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We held a very productive and lively Council Meeting on the 4th September in Northampton, and as ever my thanks go to Council for their dedication and desire to improve the Institute. We are seeing encouraging levels of membership and an increased geographical spread. What this helps to create is a global network between ICorr members, and the Institute striving to meet the goal of an improving knowledge sharing and networking opportunities.

All the branches are moving into their winter calendars and there are some interesting branch meetings planned. These meetings can be found on the website and you are all welcome to attend. Should you find yourself in a different location please feel free to join the local branch event, you will always find a warm welcome. Please also look out for OSD and CED activities as they have some very active groups that also welcome new members to attend.

ICorr and IMechE are improving their partnership, and IMechE are relaunching their training division as IMechE Argyll Ruane and have exciting plans in the pipeline.

I have just visited Krakow to attend Eurocorr, where there was a good level of representative from ICorr members. I also had interesting meetings with some of our overseas colleagues.

YEP going from strength to strength, currently focused in London, but ICorr would like to develop the principle in other parts of the UK. The current candidates have been split into groups, and been appointed a mentor to help them with their Case Study Project. They will be delivering their solutions to this highly complex case at the London Branch meeting in November, and all are welcome to come and see who wins the coveted prize to visit NACE 2019 in Nashville.

Sarah Vasey, ICorr President

Welcome to the autumn edition of Corrosion Management. The theme of this issue is “Protecting Bridges”, which is particularly topical due to the recent disastrous collapse of the Morandi motorway bridge in the Italian city of Genoa. It has been postulated that the failure was due to corrosion of the reinforced concrete stays, and highlights the need for regular inspection of bridges. According to the head of Highways England, road bridge inspections in England are being reviewed following this tragedy, when forty-three people died.

The main technical article in this issue describes a procedure for selecting protective coatings for bridge maintenance, based on in-situ testing. There is also a short article on the advantages of using rope access for inspection of bridges.

The final article covers an important topic about pipeline CP management - a lot of engineers in this field are unaware of the points raised or just not considered them.

I appreciate any feedback on the contents of this issue, or previous ones, so please contact me via the Northampton office. Also I welcome any of your corrosion-related news items which can then be shared with others in the Institute.

Brian Goldie, Consulting Editor

OMNIFLEX has been designing and manufacturing electronic products and systems for the automation and control industry since 1965. Omniflex has expanded their range of monitoring and control power products to include specialist products for impressed current and galvanic cathodic protection systems, called PowerView CP. This system harnesses their depth of experience in power control and remote monitoring in harsh environments to bring reliable cost saving solutions to the challenges associated with managing impressed current cathodic protection systems in remote locations. Working with leading experts in the field of cathodic protection, they have designed systems that can assist in reducing operating costs and the carbon footprint associated with these kinds of systems.

Omniflex solutions are being relied upon every hour of every day by major corporations around the world. An investment in solutions that carry such a large responsibility requires confidence in their track record, and the continued reliance of some of the world’s largest industries on OMNIFLEX technologies is sufficient testimony to this support.

Sarah Vasey, ICorr President
Dear Member,

The Trustees and Council of the Institute would like to invite you all to the 2018 AGM to be held on Thursday 29th November 2018 at the Council Chambers Birmingham in conjunction with a half day Midlands Branch meeting and presentation of the 2018 U.R. Evans Award.

Midland Branch Meeting
13:00 - 13:30 Lunch served
13:30 - 13:40 Welcome and introductions
13:40 – 15:30 Presentations by industry experts
15.30 to 15.45 Coffee break
15.45 – 16.30 U.R. Evans Award:
Presentation of the U.R. Evans Award to Professor Anne Neville, followed by her Plenary lecture.
16:30 – 17:30 ICorr AGM

AGM Agenda
1  Apologies for absence
2  Minutes of the previous AGM November 2017
3  President’s report
4  Treasurer’s report
5  Elections
7  Any other business

The Trustees and members of Council will be available before the meeting to answer any questions you may have regarding the Institute and its future.

Again, as in the case of 2017, the Institute’s accounts and the minutes of the previous AGM, will be available via the ICorr website (www.icorr.org). Please examine them and the website in general, as we would appreciate your feedback. The website will continue to be influential in increasing the Professional Membership and the perspective of non-members of ICorr and as a major means of communication with membership.

Your confirmation of attendance (for lunch numbers) or apology for absence will be appreciated preferably by e-mail to admin@icorr.org

We look forward to seeing you there.

Yours faithfully,

Dr Jane Lomas
Institute of Corrosion, Honorary Secretary

New Sustaining Member
Specialist Castings

Specialist Castings is a major international manufacturer and supplier of impressed current anodes and sacrificial anodes, including ferro-silicon, magnesium, aluminium, zinc, MMO and cathodic protection accessories.

They are a joint-venture company with manufacturing and storage facilities based in UK and China, and also have a U.S. company in Houston Texas that stores and distributes these joint-venture products.

All products are manufactured to the highest standards including relevant ASTM, British, European or International Standards.
**ICATS News**

**The Coatings Applicator Apprenticeship Scheme**

A Coating Applicator Apprenticeship is being developed to try and meet a recognised skills shortage in the Protective Coatings Industry. Correx is working with DN colleges in Scunthorpe to run a pilot scheme starting in January 2019. We are looking to sign up 10-12 apprentices who, at this stage in the pilot, need to be 18+ years of age. If any ICATS Registered Companies have prospective candidates please contact the office.

Upon completing the apprenticeship the candidate will require a further 12 months of working in the field to complete the ICATS Apprentice accreditation at which point they can apply to take the course to achieve full ICATS accreditation.

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**INDUSTRIAL COATINGS APPLICATOR APPRENTICESHIP SCHEME**

In a significant development for the Industrial Coatings Applicator Industry, the Trailblazer Apprenticeship for Industrial Coatings Applicator has been approved for delivery by the Institute of Apprenticeships.

Also approved is the End Point Assessment (EPA) which is the culmination of the apprenticeship and is designed to enable Apprentices to demonstrate occupational competence as an Industrial Coatings Applicator and to ensure that they meet the skills, knowledge and behaviour outcomes as defined in the apprenticeship standard. This apprenticeship has been developed by the Trailblazer Employer Group with the full support of the Training Committee of Highways England National Highways Sector Scheme 19A.

Stephen Hankinson, Chair of the Employers Group said: “Finally getting the standard approved for delivery is a timely reward after two years of effort and a major step forward for the industry.”

David Horrocks, ICorr and chair of the Training Committee of National Highways Sector Scheme 19A, said “Industrial coating applicators play a key role in protecting the nation’s infrastructures from deterioration for the benefit of existing and future generations use, however, there is currently a shortfall in not only the ‘next generation’ of applicators coming through the industry supply chain, but also the current availability of trained applicators based on present demand for this key skilled role”. David also commented “the committee, in conjunction with the employer group, has worked extremely hard over the last couple of years to not only develop the apprenticeship standard and end point assessment but to have the passion and commitment to see this through to a successful outcome, all of those involved in making this happen should be extremely proud of themselves”

The Training committee is now working with professional and educational institutions and employers to ensure that the apprenticeship standard becomes available for delivery as soon as possible and no later than Q1 2019.

Typically, apprentices will have to complete 18 months on-programme working towards the apprenticeship standard, with a minimum of 20% off-the-job training. At the end of the apprenticeship, the candidates that complete the Standard and EPA will be awarded a Certificate of Apprenticeship for Industrial Coatings Application.

The Trailblazer apprenticeship was developed following a review of apprenticeships commissioned by the UK government and resulting in a recommendation that there was a more employer-based approach to develop, deliver and fund apprentices.

For more information see: https://www.instituteforapprenticeships.org/apprenticeship-standards/industrial-coatings-applicator/

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**CP Course**

ICorr Level 2 Cathodic Protection Senior Technician, Marine Metallic Structures course will be held on 22nd to 26th October 2018, Pier Hotel, The Quay, Harwich.

Certification of cathodic protection personnel competence is a requirement for the cathodic protection industry throughout Europe in accordance with BS EN 15257 (soon to become an ISO Standard). This includes all personnel i.e. Technicians, Senior Technicians/Junior Engineers, Field Engineers, Designers and Consultants carrying out cathodic protection duties such as survey, design, installation, testing, monitoring and maintenance, within the UK and Europe (as an ISO this will be international).

This course and examination, for Level 2 Senior CP Technicians, is in compliance with BS EN 15257, and suitable for candidates with a minimum Level 1 experience in cathodic protection, or with dispensation from ICorr based on education, professional qualifications and experience to bypass Level 1, but note that full Certification to Level 2 by ICorr requires a minimum of four year’s approved marine CP experience (less with a higher level education). The course is likely to be of particular value to, in addition to Level 1 Technicians in this or other sectors:

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**Fundamentals of Corrosion Course**

The next Fundamentals of Corrosion course will be held on 12th to 16th November 2018 at Elcometer in Manchester. The cost will be £950 + VAT and anyone wishing to book should contact ICorr at admin@icorr.org
• Level 2 Senior Technicians certified in the Buried or Steel in Concrete sectors
• Engineers in the offshore Oil and Gas sectors involved in cathodic protection
• Engineers and Inspection and Maintenance personnel in the offshore wind industry.

The location of the course will be of special interest by allowing for practical measurements to be taken on site at Harwich International Port Ltd.

The topics of this course are fully set out and described in BS EN 15257 for Level 2, in Annex B1 and B3, and cover the application of cathodic protection (CP) to marine structures, for example, wharves, pilings and walls, jetties, offshore wind tower foundations and platforms.

After successful completion of the course, candidates should be able to undertake cathodic protection design work under the supervision of an individual certificated to Level 3. An individual Certificated to Level 2 may undertake simple cathodic protection design work as described in annex B of the Standard, according to established procedures in a known environment, without supervision.

The rules governing training, examination and certification are set out in ICorr REQ DOC (CP). For more information regarding both of these contact trainingsolutions@imeche.org or visit, http://www.icorr.org/education_training, CP certification scheme.

Certification is awarded to those candidates who:

a) Have undertaken a minimum of 40 hours approved training. This course, with its supplied pre-course study provides this approved training.

b) Sit and pass the examination (held on the Friday of the course).

c) Apply separately to the Institute of Corrosion, providing satisfactory evidence of required C.P. Experience (no charge at present).

The course will be conducted by Engineering Training Solutions (part of the Institute of Mechanical Engineers) on behalf of Institute of Corrosion (Principal Lecturer: Paul Segers MSc, CEng, FI Corr, MIM3 ICorr Level 3). The duration is 4 days followed by a 1 day examination (optional), with field testing being carried out at Harwich International Port, by work boat and pontoon. The cost for the course (excluding Accommodation) is £1050.00 + VAT (Examination: £250 + VAT).

For further information, or to book a place, contact +44 (0)114 3995720 or trainingsolutions@imeche.org.

Corrosion Science Division
59th Corrosion Science Symposium

The 59th Corrosion Science Symposium (CSS) was this year hosted by the Institute of Functional Surfaces in the School of Mechanical Engineering at the University of Leeds, between the 9th and 11th September. The CSS has become an established event for young corrosion scientists and engineers from across the UK, and indeed further afield. The annual CSS provides an ideal opportunity for researchers to present their recent advances in corrosion, research in progress, and to discuss exciting developments across a broad range of applications. This year there were 55 delegates, with three keynote and 16 oral talks, plus nine posters over the two days. The symposium had two strong underlying themes, (i) tribocorrosion and biocompatibility linked with issues associated with biomedical implants, and (ii) film/scale formation related to either CO\textsubscript{2} or H\textsubscript{2}S environments in the oil and gas industry.

Symposium talk highlights included, Farzana Motamen Salehi (University of Leeds) who gave an interesting overview of her work to develop a new methodology to simulate metal-on-metal tribocorrosion of the CoCrMo implant head-taper and bearing interfaces under realistic loading conditions. Mohamad Taufiqurrakhman (University of Leeds) reported his studies into the role of biological-related lubricants on the tribocorrosion reactions of CoCrMo sliding contacts. Suzanne Morsch (University of Manchester) gave a good overview into her recent studies using the atomic force microscopy-infrared technique to map transport channels in epoxy coatings. Emily Clark (University of Leeds) talked with great clarity about her studies into the generation of physiologically relevant tribocorrosion debris from nickel-titanium biomedical stents. Righdan Namus (University of Sheffield) presented interesting insights into her studies on the influence of protein concentration and temperature on the corrosion and tribocorrosion behaviour of CoCrMo biomedical alloys. Finally, Manuel Bianco (Ecole Polytechnique Fédérale de Lausanne) gave a fascinating overview of the corrosion processes affecting ferritic and austenitic stainless steels when used in solid fuel cell energy conversion devices.

The three keynote talks by Evgeny Barmatov (Gould Research Centre, Schlumberger), Roger Newman (University of Toronto), and Mary Ryan (Imperial College, London) complemented very nicely the other symposium presentations, providing critical overviews into key insights associated with corrosion inhibitors, dealloying and X-ray spectro-microscopy, respectively. All three gave inspiring talks that often challenged perceived wisdom and provided exciting insights into recent scientific achievements within their chosen topics.

The Shreir Prize is awarded to the best oral presentation by a registered student at the CSS, and this year the prize was won by Michael Dowhyj for her talk entitled ‘Characterising inhibited surfaces using vibrational sum-frequency spectroscopy’. Michael discussed with great clarity and enthusiasm how she has used this novel technique to explore nanoscale mechanistic details, thus gaining enhanced insights into the interfacial structure of inhibited surfaces.

The CSD would like to express its appreciation and thanks to the Institute of Functional Surfaces for hosting the CSS, especially for all their efforts in coordinating and running a successful symposium this year.

Other CSD matters

The Corrosion Science Division committee membership is currently stronger than for many years, with good representation from both academia and industry, plus technical expertise from across a number of UK institutions.

The committee recently approved the ICorr Council’s suggestion to make it easier for students to apply for the Galloway Award by requiring them to simply send a copy of either a submitted or published journal paper, or a peer-reviewed conference paper, from the previous 12 months. Previously, a separate technical report was the requirement that has often meant it was troublesome for students. The CSD committee agreed that the revised submission criteria would not change the spirit of the award as it was always aimed at dissemination of high quality research. Currently for 2018 there have been three submissions and an announcement of the winner will be shortly.
Local Branch News

Aberdeen Branch

As part of its preparations for the 2019 session ahead, the branch arranged two excellent presentations by Zahra Lotfi, branch University Liaison and CPD Officer, for the new student intakes of the University of Aberdeen (12 September) and The Robert Gordon University (25 September) Engineering Departments. This was initiated to highlight the increasing career opportunities in corrosion control and routes to ICorr Membership and C.Eng. status. All Aberdeen students were also activity encouraged to attend future branch meetings and become involved in the “National Corrosion Debate”, as the costs of corrosion to society continue to put those of Brexit in the shade.

The annual Aberdeen Corrosion Awareness Day event this year took place at the training centre of a key sponsor, Emerson Solutions Automation, who generously provided numerous training materials, expert technical demonstrations and of course some first class Catering. The 45 attendees came from across many different industries and from many areas of the UK, skilfully co-ordinated by Denise Aldous and Gwynneth Moore at ICorr HQ.

As in previous years, all the Aberdeen branch sponsors were invited to send 2 representatives each, and there were additionally 20 fee paying attendees who confirmed the event as being excellent value for money.

As in the past, the event had two key objectives:
1) To assist in the development of those unfamiliar with corrosion prevention issues.
2) To raise funds for ICorr, to maintain its ongoing education programmes /events.

In what was a very busy programme, delegates were treated to an excellent mix of theory and practical demonstrations, along with many exhibits of failed metallic components, coatings and of course a few more modern, non-corrodable options. A short CAD test was held at the end of the day with all delegates achieving over 75% pass rate.

Members of the Aberdeen branch committee provided all the morning lectures, with a comprehensive programme covering, principles and costs of corrosion, corrosion modelling, bacterial corrosion, cathodic protection, materials and risk based inspection (RBI).

The afternoon session was purposely designed to complement the morning session, with demonstrations of all types of process control instrumentation by the Emerson technical team – compositional, flow, pressure and temperature measurement (for corrosion modelling inputs); and corrosion monitoring devices of all types and non-intrusive clamp-on and magnetic NDT devices for wall thickness monitoring. All the above instruments can provide valuable data for CRA’s – Corrosion Risk Assessments and RBI / schemes of examination.

The day finished with Certificates of Appreciation being issued to all the contributing speakers and CPD Certificates being issued to all attendees, followed by a vote of thanks to our excellent hosts Emerson, to whom ICorr Aberdeen is extremely grateful for all their financial support to its 2018 CAD Event.

All the day’s slides can be found under “2018/2019 ICorr Aberdeen Presentations” folder on their site. https://sites.google.com/site/icorrabz/resource-center

Delegates and trainers of the 2018 Aberdeen Corrosion Awareness Day, at the Emerson Training Facility, Dyce with Andy Young (Site Team Manager at Emerson Automation Solutions) in centre.
London Branch

The branch will be holding a joint meeting with the Society of Chemical Industry at SCI, 14 Belgrave Square, London SW1X 8PS, on 25th October 2018, entitled “A Fighting Ship and Fighting Corrosion”. The Speakers will be, Dr Eleanor Schofield - Mary Rose Trust, and Jim Glynn – ICorr and Beanny Ltd. The presentations will describe the conservation strategies developed during the restoration of the Mary Rose, and the dynamic duo of coatings and cathodic protection.

The starting time is 17.30 for 18.00, and a net-working drinks reception will follow at 19.30. This event is free to attend, but please register in advance to help with catering at, http://bit.ly/2lx6C7UR. Registration can also be made through John O’Shea at, johnoshea@btinternet.com. Further details are available on both ICorr and SCI websites.

The November meeting will be devoted to presentations by this year’s Young Engineer Programme candidates on their solutions to the case study problem they were set, which is the culmination to this year's YEP. The young engineers were split into teams, assigned mentors and asked to consider the exchanger design/operating data, and propose credible root causes for the degradation of the 1st stage tube sheet. They were also asked to describe a testing scope to confirm the root cause of the corrosion damage, explain how they would perform a corrosion risk assessment to help the installation's management team determine if the train can be restarted, and review mitigation options that could applied to prolong the service life of the heat exchanger.

The winning team will be rewarded with an expenses paid trip to Nashville to attend the 2019 NACE Conference. They will be expected to report on the Technical Sessions they have attended and what they have learnt from them.

The event will be held on 8th November 2018 in the Skempton Building, Imperial College, lecture theatre rooms 163 and 164 (note these rooms are on the ground floor of the building), starting at 18.00.

It is clearly an event not to be missed, and the candidates would really appreciate your support and that of your colleagues.

Midland Branch

The branch will hold a half-day technical meeting on Thursday 29 November 2018 at the Council Chambers Birmingham, prior to the presentation of the 2018 U.R. Evans Award, and the Institute AGM (see announcement on page 5).

The afternoon will start at 13.00 with lunch, and the theme of the technical talks is pipeline integrity and will cover, pipeline coatings, concrete pipelines, and general pipeline integrity. The presenters have been confirmed as, Pipeline NDT methods - IMechE, Pipeline coating and integrity - Sherwin Williams, and Chemical treatments with respect to pipeline integrity - Intertek. Full details will be available on the ICorr website in due course.

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**IMechE ETS renamed IMechE Argyll Ruane**

The Institution of Mechanical Engineers is renaming its NDT, Corrosion and Coatings Training and Consultancy business IMechE Argyll Ruane. Formally known as IMechE Engineering Training, Argyll-Ruane was the original name of the business the Institution acquired in 2012, and the return of the familiar name invokes the values of expertise, knowledge and customer service with which the company has been synonymous since its formation in 1985.

IMechE Argyll Ruane provides world class training, examinations and consultancy support to a wide range of organisations and industries in the fields of NDT and corrosion prevention. It runs over 350 courses a year.

General Manager Chris Kirby explains “We have been working hard over the last six months reviewing and, where necessary improving, every aspect of our customer service provision, from the ease of our booking procedure through to the quality of our training and the robustness of our examinations. I am very proud to be renaming our company IMechE Argyll Ruane and will ensure that our service levels continue to be worthy of our prestigious heritage.”

The return of the Argyll Ruane name follows significant investment made by the organisation over the last 6 months. The Ultrasonic Testing department has grown with the addition of advanced UT experts Andrew King and Jordan Wood, whilst Craig Hobson has returned to head up the Examination Centre.

**Improving the anticorrosive performance of epoxy coatings**

A recent report highlighted the improvement in anticorrosive performance of epoxy coatings by the addition of various percentages of unmodified, and imidazole modified CeO₂ nanoparticles.

The surface of CeO₂ nanoparticles was modified by a layer on layer method. Firstly, the surface of the nanoparticles was coated by polyaniline via oxidative polymerization then the imidazole layer was formed on polyaniline due to opposite electrostatic charges. The modification of nanoparticles was studied by FTIR, Raman spectroscopy, TGA, Dynamic light scattering, and Transmission electron microscopy.

The anticorrosion performance of epoxy coating with different concentrations of unmodified and imidazole modified CeO₂ nanoparticles (0.5, 1 and 2 wt%) on mild steel was evaluated in NaCl 3.5 wt% solution by electrochemical impedance spectroscopy (EIS) and scanning electron microscopy (SEM). After 200 hours immersion in the salt solution, the coating resistance of epoxy/0.5wt % imidazole modified CeO₂ nanoparticles was measured as $1.19 \times 10^7$ Ω cm², which was higher than epoxy/unmodified CeO₂ nanoparticles ($5.1 \times 10^6$ Ω cm²). Also, the water uptake of the 0.5 wt% imidazole modified CeO₂ nanoparticles at the end of immersion time was 3.85% compared to the unmodified CeO₂ nanoparticles (4.56%).


**Visualising under-coating corrosion before visible damage**

A new method for visualising under-coating corrosion utilising pH indicators before any visible damage has been developed. Wherever a coating develops a defect, localised corrosion causes a decrease in the local pH at the anodic sites. Thus these local pH changes can be used to identify the location of defects by the use of a pH indicator, before any visible signs of corrosion damage occur on the coated metal sample.

The study is published in: Progress in Organic Coatings Volume 122, September 2018, Pages 72-78.

**The Protective Coatings Market in the UK (2016-2021)**

This report provides UK consumption estimates in both volume and value for protective coatings, with 2016 as the base year and forecasts to 2021. It covers resin type (including, pure acrylic, alkyds, epoxy, polyesters and polyurethane, and water-based, solvent-based and powder), end use (off-shore, civil engineering, industrial, machinery, power generation and containers) and coating type (anti-corrosive, intumescent, topcoat). There are detailed prices and market values and 2015 average manufacturers’ selling price by product, and market share by Company.

For more information about this report visit https://www.researchandmarkets.com/research/f4rnnr/the_protective

Also available from this company is the UK Marine Coatings report which includes market volumes by resin type, end-use (new build and maintenance) and functional layer (primer, topcoat, anti-fouling). Detailed prices and market values, average manufacturers’ selling price by product and market shares by company are given.

For all the latest news, events and debates join us on [LinkedIn](https://www.linkedin.com/uas/login?fromMobile=true)

**UP-COMING CONFERENCES**

**Advances in coatings technology**

The 13th International conference on advances in coatings technology will be held on 13 – 15 November 2018 at the EXPO SILESIA Exhibition Centre, Sosnowiec, Poland. The main topics to be covered include raw material developments, advanced technologies and their environmental aspects, applications, ecology and legislation, testing, and recent research projects.

The conference will be conducted in English/Polish with simultaneous translation, and the papers will be published in both Polish and English. In total, 58 papers and 5 posters will be presented by specialists from leading companies involved in coatings industry and scientists from academia and R&D institutions coming from 19 countries.

The Conference fee is €350, which includes a set of the Conference Papers, List of Delegates and Companies, Lunches, Coffee Breaks, Conference Dinner on 14 November 2018. Further information can be obtained from Ms. Anna Pajak – Chairperson of the Organising Committee, e-mail: a.pajak@impib.pl, or see website, www.impib.pl
Health & Safety

As part of the 2018-2019 Healthy Workplaces Campaign, EU-OSHA has published two info sheets on dangerous substances.

Legislative framework on dangerous substances in workplaces.

This info sheet provides an overview of the legislative framework on dangerous substances in workplaces in the European Union, with an emphasis on three European directives: OSH Framework Directive, Chemical Agents Directive (CAD) and the Carcinogens and Mutagens Directive (CMC).

Seven steps towards risk prevention are outlined, and a pool of free interactive e-tools for an easier risk assessment, such as OiRA, is provided.

The STOP principle, the hierarchy of prevention and measures to be taken after hazard identification, is also put forward.

Substitution of dangerous substances in the workplace.

The best way to reduce the risk is elimination or substitution of dangerous substances. A complete risk assessment is a key step in the process. This info sheet outlines a range of fundamental principles, practical hints, best practices, risk assessment tools and methods, and useful links to guide you through the stepwise process of substitution of dangerous substances in the workplace.

These documents can be downloaded at, https://osha.europa.eu/

STANDARDS UP-DATE

The following documents are currently under consideration by the technical committee.


These documents have obtained substantial support within the appropriate ISO technical committee, and have either been submitted to the ISO member bodies for formal approval or for voting.

ISO/DIS 2808 Paints and varnishes — Determination of film thickness (Revision of 2007 version)

ISO/DIS 3233-2 Paints and varnishes — Determination of the percentage volume of non-volatile matter — Part 2: Method using the determination of non-volatile-matter content in accordance with

ISO 3251 and determination of dry film density on coated test panels by the Archimedes principle (Revision of 2014 version)

ISO/DIS 3251 Paints, varnishes and plastics — Determination of non-volatile-matter content (Revision of 2008 version)


ISO/DIS 17872 Paints and varnishes — Guidelines for the introduction of scribe marks through coatings on metallic panels for corrosion testing (Revision of 2007 version)

ISO/DIS 22516 Paints and varnishes — Practical determination of non-volatile and volatile matter content during application

ISO/DIS 22557 Paints and varnishes — Scratch test using a spring-loaded pen

ISO/DIS 8504-1 Preparation of steel substrates before application of paints and related products — Surface preparation methods — Part 1: General principles (Revision of 2000 version)

ISO/DIS 11124-5 Preparation of steel substrates before application of paints and related products — Specifications for metallic blast-cleaning abrasives — Part 5: Cut steel wire


ISO/DIS 21153 Corrosion of metals and alloys — Measurement of environmentally assisted small crack growth rate

New standards published during the last two months.

ISO/TR 10402: Paints and varnishes — Adhesion of coatings

ISO 14993 Corrosion of metals and alloys — Accelerated testing involving cyclic exposure to salt mist, dry and wet conditions

ISO 2812-5 Paints and varnishes — Determination of resistance to liquids — Part 5: Temperature-gradient oven method


ISO 7539-6 Corrosion of metals and alloys — Stress corrosion testing — Part 6: Preparation and use of pre-cracked specimens for tests under constant load or constant displacement

ISO 19280:2017 f Corrosion of metals and alloys — Measurement of critical crevice temperature for cylindrical crevice geometries in ferric chloride solution

Continues on page 12
CEN

New standards issued during the last two months.

EN 17001 Thermal spraying - Components with thermally sprayed coatings - Coating specification

This European standard defines the requirements to be specified in the coating specification for a thermally sprayed coating. It applies to components and workpieces made of metallic or non-metallic materials that are to be partially or completely coated with thermally sprayed coatings.

EN 17002 Thermal spraying - Components with thermally sprayed coatings - Thermal spray procedure specification

The thermal spray procedure specification (TSPS) is a critically important quality assurance document in the production workflow when producing a thermally sprayed coating. This document defines the minimum requirements to be followed for the content of a thermal spray procedure specification.

Correction

In the July/August issue, the name of the author of the technical article “The selection of pump materials for handling waste waters” was inadvertently omitted. The article should have been credited to R Francis, RF Materials Ltd, UK.

Innovative Products

Improved chemical resistant epoxy coating

Belzona has released the latest formulation of its chemical resistant epoxy coating, Belzona 4311 (Magma CR1). Originally introduced in 1986, this material has long been known for its barrier properties, resisting the attack of the harshest chemical compounds, such as sulphuric and hydrochloric acid, among others.

According to the company, over the last few years, their R&D chemists have been working to improve the ease of application and performance of this product. Richard Collett, chief R&D chemist, commented that the objective was to improve the application process, as secondary chemical containment areas in need of protection were getting bigger and bigger. The new formulation is sprayable, and also has an overcoat window of up to 24 hours. These improvements mean that large secondary containment areas can be protected more efficiently and economically, saving on both. UV resistance has been increased to reduce film thickness loss over years in service, and this was confirmed in the Q-Sun cabinet according to the ISO 11341 standard for 10000 hours, which showed minor thickness loss of 5% in comparison to a standard epoxy coating’s 50%.

These results prove that the coating does not only resist harsh chemicals but can also withstand weathering in various climates, even after decades in service, and despite the reformulation, the chemical resistance of the product remains unaffected, and still provides lasting protection against a range of harsh acids and alkalis, concluded the company.

SSPC

The Society for Protective Coatings recently announced the revision of the SSPC-SP 13/NACE No. 6 “Surface Preparation of Concrete” standard, which has been updated with more relevant companion standards and information from technical papers. The standard was first published in 2003, and in the recent update, Table 1, Classes of Surface Preparation per ICRI 310.2, has been added, providing classifications for surface preparation methods to make them easier to identify, and definitions were also updated.

Minimum acceptance criteria were also increased from suggested to mandatory, though they can be superseded by procurement documents or coating manufacturer requirements. Section 6: Table 2, Minimum Acceptance Criteria for Concrete Surfaces before Coatings Are Applied, also received a boost, moving from the non-mandatory appendix in the old version into the standard proper.

The section on flame cleaning (previously Section 4.3) was removed, and the appendices were reorganized, to now include information on surface preparation methods, concrete surface tensile strength and coating adhesion testing.

The standard costs $25, and is available for purchase via the SSPC Marketplace or the SSPC app.

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Square One +44 (0)114 273 0132 enquiries@squareone.co.uk
As we all know paint is an extremely complex chemically and physically engineered material which undergoes a series of changes during application, curing and weathering during service. The manufacturers of these paints work hard to ensure the paint materials are formulated correctly and suitable for their specified uses for which they are put through rigorous testing. However, they cannot test their materials against all eventualities in the “real world” and therefore it becomes necessary to test these paint systems further in-situ, which is an important factor when consideration needs to be given to maintenance painting of existing structures, such as bridges.

Recently a Bridge Owner approached a specialised Consultancy explaining they had numerous structures ranging from gantries and small footbridges to major motorway crossings across their network, and had heard about previous trials undertaken by them to evaluate the most suitable Highways approved maintenance paint systems from various paint manufacturers, and they wished to extend these trials on to their bridges. The client also expressed their wish to produce a series of re-coating specifications/systems most suited to the bridges they had on their network, ideally concentrating on extending the life of existing coatings and which would also require compatibility to be tested during the trials.

These feasibility type trials are a sound approach to determine the optimum method of surface preparation and the extent of the requirements, and how the system performs after various methods of preparation. They also ensure a contractor tendering for future works is aware of the requirements and the difficulties in the maintenance painting, and go some way in meeting the client's requirements. However, the planned trials go a little further and evaluate paint systems which are generically the same, but produced by different manufacturers.

This article describes the testing protocol and the results obtained for specific bridge/coating specifications.

Following a review of archived documentation detailing “as built” specifications including past coating maintenance and also a physical and visual examination of a reasonable cross section of the bridge structures across the client's network, it was established that even with the changes in protective coating technology for all steel highway structures since the 1970’s there were three main paint systems present. These were modified alkyds, chlorinated rubbers and the more modern epoxy coatings. Thermal Metal Spray (TMS) was identified on a number of the bridges beneath a number of the paint systems. The coating condition of these systems not only varied between themselves but also there was a marked difference between each system of the same generic type, which would have been affected by factors such as original preparation, application and environment throughout the structures' service life.

Identifying the most typical coatings across this particular network resulted in the selection of five specific bridges which were to become the basis of trials to assess which paint manufacturers maintenance coating system would perform to its full potential. These bridges comprised of:

- A modified alkyd in fair to good condition, with a slight intercoat weakness between original primer and first intermediate build coat.
- A modified alkyd in fair condition, with a slight cohesive weakness within the original intermediate build coat.
- A chlorinated rubber in good condition, with a slight cohesive weakness within the original intermediate build coat.
- A chlorinated rubber in fair to good condition, with a slight cohesive weakness within the original intermediate build coat.
- An epoxy system in good condition, with good adhesion properties throughout the original system.

Previous trials by the consultancy on other similar structures where six to eight Highways England approved coating systems had been trialled and tested, had identified three paint manufacturers who's products had performed well when applied to aged existing systems of varying condition and type, and it was these three paint manufacturers that the client wished to take forward for this current trial.

A draft specification with relevant clauses covering cleaning, surface preparation and coating application, including mixing, storage and environmental conditions, was produced. Each of the three paint manufacturers’ Highways England approved paint systems selected would be applied over various methods of surface preparation and existing coatings:

- A full dry abrasive blast clean to an 8St2½ to assess general performance and as a baseline to overcoated performance.
- A dry abrasive blast in patches with a thorough sweep blast to a sound coated surface to assess compatibility and performance over original coating types.
- A mechanical hand and power tool abrade to remove unsound coatings and provide a “key” for the maintenance coatings to assess compatibility and performance over original coating types.

Each test area on the selected bridges was fully cleaned, prepared and primed during the trials in accordance with both the draft technical specification and the paint manufacturers’
recommendations and once the required overcoating period for the primer had elapsed the intermediate build coat and topcoats were applied. These coating systems were:

- Full primer coat of Item No. 115 (High Build Aluminium Epoxy – 2 pack)
- Full intermediate build coat of Item No. 116 (High Build Epoxy – 2 pack)
- Full topcoat of Item No. 169 (Polyurethane – 2 pack)

It should be noted that due to the fact these were compatibility trials to assess the optimum system for varying existing coating conditions and particular methods of preparation, the use of a stripe coat was omitted from the trials, which were undertaken on flat surfaces, with no fixings or welds. With this as the only exception, the trials were undertaken in the same manner as a maintenance re-painting contract.

During these trials, the consultancy provided full time inspection and Quality Control (QC) at each process step to ensure the specified criteria were being met, including visual assessment of preparation standard, surface cleanliness prior to any coating being applied, and wet film and dry film thicknesses of each coating. Mixing of the 2 pack paints was also carefully monitored. Each of the paint manufacturers were also invited along to confirm their products were mixed correctly and systems applied to their recommendations, and to a suitably prepared surface.

Once the preparation and application trials had been completed to the satisfaction of the client, paint manufacturer and the consultancy, they were left to cure and would be evaluated every 6 months for a total of two years, to assess overall performance.

On returning to the test patches after 6 months, a detailed survey and assessment was carried out on each patch at each location. This worked out at typically 18 patches per bridge to be evaluated by careful visual examination, non-destructive testing and also micro-destructive testing, along with removal of paint flakes for further microscopic examination. After this initial testing period, it was clear that there was very little difference between the manufacturers’ systems. All remained slightly soft and “cheesy” where overcoating had occurred, and a strong smell of solvent remained. St Andrews Cross-cut testing was

<table>
<thead>
<tr>
<th>Original System</th>
<th>Paint Manufacturer</th>
<th>Sa2½</th>
<th>Sweep Blast</th>
<th>Abraded</th>
</tr>
</thead>
<tbody>
<tr>
<td>A modified alkyd in fair to good condition, with a slight intercoat weakness between original primer and first intermediate build coat</td>
<td>PM 1</td>
<td>FAIR/GOOD</td>
<td>POOR</td>
<td>POOR</td>
</tr>
<tr>
<td></td>
<td>PM 2</td>
<td>VERY GOOD</td>
<td>POOR</td>
<td>POOR</td>
</tr>
<tr>
<td></td>
<td>PM 3</td>
<td>FAIR/GOOD</td>
<td>POOR/FAIR</td>
<td>FAIR</td>
</tr>
</tbody>
</table>

Comments: Although all three systems appear to have emphasised the intercoat weakness within the original system when overcoated there is far less effect from the PM 3 system.

| A modified in fair condition, with a slight cohesive weakness within the original intermediate build coat | PM 1 | FAIR | POOR | POOR |
| | PM 2 | GOOD | POOR | POOR |
| | PM 3 | FAIR | POOR | POOR/FAIR |

Comments: PM 2 performed best on the blast cleaned steel. There was little difference between the systems when overcoating the sweep blast surfaces as all performed poorly and appeared to emphasise the cohesive weakness within the original coating system, similar to the abraded surfaces but PM 3 had less impact.

| A chlorinated rubber in good condition, with a slight cohesive weakness within the original intermediate build coat | PM 1 | GOOD | FAIR | POOR |
| | PM 2 | GOOD | GOOD | GOOD |
| | PM 3 | GOOD | FAIR | FAIR/GOOD |

Comments: PM 2 performed best on all three trial patches.

| A chlorinated rubber in fair to good condition, with a slight cohesive weakness within the original intermediate build coat | PM 1 | FAIR/GOOD | FAIR | POOR/FAIR |
| | PM 2 | GOOD | FAIR | POOR/FAIR |
| | PM 3 | POOR/FAIR | GOOD | FAIR/GOOD |

Comments: PM 3 performed best on the overcoating patches but poorly on the blast cleaned steel, there was a significant embrittlement noted on this patch.

| An epoxy system in good condition, with good adhesion properties throughout the original system | PM 1 | GOOD | VERY GOOD | VERY GOOD |
| | PM 2 | GOOD | VERY GOOD | VERY GOOD |
| | PM 3 | FAIR | FAIR/GOOD | FAIR/GOOD |

Comments: PM 1 & 2 performed equally well, but PM 3 had some embrittlement throughout all patches.
used to assess adhesion and cohesion strengths and weaknesses. Solvent swab testing was used to ascertain the degree of cure and although 6+ months had elapsed since topcoat application it was interesting to find that two of the manufacturers products had not cured as fully as the third.

The removed paint flake samples were examined in both plan and cross section perspective under a microscope at 50X and 400X magnification. This found very little variance across the trialled topcoats but in cross section some differences were noted such as vacuoles within one manufacturers intermediate build coats and although relatively small could potentially impact the overall permeability of the full coating system.

After 12 months in service the trial areas were re-examined and tested. Again, there was very little difference between...
the topcoats’ condition and only some “cheesiness” remained when micro-destructively testing the systems on the overcoated areas, although the smell of solvent was less, compared to the trial patches on the bare steel areas. Adhesion and cohesion properties were similar to that found during first test period, with good adhesion throughout each system on the bare steel areas and only some slight detachment where overcoating had occurred to the chlorinated rubber and alkyd systems, the existing overcoated epoxy was found to be good throughout the three manufacturers at this time.

At 18 and 24 months was when significant differences were identified after micro-destructive examination. It became clear that one of the manufacturers systems had now fully cured and had become slightly brittle in a number of instances, both on overcoated and bare steel applications. Another of the manufacturers’ products remained similar to the 12 month trial with generally good adhesion to the bare steel but some detachment where the chlorinated rubber and alkyd paints had been overcoated. In some cases, it appeared that the properties within the original coatings had improved with the inherent weaknesses reduced slightly, some had no impact and others had emphasised the weaknesses.

It is these slight differences that the specialised consultancy were interested in, and during the full detailed evaluation of the bridge trials and laboratory examination of paint flakes a “Horses for Courses” type specification with recommended preparation and paint manufacturers systems could therefore be produced. Going forward, a coating condition survey will be used to classify each bridge structure, so the correct method of preparation and optimum paint manufacturers’ products can be selected at the ideal intervention period, without the requirement for further feasibility trials in the future, and thus providing best value for money.

A summary of the coating systems performance on each of the substrates and existing coatings is given in Table 1. The patch layout is shown in Figure 1 and the embrittlement seen after 24 months is shown in Figure 2. The influence of the original weaknesses can be seen in Figure 3 (a-c). Figure 4 is an example of the vacuoles seen in the existing coating.

In conclusion, the consultancy was able to obtain meaningful information following the trials and to produce a menu of paint manufacturers maintenance systems for a particular method of preparation, depending on the existing coating type and condition.

It is obviously essential to determine the condition of the existing paint on a bridge structure before specifying and applying a new more highly stressed overcoating material to ensure the optimum life to next major maintenance is achieved. Unfortunately though the coating condition of some bridge structures do not lend themselves to maintenance overcoating and will require complete removal. Once the bridge coating condition has been established the recommendations can be made for the way forward by selecting the most suitable method of preparation and the accompanying coating system from the bridge owner’s “a la carte” type menu.

It should be noted that the three paint manufacturers selected were purely based on performance in previous trials on similar coatings of the types and conditions to be maintained by this particular client. If the coating condition and type of coatings to be maintained had a different criteria, then an alternative list of paint manufacturers could have been selected.
Rope Access for Paint Inspection

J McCarthy, Rope Access Manager, Offshore Painting Services, UK

For bridge repairs and / or inspections, there are many options which can be considered regarding the UK Working at Height Regulations, such as scaffolding, suspended cradles and work platforms, and using rope access. The most commonly selected system of access, depending on the environment, is scaffolding. While scaffolding is a staple within the construction industry, there are several benefits which industrial rope access can provide compared to scaffolding. It can be shown that rope access is not only more cost efficient, but it's faster and safer than other options for working at height.

When it comes to cost, rope access is comparatively more affordable than scaffolding. Not only does rope access require less equipment, it also is quicker and reduces wasted time in construction or maintenance. Remember that time equals money and when you choose scaffolding, the cost of supplying the scaffolding and paying the operatives to do the necessary work once it has been erected could outweigh the cost of a rope access engineer. Not forgetting that any scaffold must be designed / engineered. Also, industrial rope access requires less time and is a faster means of access than scaffolding. While it may take days to erect the required scaffolding to complete a job, the rigging for rope access takes merely minutes to a few hours.

Safety

Although rope access methods appear perilous, overall they are far safer and have far better safety statistics than any other means of access at height. Technicians are rigged to two separate ropes, one acting as a safety line should the main line break, and the tools used are also tethered to them so that equipment can remain safe should a tool slip while in use. Statistics show that rope access is an extremely safe form of access, with a total of 110 injuries in 2017 compared to the average for all industries of 274 (based on number of accidents per 100,000 workers) [1]. The HSE’s Hierarchy of Control Measures (guidance and tools to help businesses understand what they need to do to assess and control risks in the workplace and comply with health and safety law, in this case, the Working at Height Regulations, 2005) [2], ranks industrial rope access at the bottom of the hierarchy, suggesting all other types of access are safer and should be used prior to considering rope access.

However it is difficult to directly compare the accident rates of rope access operatives with scaffolding operatives, as they are presented in different ways. Scaffolding statistics also only account for installation of the access whereas rope access statistics account for access and the works. The HSE provides no specific data which compares these two methods of access for working at height, so to suggest that rope access is the more dangerous method of access seems a little strange.

Rope access is also recognized as a safe method for project completion due to the high standard of training required. To ensure safe working practices, only certified technicians should be used on projects. Every rope access member must meet rigorous standards and pass tough assessments that will ensure they are fully prepared for performing work at height safely and efficiently.

Industrial rope access has an enviable safety record, and a safe, way to carry out work at height due to the necessary training and safety standards required.

Flexibility

Rope access methods are extremely flexible and are often the only option for certain tasks. Since rope access techniques do not require a large amount of open space beneath the work space to set up scaffolding equipment, extremely difficult to reach places can still be accessed. Bridges over rivers, estuaries and busy roads, and other structures that are not easily accessible can be quickly inspected, repaired, or replaced with little trouble.

Scaffolding is extremely bulky and can take up a lot of ground space. Since it is built from the ground up, it can affect access under the structure, on the other hand, rope access technicians work from the top down, causing less disruption.

Unlike scaffolding, industrial rope access creates minimal architectural impact. Scaffolding, on the other hand, not only takes days (to weeks) to construct, but it is cumbersome and will not go unnoticed while it is in place. Since rope access requires less set up and space, it requires very little in the terms of ongoing maintenance costs and makes for easy return visits should the project take time to complete.

In most instances for bridge inspection or maintenance, rope access techniques are the most practical way to complete tasks that would otherwise involve significant expense, time, or bridge closures.

References
2. www.hse.gov.uk/risk
Technical Article

Electrical Short Pipeline Potential Measurement and its Implication in Pipeline CP Management Practice

Xiaoda Xu, Origin Energy, Australia.

Introduction

The most important performance indicator for cathodic protection (CP) is the structure-to-electrolyte potential [1, 2]. In most coated on-shore pipelines, the resistance between the reference electrode and the pipe-to-soil surface boundary is too significant to be ignored. [3] [4]. The IR drop caused by CP current is a measurement error. It is stipulated in many cathodic protection (CP) standards that the IR component to be evaluated and excluded while assessing the pipe-to-soil potential performance in pipeline integrity management [5].

For a well-coated pipeline, the most practical monitoring technique is to use a synchronised interrupting technique by bringing the CP current to zero and to measure the potential momentarily after the current source is off. By switching all sources of current to zero, the measured potential is momentary. To improve the measured INSTANT OFF potentials, to meet the “off” potential criterion. The question has been raised whether this IR drop is authentic or a measurement error. The implications for the issue are:

1) If the IR drop measured under electrical isolation failure is, authentic, then shift the pipe potential (OFF) more negative by increasing the current output is required to meet the protection criteria.
2) If this exceptional IR drop is due to measurement error, then compensating for it by increasing CP current output may result in unnecessarily high current and possibly over-polarisation with the risk of coating damage.

Quick depolarisation of electrically shorted pipeline

The effectiveness of the CP relies on the efficacy of pipeline electrical isolation from connected station electrical earthing systems, achieved through MIJ and FIK. Pipeline operators experience showed that the effectiveness of electrical isolation joints (IJ) can be gradually breached. It appears that magnetic conductive particulates (mainly magnetite and pyrite) as well as hematite accumulating internally may be responsible for the electrical shorting in some pipelines. The magnetite and pyrite are good electrical conductors. Once trapped in MIJ/FIK, they may lead to the CP current leakage through the FIK/MIJ. This results in the CP current being undesirably lost to the nearby earthing system. The anomaly is normally rectified through routine cleaning pigging practice. However, in oil and gas upstream pipelines, it is not always feasible to maintain the electrical isolation due to high fluid conductivity, design and maintainability limitations. If electrical isolation cannot be readily restored, the pipeline may suffer a long term of electrical short to local earthing systems. Therefore, it is important to understand how to manage the pipeline CP system under such electrical short conditions.

Most modern pipelines are electrically isolated from above ground facilities, either through a flange isolation kit (FIK) or Monolithic Isolation Joint (MIJ) [6]. This is to prevent excessive current drain to electrical earthing systems which may be uneconomical or impractical. They prevent the CP current flowing to other facilities and equipment that are otherwise electrically connected to pipeline. However, in practice, the effectiveness of these electrical joints can be compromised by deterioration, or by debris in the internal surfaces, which leads to the electrical short of the pipeline to above ground facilities and their associated electrical grounding system, from time to time. The earthing system, governed by local regulation and standards, is typically copper or copper-clad steel rod conductors. The implication of this electrical short to such earthing systems in CP measurement has not been fully explored or fully understood by the industry.

There is a general misconception in industry to use OFF instead of free potential measurements without further analysis, partially because it is not easy to measure IR free potentials as well as different sizes for coating defects. In general, this is quite difficult to evaluate, and would not generally impact the entire pipeline. This article however, describes testing on a new pipeline with little coating defects (proven by DCVG), known electrical short to earth (proven by current interrupting technique [7]) to -500 mV (electrical shorting). This apparent IR drop is significantly higher than when the OFF potential for the entire line can range from -1000 mV (sound electrical isolation status) to -500 mV (electrical shorting). This apparent IR drop is significantly higher than when electrical isolation was maintained even if there is no change in other conditions. It is not usual that many operators tend to use higher output current to compensate for this IR drop and meet the “off” potential criterion. The question has been raised whether this IR drop is authentic or a measurement error. The implications for the issue are:

1) If the IR drop measured under electrical isolation failure is, authentic, then shift the pipe potential (OFF) more negative by increasing the current output is required to meet the protection criteria.
2) If this exceptional IR drop is due to measurement error, then compensating for it by increasing CP current output may result in unnecessarily high current and possibly over-polarisation with the risk of coating damage.

Experiment

Experiments were performed using a cathodic protection system equipped with a 0-36 VDC 0-5A 80 W laboratory DC
power supply with constant voltage and constant current mode. The designated buried structure was a bare steel post (1000 mm x 100 mm x 100 mm). A 500 mm x 300 mm aluminium foil was buried as temporary anode bed and located 30 metres away from steel post to minimize the anodic voltage cone effect. A 400 mm x 400 mm copper plate was submerged in a nearby fresh water pond as a local earthing. A synchronised current interrupter and data logger were used to switch the current supply and the connection between the copper earthing and the steel structure. The data logger recorded the soil/soil and copper earthing/soil potentials. Buried copper/copper sulphate electrodes (CSE) at fixed locations were utilised as reference electrodes for potential monitoring. A current clamp (clip on ammeter) was used for testing the CP current in each circuit. A 500 Ω linear (B) and single Gang 24mm potentiometer was used to simulate the variable resistance incurred by internal debris through electrical isolation joints. The experimental configuration is shown in Figure 1. A number of resistances were selected by tuning the potentiometer to simulate the gradually increasing of isolation joint short.

The pipe/soil potentials of the pipe were measured by different methods:

Method A: The Instant OFF (near IR-free) “OFF” potential of steel pipe is measured while switch K1 is interrupted and switch K2 is closed during the testing. This is to simulate the interruption techniques used in a normal survey, when it is impossible to interrupt between the steel pipe and pipe and local earthing;

Method B: The Instant OFF (near IR-free) “OFF” potential of steel pipe is measured while both switches K1 (power supply) and K2 (IJ to copper earthing) are interrupted simultaneously.

Results and Discussion

Potential of pipe isolated to copper earthing

The On/Off pipe potentials are measured while the pipe is electrically isolated from the copper earthing. The average of the pipe/soil potential while on is -1263 mV and off potential is -933 mV. The loop resistance of CP circuit is an overall resistance of anode resistance, cable resistance and pipe resistance. In this case, the loop resistance is greatly impacted by the anode/soil resistance, with better compactness and increased moisture in the soil, the loop resistance is significantly reduced from 300 Ω to 150 Ω. It is intentional to keep the loop resistance at a reasonable high level, since this will maintain a constant overall resistance without being affected by the adjustment of IJ resistance.

Anodic voltage cone effect can be measured through potential shifting of isolated structure while the CP current is interrupted. In this case, the minimum interference is preferred for meaningful comparison. This is measured by the potential of nearby isolated metallic structure while CP current is interrupted. 1 mV/ mA toward positive direction shifting is observed in nearby isolated copper earthing. For pipe potential around -1250 mV, the isolated nearby copper earthing exhibited a -11mV toward positive direction. The potential measured here is utilised as a reference ON and OFF potential while steel structure is perfected isolated to copper earthing.

Potential of pipe shorting to copper earthing

The pipe-soil potential of the pipe shorting to copper earthing through an adjustable potentiometer was measured with the resistance ranging from 2 ~ 500 Ω. The resistance of 2 Ω is to simulate the isolation joint in a dead short status. 500 Ω is to represent isolation joint in a better isolated status. An arbitrary selected resistance of 80 Ω and 190 Ω is used to represent the isolation joint shorted at different degrees.

<table>
<thead>
<tr>
<th>IJ resistance</th>
<th>Steel On potential</th>
<th>Steel off potential</th>
<th>Off potential shift than * isolated pipe</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ω</td>
<td>mV</td>
<td>mV</td>
<td>mV</td>
</tr>
<tr>
<td>2</td>
<td>-1269</td>
<td>-760</td>
<td>173</td>
</tr>
<tr>
<td>80</td>
<td>-1180</td>
<td>-735</td>
<td>198</td>
</tr>
<tr>
<td>190</td>
<td>-1229</td>
<td>-794</td>
<td>139</td>
</tr>
<tr>
<td>500</td>
<td>-1289</td>
<td>-825</td>
<td>108</td>
</tr>
<tr>
<td>Average</td>
<td>-1242</td>
<td>-779</td>
<td>155</td>
</tr>
</tbody>
</table>

* Off potential in “Potential of pipe isolated to copper earthing” section, ON -1263, OFF -933

The average of steel pipe off potentials by interrupting of K1 under different IJ shorting status (resistance), are listed in Table 1. This is to replicate the interrupting techniques used in pipeline CP survey, while the IJ electrical isolation is compromised. It is identified, while the on potential is maintained at around the same level (-1250 mV), the off potentials measured are more positive than when it was isolated from the copper earthing. The average of positive shifting is 155 mV.

<table>
<thead>
<tr>
<th>IJ resistance</th>
<th>Steel On potential</th>
<th>Average of Steel off potential</th>
<th>Off potential shift than * isolated pipe</th>
<th>∆Off - steel pipe</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ω</td>
<td>mV</td>
<td>mV</td>
<td>mV</td>
<td>mV</td>
</tr>
<tr>
<td>2</td>
<td>-1272</td>
<td>-899</td>
<td>34</td>
<td>139</td>
</tr>
<tr>
<td>80</td>
<td>-1163</td>
<td>-884</td>
<td>49</td>
<td>148</td>
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<td>500</td>
<td>-1287</td>
<td>-872</td>
<td>61</td>
<td>47</td>
</tr>
<tr>
<td>Average</td>
<td>-1236</td>
<td>-884</td>
<td>50</td>
<td>47</td>
</tr>
</tbody>
</table>

* ∆Off - steel pipe* as Table 1.

The average of steel/pipe off potentials by interruption of K1 and K2 simultaneously are listed in Table 2. Although the on-potential are maintained at the same level , the steel pipe off-potential showed significant negative shift compared to those measured by method A. It is evident that, by interrupting K1 only, and leaving the short circuit to the copper earthing in place, the pipe potential moves toward more positive range than when measured by interrupting of both K1 and K2.

Figure 1: cathodic protection system for steel pipe short to local earthing.
On and off potential of copper earthing short to steel pipe

Off potentials of the copper earth to soil are measured simultaneously with steel pipe potential by both methods (Table 3). It is evident that the off potential of copper earthing measured by method A (by interrupting of K1 only) is more negative than when measured by method B (by interruption K1 and K2 simultaneously).

It appears both shifts become more pronounced once the IJ’s resistance gets smaller (Figure 2). For steel pipe, with the reduction of IJ resistance (worse short status), the steel pipe Instant OFF potential shifts to further positive values when measured by method A. For an IJ resistance in 2 Ω and 80 Ω, the difference can reach to ~150 mV (Figure 2). The Instant OFF potentials of copper earthing show a similar trend but in a different direction. With less IJ resistance, the copper earthing to soil Instant OFF potential is more negative when measured with method B. This positive shift can reach to approximately ~180 mV under this testing condition (Figure 2).

<table>
<thead>
<tr>
<th>Resistance btw Cu/Steel</th>
<th>Copper earthing potential measured with Method A</th>
<th>Copper earthing potential measured with Method B</th>
<th>Difference in “off potential” measured between Method A &amp; B</th>
</tr>
</thead>
<tbody>
<tr>
<td>2</td>
<td>On -1238 mV Off -746 mV</td>
<td>On -1238 mV Off -568 mV</td>
<td>ΔOff -178 mV</td>
</tr>
<tr>
<td>80</td>
<td>-658 mV Off -529 mV</td>
<td>-628 mV Off -393 mV</td>
<td>-136 mV</td>
</tr>
<tr>
<td>190</td>
<td>-501 mV Off -438 mV</td>
<td>-496 mV Off -346 mV</td>
<td>-92 mV</td>
</tr>
<tr>
<td>500</td>
<td>-360 mV Off -345 mV</td>
<td>-366 mV Off -323 mV</td>
<td>-22 mV</td>
</tr>
</tbody>
</table>

Table 3: Potential and IR drop of copper earthing short to steel pipe, measured by both techniques.

Current demand for steel pipe short to local earth

It is observed that there is no change of the current demand for the steel pipe no matter which method is utilised for potential measurement as long as ON potential is maintained at the same level. This strongly suggests that positive potential shift observed in the electrical shorted pipe is not caused by the polarisation status of pipe (Figure 3). Also, there seems no linear function between IJ resistance vs the steel structure potential shift observed. It appears that with the decrease of IJ resistance, the CP current is disproportionately attracted to the copper earthing. Therefore, even if the overall output current increases, there is no significant change for the portion contributed to steel structure polarisation.

The build up of deposits in gas pipelines is not uncommon. It can eventually result in shorting of steel pipeline to local station earthing. It is not surprising that the total current demand of the system increases with the further shorting of the IJ (smaller R). The copper earthing received most of the extra CP current while the steel on-potential was maintained at the same level. This has been observed in the pipeline CP operation. While the Transformer Rectifier (TR) is under auto potential mode, even there is no apparent on-potential change for pipeline, the total current demand for the pipeline could be exceptional higher than it was in electrical isolated status. The excessive CP current is picked up by local copper earthing and returns through the shorted IJ. This is easily confirmed by applying Swain Clamp in both sides of IJ. The operational experience also showed that the short of IJs is aggravates gradually with time with the indication of CP current ramping up during this period while in auto potential mode. The CP output current drops to a lower level while on-potential is maintained at the same level whenever the pig cleaning is performed (Figure 4). This strongly suggested that excessive CP current flows to copper earthing have been stopped when electrical isolation is restored.

While a TR is operating at constant current mode for pipeline in shorted status, the pipe/soil potential level will move in more positive direction. It is not uncommon that pipe/soil potential values deteriorate by ~300 mV for pipelines suffering a long term electrical short. When the short is rectified, the protection level of pipe is restored.

![Figure 2: The difference of off-potential measured by two methods.](image1)

![Figure 3: Current demand change while IJ is compromised steel pipe on-potential keeps constant.](image2)

![Figure 4: Step current drop after cleaning pigging for TR operating at auto potential mode.](image3)
The other interesting observation is, even with an electrical short to pipeline, the potential difference between steel pipe and copper earthing could be significant. Sometimes, the potential swing method cannot easily pick up the short status. This is believed to be due to two factors, 1) the compromised 
IJ is normally not a dead short, typically in its initial stage. This 
IJ resistance will take a portion of potential difference between 
pipe potential and earthing potential. 2) The ratio of polarization 
resistances between the copper earthing and the steel pipeline 
is significantly different, particularly for a well coated pipe. 
Therefore, the current demand to shift the copper earthing 
potential needs to be significant to be measured. The local 
electrical earthing for above ground installations or stations 
comprise copper earth rods and either bare or sheathed 
interconnecting copper cables or tapes in a low resistivity soil, 
therefore, a measurable potential shift requires significant 
current.

Copper /steel coupling effect in survey

It is evident that copper/steel coupling resulting from a 
shorted IJ will play an important role for the apparently quick 
depolarization observed in CP survey. Since K2 (IJ) is impossible 
to be interrupted during the survey, only method A can be 
deployed in CP survey for pipeline that is electrically shorted to 
the local earthing. However, interruption of K1 only will form a 
dissimilar metals Voltaic cell. The driving voltage of this cell is 
the potential difference between polarised copper earthing (i.e.
cathode) and polarised steel pipe (i.e. anode). Electrical current 
flows from the copper earthing to the steel pipe through the 
metallic circuit including the IJ, and from steel pipe to copper 
earthing through soil (electrolyte) (Figure 5). In this process, 
this depolarises the anode (steel pipe) by shifting its potential 
further in the positive direction. Meanwhile, the cathode (copper 
earthing) is polarised towards further in a negative direction. 
The surface area ratio of cathodic and anodic plays a critical 
role here as well. A large ratio of bare copper to (largely 
covered) copper earthing would be required before a copper 
potential shift can be detected. The steel pipe, particularly 
when well coated, will experience more significant and faster 
depolarisation in this process (Figure 5). This explains the quick 
depolarisation in steel pipe measured through method A. This 
voltaic cell won't occur if K2 can be interrupted as proposed 
in method B. Unfortunately, it is impossible to achieve this in 
field test.

CP Management Practice Implications

The implication of this voltaic current and its impact on CP 
monitoring is profound in managing the CP of a pipeline 
shorted to local electrical earthing.

TR unit operation management

IR errors in the soil need to be evaluated carefully in cases 
where the pipeline is shorted to a local copper earthing system 
while using conventional current interruption techniques. 
This investigation has proven that the pipe/soil potential IR 
errors measured by conventional current interruption techniques 
are contributed by two aspects, a) IR caused by soil/metal 
interface resistivity, and b) potential caused by re-circulation 
equalisation currents in Cu/Steel voltaic cell. The IR drop caused 
by this voltaic cell current is a measurement error. IJ will 
to meet this falsified “off-potential” by forcing more CP current 
will be inefficient and may adversely put the coating under 
stress and may cause pre-mature failure of the coating. This 
is particularly important for some susceptible coating types, e.g.
Fusion Bonded Epoxy (FBE) coating. The alkaline environment 
caused by very negative CP potential (over-polarisation) will 
lead to the increase of pH and coating disbondment. For this 
reason, the CP levels on pipelines should be managed in such a 
way to exclude this measurement error.

Another often omitted challenge for TR units operating under 
auto potential (potentiostatic) mode with an electrically shorted 
 pipeline is the reference cell location. The TR units are often 
located at above ground installations or stations, proximate to 
the local electrical earthing system. High CP current flow to 
the earth system due to the short to pipeline will cause a 
localised voltage gradient, i.e., cathodic voltage cone, around 
the bare copper. The reference electrode or cell located within 
this voltage gradient will falsely set its reference point more 
negative to the remote earth, and lead to higher current 
output and over-protection. This voltage gradient needs to 
be mapped and the reference electrode should be relocated 
out of the adversely affected location for a pipeline prone to 
electrical short; of course, if possible, the electrical short should 
be remedied.

IJ management

Isolation Joints (IJs, or MIJs) and Insulated Flanges (IFs or FIKs) 
need to be carefully managed for cathodic protection operation. 
The effectiveness of the CP relies on the efficacy of pipeline 
electrical isolation from related above ground installations  
(or stations) earthing systems, achieved through MIJs and FIKs. 
Pipeline operators’ experience has shown that the effectiveness 
of electrical isolation joints can be breached by internal 
conductive debris [?]. This results in the CP current undesirable 
discharging to the nearby earthing system. The anomaly is 
normally remedied through routine cleaning pigging practice. 
However, in oil and gas upstream assets, the electrical 
isolation by pigging is not always practical due to 
high fluid conductivity or design limitation. It is often identified 
that resistance in IJ deceases gradually with the accumulation 
internal deposit, until it reaches to dead short.

a) Design IJ installation so that electrical shorts to local earth 
can be readily rectified.

In practice, it is not uncommon that in pipelines designed in 
such a way, that electrical shorts cannot be removed easily, this 
includes but not limited to:

• IJ located in a non-piggable path;
• the IJ cannot be removed /replaced without depressurising the 
total pipeline;
• the IJ cannot be removed /replaced till the shut down of the 
entire gas facility.

In these cases, the CP has to be managed in an electrical short 
condition.

b) Specify effective methods of IJ or IF integrity measurements:

It is noted that most used field methods to check the integrity 
of IJ are the potential difference and potential swing methods. 
Although these are simple, for a pipe shorting to a large local 
copper earthing system, these methods may not sensitive 
prone to pick up indications of the current leakage.
The use of a Swain Clamp to measure current flow in the pipeline adjacent to the LJ or IF is much more effective in detecting shorted joints. This technique will also locate partially failed (conducting) spark arrestors that are often fitted across LJs and IFs and are often not effectively tested.

c) Current monitoring for auto potential TR unit

Monitoring the current output is very useful in assessing the LJ’s isolation status. A gradual increase in current demand from the TR operating in auto-potential mode is normally a sign that electrical isolation between pipeline and electrical earthing system been breached.

d) Integrity of IJ due to the stray current from earthing to pipeline through faulty LJ (internal stray current through faulty LJ)

There is always a concern that the resistive LJ with current jump can be associated with internal metal loss. Appropriate NDT and in line inspection technique have to be incorporate into the inspection routine to identify the metal loss [8].

Monitoring techniques

This study has demonstrated that, without interruption of current flowing through LJs or IFs simultaneously, the measured “off-potentials” will be erroneous. Unfortunately, it is impossible to interrupt the current flowing through LJs and IFs during CP surveys. Alternative monitoring techniques should be deployed for pipelines prone to electrical short.

a) Coupon off potential measurement

There is some controversy related to monitoring CP “Off” potentials by coupon local disconnection [9]. Some argue that localised cathodic or anodic voltage cone can distort the coupon “off-potential” reading and misrepresents the true pipeline protection status. However, the author supports this methodology to be used in a cautious manner. Although the local anodic and cathodic voltage cone caused by coating defects is realistic, the measuring error can be assessed by taking the pipeline measurement in a current interruption “on-cycle” and “off-cycle”. This is more or less similar to interrupting both the K1 and K2 simultaneously to exclude the interference from voltaic current. The most effective method utilises a pre-synchronised interrupter inserted between this probe /coupon to pipe circuit to measure the off potentials concurrently with the ‘general pipeline’ OFF period.

b) Deployment of IR free coupons

There are reports for the use of IR free coupons (steel coupons with an integrated very close reference electrode) being used in the field successfully to assess the pipelines subject to telluric influence [10]. The benefit of IR free coupon can be utilised to assess the pipeline protection level without interrupting the current source [9]. In such a way, the voltaic current interference of bi-metal coupling can, theoretically, be eliminated. The size and shape of the probe or coupon influences the validity of the data collected [11].

c) ER probe method

By using ER probes, the electrical resistance can be measured, and is related to the corrosion rate. This is one of the accepted protection criteria in the Australian Standard [1]. The ER probe is connected to the buried pipeline, and is thus in the CP circuit. The aggregated metal loss for a period between measurements is determined and a corrosion rate can be assessed. This is a straightforward indication of pipeline CP status. It is widely used for pipeline external corrosion monitoring, particularly for pipelines affected by fluctuating interference. Surface strip element and cylindrical element types are most common designs for underground pipeline service. The size and shape of the probe or coupon influences the validity of the data collected [11].

Conclusion

The conventional current interruption technique brings significant error in measuring IR free potential in a pipe shorted to local copper earthing. This is believed caused by the voltaic current incurred by bi-metal electrochemical cell, produced after the current supply was interrupted. Forcing more CP current to meet “OFF” potential criteria will adversely lead to the over-protection and premature failure of pipeline coating. For pipe susceptible to electrical short, the regular cleaning pigging to restore the electrical isolation is always the preferred option. While it is not achievable, managing of CP for pipelines with electrical shorting have to take this measurement error into consideration. The TR unit operating management, isolation joints management and suitable monitoring techniques are keys for the success in CP management for the electrical shorted pipeline.

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

30th October 2018  
Aberdeen Branch  
18.00 - 21.00  
Venue: Room N242, Sir Ian Wood Building, Robert Gordon University, Aberdeen, AB10 7GJ  
Optimising Pant integrity and Solids control through Continuous Non-intrusive Wall thickness Monitoring  
Speaker: Chris Burke – Emerson Permasense

8th November 2018  
Young Engineer Presentation Evening  
18.00 – 21.00  
Venue: Skempton Building, Imperial College, London, SW7 2BB  
YEP, Case Study Presentations.

27th November 2018  
Aberdeen Branch, joint meeting with IOM3  
18.00 – 21.00  
Venue: Room N242, Sir Ian Wood Building, Robert Gordon University, Aberdeen, AB10 7GJ  
Downhole Metallurgy and Corrosion control  
Speaker: Ed Wade – Metal Ecosse

29th November 2018  
ICorr AGM and Midland Branch technical meeting  
13.00 – 17.30  
Venue: Birmingham Council Chambers, Victoria Square, Birmingham  
Please confirm attendance or apology for absence to admin@icorr.org

6th December 2018  
London Branch Annual Christmas Luncheon  
11.30 – 16.30  
Venue: Royal Over-Seas League, Over-Seas House, Park Place, London, SW1A 1LR

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