Designing and fitting offshore and onshore CP systems

Remembering David Deacon
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The Surface Profile Probe, part of Fischer’s materials testing range, measures blasted surfaces, enabling the user to prepare the substrate, select the cleaning method and apply the right amount of coating.

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This has been a busy month at work, however I was able to attend the CED working day and symposium that was held at the IMechE training centre in Sheffield, and which was a well-attended event. I also had the pleasure of presenting the inaugural Paul McIntyre Award to Ulf Kivisaakk of Sandvik Materials Technology in Sweden. What made the occasion more memorable was that two of Paul’s children, Gerald and Anthea, were able to join us and shared some fond memories of their father.

We have also had a council meeting which was very productive, and we continue to move along with the plans that I have mentioned in the last few editions of Corrosion Management, including the revamp of the website, which should be going live soon. This is a great step forward. I was also delighted that it was agreed to award Brian Wyatt honorary fellowship, to mark his continued contribution to ICorr.

A Membership Development committee, chaired by the vice-President, has been set up to ensure that the Institute continues to listen to its members about ways in which we can enhance the benefits of membership. The committee would love to hear from you and they can be contacted at, admin@icorr.org.

The office is gearing up for membership renewal, and you can find the new subscriptions costs elsewhere in this issue. The modest increase having been kept in line with inflation. During this membership year we will also be offering an option to receive Corrosion Management as an electronic, rather than, paper copy, so look out for this option on your membership renewal form.

Sarah Vasey, ICorr President

From the Editor

I hope you are enjoying the new format of the magazine, which this month features three technical articles, two on retrofitting CP systems from well known experts, and the third, a detailed study of costings for maintenance painting of bridges, written by specialists from the European Confederation of Paint & Ink Manufacturers.

As the magazine develops, I am aiming to cover all the disciplines and industries of interest to members over the year, and to this end, we will continue to have at least two, differently focussed technical articles, each issue. New columns are also being planned for later in the year, including a technical “question & answer” page.

However, the magazine is only as good as the articles and news published, so I would encourage you to submit topical items that would be relevant for publication.

Remember, it is your magazine, and if you have any suggestions for further improving it, please send them to me via the Northampton office.

Brian Goldie, Consulting Editor

NEW SUSTAINING MEMBER

RGL

RGL provides ultra high pressure water jetting services, specialising in precision concrete hydrodemolition, surface preparation of concrete and steel, abrasive water jet cold cutting and tube/pipeline cleaning. With over 30 years’ experience, they have amassed a vast knowledge on how to make water jets solve problems that other processes simply can’t fix. They have pioneered many industry solutions which are cheaper, safer, quicker and more environmentally-friendly than alternative methods, and with expert crews located throughout the UK, they are able to offer an accessible, convenient and cost-effective service nationwide.

NEW SUSTAINING MEMBER

PMAC GROUP LTD

PMAC was formed in 2000 to offer specialised products and services to the Oil and Gas industry worldwide. With offices in Aberdeen and Singapore, PMAC covers a worldwide market, and has gained a reputation for innovative solutions in the fields of Integrity, Oilfield Chemistry and Flow Assurance.

Since inception, it has grown from a team of 3, designing and manufacturing analytical equipment for the chemical industry, to a team of 30, providing a range of subsea and topside products & services.

PMAC’s current services include, Flooded Member Detection (FMD), Well Test/Sand Monitoring (intrusive & acoustic), Cathodic Protection Surveys, Intrusive/ Non-intrusive corrosion monitoring, and field based chemical/microbiological testing.

The company is ISO 9001, 14001 & 18001 accredited, company has recently achieved 500,000 incident free operational man hours.
UK-based LUX Assure provides a revolutionary approach to the monitoring and management of production chemicals to both upstream and downstream oil & gas activities. Their pioneering technologies, inspired by their heritage as a life sciences research company, provide unique solutions for monitoring difficult to detect chemicals widely used across the oil & gas industry, and provide critical information to support key management decisions.

OMMICA™ is an easy-to-use on-site testing kit that can rapidly determine MEG and methanol concentrations in produced oil, water and condensate.

An independent company, with global headquarters in Scotland and agents in the Americas, Middle East, Malaysia and Australia, LUX Assure serves customers worldwide. They are innovator in oil & gas intellectual property, and were ranked number 2 in the IP100 (2015), the UK’s Intellectual Property League.

**NEW SUSTAINING MEMBER**

**LUX Assure**

Fundamentals of Corrosion Course

This four day course (with an examination on day 5) has now been developed and is ready to be delivered. The first such course is scheduled for mid-September 2017. Dr Jane Lomas will be the presenter and it is likely that this first course will be held at IMechE in Sheffield.

More details will be published in Corrosion Management when they are available.

**ICATS News**

**Supervisor Course**

This new course is proving popular and has already been held three times in 2017. The course is available to any applicator who has two years’ experience following successfully completing the mandatory ICA ICATS module. Supervisors and Technical Managers who have more than two years’ experience in the industrial coating field will also be considered with supporting evidence from their employer, even if they have not completed the ICA course. Other candidates with at least five years’ verifiable experience in the coating industry will also be eligible.

For further details and course dates please visit our website www.icats-training.org and use the Supervisors Module tab, or call the Correx office on 01604 438222.

**Company Trainer Course**

We hold the Company Trainer Courses three or four times a year. Please contact the office for the date of the next course.

**CSCS**

As previously advised all new ICATS cards now incorporate the CSCS logo, confirming holders are suitably trained and qualified in Industrial Coating Application and they will not need another CSCS card to work on sites which require CSCS certification.

We are currently investigating converting to a SMART card system, so that the authenticity of the card and the holder’s details can be interrogated by Site Managers using a smartphone, tablet or PC allowing them to instantly record the cardholder’s information, and be secure in the knowledge that the cardholder is qualified for the job they do on site.

Further details of the CSCS Partner Scheme are available on the website under the CSCS Partner Scheme tab.

Keep up to date with ICATS using the website above or through the ICATS group on LinkedIn the business-oriented social networking service.

Charles J L Booker (always known by his work colleagues as Charlie) obtained an honours degree in Chemistry from Sir John Cass College and went on to achieve not one, but two PhDs! The first, in 1952, from University of London, was in Physical Chemistry, the second from Christ’s College Cambridge in 1962, was in Metallurgy. These established Charles as one of the brightest thinkers on the subject of corrosion. After his marriage in 1958 to Marylyn, he undertook a two year academic placement in Canada before returning to the UK to take up a post working under George Butler at the National Physical laboratory. Charles had a progressive view of education and strongly believed in the Polytechnic movement, and would encourage the new generation to consider higher education by giving talks at local schools. In 1965 he returned to City of London Polytechnic to become the Principal Lecturer and Course Director of the MSc in Corrosion Science and Engineering. It was whilst working there that Charles would leave his own great legacy. In 1928 and 1953 London had been struck by lethal flooding, resulting in the deaths of hundreds of people. In the 1970s a plan to create a strong flood defence barrier was born and Charles’ department was asked to lead a team of chemical engineers, tasked with ensuring the barrier’s longevity. With a group of committed colleagues he worked hard to ensure the barrier would elude corrosion in the generations to come (the Thames Water Barrier is not due to be de-commissioned until 2070, after close on century of quietly keeping watch over the city) After his retirement, Charles took a part-time voluntary Directorship at the Institute of Corrosion where he was Honorary Secretary for ten years (1992-2002), and at the conclusion of this period of service, a special award was instituted, (The Henry Cole award - a Poniard) for outstanding administrative service to the Institute, and Charles was the first recipient. He also served the European Federation of Corrosion as Honorary Treasurer in the years 2001-2004 where he worked closely with Paul McIntyre. Charles Booker was a man of distinction, whose loss will be keenly felt by his colleagues, friends and the three children and eight grandchildren that survive him.
A CED Working day and Symposium on Corrosion Engineering and Concrete was held on Thursday, 27 April at IMechE Engineering Training Centre, Sheffield. The meeting was sponsored by the Institute of Concrete Technology. Some sixty delegates were welcomed by the Chair of CED, Nick Smart (Amec Foster Wheeler), who introduced the Division for the benefit of those who were not members and also outlined the programme for the day. This was followed by an ‘Introduction to the Institute of Concrete Technology’, given by the President, Raman Mangabhai.

Chris Atkins (Mott MacDonald) addressed, ‘The trouble with concrete’. He outlined the origin of the problems with concrete caused by shrinkage and the means of overcoming its poor compressive strength by inserting reinforcement. Settlement cracking was capable of giving rise to 2 mm wide cracks, which could penetrate right up to the rebar. Other aspects of steel corrosion in concrete were then discussed including the electrochemical mechanisms of corrosion, forms of chemical attack that can occur during use, repairing chloride-induced corrosion, cathodic protection, and decisions to repair (covered by BS EN 1504), with BS EN ISO 12696 providing further guidance on conformity.

Next, David Simmons (BAM Nuttall) outlined, ‘The use of coatings to manage corrosion in concrete’. “Getting it right first time” is a phrase that is often used in construction. This applies equally to reinforced concrete if it is to be durable and provide the service life as specified by the end-user. The problem with reinforced concrete is that while engineers fully appreciate the importance of including the reinforcing steel, not much consideration is given to the low-cost, easy-to-use, void filling material that surrounds it. In effect, the concrete cover should be regarded as a protective coating, and must be properly specified, batched and used, which can only be achieved by proper exchange of information between the designer, user, and producer of the concrete.

‘Impressed current cathodic prevention of steel in concrete’ was the subject of the lecture by Hugue Bois (SAPIEM SA, France). Theoretically, steel in concrete should not experience corrosion. The concrete pH is around 13 and this alkaline environment stabilises the iron oxide or hydroxide film, thereby passivating the embedded steel. The concrete layer also presents a low permeability barrier vs. external aggressive species, e.g. chloride ions or carbon dioxide. However, in some cases, ingress of these species reduces the pH to 8 or 9, thus impairing the passive film. Examples of field experience were given, including reinforced concrete steel piles, the use of Mn/MnO2 reference electrodes, and the importance of identifying the various at-risk zones, for example of a sea wall, viz.

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Membership Subscription Rates 2017/2018

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<th>Membership Categories</th>
<th>Annual Rate from 1 July 2017</th>
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<tr>
<th>Sustaining Membership</th>
<th>Annual rate from 1st July 2017 is £386.00 (plus VAT)</th>
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<tr>
<td>“GOLD” Sustaining Membership</td>
<td>Annual rate from 1st July 2017 is £747.00 (plus VAT)</td>
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* Requires proof of enrolment as a full time student at an approved science or engineering based study programme.
The 2017 CEOCOR Congress in Luxembourg was a great success, both technically and socially. The venue was excellent, and the superb Congress dinner was held on the Princess Marie-Astrid boat on the Moselle river, famous for the signing ceremony of the EU Schengen agreement! Thanks must go to our friends in Luxembourg.

Planning for the 2018 CEOCOR Congress in Stratford-upon-Avon, is well underway. In addition to the technical presentations and exhibition, there will be a Partner's Programme, including visits to Shakespeare's birthplace, Anne Hathaway's Cottage, behind the scenes at the Royal Shakespeare Theatre, and to a nearby stately home. A sponsorship programme has been developed which offers a significant opportunity for the UK (and elsewhere) buried pipeline community to participate. The principal or Platinum Sponsorship has already been taken up by National Grid, the sole owner and operator of the high pressure gas transmission infrastructure in the UK. Cathodic Protection Co. Ltd. from Grantham has taken one of the Gold Sponsorships, and will also sponsor the BBQ and Jazz evening. Other sponsorship packages are also available and details of these can be found on the conference website, www.ceocor2018.com. Those companies wishing to secure sponsorship at the 2018 CEOCOR Congress need to be quick, as places are filling-up fast.

Conference programme, registration details, hotel package, partner's programme and news will all be available on the website, which will be regularly updated.

The final presentation entitled, ‘Latest understanding of the corrosion of Magnox, aluminium and uranium metal wastes in cement’ was given by Hugh Godfrey (National Nuclear Laboratory). An overview of the work that has been carried out in the nuclear industry on the corrosion of Magnox (magnesium/aluminium alloy), uranium and aluminium wastes encapsulated in cements was presented under the following headings: the origin of the waste; how the waste is encapsulated in cement; how the corrosion rates were measured and a comparison of the corrosion behaviour of the three metals. Uranium has the simplest corrosion behaviour - an initial incubation period followed by continuous corrosion and a steady rate. Magnox behaviour is more complex, with the corrosion rate gradually decreasing to a fixed long-term rate. This contrasts with the corrosion rate for aluminium which continually decreases without appearing to reach a steady rate.

The technical talks from this meeting are available (in pdf form) on the members area of the ICorr website.

After the presentations, the delegates were afforded the opportunity of visiting the concrete and corrosion laboratories at Sheffield Hallam University, and to participate in CED Working Group Meetings. The concrete and CP, nuclear and coatings work groups all had successful sessions.

The Paul McIntyre Award

The first Paul McIntyre Award was also presented at the CED working day to Ulf Kivisäkk of Sandvik Materials Technology R & D, Sweden, by the ICorr President, Sarah Vasey. Paul’s son, Gerald and daughter, Anthea, were also in attendance and said some kind words about Paul. Ulf then gave a short talk summarising his contribution to the EU-funded programme on developing an ISO standard test method for assessing crevice corrosion of 316L stainless steel in marine environments (“CREVICORR”), and also his investigations into HISC of duplex stainless steels.

The first Young ICorr Social was held on the 20th April at the Prince of Wales Feathers Pub in London, and a very enjoyable evening was had by all. This was planned as a networking event to help launch Young ICorr in London, and was attended by both members and non-members of the Institute of Corrosion. Young ICorr is aimed at young professionals (35 and under) who are interested in, or working in, the field of corrosion.

To hear about future networking and speaking events, please join the Young ICorr LinkedIn page at tinyurl.com/youngicorr (or search for Young ICorr®). For those who do not use LinkedIn, but wish to be kept updated with Young ICorr news and events, please send an email to Chris.Bridge@uk.bp.com to be added to a distribution list.

CEOCOR 2018

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Conference programme, registration details, hotel package, partner's programme and news will all be available on the website, which will be regularly updated.

For all the latest news, events and debates join us on LinkedIn
Institute News

BRANCH NEWS

Aberdeen Branch

The third meeting of 2017 was held on Tuesday the 28th March, with 28 attendees representing major companies including Akins, BP, CNR, DNV GL, Lloyds Register, Oceaneering, Subsea 7, TOTAL and Wood Group.

The event was an industrial visit to the premises of Cosasco Europe HQ in Aberdeen, to hear about the latest Advances in Probe and Coupon Monitoring and Safe Access / Retrieval of Data, with many live demonstrations being performed.

Corrosion monitoring devices are considered essential to help prevent against loss of containment, industrial accidents and possible HSE prosecution, and Derek Morton, Cosasco’s Business Development Manager with over 35 years industry experience, provided an excellent start to the evening with a comprehensive history of the development of Corrosion Monitoring Technologies over the past 60 years, covering every conceivable process application and both intrusive and non-intrusive devices, across all industries.

There were opportunities later to inspect at close hand, a wide range of advanced electronic sampling tools and data reporting systems, with Cosasco consultants and Engineers including, Andy Allan, Mark Maulvaney, Richard Rae, James Taylor, Sandy Tweddle and Dean Smith (Aberdeen Base Manager), all on hand to explain how such devices can be optimised to best advantage.

The activities that followed the technical presentation included informative demonstrations of pressurised retrieval operations of data logging devices, wireless monitoring technologies, probe and chemical monitoring applications and safety isolation devices. There were also a number of poster displays and the wide range of models and test rigs certainly kept the attention of the branch members throughout the evening. Advanced monitoring probes were displayed, including those intended specifically for laboratory use such LPR devices. The differing sensitivity and speed of available probes was clearly demonstrated, along with their most commonly used applications, e.g. Galvanic for water injection service and their relationship to other types of process instrumentation and to chemical injection monitoring was also explained.

The associated retrieval devices (which are either mechanical or hydraulic based tools) can work across a range of pressures up to 6000 psi with telescopic and non-telescopic options. Local intrusive cost monitoring options, such the use of test coupons were also highlighted.

Specialist equipment for solids erosion tracking and production well management was also illustrated. Solids determination to minimize erosion and determine the solids-free flow rate is considered essential practice for maximising equipment life. A lively debate followed the speaker presentation with many questions from the audience.

Many questions from the audience were forthcoming including the future integration of the CP Models with established surveys methods used by major subsea survey contractors, so as to make the best use of gathered CP data and to optimize reporting for the CP Systems owners.

The CP Flowline phenomenon aroused great interest amongst gathered delegates and the speaker explained that Beasy are intending to develop these relationships forward in the future, so as to assist the subsea industry and the extensive Marine CP markets.

For information about the Aberdeen branch activities please contact our branch secretary, Frances Chalmers, ICorr ABZ@gmail.com, alternatively a calendar of local events of interest to corrosion professionals in the Aberdeen area and the opportunity to sign up to the branch mailing list is available at https://sites.google.com/site/icorrabz/home

Aberdeen Branch have also established their new Media Centre, which can be found at https://www.linkedin.com/in/aberdeen-icorr/recent-activity/
**London Branch**

March was the Branch’s AGM, and reports were given by the outgoing chairman, Jim Gynn and the hon treasurer, Mike Allen. The branch had completed a full and successful meetings programme at their new venue, Imperial College, where they have started to see an increase in attendance with the average up from 30 to 50. The accounts showed a healthy surplus, and funds would be returned to the headquarters account. David Mobbs was elected as the new chairman, with George Winning as vice-chair. Jim also thanked, John O’Shea, Mike Allen, Geoff White, Mash Biagioli and David Dore, who have all stepped down from the committee, after giving long service to the branch.

After the AGM, Sarah Vasey, the President, gave a presentation about the Institute and its work, which included presentations on an update to Corrosion Management, Young ICorr and its aims, and the Route to Chartered Status.

Sarah started with a description of the Institute and how it is made up, including Council, Branches and Divisions, then described the awards, the Quality System, and website. The section on the Council introduced the trustees of the Institute and how they are linked to the larger Council. The members of Council and their roles were then discussed. The work of the Council involves driving a number of initiatives in which the various Branches have been heavily involved in. CED was then introduced and the role it plays within the Institute discussed, including a promotion of the upcoming CED day. It is perhaps not well known that the Institute gives out various awards and the requirements to be a recipient of these were described. Sarah discussed the implementation of the ISO 9001 quality system at Head Office and finally she mentioned the update to the website that is taking place to make it more useful to members.

The editor gave a brief up-date on the new format of Corrosion Management which had been redesign to make it easier to read, and also to include more technical articles and news relevant to the members. Chris Bridge described the Young ICorr initiative, which continues the work started with the Young Engineer program, to promote the Institute to a younger generation. The section is aimed at the 35 and under age group, but not exclusively, and as part of the process there will be events for this group to attend and hopefully branch events can be aimed at the Young ICorr members in the future. The final subject of the evening was presented by Don Harrop on “The Route to Chartered Status” via the Institute of Corrosion. We are trying to encourage Engineers to get their Chartership through the Institute, and to achieve this, a mentoring program is currently being established with experienced professionals leading them through the process so they can understand the requirements needed to achieve Chartered Status. The program is aimed to go live in September 2017, so potential candidates should put their name forward to, david.mobbs@akzonobel.com.

The evening finished with a lively question and answer session and then the usual London networking session.

The April meeting featured a presentation by Jim Britton, President and CEO of Deepwater Corrosion Services, on “Some Recent Offshore Cathodic Protection Life Extension Projects - So What’s New”. Jim has worked in the Offshore Corrosion business since 1973, and for the last 17 years focussed on Asset Integrity and in particular Life Extension.

He described six current offshore projects which were challenging because of a technical, and of course a financial perspective with owner operators who are reluctant to spend money on assets that are getting towards the end of their life. These included using using a novel series of anode belts, and utilising a novel clamp arrangement, which did not require welding, and which could be installed using an ROV, to attach new anodes to a concrete weighted pipe associated with platforms in Malaysia, where diver intervention would also be cost prohibitive.

A fully retractable suspended ICCP anode system was designed for a very old FSO in the Irish Sea, which would not be affected by inclement weather, and the largest ICCP retrofit to a single structure in the North Sea, and the first use of a containerised power supply system because of the lack of deck space. Interestingly there were members in the room who were involved in the original design which was to provide corrosion protection for 25 years, and it actually lasted 40 years.

There were a number of takeaways from this excellent presentation, but one of the major points was that whilst there are Codes of Practice for new build, there are no codes for retro-fit projects.

**North East Branch**

The second branch meeting of the year was held on 27 April at the Rosen UK facility in Gosforth. The well attended meeting included David David Mobbs (chairman London branch) and the President of Institute of Corrosion, Sarah Vasey.

Malcolm Morris, Technical Support Manager Sherwin Williams, presented an in depth technical review of ISO standards and detailed the process that is undertaken in various levels of standards committees - local, national and international. ISO committees can be split down into, Technical committees - TC’s, Sub committees - SC’s and Working Groups - WG’s. However there are also other groups which can influence the development of standards namely, IPPIC - International Paint & Printing Ink committee and CEPE - European Confederation of Paint and Ink Manufacturers. In particular, Malcolm updated the audience on the current changes to the ISO 12944-6 standard with regard to updating the performance requirements for the various environments.

Many members of the audience were unaware that there were so many steps to go through to get modifications made to standards, and the description of the current process was very informative. There were numerous questions from the audience relating to the correlation of anticorrosive testing in the laboratory with actual field data. There were definite concerns that there was indeed no correlation and therefore how could the data be relied upon. It became very evident that the key to understanding the performance of coating was still looking at ‘track record’ of coatings in a particular environment. The comments from the meeting really showed what an emotive topic this is, and how much it matters to get these standards right.
It is with great sadness that we announce the death of David Deacon on 31st March 2017. David was a stalwart of the Institute, supporting it virtually all of his long working life. In recognition of his service, he was elected an Honorary Life Fellow in 1992, and as a mark of David’s continued significant and influential contributions to the Institute, he received the Lifetime Achievement Award, a unique decoration especially created for him (a report by John O’Shea on this is given in Corrosion Management no 87, January 2000).

In 1976 he became the Technical Committee Chairman and Council member and was Chairman of Council from 1986-1988. He took on a part-time role as Honorary Secretary, became Vice-President (twice) and was President from 2002-2004. He also contributed to the work of London Branch between 2013-2015.

A more personal view of David’s life and contributions to the Institute is given below:

David H. Deacon – Recollections by Bill Cox

People always wanted to know what the ‘H’ stood for. He always used the initial, but never mentioned the name. So I asked him. ‘Humfrey’ he said (I didn’t learn about the spelling until much later). Turned out it was a family name, and way back one of the early holders had left a bequest to any of the male descendants who had it in their name. So David always kept it and always acknowledged it – and Wil (David’s son) has got it too – but it’s not spelled like a ‘regular’ Humphrey. There was always something unexpected about David.

For example, he’d been a Public Schoolboy – not many people knew that. And his Latin master christened him Praelatus – because he was a ‘Deacon’ and therefore must be a prelate of some description. Evidently this chap had a Latin nickname for everyone in the school. DHD had been a good sportsman in his day – Played cricket for the County (Hampshire? Berkshire? I’m not sure) and was a very useful footballer too. And a life-long Reading supporter.

I first met him in about 1981. In court. I was supporting David Scantlebury on a claim for Welsh Water, and David was out for the contractor. We said the ultra high-build factory-applied coating was porous. David said it wasn’t. David won. He wasn’t right, but that didn’t matter. We looked like wet-behind-the-ears academics when it came to the court skirmish. We knew well that impedance testing had shown without doubt that the coating absorbed water and was porous. It shouldn’t
have been accepted. Deacon said it was a perfectly good coating and there was nothing wrong with it. The judge believed him. I was hopping mad. I resolved never to let that happen to me again.

The next time I came across David would be around 1986. I was going to the NACE Conference in Houston. NACE had developed a Coating Inspection Training and Certification Scheme and the UK Institute of Corrosion was interested in particular UK. To offer it in Europe. David Deacon (Cards/ UMIST) was my Director and asked me to meet up with David and help with the pitch to NACE. Deacon was charming – and we were successful in convincing NACE to work with the Institute, which was excellent. Deacon’s company, ITI, was also going strong in Houston at the time – as well as in Singapore and across the Middle East, and in the UK, he and Jackie (Deacon) were tremendous supporters of ICorr and the NACE/ICorr Joint Venture collaboration. ITI had been grown out of BIE (British Inspection Engineers). David who had been heading up the Coatings Inspection activities, became frustrated with the management inertia, and decided it was time to set up his own company. Jackie was his secretary and bailed out with him.

He started out at British Aluminium, and evidently prior to that he had been employed as a young trainee in some kind of asbestos company. He told me recently of the trainees “throwing ‘snowballs’ (of asbestos fibres) at each other, and wiping the asbestos dust out of their mugs at tea break”. I never did properly understand his background but he never went to University and didn’t have a degree, but he’d obtained a Diploma in Paint Technology and Polymer Chemistry. In certain respects, he was responsible for transforming the ‘high performance coatings and linings’ industry in the UK. He was very clear that there was all the difference in the world between ‘decorative paint’ and ‘high performance protective coatings and linings’. He accumulated a collection of world-class specialists and experts – Harry Bray, Gil Hill, Derek Bayliss, John Spon – and between them, his company took over a further two years to ensure good-quality surface preparation and proper application of a high-performance anti-corrosion coating. The book he wrote with Derek Bayliss (Steelwork Corrosion Control, Spon Press) is still the benchmark reference text for coating technology.

I was never clear why he was prepared to work so hard for the Institute of Corrosion. During the heyday of North Sea Oil development in the 70’s and 80’s, he put huge effort into this. The NACE Conference, which was the single most profitable activity that the Institute had at the time. Even when the ICorr was virtually bankrupted as a result of over-ambitious expenditure and poor management, Deacon was the one person who was still prepared to go and fight for it. He gave the Institute of Corrosion a home at the ITI office, initially rent free when there was no money in the ICorr bank account, and under-wrote many of its activities until it could stand on its own financial feet once again and had Gillian (Inwood), his long-serving and faithful secretary, fill ICorr activities while employed by his own company. Four years later, there was £200,000 in the reserves and the Institute has continued to prosper since that time. Subsequently, he worked with the Institute to purchase its own premises – Corrosion House – though actually the mortgage could only be funded because SPC took the rest of the building.

In the face of massive opposition, he first proposed the ICorr premises – Corrosion House – though actually the mortgage could only be funded because SPC took the rest of the building. Inwood, his long-serving and faithful secretary, field ICorr activities while employed by his own company. Four years later, there was £200,000 in the reserves and the Institute has continued to prosper since that time. Subsequently, he worked with the Institute to purchase its own premises – Corrosion House – though actually the mortgage could only be funded because SPC took the rest of the building. In the face of massive opposition, he first proposed the ICorr premises – Corrosion House – though actually the mortgage could only be funded because SPC took the rest of the building.

I have really only worked closely with David on consultancy activities over the past ten years or so; I’d look after the metallic corrosion and he’d deal with the coatings issues. It was just so much FUN! He could be extraordinarily compassionate and nursed his wife Hilary when she developed pancreatic cancer. It took a lot out of him, but the work was a welcome diversion. There were so many contrasts – on the one hand he could be ruthlessly hard-nosed and, on the other, he could be ridiculously generous. He cared for his clients and his staff, though once he sold ITI he was less interested in the inspection side and concentrated more on consultancy activities, while Wil took primary responsibility for the inspections business.

The last trip I went on with him was to Ireland – Dublin. The visit and meeting went well enough, but we were finished early and there would be a four-hour wait for the flight. He wasn’t in the mood for a handout, so we decided to go back to Heathrow (our original reservation was for Luton), just to get back earlier on a Friday evening, even though we then needed a taxi to travel from Heathrow to Luton to collect our car. I couldn’t believe how keen he was to get home. He’d had enough. He never went on site again.

David turned 80 in October last. There was a party – just a small affair – family and a few old friends (including three other Past Presidents and a number of past and present Branch Chairmen). He didn’t stay for the whole event but he was in good form and gave a nice little speech. He was still contributing to projects even up to January of this year – he wouldn’t go to site but he was pleased to talk through what was happening and, as weak as he was, he would still make a comment or suggestion that was pithy and pertinent – still bringing it home. I know many of my clients’ memories of Deacon were of him that specified the coating for the ‘Thames Barrier’ – now coming up to 40 years in service with a single-layer hot-applied system. Other ‘experts’ had said it was impossible. Deacon proved them wrong. Deacon was the person who ended the joke of ‘Painting the Forth (Rail) Bridge’. When he’d finished it wouldn’t need painting again for at least another 25 years. As we drove around the motorway network he would point out different projects he was responsible for – the Mersey Tunnel; the Dartford Crossing; Tower Bridge (London); the Tamar Bridge; the galvanised bridge on the A1 just South of Newcastle, a footbridge here, an equipment tower there, the Cutty Sark, oil storage tanks in the UK, Ireland and elsewhere around the world. He’d worked on railway viaducts in India, Nepal, Kuwait, and given coating training courses in every major industrialised country in the world – a massive infrastructure legacy that is more reliable and less expensive to operate after David Deacon had applied his expertise.

David said he had been diagnosed the same day as Terry Wogan (in November 2015), and he’d lived a full twelve months longer than Wogan. Not bad for a guy who was given 4-6 weeks and completely typical of a person who would just never give in.

It’s not very long since Jack Tighe passed away. David wanted to go to the funeral and I went along with him. The joke that day amongst the corrosion industry crowd was that St. Peter needed the gates painted and Jack Tighe had obviously got the contract. It would appear that ‘Senior Management’ decided to call Deacon in for the independent inspection and ensure the work was done properly.

I’ve missed working with him this past few weeks/months and I know I’m going to continue to miss him, but I won’t forget the work we did together or the laughter we had while doing it. Life was always interesting with David Deacon – you never quite knew what was going to happen next, but it was always worthwhile and it was always special. You KNEW he’d probably seen it a dozen times before and you could be confident that any recommendation he gave would be sound and reliable. As with all individuals who are completely fluent in their subject area, he would tell you anything you wanted to know, and he would still know twice/three times what you knew about it when he’d told you anything he thought might be relevant. The Institute of Corrosion has lost a dedicated servant and supporter, his clients have lost a friend and a mainstay, and I have lost a close friend and colleague. There aren’t many in the world who command the kind of respect that David H. Deacon enjoyed. He really was quite a boy. RIP 31/03/2017.

Editor’s note: A more detailed account of Bill’s recollections can be found on the Institute’s website.
New Shell-Imperial Corrosion Centre

The Shell-Imperial Advanced Interfacial Materials Science (AIMS) Centre was opened recently to provide new insights into materials behavior, and to enable optimization of materials selection, design and enhanced predictive capabilities. The Centre, based in the Department of Materials, will focus on the development of innovative solutions using state-of-the-art approaches to materials challenges in industry. The Centre is led by Professor Mary Ryan and was a result of an ongoing partnership between Shell's Materials and Corrosion R&D team, led by Dr. Lene Hviid, and Imperial's Department of Materials. Professor Ryan also currently holds the Shell/RAEng Chair in Interfacial Nanoscience for Engineering Systems.

The stated long-term goal of the Centre is to make industrial processes safer, more predictable and more efficient, ultimately resulting in better asset management and operational performance.

International Symposium on Reinforced Concrete Corrosion, Protection, Repair and Durability

The Australasian Corrosion Association (ACA) is holding an international symposium to highlight the achievements of Brian Cherry. The event will be held at the Melbourne Marriott Hotel, Melbourne on 26 and 27 July 2017.

Further details can be obtained from Bianca Reardon at the ACA, email: reardon@corrosion.com.au

AkzoNobel launches new marine coatings app

AkzoNobel Marine Coatings’ International has launched a mobile app to provide customers with application guides, technical datasheets, product brochures, information cards and regional contacts, as well as social media and blog posts.

In addition, the app includes material safety datasheets (MSDS), a full version of the most up-to-date cargo resistance guide, and a glossary of terms to help users keep track of the assortment of acronyms and technical terms used in the world of marine coatings.


Paint Application Drone

Apellix drone. Apellix, a Florida startup company, founded by entrepreneur Bob Dahlstrom, has announced plans to release Worker Bee, a paint application drone, by the end of 2017.

The main problem Apellix had to solve in order to make a painting drone work was how could a small, propeller-driven drone carry paint into the air in order to apply it? Dahlstrom's solution involves a tether system- an umbilical cord attached to the drone carries paint to the unit from a tank on the ground. A compressor pumps the paint up to a small reservoir on the drone, where it can be applied by the paint nozzle. The cord also includes an electrical cable to provide power to the drone, so that it doesn't have to be repeatedly recharged during the job.

Apellix has been testing the Worker Bee with industry partners to optimize it before it goes to market. At present, latex paints have been applied using a 3,500 psi airless spray system, although experiments are starting with a 7,600 PSI system, as applying well as zinc-rich and antifouling coatings.

Already on the market from Apellix is a drone-based dry film thickness gauge called Smart Bee, which, according to the company can also be used to measure surface profile.

Huntsman Acquires UK Polyurethane Firm

Huntsman Corporation (Texas) has announced its acquisition of the UK based, IFS Chemicals Limited. IFS is a formulator of polyurethane products including coating and insulation systems for field joints for the offshore business, as well as spray-applied insulation for both pipeline applications and architectural and commercial use. According to Huntsman, the IFS acquisition represents the latest step in the plan to strengthen their differentiated downstream capabilities, and reflects their confidence in the long-term growth prospects for MDI-based urethanes.
Novel anti-corrosion pigments

Scientists, at INM-Leibniz Institute for New Materials, have reported newly developed flake-like zinc phosphate particles, which the researchers say makes them better for corrosion protection than traditional spherical zinc phosphate. The flakes are more soluble than their spherical counterparts, and repassivation of bare metal surfaces, for example due to damage, is better and faster. In addition, testing has shown that the corrosion protection offered by coatings formulated with the flakes appears to be greater and longer-lasting.

New appointment at Safinah

Safinah Ltd, a world leader in the provision of consulting services to the marine, off-shore and mega-yacht markets, are pleased to announce that Dr Tor Svenson has joined the board. Tor has a PhD in vessel performance monitoring from Newcastle University Dept of Naval Architecture and Shipbuilding. He has authored a number of papers on the measurement of vessel performance. He will have a number of key roles, including working with the MD, Dr Raouf Kattan and Director of Technology, Mr Alan Guy, to develop a road map for future research programmes that Safinah will fund. He will also carry out consulting assignments for clients in his areas of expertise.

New guide to detecting defects in bridges

The latest publication from the Construction Industry Research & Information Association (CIRIA) is, Hidden defects in bridges – guidance on detection and management (C764).

CIRIA is planning a series of regional roadshows to promote the findings and recommendations in this new guide, starting in June 2017 at Bristol’s Museum M-Shed, and hosted by consulting engineer Ramboll. Arup is hosting a similar event in the Midlands on 4th July, and further events are planned in London and Scotland in the autumn.

These events are being held to provide an overview of the good practice described in the guide, and how it can be used to mitigate the risk of hidden defects, which can lead to bridge failure, and will be of interest to professionals involved in bridge engineering, inspection and management and for more details, see www.ciria.org/hiddendefectsroadshow, or to register your interest email, enquiries@ciria.org.

According to CIRIA project manager, Lee Kelly, “as we saw last year, with the Forth Road Bridge, hidden defects can have a dramatic impact and lead to costly closure, maintenance and repair. CIRIA’s roadshow is an opportunity to bring together the bridge engineering community to discuss the latest good practice and emerging technologies that assist in bridge management and repair.”

Axalta Coating Systems to Acquire the Spencer Coatings Group

Axalta Coating Systems, a leading global supplier of liquid and powder coatings, has announced that it has entered into an agreement to acquire the Spencer Coatings Group, a leading manufacturer of high performance industrial coatings for heavy-duty equipment, general industrial and the oil and gas markets.

The Spencer Coatings Group, established in 1909, is the largest independent industrial coatings manufacturer in the UK, and well-known products include Acothane™ polyurethanes, for internal and external pipeline protection, Corroless™ coatings for a variety of steel structures, and high-performance water-based coatings for general industrial markets.

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Continued Operation of Large Offshore Platforms Requires Innovative New Cathodic Protection Systems to be Retrofitted

Jim Britton and Alex Delwiche, Deepwater EU Ltd.

Many large structures, and other offshore producing areas in the North Sea, are needing to stay operational beyond their original design life. The reasons for this are typically driven by improved geological survey and recovery technologies, that keep the reservoirs viable, and the advances in subsea production systems which, through subsea tiebacks, keep the oil and gas flowing.

This article discusses the difficulties in undertaking cathodic protection upgrades to offshore oil and gas structures, and discusses examples of where the authors’ company have undertaken upgrades or retrofits to a number of structures in UK waters.

Most of these structures were commonly equipped with sacrificial anodes in the fabrication yard, a relatively straightforward process, as the anodes were usually attached when the jacket framing was at ground level before being “rolled up into the vertical” position. In the seventies, some operators promoted the use of coatings on these facilities to reduce the number of anodes required, especially where zinc anodes were favoured over Al-Zn-In or Al-Zn-Hg. Other operators reviewed the CAPEX financial figures and opted to just increase the number of anodes, which was normally the most cost effective option. This resulted in the case of a large bare steel structure with the attachment of around 2476 anodes, with a combined weight of 666,000 kg (1). Many of these structures were designed to provide around a 20 to 25 year life.

When designing large sacrificial anode systems, two things are very important. The first being to provide sufficient anodes to deliver the required current density (mA/m²) to the submerged structure, to ensure that optimum levels of cathodic protection are established, and that it is evenly distributed to all areas of the submerged structure. This current density is normally referred to the initial, or polarization current density, and following the present design codes, is recommended to be 150 to 180 mA/m² in the Southern and Northern North Sea areas respectively (2). The second important item is to ensure that there is sufficient mass of sacrificial material to provide the required current for the design life, given that aluminium anodes typically waste at a rate of 3.5 Kg/A/Year. However, to calculate the mass of anodes required, the current density can be reduced to a lower level of 90 mA/m² which is the number quoted in the design standards as the mean or maintenance current density. The large difference between these numbers is significant when considering the question of continued extended operation.

If a cathodic protection system that has established protective deposits on the steel surfaces, and is still able to “maintain” these deposits, at about half of the theoretical design current requirement, then it is strategically advantageous to extend the system life while it is operating at this maintenance level, rather than going back to the initial, or polarization level again. It is for this reason that a pro-active intervention is recommended, whereby cost savings can be significant.

A recent example is the retrofit to an aging Northern North Sea structure, to allow continued operation. This structure was originally installed in 1979 and was fitted with the 2476 sacrificial anodes mentioned earlier. In 2010 there was evidence that the protection levels were below the required criteria. Studies concluded the current required to extend the life was 7500 A. This high current requirement presented a challenge, especially as the anode battery was at a rate of 35 A/Kg/Year. However, the required number of standard “off the shelf” systems also was cause for concern. A 450 A ICCP system was readily available following development over 20 years by our company, however the number of systems needed to meet the current requirement was unworkable, due to available sites on the sea bottom, the number of cables required, and topside space constraints for location of power units. The solution was to re-engineer the standard system to double its current capacity to 950 A, thus halving the number of units. This also required the re-design of the cables and the power units (figure 1).

Due to lack of space on the platform, a deck extension was added to accommodate a customised container which contained the 8 x 950 A transformer rectifier units (figure 2).

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**Figure 1 – 950 A ICCP Anode Sled.**

Due to lack of space on the platform, a deck extension was added to accommodate a customised container which contained the 8 x 950 A transformer rectifier units (figure 2).
The replacement system was deployed in 2016, and was commissioned that same year. The structure is now fully protected with the system operating well within its capacity. Figure 3 shows a typical depleted anode with the CP level at (-) 0.675 V vs Ag/AgCl, well below the required level prior to the retrofit.

On another group of structures, installed in 1974, the original approach was to coat the structures in addition to cathodic protection. Part of the reasoning for this approach could well have been that the zinc anodes chosen, with a reduced current capacity when compared to aluminium anodes (780 Ah/kg to 2500 Ah/kg respectively), the number and weight of which required for a bare steel structure would have presented problems. One of the corrosion engineering designers involved (3) confirmed that the coated and zinc anode option was slightly more cost effective than without coating and the owner/operator preferred zinc to aluminium anodes, as they had bad experiences with aluminium at that time. Each structure was fitted with 800 zinc anodes each weighing 360 kg, totalling 288,000 kg. It should be noted that these structures are approximately half the size of the one described above (when considering the wetted surface area).

Obviously there are many differences between the two types of structures which have a knock on effect on any life extension programme. This field was sold in 2003 to another operator, who evaluated the situation and concluded that life extension beyond the original design life of the assets was necessary, due to presence of new reserves. When this situation was realised an extensive programme of upgrades was implemented, including that of the CP system, which predictions, including CP modelling, had determined would not last beyond 2012, whereas the extended design life desired as of 2008 was 15 years.

The strategy programme for the two operators was different - one had a failing CP system when the structure was purchased and had to commission a retrofitted CP system, the other operator had a CP system that was performing well because of the coating, but opted for a proactive approach when it was clear that the system would not last through the required life extension.

Two x 500 A systems were therefore fitted to each of these structures (3 x 500 A on one platform). This was a redundant measure since the actual current required was calculated at about half this amount. The systems are currently operating at around 20% of their design capacity. The design was cross checked by various methods including anode depletion and computer modelling. It is worth noting that the cost of doubling the current capacity represented only a 10% increase in total project cost.

To compensate the upgrade requirements, the life extension was for a series of bridge-linked jackets. Most were installed with a galvanic anode system, but one jacket had been built with a close mounted ICCP system that had unfortunately failed very early on. The latter gave little confidence to the owner/operator about ICCP systems generally offshore, although the technology at the time, albeit ground breaking, was not engineered adequately to survive the harsh North Sea environment. Having continually upgrading the cathodic protection systems at great cost each time with jacket mounted anodes, as a strategic gas field with significant long term gas reserves, the owner/operator took a step back, reflected on the overall long term cost and took the plunge, and went forward with a remote anode retrofit system.

The southern North Sea environment is totally different to the relatively calm depths of the Northern North Sea. Albeit the current requirement for maintenance was not anywhere near as high as for the larger structures, but being a complex with multiple undocumented anode replacements, the actual current required was difficult to determine. The owner/operator was advised by a series of specialist consultants that the existing
and retrofitted anodes would not last for the extended life of the gas field, and some areas of the complex were already seeing signs low protection levels.

Studies were undertaken by our company and third parties, that confirmed a remote anode ICCP system would be the most effective system in terms of overall installed cost, and a 30% redundancy was included, which resulted in three 500 A systems being recommended.

However, due to the fast flowing, shallow conditions, the subsea equipment had to be modified to withstand the high bottom currents and the scour tendencies in the area.

The redesign resulted in an increased gravity base mass, extra tether arrangements fitted to the buoyant anode modules, and supplementary cable protection using flexible concrete mattresses (Figure 5 and Figure 6). The flexible mattress system allowed for the stability design to be optimised, reducing the handling cost of a traditional steel formed concrete mattress, and flexibility of where the mattress could be assembled and cast locally to the job site. The subsea ICCP system took only three days to install, with each concrete mattress being laid every 20 minutes, thanks to the planning and dedication of the owner/operator and subsea installer. As can be seen in Figure 7 the deck layout required intricate planning.

Conclusions

Cathodic protection life extensions, are by definition, customised on a project by project basis. It pays the owner to complete a front end engineering exercise to determine the optimum solution. It also pays to include healthy levels of redundancy in the designs, based on the small incremental cost of this provision.

The original corrosion protection designs by various owner/operators have proved that coating the structures has been an excellent system, as a means of controlling the need for additional cathodic protection requirements, where longevity is required.

The three examples provided have shown that remotely installed impressed current CP systems offer a cost effective and reliable solution to extend the life of large offshore structures.

References


(2) BS EN 12495: 2000 Cathodic Protection for Fixed Steel Offshore Structures

(3) Thanks to Michael Pursell, retired Corrosion Engineer, for contributing to this article
Planning an Onshore Buried Pipeline Cathodic Protection Upgrade – a CP specialist’s viewpoint

Bill Whittaker, Cathodic Protection Engineering Ltd

In general, buried pipelines within the UK are for the most part of their length externally coated and provided with permanent cathodic protection (CP) systems. (The provision of CP is given in several Codes, for example, ISO 15589, EN 12854 and NACE SP0169). These pipelines are then monitored to ensure that the CP/coating combination is adequately protecting the pipeline from corrosion, and thus protecting the product being transferred, and the environment from accidental spillage. This is the function of a cathodic protection specialist who is in the almost unique position of being able to see an entire project through from start to finish. CP personnel get to carry out the initial CP survey, then complete and install the required design, commission it, and with a bit of luck maintain the CP on the new asset for many years to come. Basically, the CP specialist is one of the first people on site, and one of the last people to leave!

This article briefly describes the planning of the initial stages of a CP upgrade design for an existing buried pipeline, the proposed design, and the installation stages:

Where does the CP upgrade for an onshore pipeline start? Typically, in the office, by reviewing the available historical CP data and noting where the data might indicate non-compliance with the relevant criteria. Once the section(s) of the pipeline requiring “improvement” have been determined, they (and possible other sections) would normally be re-inspected to ensure that there were no obvious errors with the previously reported data. This is typically referred to as a “conformational survey”. Here in the UK this may consist of one, or more of, the following surveys:

- Routine Test Post Monitoring of ON and OFF potentials and Alternating Current (AC) voltages, current densities at the affected test post facilities, along with the outputs of all CP current sources being recorded together with the measurements from any existing AC or DC mitigation systems where installed
- Close Interval Potential Survey (CIPS) - ON and OFF potentials recorded at 1-2m intervals along the pipeline section
- Direct Current Voltage Gradient (DCVG) Survey – to determine the quality of the buried coating
- Pipeline Current Mapping (PCM) where a PCM current is applied to the pipeline and traced along its length to determine if any electrical short circuits, or large coating defects exist
- Datalogging – helpful to determine the full extent of any DC Stray Current and Induced AC
- Locational Surveys to determine the exact location of the CP equipment, including cables and as required, the pipeline itself
- Possible Current Drainage Testing to determine the current requirements of any proposed CP design.
Once all this information has been collected and analysed, the CP engineer can decide on the best course of action. This, I believe, is the most important stage of the entire upgrade process. It can be all too easy to say let’s just install more CP capacity, i.e. a new CP station, but other less obvious solutions may actually be much more effective. It may be that more data is required to be collected, or that pipeline excavation is required to inspect one or more of the following: coating quality, status of sleeved crossings, backfill quality, extent of corrosion, and others. Additional work may also be required, such as: soil resistivity testing, the installation of permanent test coupons and reference electrodes combined with additional data logging, sleeve isolation testing, repeat CIPS and DCVG surveys, all of which take time and cost money. The engineer should not be afraid of stipulating that extra work is required prior to recommending the most suitable upgrade. This phase of the upgrade process can take from 2 weeks to 12 months, or even longer, depending on the nature of the fault.

Once all the required data has been collected and the decision made on the most suitable solution, the initial design works can begin. This initial stage isn’t even a CP works, more of a land/environment review, requiring that the following minimum tasks be completed:

• Discussions with the land owner
• Local services searches (important for stray current concerns and excavation safety)
• Rural Affairs (DEFRA) search, such a search identifies any statutory designations, such as: Nature reserve, Site of Special Scientific Interest special habitat, and the requirement to obtain any planning consent for the works which are to be undertaken.
• Additional local specific land searches or enquiries
• Availability of local power supplies (if required) and the associated cost

It is at this stage of the planning where groundwork locations and cable routes are discussed with the relevant parties. A suitable groundwork location from a CP point of view may not be as suitable for a land owner, due to possible future planning proposals (for example, the farmer has reserved the proposed groundwork location for a new farm building - a new groundwork site would be required), or locally known issues such as the area having multiple land drains - a new groundwork site would be required), or locally known issues such as the area having multiple land drains installed which are key to the farmer’s irrigation system.

The lands review can typically be completed within 1 month as the majority of the information is available online, leaving a suitable time for a walkthrough meeting with the land owner.

Following the lands review, a conceptual CP design can then be determined, including planning CP system, proposed configuration, location of equipment, AC power supply locations (if required), cable routes, available space for proposed CP equipment, basic construction plan (what construction is needed, how will it be carried out, is there suitable access for plant etc), based on the results of the previous stages.

Depending on the project size and complexity, the conceptual design can take from a few days to produce to 1 month.

The next stage would be a review of legal rights for the proposed CP installation. Are suitable legal rights for the CP equipment already in place, or if new equipment is proposed (rather than replacement), then new rights will generally have to agreed. The conceptual design may need to be reviewed and revised during this initial period of the legal discussions, as the designer weighs up the various options, for example, if new rights are to be sought, is it more efficient to propose a different configuration of grounded within the existing wayleave (if permitted via the existing legal agreement) and the associated additional construction and environmental considerations associated with such, versus the delay and legal cost of acquiring new legal rights for a large horizontal grounded. This and many other options are to be considered during this phase of the planning works.

Once all the options have been weighed up, the final conceptual CP system is designed, and, if required, new legal rights applied for. This is expensive and requires that the conceptual CP design is as final as possible, as if the design changes, so will the legal requirements, ending up in possible duplication and cost increases. It is likely during this stage that legal representatives will be involved from both sides (pipeline owner and land owner) plus land agents, and the costs start to quickly build up!

The application of new legal rights can take between 6 and 24 months (if not longer) depending on the legal team and the land owner’s receptiveness to the proposals.

If suitable existing legal rights are in place, where possible, the CP design will need to be tailored around these to save the delay and expense of legal modifications, or the application of new legal rights. Again, this isn’t always possible as the existing CP design may not provide the required result, and might be the reason that a CP upgrade is being completed in the first place!

With the environmental and legal work completed and agreed (at least agreed in principle based on the conceptual design), the detailed design specification can be written. During such, the following points need to be considered as a bare minimum:

• Project outcome – what is the aim of the project
• Client standards as well as national and international standards
• Regulations ensuring that the proposed system is in compliance with government regulation
• Site survey results (key input for any successful design)
• Pipeline system data (any special construction material used)
• DEFRA search results
• Legal and land limitations
• Design philosophy, which is the best type of CP system: sacrificial or impressed current. Plus consideration of the best configuration for each of type of system, deepwell, multiple boreholes, horizontal.
• Design calculations for sizing of the CP equipment specified
• Cable requirements and routes
• CP monitoring requirements, detailing the required future monitoring, including monitoring tasks and inspection periods.
• Remote Monitoring / Control requirements
• Possible AC and DC interferences, including mitigation and/or monitoring requirements
• Hazardous area considerations, most pipelines where CP is typically applied transport hazardous materials, consideration must be given to ensure that a CP system is not installed in a hazardous environment, if it is, then it must be designed to ensure it can operate safely in such an environment
• Protection from lightning and possible faults from overhead high voltage cables
• Material specifications, again one of the more important aspects of the design, as, if incorrect materials are specified, then the system may not work, however if no material specifications are given, then it is likely that the cheapest equipment will be supplied. Quality assurance must also be considered, with possible stipulations for inspections and material certifications and testing.
• Installation requirements, to ensure that the team installing the proposed CP system is competent to do so, but also specific testing to ensure that the equipment is installed correctly. Detail of supervision requirements and client review/inspections, as these are an important step in ensuring that the project is delivered as per the design requirements
• Commissioning requirements, this section of the design should be tailored to ensure that the testing completed confirms (or not), that the project aim has been achieved. For example, if a new DC stray current mitigation scheme was installed, the required commissioning test would be very different to those completed for a simple grounded replacement. Extra testing would be required, such as long term datalogging and intensive manual monitoring, possible installation and monitoring of additional permanent CP equipment such as coupons and reference electrodes, all of which would require monitoring and possible datalogging. Versus a resistance test of the new grounded and anode current monitoring
• Consideration of the Design and Management (CDM) Regulations 2015. Under the regulation, designers must make the client aware of their duties under CDM, consider all pre-construction information (typically in CP that is the site survey results), eliminate health and safety risks (where feasible) to anyone effected by the project, and control any risks that cannot be eliminated. The regulation also requires that the designer cooperates and coordinates with other designers (during the design phase), and contractors (during installation), to ensure compatibility and also to ensure that knowledge and experience is passed on.
• Reporting requirements, what information needs to be handed over, during, and following construction. What does the client need to do (update records etc), and how should this information be transferred

The last part of the planning stage of any CP upgrade is the completion of the project drawings. These are without doubt the most important part of the installation works. Detailed easy to understand drawings for each aspect of the CP system are required to ensure that the works are completed to an acceptable standard. A 100-page specification is not going to be read in a deep muddy wet hole on site, whereas a nice simple drawing will be.

The project is then tendered and awarded followed by a pre-start meeting where the project requirements and safety aspects of the works are discussed. Safety and installation methodology paperwork is submitted by the contractor for review by the client and CP designer and the installation is then completed.

If the project is well planned, properly risk assessed and designed, then unexpected events are much less likely to occur during the installation phase, but planning takes time, and should not be rushed! It should now be clear that that the CP designer has a large hand in every stage of the project lifecycle, which for me, is one of the best parts of the job!
The importance of protective coatings in preventing the deterioration of steel structures is difficult to quantify, but a study carried out in the USA with the support of NACE and the U.S. Federal Highway Administration, estimated that the direct annual costs of corrosion in the United States was $276 billion, which equated to approximately 3.1% of national GDP at that time, demonstrating the importance of corrosion prevention in the world today.

The economic benefits of implementing sound long term corrosion protection strategies is fairly obvious from this and other similar studies, but in recent years other considerations have emerged that reinforce the need for highly durable and effective protective systems for steel structures exposed to highly corrosive environments. Foremost among these considerations is the increasing demand for man-made structures – be they buildings, bridges, ships, motor vehicles or any other type of structure – to have as little detrimental impact as possible on the environment in which they are located, or in which they operate. This requirement applies to all stages in the life of the structure – from production of the construction materials themselves to the design and erection of the structure, its maintenance throughout its life, and ultimately its disposal when it inevitably reaches the end of its useful lifetime.

Protective coatings contribute to the environmental impact of man-made steel constructions in a number of different ways. Initially, the manufacture of the coating and the process by which it is applied must be taken into account, and will add to the overall environmental impact of the structure at point of commissioning. Over time, however, that initial contribution will be ‘repaid’ as the protective properties of the coating reduce the incidence, and extent of corrosion, allowing maintenance to be scheduled less frequently.

Coating manufacturers have long contended that the extended maintenance intervals made possible by the use of high performance, highly durable coating systems, will far outweigh their initial contribution to the eco-footprint of a structure when the benefit that accrues from the use of coatings is taken into account over the whole of its life.

This article discusses a study to test this contention, by quantifying the effect of coating systems of varying durability (and hence varying maintenance requirements) on the environmental impact of a steel bridge over the course of its functional life.

However, before looking at the results, some background information on sustainability and Life Cycle Analyses are necessary.
Legislative Background to Sustainability within the EU

Following the review of the EU Sustainable Development Strategy 2001, the European Council adopted an ambitious and comprehensive renewed Sustainable Development Strategy in June 2006, with the overall aim of continuously improving quality of life for both current and future generations, through the efficient management and use of resources, and the encouragement of ecological and social innovation.

This brought sustainability into sharp focus within the EU, and signalled an increase in demand for environmental assessment of materials used in construction, particularly for those materials used on buildings. Throughout the EU some form of ‘green building’ label or assessment has become a routine requirement, with materials used in building construction (including paints) needing to demonstrate environmental compliance through assessment systems such BREEM (Building Research Establishment Environmental Assessment Methodology), HQE (Haute Qualité Environnementale), DGNB (Deutsche Gesellschaft für Nachhaltiges Bauen e.V.) or LEED (Leadership in Energy and Environmental Design).

Life cycle information became a mandatory requirement for compliance of materials under DGNB, BREEM and HQE assessment, and was also encouraged under the LEED system. More recently, this information is also being required in an Environmental Product Declaration (EPD) for any materials used, or intended to be used, in buildings. EPDs are now mandatory for DGNB and HQE assessment, and encouraged under BREEM and LEED.

Other initiatives in the EU are further increasing the focus on reducing the environmental impacts of products, with Green Public Procurement (GPP) policies being adopted by public authorities in many member countries, whereby these authorities are obliged to procure goods, services and works, that have a reduced environmental impact throughout their life cycle, wherever possible. This means that potential suppliers to these authorities must provide data to support the environmental performance of their products.

CEPE support for Life Cycle Assessment

CEPE (the European Council of paint, printing ink and artists’ colours industry) quickly recognised the importance to its members of having reliable data to define the environmental impact of their products, and started a programme of work to produce life cycle assessment data for typical coatings, and a methodology, to assist its membership.

Because coatings consist of combinations of chemical raw materials, the determination of accurate data for any paint product depends very much on the availability and reliability of data for its component ingredients. The initial hurdle identified by CEPE was that much of the required raw material data was either unavailable or un-verified, so before any life cycle assessment could begin, a validated database of environmental information for chemicals specifically used by the paint industry had to be created. This led to a Life Cycle Inventory (LCI) database for the coatings industry.

CEPE members worked with a team of consultants to define the process stages, and environmental criteria involved in the manufacture of different paint types, while CEPE itself commissioned the development of a software programme utilising the LCI database, to calculate environmental impact data from inputted formulation and manufacturing details. The resultant software tool – called the Eco-footprint Tool – was subsequently made available to CEPE members as a web-
based tool, enabling them to carry out Life Cycle Assessments (LCAs) for existing and potential products at the formulation stage.

**Output Data from the ECO-footprint Tool**

The Eco-footprint Tool is designed to produce environmental impact data for all stages of manufacture, up to, and including the storage of the completed paint product – i.e. LCA values from cradle to manufacturer’s gate – and presents the results as impacts per kilogramme of liquid paint produced. Examples of the input data required, and output factors calculated are summarised in Figures 1 and 2:

**Scope of the Study**

The full LCA for a coated steel bridge consists of a series of stages as follows:

1. **Raw material extraction**
2. **Production of chemicals / paint ingredients**
3. **Paint manufacture**
4. **Warehousing and storage**
5. **Paint specification**
6. **Application and drying / curing**
7. **Life to first maintenance**
8. **End of life – reclamation or disposal**

The impact of transportation will be a factor within each of stages 1 – 5 and stage 8, and between all stages up to stage 6. Transportation impacts and equipment are not included in stage 7 maintenance activities. Waste management and disposal impacts are taken into account throughout.

Specifically, the Protective Coatings study was designed as an assessment carried out from the perspective of a highways or local authority department having responsibility for infrastructure maintenance, whose objective is to construct and maintain a bridge on a rural road passing over a motorway and with a design life of 100 years. The bridge construction was based on the design for a traditional steel composite twin girder bridge.

**Project Design Parameters**

Three coating specifications were included in the study, in which the number and/or thickness of individual coats was varied, with consequential differences in life expectancy before and between maintenance activities (Figure 3).

**Life Cycle Assessment Methodology**

A full life cycle model was prepared for the bridge, which involved defining input data for the four main stages of the life cycle – raw material inputs, construction phase, use and maintenance, and finally end of life and disposal.

The main focus of the LCA was on the ‘Use and Maintenance’ phase, since it is in this aspect of the operation of the bridge that the performance of the coating systems is under greatest scrutiny. The inputs and assumptions used for all four phases of the life cycle had nevertheless to be determined, and were assessed according to the following guidelines:

---

**Figure 1** - Input data utilised by the Eco-footprint Tool.

**Impact categories**

<table>
<thead>
<tr>
<th>Impact category</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Global Warming Potential</td>
<td>3385.1</td>
</tr>
<tr>
<td>Ozone Depletion Potential (ODP)</td>
<td>298.2</td>
</tr>
<tr>
<td>Photochemical Ozone Creation (POCP)</td>
<td>1716.3</td>
</tr>
<tr>
<td>Acidification Potential (AP)</td>
<td>20.6</td>
</tr>
<tr>
<td>Eutrophication Potential (EP)</td>
<td>8317.9</td>
</tr>
</tbody>
</table>

**Energy Content**

<table>
<thead>
<tr>
<th>Source</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Non-renewable</td>
<td>62.5</td>
</tr>
<tr>
<td>Renewable</td>
<td>2.7</td>
</tr>
</tbody>
</table>

**Waste**

<table>
<thead>
<tr>
<th>Source</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Non-hazardous</td>
<td>26</td>
</tr>
<tr>
<td>Hazardous</td>
<td>11</td>
</tr>
</tbody>
</table>

**Resource Consumption**

<table>
<thead>
<tr>
<th>Source</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Non-renewable</td>
<td>3.9</td>
</tr>
<tr>
<td>Renewable</td>
<td>6</td>
</tr>
<tr>
<td>Water</td>
<td>147.5</td>
</tr>
</tbody>
</table>

---

**Figure 2** - Example output from Eco-footprint Tool.

**Figure 3** - Coating system compositions and estimated maintenance intervals.

---

**Figure 3** - Coating system compositions and estimated maintenance intervals.
1. Phase 1 – Raw Materials
The model used for defining raw material impacts in the construction of the bridge covered, steel type and amount, concrete type and amount, amount of asphalt used and paint type and amount.

Raw material inputs were simplified as far as possible, so that only the major components were included in the model. Materials such as joints, bearings and waterproofing membranes etc were excluded from the calculations, as were the effects of transportation of materials, which would be difficult to quantify.

2. Phase 2 – Construction Phase
The following parameters were agreed for construction-phase calculations:
- Type of road – Motorway with rural A-road over
- Type of disturbance – Road closure
- Total time of disturbance – 168 hours
- Period of disturbance – Weekend nights

Re-routing distance

3. Phase 3 – Use and Maintenance
As for the construction phase above, for all the paint- and maintenance-related activities, assumptions had to be incorporated into the calculation model for the following factors:
- Type of road (which will affect volume of traffic)
- Nature of disturbance
- Number of hours required for each stage of the coating operation
- Time of day when maintenance normally scheduled
- Distance of re-routing of traffic (due to closures), where this is the nature of the disturbance

The frequency of maintenance painting over a hundred year period was calculated from the maintenance intervals quoted in Figure 3 for each paint system, these, and the assumptions made are summarised in Figure 4.

Figure 4 – Assumptions included in the calculations of Bridge Maintenance LCA Values.

<table>
<thead>
<tr>
<th>Activity</th>
<th>Type of road</th>
<th>Disturbance</th>
<th>Total time</th>
<th>Period</th>
</tr>
</thead>
<tbody>
<tr>
<td>Painting: Blasting + Primer coat</td>
<td>Motorway and rural A</td>
<td>Road closure</td>
<td>16 h</td>
<td>Weekend night</td>
</tr>
<tr>
<td>Painting: Intermediate coat</td>
<td>Motorway and rural A</td>
<td>Road closure</td>
<td>8 h</td>
<td>Weekend night</td>
</tr>
<tr>
<td>Painting: Top coat</td>
<td>Motorway and rural A</td>
<td>Road closure</td>
<td>8 h</td>
<td>Weekend night</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Specification 1</th>
<th>Specification 2</th>
<th>Specification 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total time per activity (all coats)</td>
<td>6 times / 100 years</td>
<td>3 times / 100 years</td>
</tr>
<tr>
<td>Rerouting distance per activity</td>
<td>599.455 km</td>
<td>799.259 km</td>
</tr>
</tbody>
</table>

4. Phase 4 – End of Life
End of life impacts included amounts of reinforcement steel, concrete and asphalt to be disposed of.

End of life flows were determined primarily in relation to the initial raw material inputs, but a number of criteria were excluded from the end-of-life model. These were:
- Demolition, transport and inventory of materials
- No attempt was made to include recycling in the calculations, so the results were based on end-of-life disposal only
- Coatings were excluded from the end-of-life calculations.

Life Cycle Scenarios
Three different LCA scenarios were defined for the study.

Scenario 1 – Full Life Cycle, comprising bridge construction – including supply and application of coatings - with maintenance over a 100-year lifetime and disposal at the end of that period. Traffic disturbances during maintenance were also included in the calculations.

Scenario 2 – Bridge Maintenance only, so excluding initial construction and final disposal data, but including the effects of all traffic disturbances during maintenance.

Scenario 3 - Coating Processes only – so assessment is of coating-related emissions only, over the lifetime of the structure.

Life Cycle Assessment Results
The LCA analysis was carried out using the three different coating systems in three life cycle / process scenarios, and values calculated for all the impact categories shown in Figure 3, as well as for human toxicity, terrestrial, freshwater and marine ecotoxicity and abiotic depletion potential (ADP fossil and elements).

The results for all impact categories showed the same trend, so the detailed assessments presented below for carbon footprint (expressed as Global Warming Potential or GWP), are typical of the relative impacts of all the other assessed categories.

In all diagrammatic representations of performance that follow, the key used is

System 1: 2 layer coating system with 15 year maintenance cycle
System 2: 3 layer coating system with 25 year maintenance cycle
System 3: 4 layer coating system with 40 year maintenance cycle

![Figure 5 – GWP Results for full life cycle over the bridge life of 100 years.](image)

In terms of overall contribution to the carbon footprint of the bridge over the whole of its life, the main contribution is made by traffic (mainly re-routing during construction and maintenance), which accounts for approximately 70% of the overall impact. Initial bridge materials – excluding paint accounted for a further 20-25%, with the coatings themselves accounting for only about 1% of the overall carbon footprint.

The total environmental impact is progressively reduced by the use of more durable coating systems, with system 3 producing the lowest carbon footprint for the bridge, mainly because of the significant impact the longer maintenance intervals had on the extent of traffic disruption.

Scenario 2 – Bridge Maintenance only
This LCA included only the impact of the initial painting process and subsequent maintenance activities, including traffic disturbances each time the work required road closures.

![Table of Life Cycle Assessment Results](image)
The results demonstrate the benefits of reduced frequency of bridge repainting and longer maintenance intervals, with the longest durability coating system (system 3) producing approximately 40% less environmental impact (carbon footprint) as compared with system 1.

This benefit is directly related to the reduction in traffic re-routing achieved by the use of the longer durability coating system.

In all cases, the direct contribution of the coatings themselves is approximately 2% of the total carbon footprint, and this is repeated for the other impact categories, except for their effect on ecotoxicity categories – which was slightly higher – and depletion of the elements (ADP elements), where the relative contribution of the coatings was the dominant factor.

In all cases, the higher durability of coating system 3 led to this system producing the lowest environmental impact figures over the full 100-year life of the bridge.

**Scenario 3 – Coating Processes only**

The environmental impacts of the coating systems were assessed for the individual components (coats) of each system and at each maintenance activity, and the results presented below in Figures 7 and 8.

It can be seen that in the individual maintenance activities, the higher thickness system (system 3) produces the highest carbon footprint, yet in the overall lifetime position this is the most environmentally friendly system. The higher impact of this coating specification in year zero is compensated over the lifetime of the bridge by the lower painting frequency.

It is therefore clear that the frequency of maintenance schedules is the main factor determining the environmental impact of paints over the total life cycle of the structure.

When the total GWP data is separated into the contribution made by individual coats (figure 8), it can be seen that despite having more coats applied, and a higher total film thickness than either of systems 1 or 2, coating specification 3 still gives the best results.

Of the individual coats, the zinc primer contributes most to the overall carbon footprint of systems 1 and 2, but with system 3, the MIO intermediate coat contributes the most.

**Conclusions**

Based on the evidence of the three LCA analyses, the main factors that influence the environmental performance of a bridge over its life cycle are the amount of coating used per year, and the number of road closure days per year, as shown below.

<table>
<thead>
<tr>
<th>System</th>
<th>2 layer &amp; 15 year durability</th>
<th>3 layer &amp; 25 year durability</th>
<th>4 layer &amp; 40 year durability</th>
</tr>
</thead>
<tbody>
<tr>
<td>Amount of coating (kg) / year</td>
<td>40.6</td>
<td>31.2</td>
<td>26.3</td>
</tr>
<tr>
<td>Closure days / year</td>
<td>0.18</td>
<td>0.12</td>
<td>0.10</td>
</tr>
</tbody>
</table>

The increased number of coats and additional time taken to coat the bridge (and re-route traffic) are more than compensated for by the lower frequency of maintenance painting in the more efficient and environmentally-friendly scenarios, so that the systems having the greatest number of coats and longest durabilities produce the best environmental performance over the life of the bridge.

Coating system 3 therefore has the best overall performance over the full 100-year period.

The direct impact of the coatings themselves is not significant when compared with the full bridge construction programme and the need to re-route traffic during construction and maintenance activities. Indeed, the main differences between the three coating specifications can be attributed mainly to variations in traffic disruptions during maintenance cycles. While the overall environmental impact associated with building and maintaining a bridge will be related to the size of the construction – i.e. the length and width of the bridge – the relative trends established during this study will remain valid for other (similar) paint specifications and maintenance cycles.
DeFelsko has made available a new instrument to detect holidays and pinholes in coatings on metal and concrete. The PosiTest LPD low-voltage pinhole detector is a wet-sponge tool that provides four voltage output options to provide varying degrees of sensitivity and conform with various standards.

The instrument comes with a number of optional hardware and extension accessories to increase the tool’s reach and adapt it to specific situations, and is waterproof, dustproof and shockproof, and uses three AAA batteries.

Huntsman Advanced Materials of Switzerland, recently launched three low-temperature curing agents, used for heavy-duty industrial coatings applications including oil and gas, marine, transportation and industrial maintenance.

The company says its Ara Cool products were designed to meet the need for faster curing at low temperatures and reduced levels of volatile organic compounds, and are suitable for many applications, including anti-corrosion and protective coatings, and decorative paints.

Hempel has launched two new advanced coatings, specifically developed to protect the vulnerable “splash zone” areas of offshore structures, Hempadur Multistrength 35840 and 35842.

According to the company, these 2K epoxy products are unlike conventional coatings - they are almost solvent-free and contain a much higher percentage of reactive diluents instead of conventional solvents to create superior cross-linking properties. In addition, the coatings are reinforced with glass flakes to further enhance their water resistance and strengthen them against physical impact. Their high solids ratio (99 percent) and low VOC (volatile organic compound) content makes them significantly kinder to the environment than conventional coatings.

Both products have been pre-qualified to NORSOK M-501 System 7A and 7B; including extensive testing to ISO 20340 for a variety of relevant corrosion categories, concluded the company.

Belzona has released Belzona 3412 encapsulation membrane. This coating can be brush or spray applied onto complex surfaces to protect them from the most severe corrosion. When used in conjunction with Belzona 8411, a release agent/corrosion inhibitor, it can be cut and peeled back during required maintenance, or to check the status of the substrate, before being fully resealed with an extra layer.

The new product can provide outstanding protection to a range of machinery and equipment, from the smallest bearings to the risers of offshore platforms. Its elasticity and adhesion properties allow it to encapsulate and bond effectively to many types of metallic and painted surfaces, a key example is in flange protection. The coating comes in two colours, grey and orange. The grey blends into metallic substrates whereas for safety purposes, the bright orange enhances the visibility, highlighting areas which can be peeled and inspected.

According to the company depending on the temperature and humidity of the environment, the material takes between one and four hours to become touch-dry, meaning minimal downtime for the coated equipment, and as result of its water-excluding corrosion inhibitors, it provides a durable layer of protection against many types of corrosion, such as galvanic and crevice. It is also an isocyanate-free system.

Huntington Advanced Materials of Switzerland, recently launched three low-temperature curing agents, used for heavy-duty industrial coatings applications including oil and gas, marine, transportation and industrial maintenance.

The company says its Ara Cool products were designed to meet the need for faster curing at low temperatures and reduced levels of volatile organic compounds, and are suitable for many applications, including anti-corrosion and protective coatings, and decorative paints.

The three products are:

- Ara Cool 3077, a multipurpose hardener for coatings and flooring that can be used as a co-accelerator for slow hardeners;
- Ara Cool 1047 W 80, a surface-tolerant, low-temperature curing hardener that provides adhesion even under humid or cold conditions; and
- Ara Cool 1034 XW 90, a curing hardener with low temperature reactivity suitable for applications in general protective and decorative paints.

According to the company, products formulated with the Ara Cool line, process faster in cold or unpredictable weather, which can help extend application periods into the cooler seasons and avoid breaks in the application schedule. The VOC levels in these products are in line with regulatory requirements for low temperature cure applications, and are REACH compliant to meet environmental regulations expected to be introduced in the EU in 2018.

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Institute Events

DIARY DATES 2017

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London Branch publish a monthly Newsletter; to be included on the circulation list please contact:
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Thursday 21st June 2017
North West Branch AGM, and golf day
The AGM will be held at Eccleston Park at 6.30 pm after the golf competition. This is an ideal opportunity to meet other ICorr members, and to become more involved with the Branch activities. For more information, contact the Branch Secretary, Brenda Peters at, brenda.peters@analysis-scientific.co.uk

Thursday 6th July 2017
North East Branch Meeting
Topic: Energy past, present and future
Venue: Hatfield College, Durham University
Examining the national picture for energy supply and demand, identifying the risks with discussion on what the UK can do to improve its energy security in the long term.
Speaker: Professor Jon Glyuas, Durham University.
Visit www.icorr.org for more details.

Thursday 19th October 2017
London Branch joint meeting with SCI
Venue: SCI, Belgrave Square, London, SW1X 8PS
Topic: From the Foundations of Electricity to Modern Corrosion Failures
Speakers: Dr F Parrett, SCI and Dr D Eyre, ICorr

ADDITIONAL DIARY DATES

Wednesday 26 - Thursday 27th July 2017
International Concrete Symposium
Venue: Melbourne Marriott Hotel, Melbourne
Further details can be obtained from reardon@corrosion.com.au

Friday 15th May 2018
CEOCOR 2018 International Congress and Technical Exhibition
ICorr will host the 2018 CEOCOR Congress in Stratford-upon-Avon. For further details see www.ceocor2018.com