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The President Writes

It has been a very busy few months since I last wrote to you. I recently returned from a week in Houston where I attended the Offshore Technology Conference, and it was encouraging to see the number of attendees were once again up and people I spoke to all seemed buoyant about the state of the industry.

I have also had the pleasure of attending the CEOCOR conference, which was a wonderful success, with delegate number exceeding our initial expectations, and the level of discussion and debate at the conference was first class. Our thanks must go to the organizing committee who have been hard at work on this for over 12 months, also to the CEOCOR Chairman, Brian Wyatt, for partnering with ICorr for such a mutually beneficial event to be held in the UK. I am sure that this will have helped to cement the working relationship between CEOCOR and ICorr. Undoubtedly the organizing committee will not thank me for this, but if you do have any joint conferences that you would like to work with ICorr on, please let me know.

Another very successful CED Working Day was held by Nick Smart and his committee, and I had the pleasure of presenting the second Paul McIntyre award to the worthy recipient, Dr John Broomfield.

Plans continue to move, under the watchful eye of Trevor Osborne, to a new permanent home for the Institute, and we are at advanced stages in discussions for a property in Northampton, but as you can all appreciate this is not a done deal until we have the keys in our possession.

PDTC have recently had a lively committee meeting that was kindly hosted at Elecometer, and I do believe that the future of our training offerings looks bright. All details of upcoming courses are on the website or you can contact the office for more detailed information. We have a Fundamentals of Corrosion course scheduled for next month.

The passion which is displayed by our volunteers continues to be what drives the Institute forward, and with passion comes strong commitment, which can only advance our aims further.

Finally there is another PDTC meeting and a Council meeting schedule for next month, and I will update you on the outcome of these in the next issue.

Sarah Vasey, ICorr President

From the Editor

I hope that you’re all re-charged and ready for the busy summer work period after the Easter break and two Bank Holidays. It has been a busy time for me, helping to organise the Ceocor Congress and getting this copy ready for the press.

The two technical articles this issue cover remote tank inspection using a robot to carry out the inspection of tank floors without emptying the tank and gas-freeing it to allow man entry, and the principles behind Cathodic Protection monitoring, an important process to ensure long term protection of structures, particularly in offshore locations. These are both important issues for Corrosion Protection specialists today.

To continue the column started in the last issue, further Case Histories are being prepared for the July/August edition.

As usual, if you have any comments or suggestions for improvement, please contact me via the Northampton office.

Brian Goldie, Consulting Editor

Membership Subscription Rates 2018/2019

<table>
<thead>
<tr>
<th>Membership Categories</th>
<th>Annual Rate from 1 July 2018</th>
<th>Registration Fee</th>
</tr>
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<tbody>
<tr>
<td><strong>Student</strong></td>
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<tr>
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<td><strong>Sustaining Membership</strong></td>
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<tr>
<td><strong>“GOLD” Sustaining Membership</strong></td>
<td>Annual rate from 1st July 2018 is £747.00 (plus VAT)</td>
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</tbody>
</table>

* Requires proof of enrolment as a full time student at an approved science or engineering based study programme.
ICATS NEWS

The good news is that the market is booming, new projects are on the horizon in Highways, Rail, Nuclear, and with an increase in the oil price which will release funds for projects in the Oil & Gas sector. Unfortunately, there is an anticipated skills shortage, which is where ICATS can help. This is reinforced by Paul Wolstencroft, a Director at Jack Tighe Ltd, who commented ‘Jack Tighe were one of the early operators to adopt the ICATS Training programme and have just completed their 9 year reviews. We have studied the value of the course and can state that since introducing the ICATS training in 2008 our re-work in 2017 was virtually zero. The work force is happier because they feel even more valued. The saving to Tighe is a substantial amount, and we are planning to strengthen the advantages of the ICATS scheme in the future.”

There are upcoming courses for ICATS Company Trainer and Supervisor at the Correx office in Northampton, or you can use one of the ICATS Approved Training Providers around the country to have your people trained ahead of the shortage.

Company Trainer Course

The next Company Trainer Course will be held on 26th and 27th June 2018 in Northampton, please call the Correx office on 01604 438222, or download the application form on the website, www.icats-training.org

Supervisor Course

The next Supervisor course will be held on 10th and 11th July 2018 also in Northampton. The application form can be downloaded from our website under the Supervisors Module tab, or places can be booked by calling the Correx office.

Approved Training Centres

The ICATS approved Training Centres are appointed to provide training for ICATS registered companies that wish to use their services. If it’s not possible for your staff to attend the Training Centre, arrangements can be made for the trainers to come to you if numbers are sufficient. We have 7 Training Centres situated in convenient locations around the UK.

<table>
<thead>
<tr>
<th>Training Centre</th>
<th>Region</th>
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<tbody>
<tr>
<td>Jack Tighe Ltd</td>
<td>East England</td>
</tr>
<tr>
<td>Livingstone Surface Treatments Ltd</td>
<td>Cumbria</td>
</tr>
<tr>
<td>MJ Services Ltd</td>
<td>NE England</td>
</tr>
<tr>
<td>Paintel Ltd</td>
<td>SW England</td>
</tr>
<tr>
<td>Offshore Painting Services Ltd</td>
<td>NW England</td>
</tr>
<tr>
<td>Stream Marine Training</td>
<td>Scotland</td>
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<tr>
<td>Wardle Painters Ltd</td>
<td>S Wales</td>
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Full details of the ICATS Registered Training Centres are listed on our website: www.icats-training.org, where you can also keep up to date with all the latest ICATS news.

Cathodic Protection Qualifications for the Pipeline Industry

Many in the cathodic protection industry are aware of the BS EN 15257 European Standard ‘Cathodic Protection - Competence Levels and Certification of Cathodic Protection Personnel’. This Standard has been in place since 2006 and since then the Institute of Corrosion (ICorr) has been responsible for providing training, for examinations and for the assessment of experience of Cathodic Protection (CP) personnel.

During this time Technicians, Senior Technicians and Specialists have been assessed and Certificated at Levels 1, 2 and 3 respectively in sectors covering buried, marine, steel in concrete, and internal surfaces.

In 2017, BS EN 15257 was superseded by BS EN ISO 15257 ‘Cathodic Protection - Competence Levels and Certification of Cathodic Protection Personnel - Basis for Certification Scheme’. ICorr are working hard at this time to implement the additional requirement of this ISO Standard and expect to have completed this work by early 2018.

<table>
<thead>
<tr>
<th>Standard</th>
<th>Level 1 CP Technician</th>
<th>Level 2 Senior Technician</th>
<th>Level 3 CP Specialist</th>
</tr>
</thead>
<tbody>
<tr>
<td>BS EN 15257</td>
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<tr>
<td>BS EN ISO 15257</td>
<td>Level 1 CP Data Collector</td>
<td>Level 2 CP Technician</td>
<td>Level 3 CP Senior Technician</td>
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<tr>
<td></td>
<td></td>
<td></td>
<td>Level 4 CP Specialist</td>
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<tr>
<td></td>
<td></td>
<td></td>
<td>Level 5 CP Expert</td>
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</table>

The existing Certification, under BS EN 15257 will be available for updating to BS EN ISO 15257 during their validity period. However, due to the changed structure within the ISO standard, the levels of Certification will now be:

Hence, a Level 2 Certificated CP Senior Technician in accordance with BS EN 15257 with a valid certificate will be able to apply to ICorr for a BS EN ISO 15257 certificate to Level 3. There will be no additional examination or assessment of experience as the grades are equivalent for a transition period.

Many CP personnel in the pipeline industry have successfully undertaken the training, examination and experience assessment, and have gained Certification - they are of known and established competence and this will give them, their employer and their employer’s clients, confidence that the work they undertake, within the range of activities defined in the Standard, will be competently and safely completed. The Standard also defines the levels of supervision required for particular tasks.

In the UK steel in concrete CP industry, the key clients require all personnel involved in CP activities to hold the ICorr BS EN ISO 15257 Certification and will require all its contractors involved in CP to meet the same requirements. This is likely to result in a large increase in demand for CP personnel training and Certification, and ICorr is making provisions for this increase. It is expected that other pipeline operators will follow National Grid in this policy, which will increase the confidence of both buyer and seller of CP services, that the staff are properly trained and competent in their tasks.

For more details, contact the Institute of Corrosion, Cathodic Protection Governing Board, in Northampton, tel: + 44 (0)1604 438222, e-mail: admin@icorr.org
The 2018 Congress, organised by ICorr, was held in Stratford last month. This was a fantastic success, with 150 delegates, the highest attendance ever in CEOCOR, and 25 exhibitors. Welcoming speeches were made by ICorr President, Sarah Vasey, CEOCOR President, Brian Wyatt, and Darren Thomas, the Asset Engineering Manager of National Grid, the Platinum Sponsor for the Congress.

Commitments were made by several UK companies to join CEOCOR, and there was the likelihood of increased cooperation between ICorr, Pipeline Industry Guild and CEOCOR regarding corrosion in the Water Industry.

A full report on the congress will be published in the next issue.

New Sustaining Member

Adler & Allan Cathodic Protection and Protective Coatings

Adler & Allan’s corrosion protection division provides specialist services and expertise in the application of Impressed Current Cathodic Protection (ICCP), Sacrificial Anode Systems, and surge prevention. They have a team of qualified cathodic protection engineers with over 25 years’ experience, providing specialist corrosion protection services globally to numerous industries including the water industry and the ministry of defence (MoD), covering feasibility studies, engineering design, installation, commissioning and maintenance.

Their fast acting polymer coatings are some of the toughest and most durable protective coatings available in the industry and offer a complete solution to containment and compliance. The coatings are waterproof, hydrocarbon resistant, and designed to add structural integrity to any surface. They are fast drying and withstand expansion, contraction and a wide range of temperatures, and can be used for practically any external or internal surface, protecting key assets against deterioration, degradation, and structural weakness.

Adler & Allan’s cathodic protection combined with their polyurea coating services are designed to provide protection that is guaranteed (via warranty) to significantly extend the life of critical assets, and prevent leaks and corrosion, providing the best solutions for their clients.

Corrosion Engineering Division

CED Working Day and Symposium on Atmospheric Corrosion in Industrial Applications

The tenth CED Working Day was held on Tuesday 24 April 2018 at The Centre, Birchwood Park, Warrington. Some thirty-nine delegates were welcomed by Chairman, Nick Smart. In addition, there were several exhibition stands, a visit to Wood plc test facilities, and CED Working Group Meetings.

Professor Stuart Lyon (University of Manchester) gave an introductory lecture entitled, ‘Introduction to atmospheric corrosion – mechanisms etc’. Given the large surface areas of materials exposed to the atmosphere, annual losses due to corrosion in the UK are in the order of several hundred million pounds. The atmosphere is one of the most common natural environments to which materials are exposed, however unlike most environments, the atmosphere does not provide constant exposure conditions. Thus, the corrosion rates of similar specimens exposed to the atmosphere have poor reproducibility. The main constituents of the atmosphere are essentially constant, however minor components can affect corrosion rates significantly, for example, the concentration of water vapour can vary over a large range. Three primary sources of air pollution are, volcanic action, vegetation and animal wastes, however sea-spray and dust from the earth also need to be considered. Pollutants are also classified as gaseous, particulate or aqueous (dissolved in rain) and man-made atmospheric pollution includes that from burning fossil fuels, chemical processing, sewage treatment and farming. Stuart went on to explain climate effects, macroclimates and microclimates, and that ISO 9223 provides a classification scheme for ranking pollution in a particular climatic location, which is based on the deposition rates of SO2 and Cl-. Atmospheric corrosion only proceeds when sufficient water is present to solvate ions generated during anodic and cathodic reactions. By definition, at 100% Relative Humidity (RH) condensation occurs. Metal corrosion cannot occur unless there is sufficient liquid water on the surface. The time during which RH exceeds a critical value is defined as the ‘Time of Wetness’ (TOW) and ISO 9223 also includes a scheme for ranking a particular climate in terms of TOW (hrs/year). The standard also provides a classification scheme for the ‘Corrosivity’ of an environment, based on the expected annual corrosion rate over 1 year. Finally, specific mechanisms relating to the atmospheric corrosion of iron and zinc were outlined.

Richard Bewell (Engineering Manager, BAM Nuttall) gave a presentation on, ‘Atmospheric corrosion prevention in the windpower industry’. The ‘Blyth Demonstrator Project’ (located about 5.8 km off the North-East coast of
Professor Geraint Williams (Swansea University) addressed, ‘Preventing corrosion of galvanized steel in the non-chromate age’. The EU has set a ‘sunset’ date of 2019 for the replacement of hexavalent chromium corrosion inhibitor. The problem of how the performance of new inhibitor pigments could be quantified under atmospheric corrosion was raised. Methods included, external weathering, accelerated salt spray and EIS (immersion in corrosive solutions). Assessment of organic coatings carried out at Swansea University included the use of a Scanning Kelvin Probe (SKP). This involves the use of a reference electrode in a test chamber, without physical contact – i.e. not in a ‘bulk’ electrolyte, providing a ‘spatial map’ of corrosion potentials. Ion exchange materials are promising chromium-free anti-corrosion pigments, in which ‘smart release’ inhibitors are only released whenever a corrosive environment is encountered. ‘Hydrotalcite’ is a layered double hydroxide of general formula Mg₆Al₂(CO₃)₄(OH)₁₆·4H₂O. The carbonate anions that lie between the structured layers are weakly bound giving the material anion exchange capabilities. Inhibition arises by the sequestered aggressive Cl- ions being exchanged for less aggressive ions. The action of this ion exchange mechanism was studied on hot-dip galvanized steel by SKP. The use of benzothiazole inhibitors as a non-chromate alternative was also mentioned. The mechanism is to stifle the underfilm oxygen reduction reaction. Finally, the next generation of Zn-MgAl alloys for galvanizing was introduced. These are very heterogeneous, comprising a three phase material.

The second annual Paul McIntyre Award was presented at the meeting to John Broomfield, by Sarah Vasey, President of The Institute of Corrosion. This Award is presented to a senior corrosion engineer, over the age of 30, who as well as being a leading practitioner in his field, has advanced European collaboration and international standards development (in keeping with Paul’s area of interest). Recipients must have established international reputations in the field of corrosion engineering. John had originally a background in spectroscopy and applied these studies to monolayers on steel surfaces. Later, he worked on problems with PWR reactors in the UK, later transferring to Taylor Woodrow and subsequently carried out work on concrete prestressed pressure vessels. Some very interesting slides on the pioneering work he was involved with were shown.

At the close, Nick Smart thanked the speakers, the delegates for attending the working day, Wood plc staff for the conducted tours of facilities, and the exhibitors, for a successful and enjoyable event.

Editor’s note: Text copyright: David Nuttall, released under CC-BY-NC.
The May meeting of the Young Engineers programme was held at the CB&I offices in London on the 16th May. The topic was coatings which was presented by David Mobbs and was warmly received by the enthusiastic audience. The presentation covered the high priority areas of coating including the requirement to qualify products to standards, the standards and what they mean, the testing methods required to achieve this qualification, and also looked at some case histories of coating applications good and bad.

Prior to the presentation the case study for the programme was presented to the delegates by Richard Carroll of Shell, who highlighted the importance of working together in the teams to deliver the required information as detailed in the document. In a change to previous years there will be only one case study for all the teams with each team giving a presentation in a competition to be delivered at the November ICorr London branch meeting.

This year the case study covers a number of areas in which the students are being trained including, materials, coatings, CP, failures, and the management of change. The mentors this year are John Boran, Rob Doggert and Chris Googan, and the teams will meet their mentors in the coming weeks to get started on the case study. A LinkedIn page and drop box, have been set up for the teams to help them with this process.

The next meeting on Painting, Fire Protection and Linings will take place on the 29th June again being held at CB&I offices on London.

Again we would like to thank our hosts CB&I especially Sadegh Parvisi for organising the venue, our sponsors BP and our speakers, organising committee and delegates without whom we would not be able to stage this event.

Aberdeen Branch

The third branch event of 2018 took place on Tuesday the 27th March, with 32 attendees representing major companies including, Aberdeen Foundries, ABR Engineering, Atkins, Axiom NDT, CAN Offshore Ltd, DNV GL, ICR Integrity Ltd, Lloyds Register, Lux Assure Ltd, Maersk Oil (now TEP UK Ltd), Oceanics, One Subsea, Plant Integrity Management Ltd, PROSERV, Shell UK Ltd, Sonomatic and Wood plc.

The event was an industrial visit to the premises of Element Materials Technology in Aberdeen, to attend a technical presentation of “Sour Service Testing of Carbon Steel Girth Welds” by Phil Dent, Element’s Global Corrosion Specialist, followed by a visit to the new H₂S / Sour Service Laboratories. Ian Farquharson, General Manager of Element Aberdeen and Edinburgh branches, introduced Element, and noted that is ranked as the 5th biggest materials testing and certification firm in the world following its recent merger with EXOVA. He also mentioned that Element Aberdeen is a UKAS and ISO/IEC 17025 accredited laboratory which offers one of the most comprehensive ranges of metallurgical materials testing and analysis services in the UK.

Phil Dent started his technical presentation by defining sour service conditions, followed by a description of the various types of sour service cracking mechanisms, and the environmental factors affecting the susceptibility of materials under sour service regimes. The sour service cracking mechanisms which were presented included Sulphide Stress Cracking (SSC), Intergranular Stress Corrosion Cracking (ISCC) and High Temperature Hydrogen Induced Stress Cracking (HTHISC).

Phil Dent, Element’s Global Corrosion Specialist explains SSC Phenomenon.

David (Dave) Griffiths

The Institute of Mechanical Engineers training centre in Sheffield (Engineering Training Solutions) has confirmed that Dave Griffiths has retired from his consulting role in support of the ICorr courses provided by IMechE.

Dave’s role with IMechE, and previously ARL, was multi-faceted and has been a key part of the ICorr training provided first in Rotherham, and latterly in the brand new training centre in Sheffield. Dave delivered training to many of the Painting Inspector groups but also acted as Scheme Manager and provided invaluable support to ICorr’s Professional Development Training and Certification (PDT/C) Committee over a considerable number of years.

Dave was recently awarded a plaque and certificate by ICorr President, Sarah Vasey, in recognition of his contribution to training, and all at ICorr take this opportunity wish him well.
The procedures for the H2S sour service axial tensile test, high such as those from ASTM, IP MIL and NACE. Paul summarised tests and follow international testing standards and protocols HIC, SSC tests and also more specialised Full Ring and SOHIC qualification for sour service applications and offer standard corrosion testing for sour and non-sour applications, hydrogen environmental testing simulations, including pipeline testing, pitting, full ring tests, as well as SCC tests.

Element Laboratories in Aberdeen also specialise in materials qualification for sour service applications and offer standard HIC, SSC tests and also more specialised Full Ring and SOHIC tests and follow international testing standards and protocols such as those from ASTM, IP MIL and NACE. Paul summarised the procedures for the H2S sour service axial tensile test, high temperature / high pressure, electrochemical tests and strain gauging.

The questions raised by attendees during the technical presentation and laboratory visits were well responded to by the hosts. This event attracted a high interest within the professionals and executives of major oil and gas operators, engineering consultancies, and service companies in Aberdeen, to visit one of the major testing and materials qualifications bodies here in United Kingdom. Overall, it proved to be an excellent event in every respect.

The April evening meeting had 78 attendees, and followed on from a very successful visit to Aberdeen by the Marine Corrosion Forum.

George Gair of Subsea 7, started the evening session with a thought provoking theme 'Subsea Inspection – The Future', that considered many aspects of the current cost reduction environment where there is a major focus now on how to reduce costs by incorporating new philosophies / technologies.

Very clearly the drive is to produce new and robust methods of harvesting sensor data, and subsea hardware suppliers are looking at increased in-situ equipment monitoring and intervention methods (the oceanographic community has developed remote seabed environmental monitoring systems).

George Gair highlighted many significant indicators that show a definite trend towards smarter systems, a key driver being to learn and incorporate inspection technologies from other industries such as Aerospace, Automotive, Medical and Power Generation, together with more efficient use of gathered data.

Monzar Najami and Hooman Takhtechian of Oceaneering International followed on with a similarly stimulating discussion on the theme of, 'Integrity Management of Brownfield Projects: Challenges and Rewards', highlighting the many important analysis and data gathering areas of modern RBI – Risk Based Inspection methodologies.

The presenters informed the audience that the greatest challenge to developing and implementing an asset integrity programme during Brownfield development projects, is the fact that project schedule and milestones often take primacy over integrity management processes, and in particular emerging vital integrity related interventions which can lead to conflict and disagreement. Any delay in the implementation of these activities impedes the Integrity Management Programme (IMP) and increases the level of risk to the facilities in the operating stage.

Key stages in an IMP project were highlighted as:

a) Identify stakeholders early in the project (project team, operations, planners, site personnel)

b) Define strategies and processes and add activities to the construction plan (integrated project activity approach)

c) Analyse historical data (collect the available list of failures, anomalies and review root cause analysis)

d) Material fitness for new process (review threats assessment and existing material suitability)

e) Baseline inspections: Get in early (define scope and input your inspection requirements in the manufacturer’s ITP)

f) Brownfield revamp activities: Scrutinize output (repair recommendations were challenged and resulted in major cost saving, and change in material selection)

g) Tagging and RBA output alignment with the existing CMMS (understand the existing Computerized Maintenance Management System prior to your RBA to avoid major re-work)

h) Deployment of new and advanced inspection technologies (to achieve major cost savings)

A wide range of questions followed the very comprehensive presentation and all the presenters’ slides are available on, https://sites.google.com/site/icorrabz/resource-center.

For information about all forthcoming Aberdeen branch activities, please contact, Dr Yunnan Gao, ICorrABZ@gmail.com. To sign up to the branch mailing list, go to, https://sites.google.com/site/icorrabz/home

ICorr Aberdeen will host its Annual Corrosion Awareness Event on Tuesday 14th August 2018. For further details please contact: Corrosion Awareness Chair, Steve Tate on, steve_f_tate@hotmail.com
London Branch

The last presentation of the 17/18 season was a joint meeting with NACE UK, and Francois Lirola of Saipem, gave a very interesting talk entitled, “Fusion Bonded Joint: an innovative technology for cost effective plastic pipe installed in J&S lay”.

In deepwater, corrosion protection of flowlines is becoming a major issue. Conventional corrosion allowance of carbon steel flowlines, or cladding, leads to excessive procurement costs, installation weight, welding and NDT challenges. Francois introduced an interesting alternative to achieve an acceptable corrosion protection - is the use of plastic liners. However, plastic lining has been mostly limited up to now to reel lay. SAIPEM has developed and patented an innovative and cost effective field joint system, the Fusion Bonded Joint (FBJ), which can maintain the corrosion barrier across girth weld locations along the flowline. It has minimal impact on the offshore laying rate and it is based on field proven technologies and methods that are commonly employed in gas transportation networks. The design and fabrication of the FBJ system were explained, and the results of the extensive qualification that has been carried out, were shown.

This excellent presentation led to a high level of discussion by the audience, and the chairman thanked Francois for the time taken in preparing this talk and for coming to London to deliver it.

Midlands Branch

The branch held their AGM at the evening meeting on 11th April 2018, which was hosted by Amey at their International Design Centre in Birmingham.

The outgoing branch Chairman, Trevor Box, thanked the members for their continued support, those that had taken the time to prepare talks and presentations over the previous year and thanked the organisations, companies and individuals that had offered sponsorship, either by way of providing the meeting venues or refreshments at these. The committee members were elected and the new Chairman was Bill Whittaker.

Following the AGM, a trinity of experts in galvanic anode technology for use in reinforced concrete gave presentations on developments in the industry, starting with Roberto Giorgini, consultant to Mapei, who had kindly travelled from Holland for the evening. Roberto’s presentation looked at design criteria and reviewed the basis of design for the use of galvanic anodes in concrete, and compared this with the more conventional design processes used for galvanic anodes in other electrolytes. It was noted that agreed design procedures for galvanic anodes in concrete are not documented and reliance on data from the manufacturers is required.

Gareth Glass, from Concrete Preservation Technologies (CPT), presented “Polarisation and Responsive Behaviour of Galvanic Anodes”. This covered the basis for galvanic and hybrid protection technology, the use of potential mapping and potential changes in the early age assessment of galvanic systems, the responsive behaviour of galvanic systems to environmental changes, the importance of responsive behaviour in aged systems and the use of corrosion rates in the assessment of protected structures.

Gareth explained that a simple method of checking system installation was to measure two potentials at and away from a sample of the installed anodes, and potential mapping to show early age changes in steel potential was presented. Data were also presented that indicated the current output of aged systems may fall to low levels in dry or sheltered environments and that re-activation occurs when such systems get wet, including in systems older than 10 years. It was further shown that data can be analysed and translated into corrosion rates in the assessment of the structure. Recommendations included the production of brief commissioning reports, using potential mapping to assess performance, taking into account long term responsive behaviour especially in aged sheltered systems that may dry out, and using corrosion rates to assess the condition of the protected structure.

George Sergi of Vector Corrosion Technologies completed the evening’s talks with a presentation on a new dual-phase anode system for protection of steel reinforcement that he had been instrumental in developing with Vector. George described the process by which application of an impressed current charge can increase the pH around the reinforcement and passivate the steel where corrosion is taking place, and presented some data on the extent of charge required to do this based on laboratory experiments. The presentation explained how the Vector product could provide a charge phase without an external dc power supply.

After the presentations a lively panel discussion was held with the three experts responding to the audience questions. The Chairman thanked all presenters for the time taken in preparing and attending the very informative meeting.
A Fighting Ship and Fighting Corrosion
The Mary-Rose and the Dynamic Duo – Coatings and Cathodic Protection

Thursday 25 October 2018, 17:30 for 18:00
SCI, 14/15 Belgrave Square, London, SW1X 8PS

Organised by SCI’s London Group and the Institute of Corrosion – London Branch
This evening event includes two presentations, followed by a networking reception at 19:30. Attendance to this event is free of charge, however places are limited. Please register today by visiting: http://bit.ly/2k6CXUR
The event is open to SCI, ICorr, IOM3, LMS and TWI members and guests.

Characterising marine archaeological iron degradation: worth a shot?
Dr Eleanor Schofield, Mary Rose Trust
The excavation of Henry VIII’s Mary Rose in 1982 produced a vast collection of Tudor iron artefacts, mostly in the form of cannons and shot. Iron artefacts can survive in marine environments where the exposure to oxygen is limited. However, the incorporation of chlorine during burial can make post-exavation conservation particularly challenging. This presentation will describe how different corrosion treatments on iron shot have been explored using synchrotron light, and how this information will inform our future conservation strategies.

Coatings and Cathodic Protection – The Dynamic Duo
Jim Glynn, Institute of Corrosion, and BEANNY Ltd
The presentation will take a high level, light hearted look at how these two corrosion control tools make the world a better and safer place both onshore and offshore, at least… most of the time.

Cathodic Protection (CP) and Coating example applications will be drawn from a number of industry sectors, plus an actual offshore case history ‘A Tale of Two North Sea Structures’…

Book today!
E: conferences@soci.org
T: +44 (0)20 7598 1561
www.soci.org/events
Industry News

Shropshire Iron Bridge

Constructed in 1779, the 378-ton Shropshire Iron Bridge was designed by Abraham Darby, and was the first cast-iron single-span arch bridge in the world, but is now suffering from cracking due to stresses in its ironwork. The bridge now requires conservation work, estimated at approximately £3.6 M, which is being undertaken by English Heritage, who will be repairing the cast iron frame, conducting masonry repairs and repainting the ironwork. The deck will also be resurfaced with a new waterproof membrane, all of which is vital to preserve the Iron Bridge for the future. As part of the refurbishment, the ironwork will be repainted in its original dark re-brown colour, which was uncovered through analysis of paint samples taken from the centuries-old iron span. This revealed that the original coating was a lead-based oil paint.

Standards up-date

The following is a list of new standards relative to our industry published by ISO, CEN (including joint ISO standards) and SSPC, during the past two months.

ISO

ISO 24817:2017 Petroleum, petrochemical and natural gas industries — Composite repairs for pipework — Qualification and design, installation, testing and inspection

ISO 2063-1:2017 Thermal spraying — Zinc, aluminium and their alloys — Part 1: Design considerations and quality requirements for corrosion protection systems

ISO 14918:2018 Thermal spraying — Qualification testing of thermal sprayers

CEN

EN ISO/TS 19397:2018 Determination of the film thickness of coatings using an ultrasonic gauge

The standard describes a method for determining the film thickness of coatings on metallic and non-metallic substrates using an ultrasonic gauge.


The standard describes the types of paint and paint system commonly used for corrosion protection of steel structures. ISO 12944-5:2018 also gives guidelines for the selection of paint systems available for different environments (see ISO 12944-2) except for corrosivity category CX and category Im4 as defined in ISO 12944-2 and different surface preparation grades (see ISO 12944-4), and the durability grade to be expected (see ISO 12944-1).

SSPC, The Society for Protective Coatings, guide for salts on new steel

SSPC-Guide 24 describes soluble salt testing procedures for new and shop-coated steel. The publication offers guidance on where and how frequently to test for salts on steel that is either previously uncoated or was shop-coated and requires further coating in the field. The new technology guide is meant to help owners, specifiers, inspectors and contractors determine logical locations for testing such steel surfaces. SSPC notes that new steel can become contaminated in shipping and storage, and during erection or installation, leading to a need for testing and in some cases remediation prior to coating in the field. The guide is available via the SSPC Marketplace and the SSPC app.

Supersedes the 2007 version.

Market Study: PUR - Paints and Coatings

For the first time, Ceresana has examined the global market for PUR paints and coatings in detail. The market research institute forecasts revenues generated with these products to rise to approx. USD 20.3 billion until 2025. The most important application areas for PUR paints and coatings are furniture and wood processing, transportation, and other industries. In 2017, approx. 53 % of global demand was registered in Asia-Pacific, followed by North America and Western Europe.

Demand for PUR coatings for vehicles (OEM and refinishing) accounted for more than 28% of the global market in 2017. Of all application areas of PUR coatings, the transportation segment (OEM) will account for the highest growth in percentages until 2025 at rates of 3.9% per year.

Ceresana expects the construction segment to increase its demand for PUR coatings by 2.6% per year. This downstream market is decisively affected by residential construction, commercial construction, and projects on infrastructure construction.

Demand for PUR coatings in the industrial sector amounted to about 325,000 tonnes in 2017. Protective coatings for industrial facilities and machines account for the major share within this application area. More details can be found at www.ceresana.com/en

Visit the ICorr website for all the latest news

www.icorr.org
Evaluating the risk of hydrogen embrittlement: new simulation of cold crack formation in high-strength steels

The Fraunhofer Institute for Mechanics of Materials IWM has recently issued a report on hydrogen embrittlement in high-strength steels, which play a vital role in the construction of modern vehicles and machines. If these steels are welded during the production of components, mobile hydrogen atoms can cause problems within the material, as they accumulate slowly at highly stressed areas of a component, resulting in the steel becoming brittle at these locations. This can result in so-called cold break formations which can lead to component failure. Dr. Frank Schweizer of the Fraunhofer Institute for Mechanics of Materials IWM has developed a simulation method with which component manufacturers can assess cold break tendencies and adjust their production accordingly.

High-strength steels are used to save material in lightweight construction and for structural components that require exceptionally high durability. When welding these components, various factors may lead to the unwanted formation of fine cracks, which may spread and even lead to component failure. It is very hard or impossible to assess these factors with experiments and as a result, the reject rate of laser welded high-strength steel components is high.

The special feature of this new simulation method is that it also takes into account the effect of so-called hydrogen traps, which greatly influence the “movable” hydrogen occurring with different laser welding connections. With higher hydrogen content, the thermomechanical behaviour of the material grows more relevant for the formation of breaks, the hydrogen atoms slowly collect in the narrow area of the heat-affected zone where tensile residual stress is especially high, and even after the steel has cooled down, hydrogen can collect at these points and the steel grows brittle. Hence even after hours, or days, cracks may form and can lead to the component’s rejection. Simulation results can be used to optimize laser welding processes preventing component failure, as the laser process parameters can be adjusted to keep interactions of cold crack risk factors as low as possible. Further details can be found at, www.fraunhofer.com

TQC and Sheen combine and are rebranded

After an acquisition in October 2017, testing instrument manufacturer, Sheen Instruments, and paint test equipment manufacturer TQC BV, have merged under the same brand—TQC Sheen.

Under the TQC Sheen brand, both companies will represent a range of paint testing equipment options, including viscosity meters; automatic film applicators; scrub and scratch testers; and gloss and colour meters, among others.

TQC Sheen has its headquarters in the Netherlands, with the company’s production, logistics and application lab located near the city of Rotterdam. The newly merged firm has sales offices in Germany, the U.K., Norway, the United States, Italy, Singapore and South Korea, along with a network of dedicated distributors around the globe.

A cross-reference list has been prepared so that the new product numbers of former Sheen products can be looked-up. More details can be found at, www.tqcsheen.com

British Coatings Federation Welcomes New President

The British Coatings Federation, which represents members of the paints, printing inks, powder coatings and wallcoverings industries officially welcomed its new president, David Beckford, at its recent annual conference. David is managing director of Pronto Industrial Paints, and succeeds Vincent O’Sullivan, of PPG Architectural Coatings, who served as president of BCF for the standard two-year term.
Belzona opens new training Centre

Belzona, a leader in providing industrial protective coatings and repair composites, has opened a new state of the art Training and Distribution Centre situated at their head office in Harrogate. The new £6 million facility will more than double Belzona’s current distribution area floor space, with 12 metres of usable height, adding around 4000 pallet spaces and 168,100 cubic feet of total floor area. The new training area features a new fully equipped presentation suite as well as a new practical training/demonstrating classroom, showing Belzona’s continued focus on training and raising global application standards.

Professor Brian Cherry

The death has been announced of Brian Cherry, a founding member of the Department of Materials Engineering at Monash University in Australia.

Brian, born in Leicester, UK, holds a PhD from the University of Cambridge, and joined Monash University five decades ago. He was a Fellow of ICorr and held various positions at Monash, ending with Professor, and then Honorary Professor Emeritus. At Monash, Brian was appointed to many senior roles including Associate Dean of Research and was instrumental in the establishment of post-graduate degrees at Monash - a key legacy, and above all, he was a gentleman, an educator, and a mentor to generations. He richly deserved the title of Mr. Corrosion (actually, Professor Corrosion!!) in Australia and he will be greatly missed.
The industry is well versed with the techniques of corrosion mapping of vessels and pipework. However, storage tanks are also susceptible to a range of internal and external corrosion processes. As such, inspection plays a major role in effective integrity management of storage tanks. Historically, corrosion mapping and inspection of the floor has relied on emptying the tank and personnel entry for cleaning and inspection. The industry does not like working in confined spaces and steps have been taken towards zero-man entry over the lifetime of storage and process vessels. Internal inspection for other problems also takes place at the same time. This means tanks can be out of service for significant periods of time.

A novel robotic system has been developed, which includes a range of methods for inspection of storage tanks while in-service. A key element of this is robotic cleaning and inspection of the floor, which forms part of a comprehensive inspection, whereby the tank shell is also inspected non-intrusively using ultrasonic corrosion mapping supported by statistical analysis. This article gives an overview of the technologies involved, and how these link into more efficient integrity management of storage tanks.

In-service inspection is a cost effective alternative to out of service inspection for situations where the likelihood of degradation requiring repair has been assessed as low. It can provide significant benefits to tank operators, such as removing the need for shut downs, does not reduce critical storage capacity, minimises site personnel requirements during plant shut downs, eliminates hazards associated with personnel entry to tank internals, and improved knowledge of tank floor condition, compared to existing out of service techniques.

### In Service Storage Tank Floor Inspection

The floors of storage tanks can be susceptible to internal and/or external corrosion which may lead to failure with severe consequences. Safe management of tanks therefore relies on inspection of the floor at appropriate intervals. Historically this inspection has been carried out by tools and techniques that rely on internal entry following emptying and cleaning. This type of inspection relies on the tanks being taken out of service. The robotic tank floor capability is part of a comprehensive inspection service and is aligned to the requirements of API 653 (Tank Inspection, Repair, Alteration, and Reconstruction), a standard developed and published by the American Petroleum Institute (API) which covers the inspection, repair, alteration, and reconstruction of steel aboveground storage tanks used in the petroleum and chemical industries) and EEMUA 150 (EEMUA Publication 150 Above ground flat bottomed storage tanks, is a guide to inspection, maintenance and repair), with the tank remaining in operation throughout. The key features of this robotic system are,

- Advanced ultrasonic immersion transducers system
- Integration with proprietary inspection project management and analysis software
- Suction and Discharge pumps (optional)
- Umbilical cord and Carrier with 106 m to 115 m cable length.
- Advanced navigation system.
- Purge System for products below 37.5 C Flashpoint.
- Camera and Light system (optional depending on product).
- Temperature range ~ 20 C to +50 C

This approach gives a high degree of assurance of tank floor integrity while avoiding the need for costly shut downs and minimising the hazards associated with confined space entry. The diagram below shows the steps taken to inspect and evaluate the integrity of the tank floor (Figure 1).

### Assessment and Planning

By working with the client to plan the inspection of the tank floor, both operational and integrity requirements can be considered. The key points for the operational and integrity aspects are summarised below.

#### Operational

Successful in-service inspection of tanks relies on comprehensive planning of all operational aspects. This relies on working closely with the tank owner/operator to establish a critical design, operational and safety data relevant to carrying out the inspection. With this information a detailed project plan can be developed. This covers logistics, equipment and manpower requirements as well as site requirements to facilitate the inspection.

#### Integrity

An approach similar to planning and assessment for the Non-Intrusive Inspection (NII) of pressure vessels is adopted, which is based on the DNV-RP103 (recommended practice for non-intrusive inspections). This entails developing a detailed understanding of the degradation threats and associated risks to define the most appropriate inspection strategy, e.g. Type A or Type B NII.

Type A inspection applies in situations where there is a low probability of degradation based on previous inspection history. Type B inspection applies when there is some degradation expected but it is not expected to be such as to threaten integrity in the medium term.

Detailed inspection requirements, i.e. probability of detection, accuracy and coverage are then defined for each zone of the tank. Finally, inspection plans, defining the inspection technique(s), coverage and locations for inspection are developed.

#### Screening

Prior to the robotic inspection, Short Range Ultrasonic Testing (SRUT) method is used to screen the annular ring for any degradation. As part of the screening step, Acoustic Emission (AE) is also deployed with the view of capturing the high activity region and help to evaluate which type of inspection to be applied, i.e Type A or Type B.

While the AE technology is still under evaluation, the idea is to use AE to confirm that corrosion is not active, in which case, a Type A inspection will be applied. For tanks where a Type B strategy applies, the acoustic emission is used to identify areas of corrosion activity for prioritisation of coverage for the ultrasonic inspection. This ensures that the sample inspection includes representative areas of corrosion.

#### Quantitative Robotic Inspection

By following the previous steps, the inspection strategy and plan can be developed, and using this information, the inspection robot is then deployed accordingly.
Wall thickness values are then used for the statistical evaluation of the short period of time. Once the wall thickness values have been extracted, they are then used for the statistical evaluation of the tank floor.

**Evaluation**

Corrosion has been found to show statistically regular behaviour in a wide range of situations including on tank floors. This means that a sampling approach is applicable, in which the results from a limited coverage inspection can be used to estimate the condition in the areas not inspected. Sonomatic has considerable experience in the development and application of statistical methods for analysis of inspection data, and was primary author of the “Recommended Practice for Statistical Analysis of Inspection Data” developed by the HOIS Joint Industry Project. HOIS is a joint industry project which has been running for more than thirty years and has more than forty project partners comprising Oil and gas producers (operators), Non-destructive testing (NDT) service providers, NDT equipment vendors and a regulatory authority (UK HSE).

The methods in this document are used as a basis for statistical analysis of tank floor inspection data. This process covers:

(i) automated analysis of the data using advanced signal processing algorithms to obtain wall thickness values.
(ii) Derivation of wall thickness distributions.
(iii) Identification of applicable statistical fit type and parameters.
(iv) Estimation of minimum wall thickness and probabilities for limiting conditions.

The use of sample inspections supported by statistical analysis conforms to the requirements of API 653 for internal inspection of tank floors.

The actual evaluation of the wall thickness values, depends on the type of inspection applied. For a Type A inspection, the idea is to confirm the absence of degradation and this is typically done by examining the wall thickness values extracted from the ultrasonic signals. For a Type B inspection, it uses the wall thickness values to identify the underlying statistical distribution and then making minimum remaining wall thickness estimates of the un-inspected area (Figure 2). It is important to note that depending on the inspection performance, Extreme Value Analysis (EVA) can be used for evaluation. Using the estimates of the minimum wall thickness, then the remaining life assessment is derived.

**Fitness For Service (FFS) and Remaining Life Assessment (RLA)**

A key aim of the novel inspection service is to provide information which allows effective integrity management decisions to be made, and support clients’ integrity requirements by providing fitness for service and remaining life assessments, based on inspection data collected in the field.

In the case of tanks this covers complete assessments in accordance with API 653 or EEMUA 159, and covers all levels of assessment from simple hand calculation checks on remaining wall thickness through to advanced nonlinear finite element analysis in accordance with the Level 3 requirements of API 579 (Figure 3). A key part of the approach to fitness for serviceassessment is application of statistical methods where the inspection has been performed on a sampling basis, as detailed in the previous section. The fitness for service and remaining life assessments are used to make recommendations on any repair and maintenance requirements as well as defining future inspection intervals.

The fitness for service capability applies to tanks as well as other equipment found on tank farms, e.g. pressure vessels, pipework and pipelines.

**Cleaning of Storage Tanks**

On top of providing in-service tank floor inspection, the company also provides cleaning services of storage tanks, and have experience of cleaning all types of tanks, and can treat sludge in a number of ways using highly trained technicians to meet and exceed the latest compliance and health and safety standards. The sludge can be locally disturbed to clear a space for the Ultrasonic Inspection, or the sludge can be marshalled into a particular location in the tank. The sludge can also be mixed in with the product higher up in the tank, or pumped from the floor to the roof manway and then into temporary tankage for treatment or into a neighbouring tank.

**Summary**

Difficult to reach locations and challenging conditions need innovative solutions that are guaranteed to work first time. By combining screening techniques with immediate inspection of areas of concern, inspection times can be intelligently reduced to focus on getting detailed information from the areas of plant which need attention. Accurate data enables informed decisions on continued service or replacement.

A major advantage of this novel testing procedure is that it was an ‘iterative process’, whereby a tank farm operator could screen all the tanks and identify which were detected as the worst. On opening the tank and carrying out full base plate inspection it would be possible to check the model to see how accurate it was, and by the time the third tank for example had completed its full inspection, the model would be fairly accurate, and could be used in future with more certainty.

**Editors Note**

The novel robotic inspection system was developed by Sonomatic, with the name S.O.N.A.R. Sonomatic bring a unique combination of screening and inspection tools to help solve inspection and integrity problems. They have a diverse, in-house team which bring together the disciplines of mechanical design, electrical design, software, inspection and data analysis, and all inspection engineers are suitably qualified and experienced personnel. They work either directly for the client or as a project team subcontractor, to overcome project challenges and find solutions that work.
Principles and Practice of Cathodic Protection Monitoring

Stephen Tate, Corrosion Awareness Chair, ICorr Aberdeen Branch

Worldwide, both industrial and non-industrial corrosion, continues to consume a significant proportion of GDP, estimated at 3.4% [1]. Cathodic Protection (CP) plays a very important role in reducing infrastructure losses in aggressive environments, where metals would otherwise freely corrode towards eventual failure. In value terms, the provision of CP is an extremely cost-effective corrosion prevention technique relative to total Project Build Costs, can be as low as 1% of CAPEX.

CP may be applied both internally and externally and the benefits are very well known to the corrosion control sector, but the provision of a reliable Cathodic Protection system for ‘Life of Operations’, can often present complex challenges during design, construction, commissioning and in ongoing maintenance of such systems. Regular cross-discipline communication during these discreet phases is essential to providing a fully serviceable CP system.

Cathodic Protection Monitoring (CPM), which is available through a wide range of techniques, ultimately confirms whether the project processes have in fact delivered a successful and maintainable CP scheme. Regular CPM provides alerts to Integrity Managers, as to ongoing CP system performance and any failing areas requiring remediation for optimal corrosion protection [2].

This article will consider how CPM can ensure effect CP during the lifetime of a structure.

Principles and Advantages of Cathodic Protection

There are 2 commonly used types of Cathodic Protection, ICCP – Impressed Current Cathodic Protection and SACP – Sacrificial Anode Cathodic Protection [3]. Onshore, for major projects, long term protection tends to be of the ICCP type, utilising a mains power supply and inert anode materials. For offshore installations, the use of SACP has tended to be the norm being generally more reliable, but more recently there has been a resurgence of ICCP usage with LOF – Life of Field Extensions, and Subsea Retrofits (Figure 1), especially in the North Sea area [4] and [5].

The principle of cathodic protection (CP) is to connect one or more external anodes to the metal to be protected and to pass a positive DC current between them, so that the protected metal becomes cathodic instead of anodic, in its normal operating environment.

CP is most commonly (but not exclusively) applied to steel structures, carbon steel being a low cost material is widely used but easily corrodible and inherently unstable as a material. Most usually these days, a CP scheme is specified so as to provide supplementary external corrosion protection with the main protection being provided by high quality (but still thin) multi-layer protective coating systems. By and large the selected coating system is factory or yard applied to pre-fabricated components, with field joints and welds being completed later at site with the intention of achieving similar protective properties. Some mechanical damage is however unavoidable, despite the best efforts of all concerned [6].

Whilst quality control and coating performance of field coating repairs is infinitely better now than has been previously been the case, there are still instances occurring where site repairs to coatings have become defective and anti-corrosion properties compromised. Further, mechanical damage to coatings during installation phases of fabricated pipelines and structures, ensures that no coating system is ever 100% defect free (Figure 2).

An effective CP system can provide valuable insurance against localised degradation, metal loss and penetration of component parts that may otherwise lead to in-service structural failure, pollution and fatalities.
Types of Cathodic Protection (CP)
CP has so many domestic, industrial and leisure uses from heating fuel tanks to, bridge pile foundations, process plant, ocean going vessels, offshore production facilities, reinforced concrete structures and windfarm towers, the principal sources of CP being provided by:
A) SACP - Sacrificial Anode CP, (No External Power Source required but Electrical Isolation of Structures from Copper Safety Earthing Systems is usually preferred, to ensure Adequate System Performance / Anode Life).
B) ICCP - Impressed Current CP, (Continuous Power Source Required / Electrical Isolation of Structures to be protected is preferred but not essential as Power Sources can be designed to have Variable / Compensatory Current Output), though it should be remembered that excessive ICCP can cause significant interference to Foreign Structures / Services and this may require remediation as a result.

Anode Material Selection
The Galvanic Series provides a simplified guide to anode reactivity / likely driving voltage.

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Isolation Limits
The vast majority of CP Schemes operate on the principle of purposely designed and proven isolation, i.e. the effectiveness of the CP System is ensured by limiting electrically the surface area to be protected, through the provision of either one-piece pre-fabricated monolithic isolation joints, or flanged joints containing insulating gaskets and fixings (Figures 4 and 5). In the case of pipework, buried pipework will normally be isolated from any above ground pipework, and lightening protection devices installed at all above ground / below ground interfaces. It should be ensured that CP Isolation, if specified in the original CP design, is maintained. This has 2 main benefits:
1. Reduces Capex and Opex costs for CP schemes, due to there being far lower power requirements.
2. Extends CP System life, especially for SACP Schemes.

CP Criteria and Terms
CP Operating Criteria are defined in national and company specific codes and may sometimes be modified to suit specific local operating conditions, but measurements must always be performed against consistent and previously agreed limits with the highest value, commonly known as the CP ‘drain

Figure 3. Example of SACP, as applied to the Trawling Industry.

Figure 4. Example of ICCP Conventional Monolithic Isolation Joint.

Figure 5. Example of fully insulated flanged joint with spark gap device (for lightning/surge protection.)
The base value (before CP is applied) is normally referred to as the ‘natural’ potential value of the material, versus a suitable reference electrode for the surrounding environment, seawater, soil or other conductive electrolyte. An ‘energised’ value is achieved on application of the external current source, which may be ICCP or SACP. Energisation may however introduce a resistance error in CP potential measurement, or IR drop (as per Ohm’s law $V=IR$, where $I$: represents the CP current; $V$: represents the total voltage drop; and $R$: represents the current path resistance). Elimination of the IR drop will provide the true ‘polarization’ value at the surface. This polarized value is normally obtained by temporarily interrupting the ICCP / SACP power sources where this is possible and usually requires multiple synchronised current interruption devices, that are preferably GPS controlled.

**Principles of Cathodic Protection Monitoring (CPM)**

CPM has clearly advanced in the last 30 years or so, even more so in the last 10 years with huge advances in data memory capabilities, methods of data transmission, remote monitoring and of course the deployment of a range of GPS devices, and mostly recently drone technologies for performing some of the maintenance and inspection tasks. However many of the earlier technologies from the last century still have a valuable place in supporting CPM and in particular in confirming the installed quality of as-built schemes and their associated protective coating systems (Figure 6).

**Types of CPM**

CPM can be of three main types,

1. Manual CPM, normally utilising a digital multi-meter of suitable impedance, extension cable and portable (calibrated) reference electrode with manual logging and interpretation of collected CP Data. Successful use of such equipment is wholly Operator / Competency dependent (Figure 8).

2. Semi-Automated CPM, utilising pre-determined CP routines, switching units and programmable storage / measurement devices for permanent reference cells and coupons but without any automated data transfer link to real-time plant control systems. Loggers are manually retrieved.

3. Fully Automated CPM, whereby data is collected, stored and analysed by computerised devices which may be read via remote links to plant control panels, with alarms set to notify any out of range CP data to the control room operator, each measurement point having a unique reference in the CMMS – Computerised Maintenance Management System. Note that both AC input values and DC CP output values are automatically monitored and tracked to stay within pre-set ranges / alarms. For ICCP this is absolutely critical, as protection is only provided when an external power source is available and CP TRU’s (especially if of older more basic type), can be subject to unit failure, power outages, lightning strikes, geo-magnetic activity and other fault surges (Table 2).

**CP Measurement and Frequency**

A range of routine measurements will normally be performed to provide ongoing surveillance, once the CP system has been fully commissioned and has proven / stable operation. Typically one-monthly and six-monthly intervals are used but test frequency is very much owner / operator dependent. Essential measurements for a one-monthly survey are, AC supply, CP drain points of TRU’s, DC outputs of all current sources and any other intermediate points, that are considered critical for CP protection purposes, such as inter-pipeline bonds and known critical low points (which may have loggers fitted).

The 6 Monthly Survey would include all above plus additionally:

- All CP low points (eg nodes on offshore structures, mid-points between ICCP ground beds, or at pipeline risers perhaps) Figure 9.
- All intermediate CP test points
- All bonds and isolation joints.
- Any areas of elevated temperature.
- Any areas of susceptibility to AC interference, (e.g. close to overhead power lines).
- Foreign service crossings / interaction sites.

For buried pipelines, routine CPM is often supported post commissioning, by alternate CIPS and DCVG surveys (as described below) that can provide valuable information on coating degradation and intermediate CP protection levels between permanently installed CP test points (normally at 1Km intervals only).
In cases where the power sources cannot be interrupted, then a significant shift between the ‘natural’ and ‘energised’ values is normally specified. The acceptable polarisation value will vary with the specific material being protected, lower strength carbon are steels generally more tolerant of excessive polarisation - CP ‘overprotection’. In exceptional circumstances, excessive CP potentials may lead to deterioration mechanisms such as protective coating disbondment and hydrogen induced stress related cracking, (with weldments being a common area of failure).

The use of CP test coupons can provide an acceptable way of indicating the polarised or OFF potential, the instant OFF being measured by temporarily interrupting the CP connection to the coupon, or via the use of a resistor (shunt). Measurement of the surface area of the coupon allows the CD – ‘current density’ to be calculated.

**Specialised Surveys in Support of CPM**

Typically, conventional CPM records data only at selected critical points of the CP protected structure, critical points being known areas of under-protection or over-protection, as defined by national and company CP Codes, these critical points must first be determined by other specialised GPS satellite based techniques, which may include:

1. **CIPS – Close Interval Potential Survey** (Figure 10), that ensures a polarized CP Potential is recorded at least every metre, in the case of a buried pipeline, (other criteria apply to other types of CP protected structures).
2. **DCVG – Direct Current Voltage Gradient Survey** (Figure 11) for pinpointing areas of coating degradation which may then be subsequently assessed for adequacy of supporting CP. These survey types are normally performed in conjunction with highly accurate timing devices that integrate with satellite Global Positioning Systems.

**Project Interfaces**

The period between a decision being made to progress a major project requiring CP, and the actual progression of that project to construction stage and eventually onwards towards final commissioning, can often be an extended one, sometimes
10 years or more in the making. It is possible along the way that some of the original design intentions may become have diluted or mismanaged at construction phase, such that the final installed CP scheme cannot perform as originally intended.

This situation is not unfortunately helped by the fact the CP scope has a relatively low value in the bigger scheme of things (often < 1%) and often a perception of lesser importance to the overall project, although in reality the CP system is critical to maintaining pressure retention capabilities and structural integrity. CP Schemes are often relegated to being smaller and less well controlled sub-contracts of multi-million-pound infrastructure projects, for which a tick in the box may be more easily achieved.

Full supervision of the CP scheme construction by a competent CP Engineer is absolutely essential, as too often it is only at the final commissioning stage that CP anomalies and construction faults come to light, and resolution of these can then be, extremely costly and time consuming to eliminate.

Conclusions

The main aim of this article has been to highlight both the importance of CP in reducing global GDP losses from corrosion, and the contributory way in which CPM and associated specialized techniques such as CIPS, DCVG and new remote devices can help optimize CP performance, with CP being increasingly automated through advanced data logging / transfer technologies, with rapid response times and GPS precision, increasing its value enormously in assisting CP optimisation.

Some of the key considerations are:

1. The need for competent CP personnel to properly supervise all CP Installations, (experience has shown that main contractors do not have the specialist knowledge for this and can quickly compromise the integrity of the original CP design).

2. The importance of regular interfacing between different disciplines of a project team, (who may have competing objectives).

3. The requirement for specialist surveys / close interval monitoring at project commissioning, to confirm sites of CP interference, applied coating quality and adequate protective current distribution / CP potential levels, in accordance with agreed criteria, (CP test point readings alone cannot provide a fully representative picture and intermediate readings are essential).

4. The benefits of establishing regular routines in CMMS type systems, (to prompt Integrity Managers to perform regular CP maintenance inspections and to properly review and trend all data obtained and raise notifications / remedial actions against any irregularities / non-compliances).

With these aspects all properly addressed, the installed CP system will deliver on-going low-cost protection against localised degradation, metal loss and penetration of components that would otherwise lead to in-service structural failure, loss of containment with significant environmental consequences and corrosion related fatalities.

References

The following additional sources of information provide useful and practical information in respect of enhancing existing CP systems and CPM.


References


All ICorr Aberdeen Presentations are available at, https://sites.google.com/site/icorrabz/resource-center

It is recommended that the Online Browsing Platform (OBP) of ISO also be referred to, in respect of cathodic protection standards and cathodic protection applications.

Authors Note

This article is dedicated to Dr John Leeds 1940-2018, who did much to promote DCVG technologies for the determination of external coating condition.

Acknowledgements

The Author wishes to express his gratitude to his former ACOL colleagues George Ballingall, (now of CORRPRO) and John Rae, (now of R&R Corrosion Ltd) in preparation of this article.

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Waterproofing and concrete protection product for wastewater treatment plants and harsh chemical environments

BASF (Master Builder Solutions) has introduced a new product, MasterSeal 7000 CR, to protect concrete and steel structures in extreme wastewater (and harsh chemical) environments. It is based on the company’s new technology Xolutec™ combining application and performance properties, to meet the challenges in aggressive wastewater environments.

The effects of wastewater in collection networks and treatment plants can lead to rapid deterioration of concrete surfaces and corrosion of concrete reinforcements and steel structures. According to the company, this new product has high resistance to abrasion and biogenic sulphuric-acid corrosion and is ideal to withstand the severe conditions that occur in pre-treatment and aeration tanks, digesters, or sewers. It also has dynamic and static crack-bridging abilities to protect concrete, even after non-structural cracks appear, thus prolonging life cycle of the structure.

Another key benefit of this novel resin technology is its tolerance to moisture, both in the substrate and in the environment, it can be applied on very damp substrates by spray or roller, and its fast curing properties allow contact with water under pressure as early as 24 hours after application at 20°C. This combination of properties provides long-term concrete protection while dramatically reducing the downtime of the structure, making the product the ideal solution for wastewater facilities, concluded the company.

The UK-based company Teraview has recently introduced a new technology to measure film thickness in a non-destructive manner.

The new non-contact, multi-layer coatings sensor with scanning capability, can determine the individual thickness of many paint layers on both metallic and non-metallic substrates. The system (Teracota) uses a broadband pulse of terahertz light to illuminate the coated surface from a short distance. The reflected signal contains partial reflections from the interface of adjacent coating layers, which can be analysed to determine the thickness of each layer.

Duvine has introduced the new CP150 power module, which according to the company, is ideally suited for multi-zone systems. Based on its many years of switch-mode power supply experience, the CP150 is a cost effective and robust solution which can cover up to 120 zones. The standard CP150 solution offers 0-25V and 0-10A on each output.

Duvine has been manufacturing Impressed Current Cathodic Protection power solutions for many years, in the form of the CP500 for single zones. Switch-mode rectifier technology, is an ideal power sources for ICCP applications, and offer considerable advantages over traditional transformer rectifiers, such as versatility, control, ultra-low ripple, digital display interfaces, built-in interrupters, size and weight, stated the company.
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For more information follow the link at https://trainingsolutions.imeche.org/training/coating-inspection/international-icorr-training

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Aberdeen Branch Corrosion Awareness Day
09.00 – 16.00
Venue: Emerson, Dyce
Wide Range of Corrosion Topics and Equipment Demonstrations, from the Aberdeen Corrosion Awareness Team.

25th September 2018
Aberdeen Branch/ TWI joint technical meeting
18.00-21.00
Venue: Robert Gordon University
Preferential Weld Corrosion (PWC) of Pipelines and Topsides Piping Systems.

11th October 2018
London Branch
18.00 – 21.00
Venue: Imperial College, Skempton Building, London SW7 2BB
Advanced Cathodic Protection Design by Finite Element Method
Paolo Marcassoli, Cescor

25th October 2018
London Branch Joint Meeting with the Society of Chemical Industry
18.00 -21.00
Venue: SCI HQ, 14 Belgrave Square, London SW1X 8PS
A Fighting Ship and Fighting Corrosion, Speakers: Dr Eleanor Schofield - Mary Rose Trust and Jim Glynn - ICorr and Beanny Ltd

30th October 2018
Aberdeen Branch
18.00 – 21.00
Venue: Robert Gordon University
Integrity issues and Planned Production Losses – How to Break the Cycle!

12th-20th November 2018
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