wave Radar (EMGR), in which an electromagnetic wave injected into the sensor can be used to detect both the location and extent of corrosion damage, at long distances.

The company approached the Oil and Gas innovation Centre (OGIC), Aberdeen, for support with two different projects that would help it develop next-generation sensors for its system. The first project related to the analysis of corrosion rates and corrosion correlation of various metals, and was carried out by the Condition Monitoring Research Group at the School of Engineering at Robert Gordon University.

The second research project focused on sensor manufacturing technologies, deployment of sensors, and corrosion testing under simulated CUI conditions, in order to determine which materials could be used for the outer shield of the sensor. This project was undertaken with Dr Todd Green and Professor Sudipta Roy in the Department of Chemical and Process Engineering at the University of Strathclyde. The study included a survey of manufacturers and manufacturing techniques to identify manufacturers who could make prototype sensor cables and looked at deployment options, including retrofitting sensors in existing pipework and insulated structures, and the possible use of robotic pipe crawlers, as well as addressing the relative corrosion behaviour of various metals under CUI conditions that could be employed to manufacture the cable sensors. While there was a degree of variability in the corrosion rates of all the metals tested, the research showed it was likely that copper or aluminium sensor materials could be used to assess corrosion in a carbon steel pipe.

More details on both studies can be found at, www.corrosionradar.com

Visit the ICATS website
www.icats-training.org

New Research and Development Director appointed for Elcometer Ltd

Elcometer Ltd, has announced the appointment of Paul King as their new Research and Development Director.

Paul joins Elcometer with over 17 years of leadership experience at global companies, which included mechanical engineering and technology groups. He spent a large part of his career at Nokia, finally becoming the Director of Mechanics Technology, before he was transferred to Microsoft in the position of Concepting Director.

His key responsibilities at Elcometer will include managing the overall activities in the R&D department at Elcometer’s head office in Manchester, UK, and ensuring that Elcometer continues to deliver world leading technology to its customers across the globe.

Oilfield Corrosion Science and Engineering Course, University of Leeds, 19 –20 May 2020

A two-day theoretical and technical course involving demonstrations, theory and hands-on interactive sessions covered by experienced academics and renowned industry guest speakers.

This course will provide delegates with an introduction into the numerous corrosion threats associated with internal pipeline degradation within the oil and gas industry. Academic speakers will cover the details relating to specific mechanisms. Industrial guest speakers will provide an insight into the two main corrosion control methods relating to internal corrosion; corrosion inhibitors and material selection/optimisation. Practical interactive sessions will be held to help understand how to set up electrochemical cells for corrosion measurement, whilst also covering how such systems work. Finally, demonstrations will show how various field scenarios/mechanisms can be modelled in a laboratory environment to understand corrosion threats, as well as evaluate materials and inhibitors in different processes.

The guest speakers include Prof. Bijan Kermani (KeyTech and University of Leeds Visiting Professor), who on day one, will provide a talk on corrosion management and material selection in the oil and gas sector. On day two, the guest speaker, Mr Trevor Hughes (Schlumberger), will deliver a talk on chemical inhibition in oil and gas systems.

Full details can be found in the leaflet in this magazine or at, https://eps.leeds.ac.uk/dir-record/short-courses/996/oilfield-corrosion-science-and-engineering
NACE Corrosion Expo 2020, 15-19 March, Houston, Texas

This year’s conference brings even more opportunities to get the latest technical insights from some of the industry’s leading experts through numerous symposia sessions, including new topics for this year, *Corrosion in Sweet and Slightly Sour Production Conditions*, which will feature technical papers on laboratory and/or field experience of CO₂/H₂S corrosion and mitigation in a hydrocarbon containing environment, and *Innovations in Chemical and Mechanical Cleaning and Fouling/Corrosion Mitigation*, featuring papers that will provide a fundamental insight into new and up-and-coming innovations in the field of chemical and mechanical cleaning, including new chemistries, methods, applications or techniques, emerging equipment, and innovative partnerships.

The plenary lecture on Tuesday, March 17 will be given by William H. Hartt, Professor Emeritus, Florida Atlantic University-SeaTech, on “Corrosion, Fracture, and Failure Issues for Post-tensioned Concrete Bridge Structures”, and the full advance programme can be found at, nace.org/events/c2020

Corrosion and Scale Inhibition – theory, testing and application course, 18 – 20 February 2020, Iserlohn, Germany

The addition of functional chemicals (inhibitors) to aggressive media is a good solution for preventing corrosion failures and/or formation of unwanted scales in industrial assets. Thus, in oil and gas production and transport, energy production and distribution, production of metallic materials (specifically steel), and in many other areas, the use of appropriate inhibitors today is indispensable for the integrity, safety, sustainability, and economy of plants and installations. Inhibitors are effective even in small concentrations in a wide range of environmental conditions such as temperature or aqueous and non-aqueous media. The selection of appropriate chemicals or mixtures of substances is no “black magic”, but has a sound scientific basis.

The course, organised jointly by the WCO and EFC (EFC Event 456), will summarise the present day knowledge in theory, testing and application of corrosion inhibitors and scale inhibitors. The emphasis is on application and environmental aspects, and is intended to provide enough information to enable course participants to tackle inhibitor problems efficiently.

For more details concerning the course and to register go to, efcweb.org/Events/Courses.html

Further WCO events include a forum in conjunction with NACE Corrosion 2020 in March, entitled “Corrosion in low-carbon energies (renewables, nuclear and carbon capture): issues and solutions” and a workshop on renewable energies and corrosion as part of the 21st ICC to be held in Sao Paolo, Brazil in May 2020. There is also a workshop on the topic of “Corrosion in low-carbon energies” being planned at EUROCORR 2020, Brussels, Belgium. Updated information on these events can be found at, www.corrosion.org

EUROCORR 2020, Brussels, 6-10 September 2020 - CALL FOR PAPERS

This meeting organised by VOM, together with EFC, and DECHEMA, has the theme of “Closing the gap between industry and academia in corrosion science and prediction”. The scientific programme will give delegates the opportunity to catch up with the most recent and reliable scientific results and the latest industrial achievements, and to take part in the development of new standards and regulations on the subject of corrosion control. As always during EUROCORR, each day 12 to 14 parallel sessions will run, some dealing with the most important general corrosion problems and some focusing on those specific to each branch of industry.

Deadline for abstract submission is 15th January 2020 and instructions and the online submission form are available on the congress website, from which further information about the event can also be found. https://eurocorr.org/2020.html

PaintExpo, 2020

The Leading Trade Fair for Industrial Coating Technologies will be held in Karlsruhe (Germany) from 21 to 24 April 2020

The theme of this PaintExpo is Adjusting Painting Processes to New Requirements, and exhibitors will be presenting future-oriented solutions for meeting the increasing demands now being placed on quality, flexibility and productivity, as well as material, energy and cost-efficiency. As of August 2019, more than 450 companies from 22 countries – including all of the market and technology leaders – had already confirmed their attendance

Further information, the entire exhibition portfolio and a preliminary exhibitor list can be accessed at www.paintexpo.com.
INLET FLOW CONTROL VALVE AT LADYBOWER RESERVOIR GOOD FOR ANOTHER 60 YEARS

Leeds based corrosion protection and engineering services specialist, Corroserve, was contracted to repair and protect a 36” inlet flow valve which had been in service at Ladybower Reservoir for over 60 years, against any further corrosion. The reservoir, situated in the Upper Derwent Valley in Derbyshire, holds some 28 million cubic metres of water when full and is the largest of three connecting reservoirs which supply the water needs of Sheffield and the East Midlands.

The reservoir’s inlet flow control valves have to withstand the most demanding requirements of water system control – including erosion and corrosion, so a reliable protective coating system that would ensure the valve would require minimal maintenance over a long period of time was required. Corroserve proposed abrasive blast cleaning the valve body and internal parts to Sa 21/2 to remove existing corrosion products and provide a suitable profile for the application of high performance coating systems. Multiple coats of a glass flake vinyl ester copolymer were then applied to all internal surfaces to achieve a minimum of 1000 microns dry film thickness, and two coats of a 2-pack epoxy surface tolerant glass flake inhibitive primer with a 2-pack solvent free polyurethane/acrylic topcoat were applied to the valve externals. After curing, thickness and spark testing was carried out to ensure the quality of the coating work. The vinyl ester coating is suitable for immersed environments and is resistant to chemicals across the pH range, and is WRAS approved for town water and potable water service.

The flow control valve (left) after abrasive blast cleaning which revealed significant erosion corrosion and (right) after being lined with multiple coats of glass flake vinyl ester.

Pennsylvania refinery fire caused by corroded pipe

A degraded piece of metal pipe has been found to be the culprit behind the fire at a Philadelphia crude oil refinery that occurred in June, according to a report from U.S. Chemical Safety and Hazard Investigation Board.

The report noted that a pipe elbow in the refinery’s alkylation unit had corroded to roughly half the “thickness of a credit card” and ruptured, resulting in the release of process fluid that included over just over 2 tons of hydrofluoric acid. The report also detailed that the elbow was susceptible to corrosion due to the hydrofluoric acid in the process fluid, and though the pipe thickness was measured periodically, the elbow at issue had not been assessed for corrosion. That segment of piping also had high nickel and copper content, and as the Board commented, “Various industry publications have found that carbon steel with a higher percentage of nickel and copper corrodes at a faster rate than carbon steel with a lower percentage when used in a process with hydrofluoric acid.”

Milestone shows major rail project is on right track

A leading galvanizing business has reached a significant milestone as part of its work on one of the biggest rail projects in the UK. Worksop Galvanizing is playing a key role in a major programme to upgrade the Midland Main Line, which runs from London to Sheffield. Huge sections of infrastructure used to support new electric cables are first being sent to the plant for the application of a protective coating, and the amount of the steel galvanized so far has reached 3,000 tonnes.

The state-of-the-art facilities at the plant include the largest acid bath in the UK, which enabled sections as long as 30 metres to be galvanized at once, which meant that projects like this could be turned round very quickly.

Network Rail’s £500m-plus upgrade and electrification programme is designed to reduce journey times and increase passenger capacity on the entire length of the line which bypasses Luton, Leicester, Derby and Nottingham. It includes the erection of 6,000 main steel components to support the overhead line equipment and current focus is on the section running from Bedford to Corby. Supporting infrastructure is being supplied by Adey Steel.

The Bedford to Corby project scope is scheduled to be completed in 2023.
The following documents have obtained substantial support within the appropriate ISO technical committees during the past two months, and have been submitted to the ISO member bodies for voting or formal approval.

ISO/DIS 2409 Paints and varnishes — Cross-cut test (Revision of 2013 standard)

ISO/DIS 8502-15 Preparation of steel substrates before application of paints and related products — Tests for the assessment of surface cleanliness — Part 15: Extraction of soluble contaminants for analysis by acid extraction


ISO/DIS 22858 Corrosion of metals and alloys — Electrochemical measurements — Test method for monitoring atmospheric corrosion

ISO 26202 Magnesium and magnesium alloys — Magnesium alloys for cast anodes (Revision of 2007 standard)

ISO/FDIS 11844-3 Corrosion of metals and alloys — Classification of low corrosivity of indoor atmospheres — Part 3: Measurement of environmental parameters affecting indoor corrosivity (Revision of 2006 standard)

ISO/FDIS 18086 Corrosion of metals and alloys — Determination of AC corrosion — Protection criteria (Revision of 2015 standard)

ISO/FDIS 21062 Corrosion of metals and alloys — Determination of the corrosion rates of embedded steel reinforcement in concrete exposed to simulated marine environments

New international standards published during the last two months


ISO 21068:2019 Non-magnetic metallic coatings on metallic and non-metallic basis materials — Measurement of coating thickness — Phase-sensitive eddy-current method


ASTM

New Passive Fire Protection Coating to Safeguard Civil Steel Structures

Hempel has announced a new generation fire-protection coating – HempaFire Optima 500, which is specifically designed to improve the productivity of passive fire protection (PFP) coating applications. It achieves this by reducing the number of coats required and the process time required to apply them – saving time and costs.

Innovative Products

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According to the company, the product helps to maintain the stability of steel structures in large infrastructure buildings such as airports, stadiums and commercial centres by delivering up to 180 minutes protection against cellulosic fires, and being optimised for 120 minutes in ISO 12944 C3 interior environments. It is a one component waterborne acrylic intumescent coating with zero volatile organic compounds (VOC) and can be used for both open or closed steel sections. It is fast drying and highly resistant to sagging, and dries to an excellent aesthetic finish meaning there is minimum surface reworks to achieve the required cosmetic finish when applying a topcoat. The ease of application allows customers to improve their painting process by reducing the number of coats needed, minimising drying times and maximising the speed of the application. Taken together, these properties save both time and money as projects can be completed faster and with lower total application costs.

At 40 °C it can easily be applied at 750 microns DFT per coat, and can be recoated with a PU topcoat after 16 hours. This means that the whole system - primer, PFP, and topcoat - can be applied and dry to handle within a 48-hour period, concluded the company. Hempafire Optima 500 is now available in the Middle East and Europe.

NEW RANGE OF INTERPON COATINGS SIMPLIFIES CORROSION PROTECTION

AkzoNobel Powder Coatings has announced the launch of a range of high performance primers. The new Interpon Redox range consists of four innovative systems developed to cover a variety of substrates, surfaces, and environments – from swimming pools to chemical plants and high humidity to highly corrosive areas. The range consists of:

- Interpon Redox Active, a robust primer system with a wide curing window and excellent edge protection.
- Interpon Redox Plus which offers durable protection for a wide variety of substrates and pre-treatment methods.
- Interpon Redox PZ, a high performing powder primer for corrosion protection over blasted steel.
- Interpon Redox Triplex an extremely protective three-layer system for highly corrosive environments.

Powder coatings offer inherent sustainability benefits, such as no VOCs, reduced energy use, and less waste, and the new Interpon Redox range is suitable for everyday from bus shelters, elevators and security gates, to wind turbines, metal fences, and agricultural equipment, concluded the company.

NEW DURABLE COATING SYSTEM FOR OFFSHORE WIND TURBINE FOUNDATIONS

Master Builders Solutions® has launched MasterProtect 9000, which according to the company is the first coating system which ensures 25 years of maintenance-free protection for offshore and marine structures. The coating system is based on a hard wearing high-build hydrophobic PU membrane which provides extremely effective protection for two main critical areas of the offshore structure, the splash zone and the submerged part of the foundations. Additional properties of the system are chemical and mechanical resistance and high flexibility. The hydrophobic properties protect the steel structure from the aggressive impact of seawater. The chemical and mechanical resistance of the product are fit to withstand severe attack by waves, abrasion and impacts, especially affecting the splash zone and the high flexibility ensures that the barrier will not crack and will keep its integrity even after years of weathering, impact and vibrations. The combination of all these properties results in a consistent, reliable and highly durable protection against steel corrosion. In addition, the coating helps in significantly reducing the application time and cost compared with the most common epoxy paint systems used in the market, as the full system can be applied in only one day, concluded the company. The system has been tested by the independent Fraunhofer institute in accordance with the international standards NORSOK M-501 and ISO 20340.

A NEW STATE-OF-THE-ART PROTECTION FOR STEEL REINFORCEMENT

Master Builders Solutions® has also launched MasterProtect 8300 CI, a new corrosion inhibitor developed by BASF to enhance and complement their broader refurbishment and repair portfolio for concrete. It is a dual-function, silane-based corrosion inhibitor that can be applied to the surface of all types of reinforced concrete structures – both new and existing – without changing the appearance of the concrete. In addition, it has a very low viscosity to improve penetration into the concrete over a wide temperature range, a lower VOC content and a higher flash point, which together makes the handling of the product and its application much easier and safer than many other inhibitors.

AKZONOBEL LAUNCHES RECYCLED PAINT TO HELP CLOSE LOOP ON WASTE

According to AkzoNobel it has become the first major manufacturer to launch recycled paint due to a ground-breaking partnership in the UK with resource management experts Veolia. Developed by the company's Dulux Trade brand, the revolutionary Evolve matt emulsion is made from the waste of other people's paint tins in a bid to reduce the amount that goes to landfill. Once any leftover white paint has been reclaimed, it is sorted, filtered and refined by Veolia. It's then re-engineered with new paint by AkzoNobel and tested extensively to ensure that every tin meets the high standards expected from Dulux Trade. The final product contains 35% recycled paint, and is initially only available in white.

www.icorr.org November/December 2019 15
Technical Article

Field testing for Soluble salts – A problem to be aware of

Simon Hope, Consultant, Augharney Associates Ltd.

It is well recognised by our industry that proper surface preparation prior to the application of a protective coating is paramount in ensuring good long term corrosion protection of steel substrates. The amount and type of this preparation depends on the state of the existing surface, the particular coating to be used, and its application method.

However in all cases the object is to get the surface as clean as practicably possible, and in compliance with the specified standards.

The contaminants on a surface which can affect the coating’s adhesion, and hence performance, can be split into those visible to the naked eye, for example, oil and grease, mill scale, old coatings, dust and detritus and rust, and those that are not, the so-called soluble salts and micro particulates. To further ensure good adhesion of a coating, the steel substrate is normally roughened to significantly increase its surface area and hence improve the surface for bonding of the coating. The most common method of carrying this out is by abrasive blasting.

Painting specifications normally include a requirement for pre-cleaning of the surface to be carried out before any surface roughening, to ensure that any contamination present is not just spread across the surface, or driven into it, and hence not removed. Typically this cleaning involves solvent washing, fresh water washing with or without detergent, or a combination of these, and this step is covered in various standards.

However, by far the most difficult contaminants to remove, and detect, are the soluble salts, and the presence of these is a major factor in premature breakdown of protective coatings, and resultant increased maintenance costs for the asset owner.

In the context of surface contamination of steel surfaces before coating, these salts are typically chlorides, sulphides/sulphates and nitrates, of calcium, magnesium and sodium, which are commonly found in the atmosphere and environment, and although they are termed “soluble”, this is not true in all cases, as otherwise they could be simply washed away easily. The solubility of a salt depends on both the cation and anion present, as well as the concentration and the temperature, but put simply, nitrates are soluble, most chlorides are soluble, as are most sulphates, however carbonates, hydroxides, and sulphides tend to be mostly of low solubility.

Of particular concern for maintenance painting are the salts which can be deposited on a steel surface by acid rain, or by exposure to a marine or chemical processes environment.

Why are these salts a problem in the corrosion protection industry?

As corrosion is an electrochemical process, the rate of reaction is heavily influenced by the conductivity of the surrounding electrolyte. It is well known that these soluble salts, particularly chlorides and sulphates, can initiate and accelerate corrosion of steel due to the high conductivity of their aqueous solutions. Over time, soluble salts can be trapped, along with the products of corrosion, on the steel surface or more seriously, in pits. They are therefore the prime candidates responsible for causing coating breakdown due to osmotic blistering which subsequently leads to coating disbondment and ultimate failure. Osmotic blisters form due to the semi-permeable nature of the applied coating, when a strong solution is on one side and a weaker solution on the other, nature likes equilibrium, so solvent (in this case water) migrates through the membrane (coating) until equilibrium. Osmotic pressures can create huge pressures as is seen by the osmotic pump in trees that moves water from the roots to the leaves, which on a 100 foot pine equates to over 3 bar; they can also produce areas of different concentration and hence areas of different potential, which allows a corrosion current to flow, and in addition certain salts can lower the pH at the coating/steel interface, resulting in acid attack.

Where owners suspect that a surface may have been contaminated by salts, the painting specification will quote a level of salt, generally always specified as chloride ion, which is acceptable before the coating is applied. There are two commonly used sets of units used to describe soluble salt levels, namely milligrams per square metre (mg/m²) or micrograms per square centimetre (µg/cm²). It is important to note that these are NOT equivalent. Any numerical value expressed as mg/m² is a factor of 10x the value expressed as µg/cm².

These levels differ between existing standards and specifiers, as there is no consensus as to what level is safe. For example the maximum levels, quoted as sodium chloride, vary from <15 to <70 mg/m², and a typical figure would be < 20 mg/m², as given by the NORSOK M-501 and ISO standards (ISO 8502, parts 6 and 9).

If we cannot see these salts, then how do we measure them?

One of the most common tests used to measure the presence of soluble salts is the Breslé test (ISO 8502-6). This involves injecting distilled water into a patch placed on the steel surface. This water dissolves any salt present to form an electrolyte, and the conductivity of this can be measured with a standard conductivity meter. It must be remembered that it is the total salts and materials present which are dissolved, and depending on their solubility in distilled water, and the nature of the salt, that will determine the conductivity. As it is generally not known which salts are present, then to arrive at a result to compare with a specification, a very naive and dangerous assumption has to be made. The conductivity is through this assumption interpreted as being due solely to sodium chloride, and a correction factor is applied to the conductivity measured to give a result equal to ‘x’ mg/m² of sodium chloride. This value is then compared to the specification, and if found to be equal to or below this, then it can be said that the surface is acceptable for coating. But what if the value is higher than the specification, does this mean it has automatically failed? If a higher reading than the specification is recorded, then normal practice is to repeat the washing stage and re-blast to the specified standard. However if the re-test still gives a higher than acceptable result, competent inspection would deem that further investigation really should be carried out to determine the source of the increased conductivity. This situation is demonstrated in the case study described later.

Breslé test kit.

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Breslé test kit.
Under laboratory conditions the Breslé method is an excellent test for the detection of water soluble ions on metal surfaces, but in the field there several ways in which the reading obtained by the this method can be influenced by other sources of electrolytes. The main examples being:

- using contaminated distilled water;
- contaminated calibration solutions;
- inadequate flushing of the meter;
- poor cleanliness (ie not wearing clean gloves throughout the entire process);
- leaving test kits unsecured and unattended where third parties can interfere with it);
- continually re-using syringes and hypodermics from previous tests;
- the quality of the “patch” used for the extraction;
- the temperature and relative humidity when the test was carried out;
- or simply the conductivity of the water used to carry out the initial surface washing.

From a general safety and quality perspective, this method of testing can be unreliable as it assumes that the operative is fully trained and competent to undertake the testing and then report/record the results accurately, also many sites do not like ‘sharps’ at the workplace, let alone hypodermic needles being carried around, often in someone’s pocket.

There are several other conductivity-based methods available to the industry (often proprietary) for field measurement, for example,

- Proprietary “soluble salt meters” are available, which also use the conductivity method to measure salt concentration, but these hand-held devices are different from the Breslé method in that they perform both the taking of the sample and its analyses automatically. Measurement is faster as the number of steps is fewer, thus reducing the possibility of error, and they are claimed to have more reliable and repeatable performance.
- Paper extraction methods, which remove the need for patches, use filter papers onto which a measured amount of water is added, this in theory absorbs any soluble salts present, and the conductivity can then be measured by a modified meter. However, these methods still have most of the drawbacks of the Breslé method, and can also introduce other errors.

There are alternatives to the use of conductivity to determine the presence of soluble salts, however these methods are generally more suitable for use in a laboratory. These include titrimetric determinations, a highly accurate method and ion specific, ie it can measure the chloride ion concentration alone. Other laboratory methods use ion selective electrodes and spectrophotometry to determine individual salt concentrations and these are also highly accurate and specific quantitative test methods.

One method which does not rely on conductivity, and which is suitable for field use involves ion exchange technology, and is described in ISO 8502 Part 5. For example one proprietary system uses a calibrated titration tube containing a silver chromate solution which reacts with any sodium chloride present in an extract from the surface to form a white precipitate.

\[2NaCl (aq) + Ag_2CrO_4 (aq) \rightarrow 2AgCl (s) +Na_2CrO_4\]

A major benefit of this method is that each test is stand-alone and cannot be contaminated by earlier tests. Simply, a known area is washed with a correspondingly known volume of a specific reagent, to create a solution that is drawn up into the titration tube which is calibrated in ug/cm². The colour change on reaction with chloride is from pink to white, and the concentration of chloride can be read directly on the tube at the interface of the two colours. However it should also be noted that the presence of other halides (bromides, iodides and fluorides) and sulphide ions (which produce a brown stain) will give positive, bogus readings that should be taken as indicatives of other contaminants that may need investigation. Kits are also available for the specific determination of sulphates and nitrates.

Case Study

The following case study demonstrates the possibility of other sources of electrolyte affecting the result from a Breslé test, and the resultant increase in (unnecessary) surface preparation costs.

During maintenance painting of areas of an offshore structure, Breslé patch salt testing was carried out on two random areas after abrasive blasting. A very high reading for ‘sodium chloride’ was obtained and the surface was washed further. Subsequent testing also produced a high result. The surface was then re-blasted and rewashed, but the measured salt concentration was still too high.

The coating that was being removed had been in situ for a period of around 25 years and had been exposed to a C5M environment, and was generally in fair condition with only breakdown where mechanical damaged had occurred. This was interesting as if, as had been thought originally, that the contamination was on the steel from the initial manufacture, why hadn’t the coating failed catastrophically within a short period of the original application? The readings indicated levels of contamination 9x higher than acceptable to NORSOK M-501 and over 3x the maximum acceptable to the manufacturer. So this should have precipitated a train of thought to wonder what was in reality going on?

An independent inspection was then carried out for further testing, this time using a proprietary ion detection tube method, alongside a direct comparison Breslé patch test. The results of which showed that no chloride was present by the chloride specific test but the Breslé test still gave a very strong positive test.

The problem, when analysed, was attributed to the dissolution into the distilled water of zinc salts (from the very finely
dispersed metallic zinc within the original primer used) being driven into the surface during blasting which created an electrolytic solution mimicking the conductive behavior of sodium chloride. If an ion selective test had been carried out initially, it would have shown that the surface had minimal chloride level and was perfectly satisfactory and compliant for coating. This would have saved the time and cost of the (ineffectual) re-washing and blasting.

It should be noted that ion-specific test kits are also available for the determination of sulphate and nitrate soluble salts which can be just as damaging to coating adhesion. However in this case, as there had been little or no failure of the original coating, which was thought to have been caused by the presence of salts beneath the coating, then these other contaminants could not be present either.

The biggest problem in the inspection of a surface prior to coating is in knowing what is being checked for. Soluble salts are not just sodium chloride as often defined in specifications, as noted above any salt or other contamination on the surface can contribute to the overall conductivity and hence the potential for osmotic blistering and coating failure. Test results between conductivity and ion specific methods can lead to large differences and any anomalies should be investigated further to find the root cause of the problem.

Breslé patch and any other tests that rely purely on conductivity need to be treated with caution, negative readings are fine and can be used as a definitive guide but ‘positive’ readings need to be treated as ‘non-negative chloride’ until it is confirmed as being the source of the conductivity.

One wonders how often major cleaning and surface rejections of a substrate have taken place that with a bit more investigation were perfectly fit for purpose, and what the cost and time implications of this have been. Perhaps also the definitions of soluble salts in specifications need to be reviewed and tightened-up, but that is for another article.

Surface cleanliness is defined under the ISO 8502 series of international standards, along with equivalent standards from organizations such as NACE and SSPC.

ISO 8502 consists of the following parts, under the general title, “Preparation of steel substrates before application of paints and related products — Tests for the assessment of surface cleanliness”.

- Part 2: Laboratory determination of chloride on cleaned surfaces
- Part 3: Assessment of dust on steel surfaces prepared for painting (pressure-sensitive tape method)
- Part 4: Guidance on the estimation of the probability of condensation prior to paint application
- Part 5: Measurement of chloride on steel surfaces prepared for painting (ion detection tube method)
- Part 6: Extraction of soluble contaminants for analysis — The Breslé method
- Part 9: Field method for the conductometric determination of water-soluble salts
- Part 11: Field method for the turbidimetric determination of water-soluble sulphate
- Part 12: Field method for the titrimetric determination of water-soluble ferrous ions

In addition, new ISO standards are under development to describe some of the other commonly used methods for determination of soluble salt levels.
Correct Cladding Systems are the Key to Reducing Corrosion under Insulation

James Meier, ProClad Systems, USA.

Corrosion under insulation (CUI) refers to the external corrosion of piping and vessels that occurs underneath externally clad/jacketed insulation as a result of the penetration of water. By its very nature CUI tends to remain undetected until the insulation and cladding/jacketing is removed to allow inspection, or when leaks occur. CUI is a common problem shared by many industries, particularly the refining, petrochemical and power sectors. CUI typically occurs on insulated systems operating in a temperature range from -4 to 150 °C. This is an ongoing and growing concern among facility owners and is estimated to cost a $300 Billion per year problem in the United States alone and over a trillion dollars on a global scale.

There are three key components to a good CUI risk minimisation programme. The first is to have the correct and suitable coating on the insulated surface. The second is to have an insulation system that minimises the intake of moisture, such as a closed cell foam or hydrophobic type material. The third component, which is the focus of this article, is to use a cladding system that minimises the ingress of moisture, and has high resistance to mechanical damage.

Current Issues with Metallic Cladding Systems

Metals such as aluminum, stainless steel, or aluminised steel have been used as the cladding of choice over industrial insulation systems for many years. They have provided an adequate barrier to weather, have been key components in fire protection systems, and can offer some chemical resistance in certain atmospheres. There are, however, several growing concerns over the use of metal as a cladding over this type of insulation.

The biggest concern from a CUI point of view is the mechanical means by which the individual metal sheets must be joined. Typically, self-tapping screws or rivets are used to tie these together. At each of these points the vapour barrier can be compromised, and each penetration requires a sealant to be used. Although this is normally properly addressed in specifications, in practice it is very hard to accomplish, and inspect.

Another issue with metal jacketing is that it often relies on the strength of the insulation underneath to give it rigidity. If the insulation is fibrous, or if the contour of the metal doesn’t exactly match the form of the insulation underneath, as is often the case at elbows or transitions, the metal cladding can be highly susceptible to mechanical abuse which can open the joints. Metal cladding systems are not ideal for pre-insulated systems or for modular designs. This is because of the tendency of the metal to dent easily or open at the joints when transported. Finally, the price volatility of the metals market can make it difficult for a maintenance manager to properly budget this item. Figures 1 shows a typical example of these faults.
Benefits of Pre-Cured GRP for Reducing CUI

Pre-cured GRPs have many benefits over a traditional metal cladded system. They are fabricated from UV-cured GRP, and are a composite laminate based upon high grade isophthalic polyester resins and chopped glass fibres. This cladding arrives at the site pre-formed and pliable for easy installation. When installed with the manufacturers’ adhesive it can provide an instantly hard and durable cladding system.

The benefits of this type of cladding are,

- No mechanical attachments such as screws or rivets are required to hold it in place.
- It is easily modified on site and can be cut using standard metal cutting tools, which allows correct fitment at terminations.
- High risk water ingress points can be sealed using an un-cured GRP roll, which once cured in situ, has high adhesion strength to coated metal substrates. This can provide a long lasting watertight seal.
- Overlapping joints are fully waterproof and will pass-wash down tests from high pressure washing and deluge system testing.
- It has excellent resistance to chemical attack when compared to some metallic cladding systems.

Figure 2 shows how un-cured GRP can be used on-site to easily cover non-standard insulation, and then cured by natural sunlight or a UV light source, and figure 3 shows how pre-cured GRP cladding can be easily modified using standard metal-working tools.

Fire Performance

Pre-cured GRPs can be ideal in fire rated areas. These systems do not drip like aluminum and are self-extinguishing with low smoke production. Pre-cured GRPs have been tested against, and have passed a variety of industry standard fire tests and requirements (see below), however it is essential that each individual product is specifically tested for the particular environment that it is going to be used in.

- ASTM E-84 (15/50)
- ASTM E1317
- IMO FTP Code 2010 Part 2
- IMO FTP Code 2010 Part 5
- BS 476 part 7
- NFPA 274
Pre-Insulation with Pre-Cured GRP (figures 4 and 5)

Pre-cured GRP cladding is also suitable for use in the construction of pre-insulated systems. Due to its high strength and the fact that it can be chemically bonded at the joints, a vessel or pipeline pre-insulated and jacketed with it should have a lower risk of damage due to mechanical stresses and/or water ingress. This is a key concern with the growing trend for today's mega projects to build pre-fabricated modules in overseas construction yards and then ship them, often thousands of miles, to the jobsite. This trend will most likely continue as energy companies are working on new projects in increasingly remote destinations. The strength and flexibility of the pre-cured GRP is ideal for withstanding the mechanical abuse that inevitably occurs during handling, shipping and installation of these modules. Full sealing and joint integrity are also critical as often imported modules will be quarantined and subjected to wash down procedures, which is the norm for modules imported into environmentally sensitive regions. These two key points are integral for a pre-fabricated system which reduces CUI risk, and has the added benefits of providing better schedule control and lower scaffolding costs.

Figure 6 shows a typical LPG module pre-insulated at an off-site location prior to shipping and installation, and figure 7 shows piping for pipe-racks pre-insulated in an off-site workshop.

Conclusions

CUI is a major maintenance issue that must be addressed by owners. A key component to reducing CUI is having a cladding system that is strong enough to handle the mechanical abuse that inevitably occurs in an industrial environment.

A good cladding system also maintains tight seals at overlaps and terminations and fully protects the integrity of the vapour barrier and insulation system underneath. Though metallic cladding has been the choice of many specifiers and owners, there are some fundamental problems with these systems that have contributed to the CUI problem industry now faces on a global scale.

A good alternative in the CUI process range is to use UV-cured GRP and pre-cured GRP systems. These exhibit superior resistance to mechanical damage, compared to metal cladding, and offer greater potential to seal the overlap and termination joints. Both systems can also offer better fire resistance and chemical resistance compared to typical metal cladding.
Failure Investigation of Internal Anodic Protection of Sulphuric Acid Tank

Ahmed Wahba Mahgoub, Cathodic Protection Specialist.

It is well known that corrosion can sometimes be controlled by cathodic currents and, even with an elementary knowledge of electrochemistry; it is easy to appreciate why this should be so. Corrosion involves the oxidation of the metal and it is reasonable to expect that cathodic polarization, which discourages oxidation and favours reduction at the metal surface, should give protection. In fact, the position is somewhat more complicated and, in many cases, other factors override this apparently simple one.

What is not so well known is that corrosion can also be prevented in suitable cases by anodic polarization, and it is certainly very much more difficult to understand why this should be so from the somewhat oversimplified theory of corrosion which the non-specialist is bound to have. It is probably because of this that anodic protection is not so well known type of protection due to the lack of experience in this not so well known type of protection.

Overview of Anodic Protection

Anodic protection is one of a number of electrochemical techniques used to prevent corrosion of immersed metals. These techniques employ a controlled DC current to influence the rate of the corrosion reaction. Figure1 illustrates the applicability of anodic protection with respect to pH of the electrolyte.

Although the selected technique is dependent on the metal/process stream combination, all techniques share a common electrochemical theory and all systems share common components.

This section discusses both the theory and the function of the system components required for the anodic protection of carbon steel in sulphuric acid.

Sulphuric acid is normally stored in large vertical cylindrical tanks fabricated from carbon steel. Tank design can vary
from region to region but is usually based on available 'local' standards such as American Petroleum Industry [API] 650 welded steel tanks for oil storage, or an equivalent specification. While these specifications are a sound basis for storage of oil and other fluids, they fail to take full recognition of the unique physical properties of sulphuric acid, in particular its density and the corrosive nature of the liquid.

Commercially sulphuric acid is normally produced in grades ranging from 93 to 98% \( \text{H}_2\text{SO}_4 \), due to their low freezing points. Sulphuric acid is highly corrosive, and the corrosion occurring within a given storage tank is dependent on a number of issues, e.g. temperature, concentration and activity of tank and purity of acid.

Anodic protection uses an external source of controlled direct current as shown in figure 2 to keep the solution potential of the immersed tank wall in the passive, low corrosion rate zone. Direct current is discharged from the tank walls to the cathodes suspended from the tank roof. DC power cabling is routed from the positive output terminal of the source to the tank, and from the source negative terminal to the cathode. The resulting change in solution potential is measured with respect to a reference electrode immersed in the acid and used to control the current magnitude to maintain the potential in the passive range.

![Figure 2 - Anodic Protection System.](image)

Figure 3 shows an idealised potentio-dynamic curve for carbon steel in sulphuric acid. When solution potentials are in zones ‘A’ (fig 3), active corrosion occurs. Small changes in solution potential result in large differences in corrosion rate due to the logarithmic nature of the solution potential/current density curve. Solution potentials in zone ‘B’ represent passivity and a correspondingly low corrosion rate.

The presence of a passive zone of solution potentials is common for carbon steel in both strong caustics and acids. Ensuring that solution potentials are always in the passive zone would also ensure a correspondingly low corrosion rate, where corrosion rates are an order of magnitude lower.

**Benefits and Dangers of Anodic Protection**

Anodic protection is particularly suitable for application in the heavy chemical industry, but the solutions handled in chemical plants differ so greatly, that each case has to be studied. The following section illustrates the benefits and dangers of using an anodic protection.

The most important benefit however, is in tanks with varying liquid levels. Once passivated and maintaining the passivation criteria, the corrosion rate in the continuously immersed zone can be reduced by up to a factor of ten. The operating costs also need to be considered, as after initial passivation, power requirement is nominally several Kw.

An anodic protection system is cost effective when compared to cathodic protection combined with coatings or linings for the same application. It should be noted that it is potentially dangerous to coat the anodic member of the couple. This reduces its area, and severely accelerated attack can occur at the holidays, or imperfections in the protective coating. When using barrier coatings to control galvanic corrosion, it is always the cathode which should be coated. Hence a tank which is internally coated cannot be protected by an anodic system.

The greatest danger comes, however, when the potentials are just below or above those at which protection is established, as the rate of corrosion is very high (this can be seen from the shape of the curve sketched in figure 3). In some cases this rate can be many orders of magnitude greater than that of the passivated metal.

If a tank were to be actively corroding, then in order to re-establish passivity, a current equivalent to the highest possible rate of corrosion would need to be applied. This means that the potential control must be able to provide a current many orders of magnitude greater than that of the passivated metal.

Another limiting factor of the anodic protection application is that when the acid level falls to a low level, and before acid/cathode contact is lost, an instantaneous change in system resistance will be created and with explosive gas mixtures, the possibility of sparking (arching) may exist in this type of storage tank.

Additional precautions are therefore required to overcome this risk through the use of spark preventers and an auto-shutdown system which uses the process level sensor for feedback.

**Case Study**

A 7m diameter and 6m high storage tank, commissioned in 2012, containing 98% sulphuric acid at ambient temperature was protected against internal corrosion with an anodic protection system. It had an air-cooled transformer/rectifier with potential and current control modes, and an auto shut down option in case of low tank acid level, but which was not activated in this tank.

Three cathode rods, made of hastelloy composite with a copper core were installed through hardware in the roof of the vessel. The arrangement of the cathodes was designed to provide a uniform current density on the wall of the tank. The designed low acid level of the tank was 10% of the maximum level of the tank (0.54m), with maximum tank level at 5.4m.
One end of the cathode inserted through the roof was insulated by Teflon. The other end of the cathode was submerged in the acid. The submerged end of the cathode has a niobium end cap to protect the copper core.

The system included two platinum (Pt) reference electrodes for measurement of the solution potential. One is the primary reference electrode and used for control in concert with the transformer/rectifier, and the other is secondary, used to validate the controlling reference electrode. The normal SET potential for acid tank anodic protection systems to assure passivation is +400mV with respect to platinum.

The reference electrode solution potentials measured at the reference electrodes (mV) should be within 20 mV of the set potential and each other; thus ensuring that the tank is in the passive, low corrosion rate zone.

A leakage incident occurred in 2018, and an investigation was carried out, and the findings are given below.

On commissioning, the sulphuric acid level inside the tank was 50% of the electrolyte height and the transformer/rectifier was being operated in current control mode NOT potential control mode. The recorded potential measured with respect to the primary and secondary platinum reference electrodes was +460mV and +350mV respectively, and no comment was made regarding the 110mV difference between both reference electrode measurements in the commissioning report.

The anodic protection system had been commissioned on the basis of the measurement of the primary reference electrode, which matched the required potential criteria (+400mV with respect to platinum).

The sulphuric acid level trend for 12 months (July-2017 to July-2018), showed that the maximum operating electrolyte level was only 37% (i.e. 1.99m) while the minimum operating level was approximately 17% (i.e. 0.91m). The fixed distance between the end of the cathode and the tank bottom is 1.1m, 20% of the maximum electrolyte level. Consequently, the current required to maintain passivation was not achieved all the time, as the actual level of sulphuric acid for a period of time was less than the distance between the end of cathode and the tank bottom and therefore there would be no DC output from the transformer / rectifier.

Table 1 shows the maintenance records for the latest three annual surveys, and from this it can be seen that there is shift in potential between the two reference electrodes (REs) A calibration check carried out for both electrodes with respect to the master RE to check the accuracy, showed that the primary RE was not accurate with a +60mV shift in potential. The accurate potential reading is the secondary RE measurements.

The noticeable change in polarisation level is due to the dramatically fluctuating sulphuric acid level during the time of tank operation.

### Table 1 - RE potentials in last three annual surveys.

<table>
<thead>
<tr>
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<th>Survey-2015 (mV)</th>
<th>Survey-2016 (mV)</th>
<th>Survey-2017 (mV)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Primary RE</td>
<td>+320</td>
<td>+386</td>
<td>+559</td>
</tr>
<tr>
<td>Secondary RE</td>
<td>+255</td>
<td>+311</td>
<td>+503</td>
</tr>
</tbody>
</table>

Table 2 illustrates both maximum and minimum potentials for the last three years and the variation between the maximum and minimum potentials is due to changes in the electrolyte level inside the tank and the anodic protection system operating under current control mode, which cause changes in protection level of the protected zone inside the tank.

Maximum potentials recorded (+300 and +347) in 2015 and 2016 respectively, and the minimum potential +455 in 2017 w.r.t secondary RE shows that the tank is outside the passivation / low corrosion rate boundary (as can be seen in figure3), meaning the tank has been under corrosive attack for the last three years!

### Table 2 - Max &Min potentials in last three annual surveys for both REs.

<table>
<thead>
<tr>
<th></th>
<th>Survey-2015 (mV)</th>
<th>Survey-2016 (mV)</th>
<th>Survey-2017 (mV)</th>
</tr>
</thead>
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<tr>
<td>Primary RE</td>
<td>+357</td>
<td>+405</td>
<td>+623</td>
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<tr>
<td>Primary RE</td>
<td>+278</td>
<td>+326</td>
<td>+508</td>
</tr>
<tr>
<td>Secondary RE</td>
<td>+309</td>
<td>+347</td>
<td>+579</td>
</tr>
<tr>
<td>Secondary RE</td>
<td>+221</td>
<td>+286</td>
<td>+455</td>
</tr>
</tbody>
</table>

### Conclusions

In this Case Study, as the transformer/rectifier unit was operated in current control mode, the changing sulphuric acid level would affect the degree of protection/passivation, as the current output of the DC supply is always constant. It is necessary to set the anodic protection system for internal tanks in potential control mode to assure it sustains the passivation potential required regardless the level of the electrolyte.

It can be easily seen that reference electrodes should be calibrated with respect to a master reference electrode to ensure the desired accuracy, as reference electrodes are critical to system operation and effective control of corrosion rate. Because anodic protection must be a potential controlled system, the reference electrode solution potentials measured at the reference electrodes (mV) must be within 20 mV of the passivation criteria, thus ensuring that the tank is in the passive zone.

For this application, it is essential to maintain the level of sulfuric acid inside the tank higher than the distance between the end cap of electrode and the tank bottom (20% of the maximum electrolyte level) to assure maintains the required current for passivation. If the actual level of sulphuric acid is less than the distance between the end cap of cathode and the tank bottom, there would be no DC output from the transformer/rectifier.

In addition, use of spark preventers and an optional auto-shutdown system that uses the process level sensor for feedback in order to avoid the possibility of sparking (arching) is recommended.

Braided nylon rope can be also used in case that the level sensors are inaccurate and the level falls below the cathode, to allow the acid to ‘wick’ up to the cathode tip thereby preventing an instantaneous change in system resistance, which could create a spark.

Updating the plant preventive maintenance strategy is recommended to minimise the inspection interval of the anodic protection system. The operating parameters should be recorded and reviewed weekly to ensure the required passivation level for the tank is being maintained.

Periodic ultrasonic thickness measurements should be carried out on piping exiting or entering the tank, below the maximum fill level, between the tank wall and the first downstream or upstream valve to identify any possible interference, resulting in the steel piping connected to the tank experiencing an increased corrosion rate due to the operation of the anodic protection system.

Maintenance personnel should be familiar with the operation procedures of these units and anodic protection techniques. Only qualified personnel should be allowed to work with this equipment, under competent supervision.
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<td>Robert Gordon University, Two key areas of risk based inspection, pressure safety valves and FPSO cargo tanks. John Morgan, Chris Bell, and David Baxter, DNV GL.</td>
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<td>Painting Inspector – Level 1 IMechE Argyll Ruane, Sheffield</td>
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<td>8th January 2020</td>
<td>ICorr Coating Inspector Levels 1 &amp; 2, Workshop &amp; Assessment Corrodere, Surrey</td>
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