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The President Writes

I have recently had the pleasure of attending some excellent branch meetings, firstly in Aberdeen which had an excellent turnout for a very interesting evening on the potential for Acoustic Emission (AE) to detect both cracking and corrosion activity given by speakers from the School of Engineering, Robert Gordon University. What impressed me was what a dedicated and hardworking committee Aberdeen branch has, and the overall feeling of the meeting was very welcoming and people had an enjoyable evening. As members of the Institute I would encourage all of you to attend your local branch meetings, and if you are travelling, to attend meetings at other branches, wherever possible.

I also attended the London Branch AGM where we saw the handover from Jim Glynn to David Mobbs and George Winning, and I wish them the very best in their respective roles. My thanks go to Jim for his continued service to the Institute, and also to John O’Shea, past ICorr President, who stood down from London Branch, for all his years of dedication and enthusiasm. The branches are a great way to get involved in the organisation and I know support is always welcomed.

The Institute needs young professionals to become involved, and as already reported, Chris Bridge from BP, has been elected as the Young ICorr representative on council. Chris has set-up a LinkedIn group and is organising local social evenings, the first of which will be held in London in April (see the Young ICorr section later in this issue). I would encourage all members to reach out to their younger colleagues, to support this initiative.

Training is also a key focus for the Institute, and a lot of work has been carried out to improve the professional development opportunities for members, and the “route” towards Chartered Engineer status has now been mapped-out. I will keep you up to date with this development.

Just as the magazine was going to press, I heard of the death of David Deacon on 31st March. David was a past President of the Institute and stalwart supporter, and on behalf of the institute I would like to offer condolences to his family. I’m sure there will be a fitting tribute to him in the next issue.

From the Editor

I hope you like new format of the magazine, and that you will agree it has improved the visual impact, and that the increased technical content has proved useful. In addition to bringing you technical developments and news from further afield, we are trying to cover all the disciplines and industries that are concerned with corrosion protection. A list of the editorial topics planned for the coming issues of the magazine can be found in the media kit, which is published on the Institute’s website. I would encourage readers who want to publicise their work to check this, and before the next issue, an up-dated set of guidelines for article submission will be added to the website.

If you have any suggestions for improving your magazine further, please send them to me via the Northampton office.

Brian Goldie, Consulting Editor

EUROCORR 2017 and World corrosion Organisation

EUROCORR 2017 and the 20th ICC & Process Safety Congress 2017, will take place in Prague, Czech Republic, from 3 to 7 September 2017. The Congress will provide a unique networking opportunity for scientists, representatives of research institutions, universities and industry and graduate students in a vibrant professional setting and atmosphere.


Furthermore, the World Corrosion Organization has developed a new strategy for the future, including setting-up a conference series on potable water – the first of which will be at the Eurocorr Conference 2017 in Prague. It is planned that expert speakers from different regions of the world will report on the condition of water supply facilities in their countries, and how corrosion has an impact on them. It is also the aim to show best practices from the different regions of the world, and how corrosion protection can make a difference. The results of this workshop will be summarized in a White Paper which is intended to be published by the end of this year. This topic will then be continued at the NACE conference in 2018.

Last year there was also a change in WCO leadership, George Hays handed over the position of Director General to Willi Meier of DECHHEMA Germany, who also holds the position of a Director General of the European Federation of Corrosion, and as such the links between WCO and EFC will be strengthened. George will focus now on his work with the UN to take that collaboration to a new level.

Visit the ICorr website for all the latest news
www.icorr.org
YOUNG ICORR

A LinkedIn group has been created to help connect engineers interested in getting involved with Young ICorr. Young ICorr is aimed at young professionals (35 and under) who are interested in, or working in the field of corrosion, and is open to both members and non-members of the Institute of Corrosion. The LinkedIn group will be used for advertising events and encouraging discussion. Please encourage interested parties to join 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.

ICATS News
Supervisor Course

As advised previously we have introduced the new revised ICATS Supervisor Course, approved by the Institute of Corrosion. The course is available to any applicator with 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.

Corrosion Engineering Division

The Institute of Corrosion’s Corrosion Engineering Division and the Institute of Concrete Technology are holding a SYMPOSIUM on ‘Corrosion Engineering and Concrete’ on Thursday 27 April.

This one day meeting will be the latest in a series of recent working days of the Corrosion Engineering Division, and will be held at the Institute of Mechanical Engineers Engineering Training Centre, Sheffield. This year’s meeting is wide ranging and covers Corrosion Engineering and Concrete in its broadest sense. In parallel there will be a visit to the concrete and corrosion laboratories at Sheffield Hallam University (transport will be provided) and an exhibition. This is a good opportunity to network with other corrosion professionals from different industry sectors and to learn about some of the latest developments in the field of corrosion in concrete. A registration form was enclosed with the last issue of Corrosion Management and it can also be downloaded from http://www.icorr.org/events. There will also be the presentation of the inaugural Paul McIntyre award to the 2017 winner, Dr. Ulf Kivisäkk, AB Sandvik Materials Technology, Sweden.

ICATS Registered Company Directory

The previous regular listing of ICATS Registered companies in Corrosion Management filled 4 pages and was not really suitable content for this journal. The company details are available on the website, but as a printed listing is still useful to many, we will be introducing an ICATS Directory which will be distributed with Corrosion Management, and we are offering the opportunity for ICATS Companies to advertise and enhance their listing.

CSCS

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.

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.

Company Trainer Course

The next Company Trainer Course will be held on 3rd – 4th May in Northampton.
Acoustic emission is essentially a non-destructive technique where a test sample is subjected to a stress condition, under which, crack growth, local yielding and corrosion product fracture may occur, resulting in a sudden release of energy that can be detected by transducers.

The speakers described their recent findings from a range of RGU experiments, including those on thin aluminium and steel plates in different corrosive environments.

It is important to note that the AE from corrosion usually releases much less energy than emission from crack growth, and so is more difficult to detect in the field, however the results present a trend (as an exponential curve) between the concentration of the corrosive environment and the energy of the acoustic emission signal.

AE only occurs when corrosion scales fracture and corrosion needs to be active, although the presence of inactive / previous corrosion may be found by causing the scale to fracture by changing the strain sufficiently in the base material.

An extensive range of questions followed from the large audience during which the practical application of AE within the energy sector was further explored. Generally the role of AE was perceived as being in support of other NDT technologies and for specialised applications such as inspection of tank floors, and occasionally for critical components of high value, or high production impact.

They emphasized the need to continuously gather quality real-time data to allow accurate determination of the rate of internal damage to key production components, operating under high temperature, high pressure and variable flow conditions.

It was pointed out that more traditional and less automated methods may provide over-cautious and sometimes unreliable information, owing to their reduced sampling frequency, manual nature and limitations on safe access. The availability of enhanced pipe wall data from all sources, can raise confidence levels, facilitate longer service intervals, and minimize production losses. A large number of case studies were used to illustrate these points and the potential gains from such systems.

It was emphasised however that all truly holistic inspection regimes utilize a full range of intrusive and non-intrusive devices for fluids and solids management to ensure continued safe operation of ageing assets. As with other complimentary monitoring devices, a recent key change in the application of such technologies has been the huge advances in wireless data transmission, greatly improved battery life and much improved integration with plant control systems, to provide ‘side by side’ data that is now much more meaningful to integrity specialists.

The closing question and answer session covered many diverse topics that truly demonstrated the value of evening, the level of interest and its excellent speakers. A wide range of Clamped and Magnetic wall thickness monitors were then made available for the audience to inspect.

For information about the Aberdeen branch activities please contact the branch secretary, Frances Chalmers, ICorrABZ@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.
London Branch


Alan Denney illustrated his past experience with numerous and far reaching projects and corrosion problems, including reinforcement corrosion in buildings, graphitic corrosion of cast iron, the use and misuse of Cor-Ten steel, the use of duplex stainless steels in architectural demanding buildings together with a number of issues in the oil and gas industry.

Bill Hedges then looked at what the corrosion industry was doing well, such as technical development, networking and training, risk assessments, corrosion modelling, effective corrosion barriers and management systems. He then stated that opportunities for improvement existed in, attracting the next generation of engineers, project cost control, corrosion monitoring and inspection, sharing of knowledge across the industry, and the adoption of common standards. Steve Paterson detailed key future challenges including an ageing infrastructure, marginal field development, dealing with high pressures and temperatures, extreme environmental conditions, materials for sustainable energy together with the development of artificial intelligence, commercial acumen and a greater awareness of risk/probability.

Following the presentations, the 45+ attendees participated in a question and answer session which particularly discussed the way to attract young people into the industry who will be innovative and creative and use good judgement in the use of corrosion protection.

On 9th February, the Branch met to enjoy a technical presentation entitled ‘Corrosion Inhibitor Testing – The Journey’ given by George Winning; corrosion specialist for Element Materials Technology.

George began his presentation with a quick review of the 70 year history and development of chemical products, the study of the inhibitor mechanisms, together with some of the key characteristics an inhibitor should have, to ensure that they will work for a particular oil and gas system.

The presentation looked at the many tests that are needed to be carried out to identify the correct product for a system, and how a set of tests may vary between an application in low oil cut systems through to high water cut systems, and the different tests required for gas systems. George made particular reference to the problems associated with the effects of flow, the difficulty of achieving full inhibition where ‘under deposit corrosion’ (UDC) is occurring, the problem in combating ‘preferential weld corrosion’ (PWC) and the specific techniques required to combat ‘top of line corrosion’ (TOLC).

He then summarised ‘The Journey’ to be made for success, including review of the application, design of the test program, the selection of performance tests, field testing, re-evaluation and performance monitoring. After negotiating a question and answer session with the attendees, Committee Member, Polina Zabelina thanked George for his comprehensive review on all that needs to be considered, and invited all present to enjoy the traditional hospitality of the London Branch.

Details of forthcoming Branch technical meetings can be found on the ICorr website and in the Diary Date page of Corrosion Management, and are held at Imperial College Skempton Building, at 18.00 for an 18.30 start. Enquiries can also be sent to icorr@london@gmail.com

North East Branch

The branch held its first event in 2017 on 21 February, which was hosted by ROSEN UK at its offices at Quorum Business Park, Newcastle upon Tyne. About 20 people attended the event and had an opportunity to learn about Flow Modelling and Flow Assurance through two presentations.

The first presentation, titled “Introduction to Flow modelling and Flow Assurance in Oil and Gas Industry” was delivered by a senior flow assurance engineer at ROSEN UK, Mr. Ashwin Pinto. His presentation discussed the basic concepts and methodology behind the flow assurance, whilst also highlighting advantages of undertaking flow analyses to better understand performance of production systems, optimize oil and gas operations, and improve system designs.

The second presentation was given by Marguerite Forde, a senior engineer at ROSEN UK, entitled “Optimization and Validation of Internal Corrosion Direct Assessment – Prediction vs. Reality”. Ms Forde presented a case study focused on (i) demonstrating the accuracy of predicted corrosion rates vs. those rates experienced by pipeline assets in reality and (ii) utilization of available direct inspection results to fine-tune corrosion models to predict the condition of sections of the pipeline which cannot be inspected directly.

This year, the branch will hold a summer event on 6th July 2016 at Hatfield College, Durham University, when Professor Jon Glyyas, Durham University, will give a presentation on “Energy past, present and future”. The talk will examine the national picture for energy supply and demand, identify the risks, and then comment on what the UK can do to improve its energy security in the long term.

The evening starts at 17.00, with a tour of Durham Castle at 17.30, followed by the presentation, and a buffet and drinks from 19.30, together with time for networking. The costs are £5 for members and the first 10 students registered, and £10 for non-members. A Registration form will be available on the ICorr website, and as there are limited spaces, early booking is advised.
Institute News

OBITUARY
Professor Graham Wood, DSc, FREng, FRS (1934-2016)

Graham Wood was born in Farnborough, Kent, and became a towering figure in the somewhat arcane subject that we know of as corrosion science. Graham attended Bromley Grammar School, excelling at cricket and football as well as academically, and obtained a state scholarship to attend Christ's College, Cambridge University, where he graduated in Natural Sciences, and narrowly failed to obtain a “blue” in cricket. He subsequently undertook a PhD with T.P. (Sam) Hoar, collaborated with Ulick Evans, and continued as a postdoctoral researcher with Alan Cottrell and subsequently moved to the then University of Manchester Institute of Science and Technology (UMIST) in 1961, as Lecturer in Corrosion Science in the Dept. of Chemical Engineering.

The UMIST Chemical Engineering department was run in those days by Professor T.K. (Ken) Ross, who recognised early in his career that corrosion and materials degradation of chemical plant was a major threat to operations, and so built up a strong research group in corrosion science, rivalling the then activity at Cambridge. When the “Committee on Corrosion and Protection” under Sam Hoar published its findings in 1971, one of its main recommendations was the establishment of a “National Corrosion and Protection Centre”. Ken Ross immediately saw this as an opportunity for Manchester and strongly supported Graham’s appointment in 1972 as Britain’s first Professor of Corrosion Science, with a remit to establish and grow an academic-based “Corrosion and Protection Centre”. From 1972 to 1982 Graham built this up to a steady state of around ten academic (faculty) staff with associated support staff, with the MSc programme in Corrosion Science and Engineering (established earlier in 1981) feeding into PhD research. He also set up CAPCIS (now part of Intertek), under the direction of David Gearey, when it became apparent that the demand from industry for consultancy services far exceeded the capacity of academic staff to deliver.

As Head of the Corrosion and Protection Centre, Graham was a demanding taskmaster to colleagues, but even more so on himself, but after 1982 he increasingly took a back seat in the day-to-day operations of the Corrosion and Protection Centre, and focussed more on academic administration while ensuring that he kept his hand in guiding and mentoring research students and directing novel research. When I arrived in Manchester in 1983, he was Vice-Principal for Academic Development and over the years to his retirement in 1999 served in various roles up to Dean of Faculty and finally Deputy Principal.

This is not the place to list all his achievements (academic or otherwise) and his collaborators, however, February 1934 was clearly an auspicious time for corrosion science since Graham, Bob Rapp and Roger Staehle were all born within a few weeks of each other. Graham was a principal consultant to the Electric Power Research Institute (EPRI) in collaboration with John Stringer for many years, and was the first Chair from outside North America of the Gordon Research Conference on Corrosion. He was President of the predecessor body to the UK Institute of Corrosion (1979-1980) and a member from 1975 – 2015, and also Chair of the International Corrosion Council for many years. His most notable work at Manchester was carried out in collaboration with Howard Stott (in oxidation and hot corrosion) and George Thompson (in passivity and the properties of anodic films). Amongst other prizes and awards, he received the Beilby Medal and Prize from the Society of Chemical Industry in 1972, and in 1983 was presented with the U.R. Evans award of the Institute of Corrosion. In the same year he obtained the Carl Wagner Memorial Award of the Electrochemical Society and was appointed a Life Member. In 1987 the European Federation of Corrosion presented Graham with its premier prize, the Cavallaro Medal and, in 1990, he was elected to the Fellowship of Engineering (now the Royal Academy of Engineering) as FREng. Finally, and following on from Davy, Faraday, Bengough and Evans, in 1997 Graham was elected a Fellow of the Royal Society (FRS), the highest UK scientific honour.

Rather unassuming, intensely private, but unfeasibly talented, Graham was a true “gentlemen scientist”. His passing deserves reflection on a life well lived. He is survived by his wife Freda and children, Louise and David.

Stuart Lyon, Corrosion and Protection Centre, School of Materials, The University of Manchester, with thanks to Professor Wood’s family, former colleagues and collaborators who provided anecdotes and filled in my gaps in knowledge.

Visit the ICcorr website for all the latest news
www.icorr.org
AkzoNobel plans new innovation hub in the UK

AkzoNobel has announced a new €12.6 million research and innovation hub which it says could revolutionize the company’s portfolio. To be located in Felling, the facility will be home to teams of scientists and technical experts who according to the company, will work on developing protective coatings for the energy, mining, infrastructure and oil and gas industries. The main focus will be on delivering cutting edge innovations and efficiencies for protecting steel and concrete structures from damage caused by corrosion, abrasion and fire. The new innovation hub will also offer a world class testing and simulation facility, enabling tests to be carried out in conditions experienced in the world’s most extreme environments.

“Our work at the state-of-the-art lab will have an important impact on our most critical industries,” said Conrad Keijzer, AkzoNobel’s Executive Committee member responsible for Performance Coatings. “More than 100 top scientists and technical experts will be working on future solutions that will offer essential protection to a wide variety of products for our customers.”

The facility is expected to be operational at the end of 2018.

AkzoNobel and partners developing drone technology to make marine industry safer

According to AkzoNobel, safety in the marine industry is set to be improved after they, oil and gas tanker operator Barrier Group, and DroneOps, joined forces to develop a drone capable of remotely inspecting enclosed spaces and ballast water tanks. The Project will use advanced reality technology to deliver safer, more accurate, evaluations of water ballast tanks, offshore windfarms and other difficult to access spaces on ships and marine structures, including inspection of coatings and corrosion. Traditionally these inspections are carried out by crew, surveyors or inspectors, but by replacing human inspections with a drone, routine maintenance can be monitored remotely and in real time by office-based staff, with instant feedback available to the vessel or offshore structure’s superintendent. This in turn will reduce costs, increase efficiency and significantly reduce risk to human life during essential maintenance.

The partnership itself offers a complete overview of the issues and challenges associated with enclosed space inspections. And additional coatings expertise will be provided by Safinah Ltd, a leading coatings consultancy.

As the project progresses, the drone will undergo flight trials at AkzoNobel’s UK coatings test site and Barrier Group’s indoor training facility. The drone’s completion and launch is planned for October 2017, concluded the company.

Element’s State-of-the-Art Corrosion Facility in Aberdeen Open for Business

Element Materials Technology’s, new, state-of-the-art corrosion facility in Aberdeen was opened on 24 January by the Institute of Corrosion President, Sarah Vasey. According to the Company, the facility is a purpose built, independent corrosion test facility, featuring sour gas capabilities, an ambient testing laboratory for routine testing, HPHT laboratory for high pressure and temperature testing, as well as a development area for design and operation of bespoke tests and research.

Prior to the official opening, Charles Neall President and Chief Executive of Element, gave a brief introduction to the Company and was followed by Rod Martin, Element's Executive Vice President, Oil & Gas, who gave an update on the Company’s Oil and Gas business. In Sarah’s opening address, she highlighted the close links between Element and the Institute of Corrosion, as well as promoting the local events of the Institute.

After these formalities, the 30 attendees were taken on a tour of the corrosion and the fracture mechanics facilities within the laboratory. Afterwards, there was then a chance to discuss Element’s capabilities in fracture mechanics and corrosion, with Element's technical expert Andy Barton, and ECA and council member for the Institute and vice chair of Institute of Corrosion London Branch committee, George Winning.

Two of Britain’s biggest energy contractors, Amec Foster Wheeler and John Wood Group, are joining forces

The board of Amec Foster Wheeler has approved an all-share takeover approach from John Wood.

The transaction will result in Amec Foster Wheeler shareholders owning approximately 44% of the share capital of the combined group and John Wood shareholders having 56%.

Wood Group chairman Ian Marchant said: “The combination represents a transformational transaction for Wood Group, which accelerates our strategy and creates a global leader in project, engineering and technical services delivery across a range of industrial sectors. The Combination extends the scale and scope of our services, deepens our existing customer relationships, facilitates further development of our technology-enabled solutions and broadens our end market, geographic and customer exposure.

Continues on page 10
“The combination will create an asset-light, largely reimbursable business of greater scale and enhanced capability, diversified across the oil & gas, chemicals, renewables, environment & infrastructure and mining segments.”

“By leveraging Amec Foster Wheeler’s and Wood Group’s combined asset life cycle services across project delivery, engineering, modifications, construction, operations, maintenance and consulting activities, the combined group will be able to better capitalise on growth opportunities across a broad cross section of energy and industrial end markets.”

Amec Foster Wheeler chairman John Connolly said, “The board believes that a combination with Wood Group adds to the standalone prospects of Amec Foster Wheeler, by accelerating the delivery of the future value inherent in the Amec Foster Wheeler business and, at the same time, helps to realise the full potential of each of Amec Foster Wheeler and Wood Group. The all-share structure of the offer allows our shareholders to benefit from the significant synergies and other strategic benefits that are expected to be realised from the combination. Amec Foster Wheeler will also be well represented on the board of the combined group, with four of our directors joining the combined group’s board, including Roy Franklin, who will be appointed deputy chairman and senior independent director.”

Hempel gives notice of price increases

Hempel has announced that with the raw material cost increases of 2016 set to continue into 2017, the price of certain products will increase.

According to the company, the cost of many raw materials used in the manufacturing of coatings has increased over the past year. Since January 2016, for example, the cost of copper has risen by 34 per cent and the cost of zinc has gone up by 78 per cent (source: London Metals Exchange and ICIS Pricing). Titanium dioxide, another key raw material, has also shown significant increases in cost.

As raw materials constitute a major part of the cost of manufacturing coatings for the protective, marine and decorative industries – and, while Hempel is doing everything possible to mitigate these cost increases, it has stated there is a limit to how much can be absorbed.

“There may be regional differences in some raw material costs, but the overall trend is very clearly up,” explains Lars Petersson - Executive Vice President & Chief Operating Officer. “We have limited the impact to our customers by working proactively with our suppliers, our R&D and our manufacturing setup, but, as the trend is continuing, we have no other option than to increase the prices of some of our products.”

Standards Up-Date


ASTM

The new standard, "G327 – 16 Standard Guide for Corrosion Monitoring in Laboratories and Plants with Coupled Multielectrode Array Sensor Method", is aimed at operators who monitor structures with metal components, including bridges, buildings and power transmission lines.

The standard outlines ways to monitor corrosion in laboratories and plants using a new technology called the coupled multi-electrode array sensor (CMAS) method. According to ASTM member Lietal Yang, Corr Instruments, CMAS measures non-uniform, especially localised, corrosion for which there has not been a real time and quantitative method available.

NACE/SSPC

A new standard, SSPC-CPC 1/NACE SP21412-2016, Corrosion Prevention and Control Planning, has been developed by a joint task force consisting of representatives of the US DOD Corrosion Office, SSPC and NACE. It will act as a guide to navigating the requirements of corrosion prevention and control (CPC) planning. According to SSPC, the standard defines the key elements/composition of CPC planning for all sector users, as well as product suppliers and facility owners and managers. Although intended for use by federal agencies, it can also be applied to private industry.

The standard defines the key elements and composition of what corrosion prevention and control planning encompasses for the design, manufacturing, construction, operation and sustainability of products and facilities. It also considers material selection and design to minimize corrosion, and factors that might come up during CPC planning in relation to fabrication and construction, operation and use, and maintenance and sustainability.

The ten largest global coatings producers hold a market share of roughly 60% with AkzoNobel and PPG competing for the top place, however they will both lose this spot when the Sherwin-Williams and Valspar deal is concluded. If these two deals close, the market share of 60% will then split among only eight companies, which could lead eventually to less competition in the global market, but perhaps more niche markets for the smaller players.

AkzoNobel has also reported that it had rejected a second unsolicited, non-binding and conditional proposal of 20 March from PPG Industries Inc. for all of the issued and outstanding ordinary shares in the capital of AkzoNobel. According to the company, the proposal not only fails to reflect the current and future value of AkzoNobel, it also neglects to address the significant uncertainties and risks for shareholders and other stakeholders.

PPG bids for Akzo Nobel

The American paint producer PPG, has offered to buy Dutch coatings manufacturer AkzoNobel, but according to the AkzoNobel, the offer “substantially undervalued” the company, and was rejected.

The possibility of another offer was not excluded as PPG published a statement saying that, in conjunction with its financial and legal advisors, it had devoted significant time and resources to analyzing a potential combination of PPG and AkzoNobel and was confident in its ability to execute and complete the proposed transaction and to obtain all necessary regulatory approvals.
We've all seen concrete structures with steel rusting away, bits of concrete falling off, and generally looking a bit tired and emotional. Anyone with a corrosion background will be wondering how it happened, and why aren't we doing something about it. To understand this, there's a little bit of history that is needed.

In about 1824 when Humphry Davy was talking about cathodic protection, Joseph Aspdin patented Ordinary Portland Cement, the Institution of Civil Engineers received its Royal Charter, and a couple of patents were issued for making things out of concrete with reinforcement in. This didn't really catch on until Francois Hennebique developed his system for reinforced concrete around 1900. Reinforced concrete now had design processes, so its use increased. In the same way it takes a while for corrosion to start due to carbonation, it took a while for the consequences of typical corrosion of concrete rebars (M4 elevated motorway, Chiswick).

In 1909, The Institution of Civil Engineers organised a committee on reinforced concrete, their preliminary and interim report stated “The durability of reinforced concrete in seawater was an open question...”. Even in the early days, we weren't sure how long it would last.

Design codes followed covering how to manage stresses and strains, and generally how to make big structures out of it. Everything was going along quite nicely - the steel didn't rust much, the structures were built by craftsmen, and there was enough spare capacity in the materials for them to survive nicely. From a corrosion point of view, this was because concrete is alkaline and steel in alkaline environments is passive. However concrete can lose its alkalinity over time, by reacting with atmospheric carbon dioxide, but this takes a long time, so for the first 40 years or so, steel corrosion in concrete didn't really happen. There were a few cases, but these could be pinned on the people that built them not doing a proper job- it didn't look like a problem.

In 1940, in amidst the chaos, the city of Detroit became the first city in the world to salt its roads in winter. In the winter of 1941 to 1942, New Hampshire became the first state to adopt a general policy of salting the roads. About 5000 tons was spread on the roads that winter. This caught on, not surprising really, since the numbers were staggering. A study carried out by Marquette University in Milwaukee, Wisconsin, found that road salt reduced crashes by 88 percent, injuries by 85 percent, and accident costs by 85 percent. In the USA the use of salt doubled every 5 years during the 50's and 60's, growing to nearly 10 million tons per year by the early 1970s. (The UK currently uses 0.75 to 2 million tonnes). The use of road salts coincided with a major boom in the use of reinforced concrete. The UK highway network constructed around 15,000 concrete structures in the same period. Towards the end of this it was realised that parts could be built in factories. Factories meant better control so there should be fewer problems.

In the same way it takes a while for corrosion to start due to carbonation, it took a while for the consequences of
salt on concrete to be understood. You may not have noticed, or not got there yet, but as people get to 30 to 40 years old, things change, aches and pains appear, bits start sagging, and it all looks a bit tired. The same happened with concrete, 30 to 40 years after we started using salt, and building lots of concrete structures, we realised that things were not quite as they should have been. Blaming the contractor who built it wasn't really working as an excuse. Towards the end of the 1970s it was realised that chlorides were causing corrosion of reinforced concrete. Unfortunately this was a bit late in the day as we'd already built tens of thousands of concrete structures, and chucked salt on them for 30 years. In 1977, the practice of adding salt to concrete to make it set quicker, was banned. We thought the precast concrete was better as it was built in a factory, but those of you who have experienced the achy sagging bit of life, may have owned something built in a factory in the 1970's. It wasn't a great time for product control. Prestressed concrete was fine when insitu concrete started suffering, because it was 20 years younger - the teenager was mocking its fat aching parent, but guess what, it's now heading the same way.

Bringing us up to date it's safe to say the link between chlorides and corrosion of steel in concrete is well established, although there are occasional pockets of resistance. Design codes now consider durability more seriously, with theoretically more durable concrete and better control on site. The materials currently in use perform well in the lab, but it will be 30 or 40 years before we know if it actually makes a difference. The good (for the repair industry) /bad (for structure owners) news is that even if we have cracked how to make durable concrete, there are still tens of thousands of structures built before we worked this out, that are at varying points on the deterioration curve. We'll be busy for a while.

We've been repairing concrete for that long that there are standards that cover concrete repair: BS EN 1504 explains how to repair structures, including the staggering step of identifying what the problem is, rather than just sticking stuff in holes. Repairs should now be planned, the materials should be CE marked, the contractor will have a QA scheme taking relevant records, and there will be a record of what was undertaken. The CDM regulations say that whoever designed the thing in the first place will have considered how it's going to be maintained and repaired. People designing repair systems will also consider the contractors having to do it. It is surprisingly not fun to be up scaffold in the dark, cold and wet trying to work out what the designer meant, and the designers should therefore be listening to feedback from the people doing the work, and considering how to make their life easier.

For chloride contaminated concrete, the main approach is the use of cathodic protection. We don't do it because it's clever, or comes with shiny remote monitoring and computers, we do it because it works out cheaper. We can leave sound, but chloride contaminated concrete behind, so there's less to repair, less access, and we don't have to “prop-up” whatever the concrete
is carrying for as long. When you repair concrete you have to break out the broken stuff, and structurally that can be quite serious, so we have to sometimes support the structure while we do it. This needs to be done very carefully, and thus is expensive.

The standard governing cathodic protection of reinforced concrete is now BS EN ISO 12696. There’s an existing BS EN standard that governs training and certification of the people doing it, that will shortly become ISO 15257. It is reasonable to say the Institute of Corrosion lead the world in training and certification of concrete CP people. The reputable contractors have bought into it, the clients are specifying it, and standards are being raised. The Structural Concrete Alliance members are routinely promoting it, and there are a wide range of anode systems available to apply cathodic protection to concrete. As with any system you can use impressed current or galvanic (anodes) protection. We also have hybrid systems at our disposal. Impressed current needs a power source but doesn’t have a limited life and can be adjusted. Galvanics are their own power source, but will eventually run out, although they can be simpler to install than impressed current systems. The hybrid systems start off as impressed current to give the steel a kick in the right direction, then settle down to a galvanic life. It has been found that if you run a CP system on concrete for a while, good things happen - chlorides move from the steel, alkalinity is generated and so long life and back-up power supplies are less of a worry. If you are using an external power source you may as well use it to run a computer, and routinely collect data that can be analysed off-site. This used to involve modems making strange noises, laptops running DOS or Windows 3.1, plus hand written software exporting data to Lotus 123, floppy disks that could hold more data than you could ever imagine (1.44Mb), all of which were future proof at the time. It turned out that was a little bit overstated. It also involved trying to get a telecoms company to fit a phone line to a bridge (What’s the postcode? – it doesn’t have one, it’s a bridge). Now the mobile network is pretty good, and if there’s no mobile network even satellites can be used. We can access data via websites which should help with future compatibility, but the trouble is we don’t know what the future will bring.

Generally however we can fix most things concrete related. We have anode systems we can stick on the surface or embed in concrete; systems that can collect their own data and adjust themselves; systems that power themselves and a bunch of people doing it who have certificates that say they know what they’re doing, so it’s no longer a matter of hoping the expert you’ve appointed knows what they’re talking about. The contractors are more involved at an earlier stage and the consultants consider how to make it simple for them to do.

That’s what has happened, we built things and didn’t understand how they were going to perform. We do now, so things should be better.

Why aren’t we doing something about it, well we are. There is an established industry doing a remarkable job of fixing some particularly difficult things. Unfortunately we can’t fix everything at once. There isn’t the manpower available and there isn’t the money around. Financially everything is being squeezed and bridges only make the news when they fall down, and there’s a general perception that they don’t. The problem arising is that everything that falls down has a long period of not falling down, right up until the moment of collapse. This is complicated by the fact that design codes changed between when it was built and the current period, so what it was designed for may no longer be enough, or simply the design codes at the time used assumptions that are just wrong.

Collapses have brought this into focus. The American Society of Civil Engineers publishes reports on the condition of infrastructure in the US. In 2017 they stated: “The U.S. has 614,387 bridges, almost four in 10 of which are 50 years or older. 56,007 — 9.1% — of the nation’s bridges were structurally deficient in 2016, and on average there were 188 million trips across structurally deficient bridges each day. While the number of bridges that are in such poor condition as to be considered structurally deficient is decreasing, the average age of America’s bridges keeps going up, and many of the nation’s bridges are approaching the end of their design life. The most recent estimate puts the nation’s backlog of bridge rehabilitation needs at $1.26 trillion.” (1)

For the UK, the RAC Foundation reported the following for local authorities: “The 3,203 substandard bridges represent 4.4% (about 1 in 23) of the roughly 72,000 bridges to be found on the local road network. The number of substandard bridges is 35% greater than that estimated by the RAC Foundation to have been substandard two years earlier. If money was no object, then councils would ideally want to bring 2,110 of these back up to standard, the RAC Foundation said. However, budget restrictions mean councils only anticipate 416 bridges will have the necessary work carried out on them within the next five years.

The one-off cost of bringing all the substandard bridges back up to perfect condition would be around £890m. This is the equivalent of £278,000 per structure. The total cost of clearing the backlog of work on all bridges – including those that are substandard – is estimated at £3.9bn.” (2)

The basic problem is which one to fix first, and how long can we leave the rest, in other words, asset management. We’ve moved on from knowing the problem and how to fix it, to predicting the structural capacity with respect to time, and that is a tale for another day.

References
1. http://www.infrastructurereportcard.org/cat-item/bridges/
Impressed current cathodic prevention of steel in concrete

Hugues BOIS, Cathodic Protection technical expert, MAE Material and Engineering Services, SAIPEM, France

Steel in concrete should not experience corrosion. The concrete pH is around 13, and as this alkaline environment stabilizes the iron oxide or hydroxide film, the embedded steel is therefore passivated and the corrosion rate becomes insignificant which means protected from corrosion as per Pourbaix’s diagram.

The concrete layer also presents a low permeability barrier, to protect against external aggressive species such as chloride ions or carbon dioxide.

The concrete quality is therefore the first level of protection. Standards about concrete formulation and covering thickness define the requirements to limit chlorides or carbon dioxide penetration for up to 100 years. These parameters should be routinely checked on samples in a laboratory.

However, it has been observed in some cases that carbon dioxide or chlorides ingress through the concrete to the steel. The carbon dioxide reaction in concrete, called carbonation, reduces the pH to 8 or 9, at which the passive film is no longer stable.

Chlorides in concrete can cause different forms of corrosion, due macrocell or microcell formation, leading to loss of passivity and corrosion.

All these corrosion phenomena occur in the presence of oxygen, which is difficult to avoid in concrete, and the corrosion rate is thus accelerated.

Of course the problem of corrosion of steel in concrete is not particularly related to the loss of steel because a corrosion allowance could be added to take this into account. The main problem is the volume of this produced corrosion product around the steel, there is no available space for the evolution of this and the concrete is forced to crack, losing its mechanical properties.

An additional protection method is therefore needed to avoid this detrimental corrosion, and different methods are available.

Correctly applied cathodic protection/prevention is one of the best ways of protection, but it requires careful and accurate design, a sufficient conservative margin, use of high quality materials and detailed follow-up of all related construction activities by experienced cathodic protection specialists.

This article will cover only cathodic protection or prevention by impressed current, and chloride penetration.

The term, cathodic “protection” of steel in concrete is applicable to repaired concrete structure, and the terminology of cathodic “prevention” is applied to new build projects.

The difference between cathodic prevention and cathodic protection is mainly based on the current density design value. The cathodic protection/prevention limits the corrosion by introducing external electrons to the steel, and shifting the steel potential in concrete to more negative values, thus maintaining the passivation state of steel and also by keeping/removing chlorides from the steel due to the modified electrical field gradient.

In impressed current cathodic protection systems, the direct current is provided by an external power source. The external power supply can be from a so-called transformer-rectifier, powered by an alternating current source, and after transformation and rectifying, provides the required direct current. Other sources of direct current can be used, such as solar panels. These transformer-rectifiers are mostly provided with multiple current outputs to feed different zones of protection. The current is then spread to the steel in the concrete by an anode system, installed inside the concrete, or remote if allowed by environment and structure design. A network of cables and junction boxes is necessary to ensure current distribution. In order to ensure the correct operation of the system and a check on the efficiency, a permanent monitoring system using reference electrodes, polarization...
probes or other probes can be included. This monitoring can be also be carried out by portable measurements and equipment. For cathodic protection, the design current density specified in numerous international documents, ranges from 2 to 20 mA/m² of steel, and for cathodic prevention, the range is from 0.2 to 2mA/m² as per ISO 12696 [1]. These ranges are mainly related to the level of chloride contamination in concrete and the state of corroded steel.

The type of cathodic protection to apply depends on the type of structure and its environment. The design can rely on distributed individual anodes (such as Ti/MMO tubular anodes) exposed to sea, or on buried ground beds, or on discrete anodes or ribbon mesh embedded in concrete (figure 1).

The remainder of the article relates to cathodic prevention, and feedback from our experiences with the method, such as:

• **Distributed impressed current anodes can efficiently protect permanently immersed zones.**
• **Buried zones can be fully protected by shallow or deep-well grounded.**
• **Splash, tidal and aerial/atmospheric zones can be protected by ribbon mesh embedded in concrete.**

To ensure that the CP is working properly, at least one of the following criteria according to ISO 12696, must be obtained:

• **Type (A) an instant off potential (measured between 0.1 and 1s after switch-ing the DC circuit open) more negative than -720mV with respect to AgAgCl/0.5MKCl.**
• **Type (B1) a potential decay over a maximum of 24h of at least 100mV from instant off**
• **Type (B2) a potential decay over an extended period (typically 24h or longer) of at least 100mV from the instant off subject to a continuing decay and the use of reference electrodes (not decay sensors) for the measurement beyond 24h.**

Particular attention should be taken during the analysis of measurements as in some particular atmospheric or tidal/splash zones, potential readings can be influenced by the environmental conditions - rain, tide, waves.

It was highlighted above, that correct cathodic prevention can be only ensured provided that the engineering/design, follow-up of construction and commissioning, are carried out by experienced Specialists in Cathodic Protection, as once the concrete is cured, all remedial works will be costly and destructive for concrete.

The design, installation and commissioning requirements rely on standards application and experience of the contractor.

Regarding the main criterion, we found that the design current density, of 2 to 3 mA/m² of steel, was high enough to protect the rebars, according to the instant-off potential criteria, or decay criteria (B1) or (B2). A minimum of 50% additional margin should be included however in the design, and the design should also include internal and external steel.

The spacing between the ribbons, where applicable, can be kept conservatively between 200mm and 300mm.

An important requirement is the continuity between reinforcing steel rebars. This has to be ensured by welding, and carried out by a dedicated team. In order to avoid short circuits, all metallic ties should be removed before concrete pouring.

On the contrary, anode network isolation from the rebars should be constantly checked during pouring to avoid short circuit.

The use of Ag/AgCl permanent reference electrodes inside the concrete in immersed and buried zones, has sometimes led to premature failure. However use of, Mn/MnO₂ reference electrodes has led to positive feedback.

One project we were involved with was the cathodic prevention of 400 reinforced concrete steel piles, they were 20m long and 500mm diameter, supporting a concrete tank slab, laid on the ground. The tank slab diameter was around 80m.

These buried piles were protected by distributed vertical ground-beds, of impressed current cathodic protection type. One central and 4 peripheral deep well ground beds were installed as shown in figure 2.

After gradual increase in current, the piles and slab in contact with the soil were correctly protected at all levels at around -900mV/AgAgCl instant-off potential, this was checked using MnO₂ reference electrodes located at different levels in different piles.

Another example was a project involving the cathodic prevention of reinforced steel hollow concrete blocks, which were part of a 3km long seawall dike.

Different zones were protected by different impressed current systems - immersed wall, buried wall, atmospheric, splash and tidal zones.

Each immersed concrete wall was protected by one Ti/MMO impressed current tubular anode freely exposed to sea, installed on the structure concrete wall.

After gradual increase in current to design value when required and effective polarization, the more negative than -720mV criteria was obtained, values were around -1000mV versus AgAgCl.

Each buried concrete wall was protected by a semi-deep vertical ground-bed drilled, at central position and fitted with Ti/MMO impressed current tubular anodes. The ground bed was made of slotted HDPE tube, fitted with a filtering mesh to avoid internal backfilling, the internal electrolyte being seawater. After gradual increase in current to design value when required and effective polarization, again the values obtained were around -1000mV versus AgAgCl.

The atmospheric, splash and tidal zones were protected by Ti/MMO ribbon, mesh type, installed inside the concrete at 300mm spacing between each other.

After gradual increase in current to design value when required and effective polarization, depending on zones, at least one, and sometimes two, of the three criteria in ISO 2696, were obtained.

**Reference**

1. ISO 12696 (2012) – Cathodic Protection of Steel in Concrete
Measuring Sodium Chloride, Salt and Soluble Contaminants - Part 2

By Nico Frankhuizen, TQC, The Netherlands

Salt contamination on the surface beneath a coating can cause serious failures due to the hygroscopic nature of salt, combined with the permeability of a coating, creating an ideal environment for corrosion. The majority of paint specifications nowadays can include limits for soluble salts. The issues with the analyses of surface contaminates using presently available techniques was introduced in the previous issue of Corrosion Management (January/February 2017), where the chemistry of salts and their occurrence, together with some of the common errors made in their measurement, were discussed.

In this article, some other conductivity-based methods for the determination of salts available in the industry, are described together with alternative analytical measurement techniques.

Direct Conductivity measurement on the surface

Proprietary Soluble Salt Meters are available on the market, which also use the conductivity method to measure salt concentration, with main difference from the Bresle method that the measurement cell is integrated within the patch and adhered to the surface by magnetic force. These are hand-held devices that perform both sample extraction and analyses automatically. They are claimed to improve speed of the analysis by reducing the number of steps needed, remove need for patches and syringes, and improve accuracy. This fusion of functions creates some new possibilities but also creates the possibilities for errors. There has been some concern that there is no means for a visual check for full surface washing or volume losses when measuring on rough surfaces, which could cause errors.

However, one of these proprietary meters is stated to be ISO 8502-9 equivalent in accordance with NACE SP0508-10, and is approved by SSPC Guide 15, “Field Methods for Extraction of Soluble Salts on Steel and Other Nonporous Substrates".

Solubility within a test chamber like a Bresle patch or the ridged cell is significantly influenced by three main factors. 

• Agitation: The amount of movement of the water within the test chamber along the test surface.
  Creating an increase in enthalpy to help dissolve the soluble contaminants.

• Temperature: Increased solubility with higher temperature is also caused by the increase in enthalpy. Temperature influences the solubility constant of every salt. With higher temperature comes increased dissolving speed and solvability.

• Concentration: The amounts of salts present on the surface and already dissolved in the water determine the speed of dissolvability of the other salts.

These proprietary meters have limited compensation for differences in temperature, however there has been some concern that the rotary or piston motion used in both types of ridged cell salt meters could adversely influence the agitation. With the propeller method only the outside of the test chamber is adequately agitated by centrifugal forces, and the piston mode can create too little agitation on vertical surfaces.

Paper extraction method

An alternative method to eliminate the use of patches and the possible residues left by their use on the test surface, is the filter paper method. In this, a measured amount of water is applied to the paper which is then placed on the surface and left there for a defined time. Any salts on the surface are drawn up and absorbed by the water contained in the filter paper. The filter paper is then removed from the substrate and the conductivity measured by means of a modified conductivity meter.

The amount of water that can be contained in the filter paper depends on the density of the paper and temperature. When the test is used on heated pipeline installations, the amount of water contained is of significant. These hot surfaces are often too hot for measuring with conventionally adhered patches. A problem with the filter paper method however, is evaporation. When the wet filter paper is applied to the hot pipe, the water can evaporate rapidly and the error caused by the drop in volume can be significant (as high as 70% when measurements are taken on hot surfaces, or in dry environments). While the loss in water would suggest that the sample would be concentrated, the final measurement can in fact be significant lower than the expected outcome. The loss of water can be so significant that the filter paper will contain salts in crystalline form, this due to the lack of ions, will not contribute in conductivity. Therefore care should be exercised when using this method.

Alternatives to the use of Conductivity Titrimetric determinations

A highly accurate method of determining the chloride ion concentration in the fluid extracted from the Bresle patch, is titrimetric determination. The advantage of this method is, it is ion specific - enabling testing for one specific ion with accurate results. Over time multiple methods have been developed, all with different ease of use, however the required glasswork and chemicals makes the method less suitable to perform in the field, requiring samples to be either sent to a laboratory or to provide a special test location onsite.

The main ion determined by titrimetric determination is chloride, other ions can also be determined but often require
more work or larger samples. Due to the limited amount of sample volume available (from a Bresle patch) often only partial analysis of all salts present can be done. For most salt contamination analysis, chloride levels will be sufficient, but in industrial environment, analysis of sulphates or nitrates could also be of interest.

Most titrimetric determinations for chloride are based on precipitation. Visually this is often hard to see, however by using a Pt-electrode for a potentiometric titration, the accuracy is significantly increased. The precipitation reaction of both methods is based on the poor solubility of silver chloride. A silver nitrate solution is reacted with the chloride ions present and forms a white precipitation.

\[ \text{AgNO}_3(aq) + \text{Cl}^- (aq) \rightarrow \text{AgCl(s)} \]

Visual determination of the end-point is assessed by introducing a secondary precipitate as an indicator. The three main titration methods on the market using the secondary precipitation principal, are Volhard, Mohrs and Fajans, which all work the same, however with different indicators.

The modern day introduction of more stable and advanced electronics could mean an re-introduction of this method to the field. When applied in the field this could form an eventual addition to the analytical possibilities of ISO 8502-6, however present health and safety regulations, due to the use of some chemicals, prevent the implementation of most of the simple titration methods in the field. Currently ISO 8502-2 "Preparation of steel substrates before application of paints and related products – Tests for the assessment of surface cleanliness Part 2: Laboratory determination of chloride on cleaned surfaces" and the withdrawn ISO 8502-10 "Preparation of steel substrates before application of paints and related products – test for the assessment of surface cleanliness – Part 10: Field method for the titrimetric determination of water-soluble chloride" are the two tests utilizing the titrimetric method.

**Ion Selective Electrode**

The use of Ion Selective Electrodes (ISE) to determine chloride, and other ion concentrations, are gaining ground. This can be a fast and a relatively reliable tool. Samples for analysis by ISE need to be stabilized to suppress interfering ions, and make the matrix sufficiently stable for measurement. Many ions require pH-stabilization due to the nature and properties of the electrodes, and the pH value can significantly influence the final results. The need to stabilize with an ISAB (Ionic Strength Adjustment Buffer) means it is not possible to measure multiple parameters within one sample as these ISAB are ion specific and cannot be combined, thus rendering the method unsuitable for field analysis without obtaining vast quantities of sample to test.

The ion selective method is at this moment not yet standardized for field determination of soluble salts, and thus is not a part of the ISO 8502 test protocols.

**Spectrophotometric/Turbidimetric measurements**

For many decades, spectrophotometric determination of ions in general, has been used in laboratories around the world. Recent developments in equipment, light sources and monochromators have resulted in a decrease in size of the equipment, and making them suitable for field use. The present field-size spectrophotometers have improved quality and spectral range, although most models in the field are only usable to measure turbidity, and contain no monochromator.

More recent devices contain a filter system to replace bulky monochromators and are often significantly more sensitive to enable measurements in low concentrations. This technology has been widely adopted within swimming pool management, as a means of measuring chlorine concentrations.

The main principal of the test is that the loss of transparence of a sample is determined either in the full spectrum (turbidity) or in a specific spectrum (spectrophotomeric). The turbidity is created by adding a reagent to the sample tube that creates a precipitate. This precipitate blocks light from passing through the sample container and this change in translucency correlates to the concentration of the ion under determination. The same principle is used for spectrophotometric determination, with the exception that it is not a precipitate that is formed but a color change due to the chemical reaction. Every ion that needs to be determined requires its own set of reagents and indicators. The method is thus ion specific, however some ions can be affected by the sample matrix, just as with the ISE method, and these need to be suppressed.

**Ion exchange**

Ion exchange technology as used in the test tubes described in ISO 8502-5 "preparation of steel substrates before application of paints and related products – tests for the assessment of surface cleanliness – Part 5: Measurement of chloride on steel surfaces prepared for painting (ion detection tube method)" offers a basic and easy to use method, however they do not necessarily give stable readings, as the readings can fluctuate due to interference from other ions. Ion exchange methods are used to determine further contamination, for example sulphates and other contaminants, as the chemicals used in the tube not only react to the intended ion but also specific interfering ions. In addition, the method utilizes chromate containing tubes, for chloride determination, which require specific waste disposal in most countries.

Though officially a test method when the water is used, a common in-field test uses instead an acidic solution to dissolve the salts from the surface, and although often referred to as a measurement according to ISO 8502-5, due to the use of the acidic solution, it is not, as the water solubility and acid solubility of ions differ. Such a simple error can cause significant problems. Besides the difference in result due to the use of an acidic solution, the non-conformity to the standard could mean that entire coating-jobs have to be redone due to improper conformity to the specification and standard.

**Reporting results**

Irrespective of which methodology is used to determine the level of salt contamination, each report produced on soluble salt levels should include climatic conditions and substrate temperature. The ISO 8502-8 standard demands that the test be done at 25°C and a relative humidity of 65%. Any deviation from the defined parameters has to be reported and agreed upon by both inspector and customer. Surface temperature also influences the test, meaning that this parameter also needs to be recorded. During any arbitration, the lack of these recorded values could render the acquired results invalid.

Also when preparing specifications and reports, assumptions cause the biggest errors, and assuming that everybody understands that what you meant, and what was measured, is unfortunately wishful thinking. Many specifications just require that salt levels need to be measured and forget to state a method or a maximum allowed concentration. In even more cases the specification itself will already include improper wording, such as measuring chloride according to ISO 8502-6 & -9 or soluble salts according to ISO 8502-5.

**Conclusions**

Although this article has shown that there is a lot of “science” behind proper testing for salt contamination, inspectors can benefit from readymade test-kits, which are available on the market, making these tests quite simple. Up-dated Bresle kits offer different solutions to the testing of salt contamination, each with its own strengths and weaknesses. The results obtained with different methods sometimes need to be taken with a grain of salt. You can’t compare apples and oranges!
are now available with Direct Sampling Procedure, which enables inspectors not only to work faster but also produce more accurate results. The combination of the new technique, high quality gauges and patches, makes these kits even easier to use. Many suppliers are modifying their test kits to be more flexible and suitable for easy and simple testing. However each method has its pro’s and con’s just like the humans performing the test, but these errors are not the biggest cause of problem. Modern test methods with simplified calculation options have a significant higher accuracy. Failures during extraction are often only caused by impatience and stubbornness of the user and produce irreproducible results. The biggest problem in the coating industry is that we are all comparing what cannot be compared. Salt is not just sodium chloride and vice versa. Comparisons are made between nonspecific and ion specific methods that sometimes can lead to differences of 70%, because the ion measured in method “A” only represents 30% of the total salts on the surface as measured by method “B”. You just cannot compare apples and pears/oranges. In future, let’s clearly state the salt contamination on surfaces in a responsible way where we all know what we are talking about.
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BRANCH DATES

Tuesday 25th April 2017
Aberdeen Branch Meeting
Speaker: Tim Froome, Beasy
Venue: Palm Court Hotel, 81 Seafield Rd, Aberdeen AB15 7YX.
Visit www.icorr.org for more details.

Tuesday 30th May 2017
Aberdeen Branch Meeting
Speaker: Simon Daly, Hempel
Venue: Palm Court Hotel, 81 Seafield Rd, Aberdeen AB15 7YX.
Visit www.icorr.org for more details.

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 Glynnas, Durham University.
Visit www.icorr.org for more details.

ADDITIONAL DIARY DATES

Thursday 27th April 2017
Corrosion Engineering Division Working Day
‘Corrosion Engineering and Concrete’
A combination of invited talks, CED working group meetings, a laboratory visit to Sheffield Hallam University and presentation of inaugural Paul McIntyre award.
Venue: Institution of Mechanical Engineers Engineering Training Centre, Sheffield Business Park.
Visit www.icorr.org for more details.

Monday 8th - Friday 12th May
ICorr Level 2 Cathodic Protection Technician Marine Metallic Structures Course
Duration: 5 days
Course content: Covers the application of cathodic protection (CP) to the following marine structures: Harbours, Wharves, piling and walls, Jetties, Subsea structures, Offshore pipelines (submerged and buried), Offshore platforms, Ship external hulls
Venue: Poole Museum and RNLI Poole Base.
Course and examination enquiries: +44 (0)/114 3995720 or trainingsolutions@imeche.org

Institute Events
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