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CORROSION & MATERIALS

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ASSET MANAGEMENT FEATURE

Inside this Issue:

CONTENTS

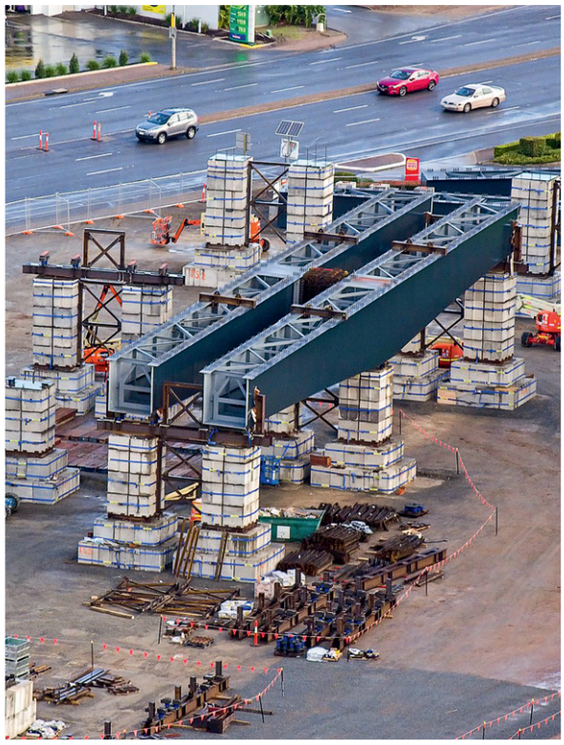
Corrosion & Materials

Corrosion & Materials is the official publication of The Australasian Corrosion Association Inc (ACA). Published quarterly, *Corrosion & Materials* has a distribution of 2,500 to ACA members and other interested parties. Each issue features a range of news, information, articles, profiles and peer reviewed technical papers. *Corrosion & Materials* publishes original, previously unpublished papers under the categories 'Research' and 'Professional Practice'. All papers are peer reviewed by at least two anonymous referees prior to publication and qualify for inclusion in the list which an author and his or her institution can submit for the ARC 'Excellence in Research Australia' list of recognised research publications. Please refer to the Author Guidelines at www.corrosion.com.au before you submit a paper to Tracey Winn at twinn@corrosion.com.au

ACA also welcomes short articles (technical notes, practical pieces, project profiles, etc.) between 500 – 1,500 words with high resolution photos for editorial review. Please refer to the Article Guidelines at www.corrosion.com.au before you submit a short article to Tracey Winn at twinn@corrosion.com.au

The Australasian Corrosion Association Inc

The ACA is a not-for-profit, membership Association which disseminates information on corrosion and its prevention or control by providing training, seminars, conferences, publications and other activities.



Front Cover Photo: *Darlington Upgrade Project – SA. Photo courtesy Bowhill Engineering. Fabricators Haywards Steel Tasmania and Bowhill Engineering SA. McElligotts Tasmania are the applicator for Haywards.*

Photographer: South Australian Drone Services.

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CONTENTS

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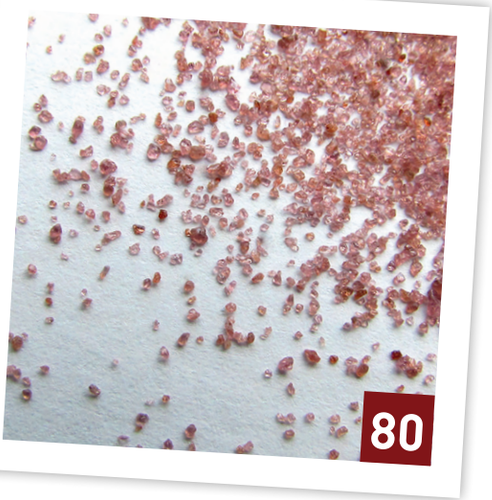

Dr Matthew Dafter
President

Wesley Fawaz
Executive Officer

Well it's that time of the year again with the annual Corrosion & Prevention conference almost upon us. This will be the first time that the ACA holds a conference at Sydney's new International Convention Centre on Darling Harbour and it's shaping up to be the biggest ACA standalone conference ever hosted.

Thanks to the dedication of the conference technical committee, the reviewers, session chairs and presenters, the technical program which has been assembled includes over 100 papers, technical forums across most industry sectors (including the inaugural applicator forum) and some excellent plenaries.

As the major sponsor, Jotun must be applauded for their continued support of the ACA, along with Russell Fraser Sales, Freyssinet, 3CCC and Marine & Civil Maintenance for their supporting sponsorship. So we ask that you please register now and make you way to this conference to learn & connect with these industry partners, presenters and your peers.

Following a call for nominations for directors to the ACA Board, the ACA Council which meets prior to the conference will fulfil its role to elect three directors to fill the three vacant positions. The directors of the ACA contribute significant amounts of their time and energy to the strategic and governance success of the ACA and so we thank Graham Carlisle, Dean Ferguson, Wayne Thomson and Dean Wall for their nominations and good luck to them during the election.

As President, Matt attended the ACA Board meeting in May and ensured that an assessment of the Board's performance was undertaken in August. We are both very pleased with the results which highlight that the ACA Board is operating well, which is a key factor in why the ACA is in such a great current position.

The ACA recently organised the first NACE Pipeline Corrosion Integrity Management (PCIM) course in Australia with Pat Teevens making his way out from Canada to lecture. The course was held in Melbourne, students flew in from all over Australia and New Zealand to attend.

The 2018 training calendar has been announced (which includes another PCIM course) and the 2018 events scheduled will be available soon. We are currently aiming to arrange Corrosion Under Insulation workshops with an international expert, a joint event with NACE in Cairns, more focused technical seminars and more site visits to members' facilities.

As Matt's tenure as President concludes at the end of the conference, he takes this opportunity to thank the members, the ACA Board and all those involved within the ACA for their continued great work in fulfilling the objectives of the Association.

Dr Matthew Dafter
President

Wesley Fawaz
Executive Officer
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THE AUSTRALASIAN CORROSION ASSOCIATION INC.

TRAINING

ACA Training Calendar 2018

All registrations are subject to ACA's published terms, conditions and policies

ACA/ACRA Corrosion & Protection of Concrete Structures

Member $1170 Non-member $1465

Melbourne March 19-20
Sydney June 4-5
Brisbane September 6-7

ACA Coating Selection & Specification

Member $1640 Non-member $1995

Adelaide April 30-May 2
Perth June 13-15
Sydney September 3-5

Corrosion Technology Certificate

*(Also offered as Home Study)**

Member $2450 Non-member $2870

Brisbane May 21-25
Melbourne October 15-19
**Start any time*

Hot Dip Galvanizing Inspector Program

Member $1640 Non-member $1995

Melbourne March 5-6
Brisbane July 12-13
Sydney November 29-30

NACE Cathodic Protection Program CP 1 – Tester

Australia Member $3500 Non-member $3855

Sydney April 9-13
Brisbane September 17-21

NACE Cathodic Protection Program CP 2 – Technician

Australia Member $3500 Non-member $3855

Sydney April 16-20
Brisbane September 24-28

NACE Coating Inspection Program Level 1

Australia Member $3950 Non-member $4490
Thailand Member $3105 Non-member $3348

Perth February 5-10
Brisbane March 12-17
New Zealand May 7-12
Melbourne June 4-9
Thailand June 18-23
Perth July 9-14
Brisbane August 20-25
Sydney September 24-29
Adelaide October 29-November 3
Thailand November 19-24
Perth December 3-8

All Australian course fees listed are GST inclusive. All NZ and Thailand course fees are exempt from GST.

To calculate the fee pre-GST, divide the fee by 1.1

NACE Coating Inspection Program Level 2

Australia Member $3950 Non-member $4490
Thailand Member $3105 Non-member $3348

Perth February 12-17
Brisbane March 19-24
Thailand June 25-30
Perth July 16-21
Brisbane August 27-September 1
Adelaide November 5-10
Thailand November 26-December 1

Prerequisites now apply to this course.

NACE Pipeline Corrosion Integrity Management

Member $2950 Non-member $3250

Brisbane July 30-August 3

SSPC Concrete Coating Inspection Program

Level 1 $3150 Level 1 and 2 $3675

Melbourne April 9-14

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IMAC receives the ICOM-CC

Dr Ian D MacLeod was presented with an International Council of Museums - Committee for Conservation (ICOM-CC) medal at their recent Triennial conference in Copenhagen. ICOM-CC is the peak body representing conservators in all cultural sectors around the world. In the citation it was noted that Ian has provided continuous support for many decades to emerging conservators in second and third world countries and has been a wonderful mentor. He was applauded for his generous response to solving other peoples corrosion and conservation problems and coming up with practical solutions.

In his presentation following the award Ian inspired the audience with his achievements in the past 18 months since 'retiring'. The ACA and members congratulate Ian on receiving this prestigious award.

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VALE

A Cathodic Protection Enthusiast: A Tribute to Kevin Woodland by his Colleagues

On Monday 31st July, 2017, Kevin Woodland, our colleague and friend tragically passed away. Kevin was the answer to our one-year search for an industry-recognised Cathodic Protection Specialist. He brought invaluable experience to our team and to SMEC as a whole. Kevin was an active member of NSW ACA branch following his arrival from the UK in 2012. His passion for corrosion engineering and cathodic protection was "infectious" and his knowledge and experience in this area was well-respected by industry.

Kevin's career in the construction industry started with his time working as a site engineer for Tarmac Construction. Kevin joined their specialist division, Tarmac Structural Repairs and trained as a Quantity Surveyor, but his ability in engineering meant that he took great interest in the practical aspects of the firm's projects, which at the time included some of the earliest large-scale projects in the UK for the cathodic protection of reinforced concrete. Kevin's interest led him to have considerable involvement in the use of one of the earliest remote monitoring systems for cathodic protection, installed at the Runcorn-Widnes bridge in 1993.

After continuing in the field of structural repair at Connaught, Kevin then joined Corrosion Control Services Limited (CCSL) in 1997 and specialised exclusively in the field of cathodic protection in his career after that.

Kevin joined Mouchel Ltd as a Principal Engineer and Electrochemical Repair Team Leader between 2008 and October 2010. During his time at Mouchel Kevin worked on a variety of projects with a number of clients in the UK, these included large scale concrete repair and CP design, supervision and installation projects for the Midland Links Motorway Viaducts.

Kevin was equally at home in the design office as on site. He was always ready to travel and undertook design and project management roles throughout the UK and overseas including the Middle East and Europe. His work included working on the design and implementation of major cathodic protection systems for ports and harbours, and major new-build marine and highway structures in the Middle East.

Kevin joined SMEC in 2012 in our Sydney office before moving to the Gold Coast in 2016. His specialist background meant that he was in high demand and was involved across the business from Oil & Gas pipelines in Iraq to major highway upgrades and civil/marine infrastructure rehabilitation projects in Australia.

Kevin was a perfect gentleman and was well-liked by his peers and colleagues. He was a consummate professional, usually unflappable and always with a dry sense of humour. He had a passion for life and was an avid lover of sports and photography. He impacted everyone he came into contact with due to his light-hearted spirit, and 'explosive' laughter.

On Saturday 5th August his family and many of his work colleagues attended a memorial. Kevin will be sorely missed, and our deepest sympathy is extended to Kevin's' wife Karen and his family at this time of sadness.

By Luke Menefy, Jim Preston, Daniel Anstice

Kevin on a CP commissioning visit to the Shaikh Khalifa Bridge in Bahrain, 2004.

Corrosion & Prevention 2017 Early Bird Prize Winner

Dr Graham Sussex of Sussex Materials Solutions Pty Ltd, was the lucky winner of the Corrosion & Prevention 2017 Early Bird Prize of a Sydney Harbour Bridge Climb.

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Researchers develop a way to better predict corrosion from crude oil


Credit: iStockphoto.com

Using X-ray techniques, scientists are developing an analysis tool that can more accurately predict how sulfur compounds in a batch of crude oil might corrode equipment– an important safety issue for the oil industry.

The results of these ongoing experiments at the Stanford Synchrotron Radiation Lightsource (SSRL) at the Department of Energy's SLAC National Accelerator Laboratory will improve industry guidelines. The goal is to characterize the types of sulfur that are most critical to identify in the oil, in order to better anticipate the potential for corrosion rates.

A team of researchers from Chevron and the University of Saskatchewan are performing a series of studies at SSRL to closely examine forms of sulfur in crude oil.

"By looking at crude oil with a combination of X-ray spectroscopy techniques, we were able to examine and describe the complex chemistry of the sulfur compounds with high specificity," said Monica Barney, a materials research engineer at Chevron.

Complexities in the Data

Nearly a million barrels of oil are processed on a given day at Chevron's major refineries throughout the United States, and the sulfur present in the oil can react with the metals in various types of equipment and cause damage. These reactions are something engineers must consider to ensure safe and reliable processing.

But high sulfur concentrations don't always correlate with high levels of corrosion, or the other way around, and this makes it difficult to anticipate how corrosive a particular crude oil will be.

"We can measure the concentration of sulfur, but it doesn't tell you about the reactivity," says Barney, who is leading the studies. "Knowing the type of sulfur in crude oil is critically important for predicting properties related to corrosion."

The collaboration began when Barney was working on a separate corrosion study at SSRL. After collecting the data, the Chevron team was struggling with how to interpret the complexities they saw in the results.

In an online search, they came across a diagram developed by two professors at the University of Saskatchewan, Graham George and Ingrid Pickering, while they were on the staff at SSRL. They have conducted molecular biology and toxicology experiments at the SSRL synchrotron for years.

The diagram showed spectroscopy information gathered from the superimposition of data on many sulfur types, similar to what's seen in crude oil. It showed how comparing an overall spectrum to a library of standards could identify individual types of compounds.

"When I came across this figure, I thought, 'This is it. This is what we need.' It's what we'd been seeking for years—a characterization method that could quantify the amounts of each type of sulfur," Barney says.

The idea was to use the same technique—sulfur K-edge X-ray absorption spectroscopy—to measure and determine the types of sulfur in crude oils.

Barney soon began collaborating with George and Pickering to find a solution. Both worked previously in the oil and gas industry, and Barney says their expertise was a perfect match with what Chevron wanted to study.

With this analysis method, the team developed an approach to examining the crude oil with "tender X-rays," which occupy the middle ground between high-energy and low-energy X-rays.

Tuned to the correct energy, X-rays allowed the researchers to collect detailed information about the sulfur and its chemical neighbors and help tease through the overlapping information generated by similarities in the sulfur compounds.

Understanding Sulfur Chemistry

The large number of various sulfur compounds present in the crude oil, each subtly different from the others, makes the results from most types of characterization techniques difficult to interpret or even inconclusive.

The X-ray absorption spectroscopy work at SSRL allows the scientists to see a precise description of the crude oil's sulfur chemistry.

"This is an example of using state-of-the-art spectroscopy for a real-world application," George says.

This work is part of a larger collaboration at Chevron that is using several other techniques to understand the chemistry of sulfur in crude oil. The experimental data from several chemical characterization methods are combined and compared to data from corrosion studies and predictions from computer modeling.

Provided by: SLAC National Accelerator Laboratory (www://phys.org)

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Scientists get a nanoscale look at corrosion in real time

A new device has given scientists a nanoscale glimpse of crevice and pitting corrosion as it happens.

Corrosion affects almost everything made of metal—cars, boats, underground pipes, and even the fillings in your teeth.

It carries a steep price tag—trillions of dollars annually—not mention, the potential safety, environmental, and health hazards it poses.

"Corrosion has been a major problem for a very long time," says Jacob Israelachvili, a chemical engineering professor at the University of California, Santa Barbara.

Confined spaces

Particularly in confined spaces—thin gaps between machine parts, the contact area between hardware and metal plate, behind seals and under gaskets, seams where two surfaces meet—close observation of such electrochemical dissolution had been an enormous challenge. But, not any more.

Using a device called the Surface Forces Apparatus (SFA), Israelachvili and colleagues were able to get a real-time look at the process of corrosion on confined surfaces.

"With the SFA, we can accurately determine the thickness of our metal film of interest and follow the development over time as corrosion proceeds," says project scientist Kai Kristiansen.

The researchers' setup also allowed them to have control of the salt composition of the solution, and temperature, as well as the electric potential of the nickel surface.

Crevice and pitting corrosion isn't the kind of widespread surface rusting you may see on the hulls of old ships exposed to the ocean. Instead, they are intense, localized attacks, where visible decay can look deceptively minor.

In fact, things appear just fine until they fail catastrophically: machines break apart, bridges buckle, seafaring ship engines malfunction, dental fillings fall out.

For the new study, that appears in the Proceedings of the National Academy of Sciences, researchers studied a nickel film against a mica surface. They focused on the initiation of corrosion—the point at which the metal surface begins to dissolve.

The degradation of the material didn't occur in a homogenous fashion. Rather, certain areas—locations where there were likely microscale cracks and other surface defects—would experience intense local corrosion resulting in the sudden appearance of pits.

"It's very anisotropic," Israelachvili says, explaining that even within the crevices, different things are happening near the opening versus deep inside the crevice. "Because you've got diffusion occurring, it affects the rate at which the metal dissolves both in and out of the crevice. It's a very complex process."

"The first step in the corrosion process is usually very important, since that tells you that any protective surface layer has broken down and that the underlying material is exposed to the solution," says graduate student Howard Dobbs.

From there, corrosion spreads from the pits and often does so rapidly, because the underlying material is not as resistant to the corrosive fluid.

"One of the most important aspects of our finding is the significance of the electric potential difference between the film of interest and the apposing surface in initiating corrosion," Kristiansen says. When the electric potential difference reaches a certain critical value, the more likely corrosion will begin and the quicker it will spread. In this case, the nickel film experienced corrosion while the more chemically inert mica remained whole.

"We have seen this interesting effect before with other metal and non-metal materials," Dobbs says. "We have some pieces of the puzzle, but we are still seeking to unravel the full mechanism of this phenomenon."

This research into real-time, micro-, and nanoscale mechanisms of corrosion provides valuable information that the scientists can build upon, which may lead to models and predictions of how and when materials in confined spaces are likely to corrode.

"Basically it's a matter of prolonging the lifetimes of metals and devices," Israelachvili says. Especially these days where devices can be very small, and you can even put them in the body, understanding how to properly protect corrosion-prone surfaces will reduce the need to replace them due to damage.

Conversely, understanding how to accelerate dissolution where it would be appropriate would also be beneficial, such as with nontraditional (e.g., aluminosilica) cements that produce less carbon dioxide.

"An important step in the cement formation is the dissolution of cement's main ingredients, silica and alumina, which is very slow and requires highly caustic conditions unsafe for use in large-scale production," Dobbs says. "Improving the dissolution rate while avoiding the need for unsafe, caustic solutions would remove a technological barrier in the implementation of nontraditional cements."

Source: UC Santa Barbara (www.futurity.org)

Credit:Getty Images

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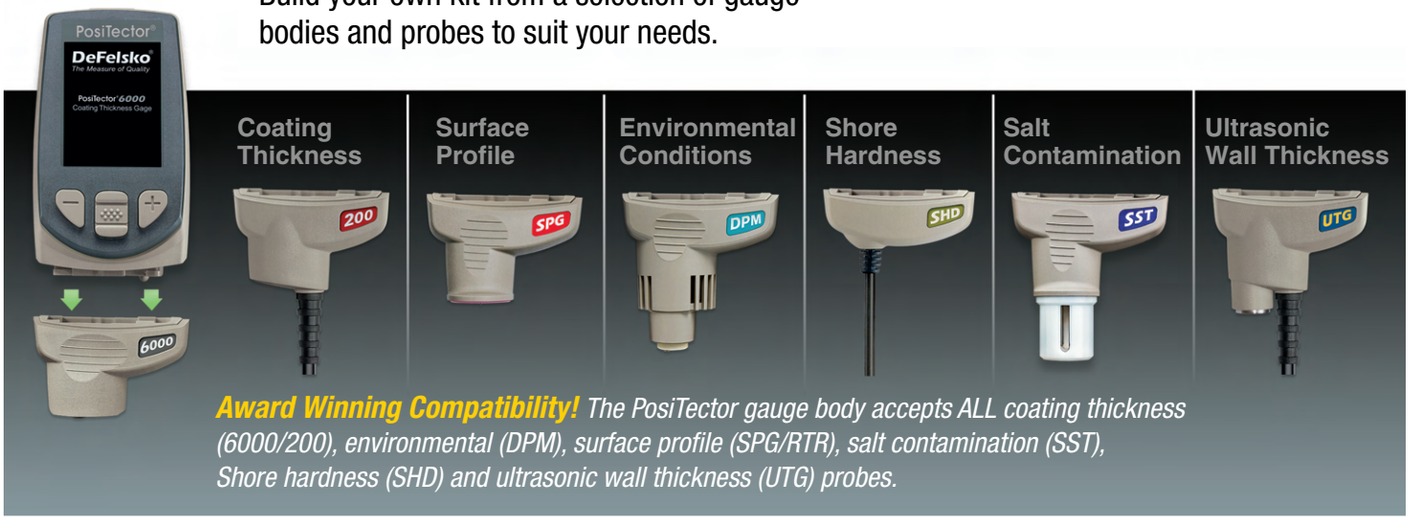

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Sika (NZ) Ltd
SLH Contracting Ltd
Solutions 4 Steel Pty Ltd
South East Water Limited
Southern Ports Authority
Specialised Coating Systems
State Steel Treatment (AMW MIH Pty Ltd)
Steel Mains Pty Ltd
Steelpipe Limited
Stott Industrial Supplies
Sulco Limited
Summit Fertilizers
SunWater Limited
Surface Removal Specialists
Sydney Trains
Syntech Distributors Ltd
Tasmanian Ports Corporation Pty Ltd
TasNetworks
TasWater
Tcorr Inspection
Thermoshield Batty
Tincone Pty Ltd
TOD Consulting
Total Paint Protection (Walz)
Traditional Coatings
Transpower New Zealand Ltd
Trelleborg Marine Systems Pty Ltd
Tristar Australia Pty Ltd
UGL Kaefer
Undersea Construction Ltd
Valicote Pty Ltd
Vappro Corrosion Control Australia Pty Ltd
VDM Metals Australia Pty Ltd
Vincent Painting
Viva Energy
VT Industrial Coatings
WAG Pipeline Proprietary Ltd
Wannon Region Water Corporation
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TECHNICAL GROUP EVENT REVIEW

11 HIGH-PROFILE INTERNATIONAL SPEAKERS!

Brian Cherry INTERNATIONAL CONCRETE SYMPOSIUM

26 – 27 JULY 2017

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REINFORCED CONCRETE CORROSION, PROTECTION, REPAIR & DURABILITY

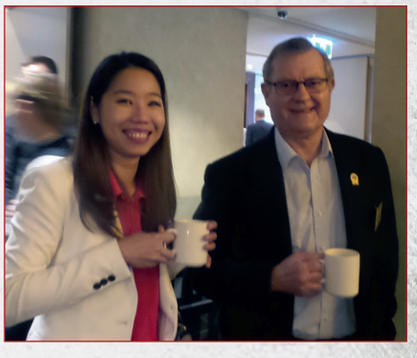
Coming from all around the world and all over Australia, more than 135 people were in attendance at the Melbourne Marriott Hotel on the 26 & 27 July 2017 for an International Concrete Symposium named to honour Professor Brian Cherry. The special symposium was indeed as special as its namesake and ten International and three Australian speakers of high distinction presented keynote papers of 45 minutes duration. A panel discussion and open forum was held at the end of each day. The format and quality of content was synonymous with a symposium of significant impact and timeliness – highlighting the important role that the ACA, people, and technical exchange continue to play in our engineered world. The papers from the symposium were published in a book of the Symposium proceedings (available from the ACA, inclusive of the list of symposium exhibitors – accurate at the time of print).

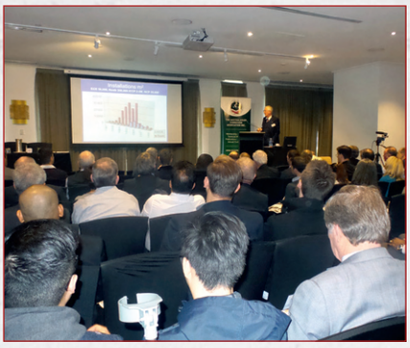
If Percival Faraday (P F) Thompson is considered the 'Grandfather' of corrosion science and engineering in Australia, then surely Professor Brian Cherry of Monash University can be considered to be 'the Father'. Professor Cherry has not only educated many of the leading corrosion science and engineering graduates in Australia, but also many other corrosionists through his presentations at conferences, seminars and symposia delivered throughout the world. We are thankful also for his numerous research and investigative achievements in various fields of corrosion science and engineering. One of these fields favoured by Professor Cherry over many decades is 'Reinforced Concrete Corrosion, Protection, Repair and Durability' in the areas of:

- 'Reinforcement corrosion in concrete;
- condition assessment of reinforced concrete;
- modelling & deterioration prediction of reinforced concrete;
- concrete repair & protection;
- cathodic protection of reinforced concrete;
- concrete corrosion inhibitors; and,
- alternative metallic reinforcement for concrete.

"I thought the Symposium went very well last week and I enjoyed the event"

Speaker John Drewett





"Congratulations on a job well done. The organisation of the event appeared seamless and the invitees were inspiring. Thank you."

Delegate Shannen Masia

"Thank you again for the invitation to the Symposium. It was very interesting and a very well organized event. Congratulations."

Speaker Zita Lourenco

The dinner in the evening presented an opportunity for Professor Nick Birbilis, Head, Materials Science and Engineering, Monash University to avail the audience of the forces of nature that brought Brian to Australia (originally born in Leicester, UK), importantly (for all of us) him joining Monash University five decades ago, becoming a member of the ACA in 1969, and as they say, the rest is history.

A memento of appreciation was presented to Brian, which then meant that the audience could be entertained by a most heart-warming speech from him. Hs wife Miriam was present, the meal was most appetising and the wine flowed.

"It was a great event with excellent organisation, so thank you.."

Speaker Jim Preston

"Thank you for a wonderful conference, it was great to catch up with many old friends, including Brian of course, and the technical content was excellent."

Speaker John Broomfield

The networking continued beyond the allotted time but that was to be expected, given the nature of the event and who it was in honour of. As Nick Birbilis noted in the Foreword to the proceedings:

"Friends, colleagues, students, collaborators and indeed members of the ACA, have been privileged to be beneficiaries of the passion, inspiration, hard work, loyalty, dedication, generosity and education from Brian Cherry. His place in Australian history is cemented (pun intended!)."

Warren Green

"The conference and people were great. I'm glad that I was invited to participate."
Speaker Neal Berke






"Many thanks for organising such an excellent conference. Organisational aspects were 'immaculate' compared with several annual conferences which I attend."
Delegate Nihal Vitharana

"It was a privilege to participate and the conference was really well organized. Congratulations for a job well done!!"
Speaker Partner Jean Tinnea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International

ASSET MANAGEMENT COUNCIL

Applying Corrosion Prevention & Structural Integrity into Asset Management to save 3% of GDP

On the 31 August 2017, we hosted the joint Australasian Corrosion Association and Asset Management Council seminar in Sydney.

The high calibre of presenters and the depth of knowledge provided the audience relevant case studies in Asset Management and the underlying processes for managing corrosion.

During the seminar, it was unanimously agreed that:

Organisations need to consider all stakeholders, not just the end customer.

A whole of life perspective is important but many organisations are challenged with cost recovery and sometimes the lines between urgent and important are blurred.

During tenders, a greater appreciation of coating standards can save organisations significant sums in the longer term and often at no additional cost in the early stages of a project.

Data quality is important but without domain, knowledge context can be lost, resulting in poor decisions. (reactive vs. responsive).

Knowledge transfer is key to organisation growth but we are often challenged with contractor models geared to quantity ahead of quality.

Function Failures get the attention of stakeholders but Condition Failures (i.e. Corrosion) are slow moving failures that are often ignored until it is too late!

Quality Assurance (QA) and Quality Control (QC) go hand in hand. Having one without the other can have dire consequences (cost and safety).

The concept of Asset Management maturity was expressed in how organisations approach Maintenance… "Corrective (unplanned), Preventative (planned), Predictive (anticipated)".

Reliability Centered Maintenance (RCM) is a sound approach for any organisation based on a set of simple questions. This proven approach is industry neutral.

ISO5500x provides the principles & structure to build sustainable outcomes for stakeholders. ISO55001 promotes transparency and visibility for decisions made across an asset lifecycle.

On behalf of the Australasian Corrosion Association and Asset Management Council of Australia, we would like to thank the presenters, our attendees, the event sponsors (Galvanizers Association of Australia and International Paint) and we look forward to furthering industry events in the quest to share knowledge.

Martin Kerr

Mark Dragar | Jemena

Norbert Schaeper | Sydney Water

Will McLean | GAA

Protective Coatings for Asset Preservation

14 September 2017

Hobart

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ASSOCIATION OF AUSTRALIA

PROUDLY PRESENTED BY:
AUSTRALASIAN CORROSION ASSOCIATION INC.

The Coatings Technical Group of the Australasian Corrosion Association hosted their annual event in Hobart on 14 September 2017 at Salamanca Inn, in Tasmania.

With a great line up of presenters the day was well attended by a mix of Asset Owners, Product Manufacturers, Applicators and Consultants.

Often persons have company allegiances and are guarded about real life experiences however, this event was eclectic with thoughtful and honest discussion contributed by all.

Discussions included;

- a history of the Storey Bridge provided by TAS State Growth
- a description of access issues provided by McElligott Partners.
- a 'who dunnit' specification scenario hosted by Daniel McKeowan of Dulux Ltd.

The attendees' travelled far from the mainland and even from the North of Tasmania, as we were reminded of the rivalry between the northern and southern halves of the island.

With the travelling crowd we enjoyed impromptu dinners the night before and the night after making for great networking opportunities.

Next years Coatings TG Event is scheduled for May 2018 in Newcastle, NSW and we encourage you to attend.

Dean Wall

Innovation: SPA's New Discrete Anode for Concrete Application

Discrete anodes in concrete have been used extensively in reinforced concrete structures especially for concrete elements located in tidal and splash zones.

Due to their encapsulation within the concrete, discrete anodes eliminate the risk of grout acidification which is caused by sea water in splash zones. These anodes are proven to be sound and highly effective for the corrosion prevention of reinforced concrete piles, beams and headstocks.

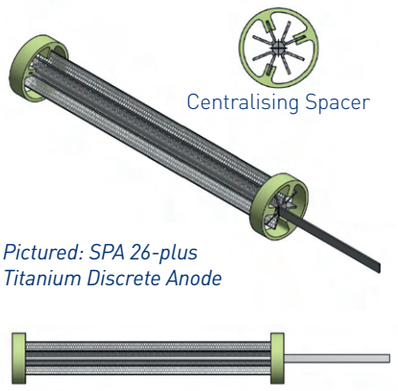
A new state-of-the-art development from Savcor Products Australia improves and economises the installation process for discrete anodes in concrete.

The new patented SPA 18-plus and SPA 26-plus anodes incorporate centralised spacers which centre the anode within the designated hole eliminating potential short circuits between the anode and rebar by providing sufficient grout cover to encapsulate the ribbon mesh. This further eliminates the need for any down-the-hole covermeter testing and multiple drilling into concrete to find the appropriate locations for installation.

The advantages of the new design include:

- Major reduction in cost for anode installation.
- Eliminates weakening of the structure from excessive drilling.
- Very fast installation.
- Elimination of short circuits between anode and rebar.
- Major reduction in engineering time during site testing.

This patented invention will guarantee major reductions in the cost of corrosion prevention by eliminating multiple holes and unnecessary drilling into existing concrete, and significantly reducing engineering time during site testing.



Pictured: SPA 26-plus Titanium Discrete Anode

VIC Branch – Corrosion Management on Major Infrastructure Projects

13 September 2017

The Victorian Branch held a technical meeting at the Royal Society of Victoria, featuring four speakers that discussed the management of corrosion on major infrastructure projects. Philip Vimpani (Associate, ARUP) explored the durability requirements and the management of accelerated low water corrosion in the development of Webb Dock in Melbourne. Chris Weale (Principal Engineer, GHD) and Marcin Wieloch (Senior Materials Engineer, GHD) discussed aspects of durability design, with a focus on underground structures including tunnels. Ulf Kreher (Leader Materials Technology Group, Aurecon) rounded off the presentations detailing how electrolysis mitigation requirements impact on structural design details, with a focus on the Level Crossing Removal Project between Caulfield and Dandenong in Melbourne.

Jess Lyndon

NSW Branch – Specifying the Inspection and Repair of Concrete Structures

4 September
UNSW, School of Materials Science and Engineering

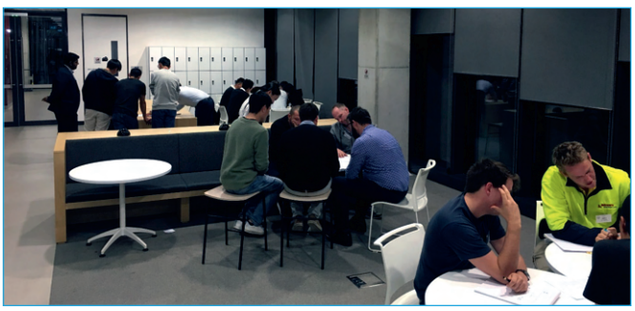
The night began with a quick introduction to corrosion inspection techniques and repair methodology. William Ward (PCTE) gave a presentation on the different equipment used during an investigation and conditional assessment of a concrete structure, along with the interpretation of results and how it reflects the state of the inspected structure. Houssam Ben Mansour (Infracorr) summarised the processes for design and specification of a repair system, using results from the initial investigation.

The attendees were then grouped into teams of 4 to 6 people, each with a range of professional backgrounds. They were given a hypothetical case study of a damaged concrete structure and the first task was to choose different investigation techniques, each with an indicative unit cost, to assess its condition. The teams were asked to balance thoroughness of investigation and financial feasibility in their planning.

After a short break for networking, the teams were then tasked with choosing the most suitable remediation methods to ensure the structure can return to service, achieve its intended design life and have the lowest cost for continuing maintenance. To ensure consistency of response, the teams were given indicative costs of the various processes they might consider.

Finally, each team outlined their choices of investigation technique and remediation methods. The presentations were judged by a panel of experts and a prize awarded to the winners.

Alan Bird



ACA Auckland Division

6 August 2017

The Auckland meeting was held at a new venue called *One Bistro* in Ponsonby on August 16th. The meeting was addressed by Ash Arya, Director of CSP Coatings Ltd, on the topic of "*A look back at the Panmure Rail Interchange upgrade – the good, the bad, and the rusty*". CSP Coatings Ltd is the largest integrated galvanizing operation in New Zealand.

The meeting commenced with Ash giving an overview of the $17.5M upgrade of the rail-bus interchange station at Panmure in Auckland, carried out in 2014. Most of the infrastructure installed was working well. However, the major project included installation of large segments of painted balustrades on the electric rail-busway pedestrian plaza. After only two years in service the steel balustrades, that cost over $500K, showed premature corrosion damage. The corrosion due to a poor coating system on the steel was severe - the balustrades had to be completely removed for extensive restoration work. It transpired that the balustrades were inadequately specified and poorly coated for the service environment.

The remedial treatment on the balustrade structures involved a full garnet blast, application of a hot-dip galvanized coating (150 microns zinc), sweep blasting of the HDG, followed by application of a high quality polyester powder coating. The reinstated balustrades are now performing well in the service environment. However, the remedial work to rectify the corrosion damage cost over $300K. The poor design and lack of QA cost the contractor a very substantial amount of their profit from the project due to re-work of avoidable corrosion.

The Q&A session that followed Ash's presentation was interactive and extensive. Many attendees bemoaned similar types of corrosion issues with infrastructure projects, that occurred due to poor coating specifications, lack of good QA, inadequate inspections and dealing with contractors/asset owners who had little knowledge and no interest in corrosion avoidance on major projects. The Auckland Chairman, Raed El Sarraf, then thanked Ash for his interesting and thought-provoking presentation.

Les Boulton

Ash Arya, CSP Coatings, gives his presentation.

Attendees at the ACA meeting at One Bistro.

Attendees converse with speaker Ash Arya.

WA Branch Event

20 October 2017

The evening of the 20th October saw the WA Branch host a technical evening for over 35 of its members at The Atrium in Perth, with a presentation from Dr. Derek Scales, Lead Engineer at Atteris Pty Ltd.

Dr Scales discussed a novel risk based assessment methodology in a presentation titled 'Risk Based Assessment of Internal Corrosion Features to Reduce Inspection Requirements'. The presentation focused on the need for reassuring the integrity of subsea pipelines that had been placed on the bottom of the ocean and flooded with treated seawater to kill microbes and to prevent corrosion. Before being placed in service, these pipelines may need to undergo an in-line inspection as a common method to detect anomalies within the carbon steel pipelines; however the cost of an intelligent pigging campaign is sometimes not economically viable, particularly for situations requiring subsea to subsea pigging.

Dr Scales went on to discuss a risk based assessment methodology which can utilise results from a limited number of spot inspection checks along a pipeline, as long as the inspection locations consider all credible potential corrosion mechanisms within the pipeline in all credible risk areas. This methodology is supported by engineering standards like the DNV-OS-F101 risk based standard, which in turn simply requires that the probability of failure be lower than the pre-determined levels for a particular safety class of the pipeline. A hypothetical case study for a wet parked flowline was used to illustrate how the use of this particular methodology may be used to minimise the overall number of spot inspections that may need to be undertaken, which of course influences both the extent and cost of any such subsea inspections.

Graham Carlisle

2017 CORROSION TRADE SHOW TASMANIA

The Tasmanian ACA Branch held its biannual Trade show on the 3rd August 2017 at the Woolstore Apartments in Hobart. There was strong attendance with 13 trade exhibitors and 52 registered guests.

This event was a perfect way to show case what Tasmania has to offer regarding corrosion protection. Run over three hours the evening was a wonderful opportunity to engage members in a relaxing social environment.

Thank you to all the exhibitors, Bianca Reardon and the Tasmanian ACA branch committee members for their ongoing support in Tasmania.

Newcastle Branch Event

30 August 2017

Newcastle Branch hosted its latest bi-monthly technical event and dinner on the 30 August. The topic was 'Electrostatic Painting' and a representative from Graco presented on the night to inform the audience regarding what electrostatic painting was, how it works, the pros and cons, and the technology used for the process. Forty people attended, mostly from the blasting and applicating industry. ACA life member Garry March of East Coast Protective Coatings gave the event two-thumbs up! Drinks were kindly sponsored by Wattyl.

Simon Krismer

ACA Auckland Young Corrosion Group Meeting 2017

27 September 2017

The ACA Auckland Young Corrosion Group meeting held at the Surrey Hotel, Grey Lynn, on 27th September was addressed by Dr Wayne Thomson, General Manager, PFP Systems Pty Ltd on the subject of 'The Corrosion Industry and Opportunities for Personal Development'. Wayne is the Secretary of the ACA Queensland Branch and his business role covers the Australasian and Asia-Pacific regions. Wayne was recently awarded his PhD in Business Management from the University of Auckland. The YCG meeting was preceded by refreshments and the usual social gathering of young people who attended this annual event.

Wayne commenced his talk by noting that the corrosion control industry in Australasia is much bigger than many people think. He outlined some career opportunities that existed and which were growing due to ageing infrastructure in the region. He believes that the work and jobs are there but they are not always obvious as being part of the corrosion prevention industry. In the modern industrial world, there exists a personal development paradigm where people in employment must adapt to survive. The paradigm results in young people entering the corrosion control industry after thorough training in other disciplines such as materials, structural, civil, and mechanical engineering.

Wayne then described a number of industries to illustrate his point that due to ageing infrastructure the corrosion control industry is growing. Examples outlined included the oil and gas industry, process industries, water and waste water treatment, road transport bridges and military services - the list was getting longer all the time.

However, on a downside, some NZ industries such as those utilising buried pipelines require better regulation. The ACA-sponsored NZ Electrolysis Committee (NZEC) is working towards this long term goal. Wayne also believes that ACA is doing a great job, but there is still more to be done, including improving technical competency, the better use of Standards, and developing the business side of the Australasian corrosion control industry.

Wayne thinks that the gateways to the corrosion industry for young people exist, the pathways are becoming clearer, and opportunities for careers in the industry are already there. After a Q&A session, Auckland Chair Raed El Sarraf thanked Wayne for his thought-provoking presentation and his valuable insights into the future of the Australasian corrosion control industry.

Les Boulton

Dr Wayne Thomson, PFP Ltd, presents at the Auckland YCG meeting

The Materials Australia Victoria & Tasmania Branch

19th Annual Technologists' Picnic
1 September, 2017

On the first day of Spring the 19th Annual Technologists' Picnic was held at Sovereign Hill in Ballarat. Members and partners of the five participating groups arrived along with the spring breeze, expecting a warm gathering with other members and of course a great talk from Stephen Macdonald, CEO and Director of Albins Performance Transmissions Pty. Ltd. http://www.albinsgear.com.au/

Stephen described how the company progressed from being a small enterprise in 1978 specialising in the machining of gearbox components for local racing cars and dune buggies through to being the major supplier and controller of transmission systems for the V8 Supercars both locally and in the USA. Stephen candidly spoke about the disastrous effects of the Global Financial Crisis on Albins but it sparked the need to innovate and diversify into new products, markets and supply chains.

The company was consequently one of the first in Australia to use 3D printing for patterns of prototypes and realised the advantages of engaging with Australia's R&D ecosystem such as CSIRO and Universities. Albins is now able to take an idea from the 'back of an envelope' to a final product in a minimum of time while ensuring that strict quality assurance is maintained. Albins has become a supplier of global company Thales and currently manufactures complete transmission systems for the ADF.

Stephen was evidently pleased to report the company has completely recovered from the financial setback caused by the GFC and has expanded considerably in recent years to meet the current demands for its 'know-how' and products. Stephen, together with Albin's Manufacturing Manager and Director, Steven Nicholson, recently received the Federation Business School's 'Business of the Year' Award and the Commerce Ballarat 'Manufacturing Award'.

The participants at the Technologists' Picnic greatly enjoyed Stephen's very candid and honest presentation and wished Albins every success in the future.

The night was wonderful not only because of the delicious two-course meal but also the passionate story shared by Stephen. Thel Technologists' Picnic is an annual dinner meeting organised since 1999 for members and partners associated with the Australasian Institute of Mining and Metallurgy, the Australian Foundry Institute, Materials Australia, Engineers Australia, and the Australasian Corrosion Association.

This dinner-meeting will continue as a platform for members to gather annually and act as a network linkage with members of other professional organisations and the public. Interested members of the general public or members of other professional organisations are most welcome and encouraged to participate in this meaningful event.

Gary Bunn

Stephen Macdonald (CEO and Director), Gary Bunn (Convenor) and Steven Nicholson (Manufacturing Manager and Director) after the conclusion of the annual dinner-meeting.

The audience assembled from AusIMM, AFI, MA, EA and ACA and their partners and guests were absorbed by Stephen Macdonald's excellent presentation.

VIC Branch Annual Round Table Conference

9 August 2017

The Victorian branch Annual round table conference was held in the cellar room of the Grace Darling Hotel. Built in 1854, it has a long and storied past as the first stone building in Collingwood and the second oldest pub in Melbourne. Dr Rob Francis gave a fascinating presentation that mapped out the seven non-corroding wonders of the world. Attendees were treated to touching a piece meteorite found in Sweden in 1906, known to be extra-terrestrial because the structure of iron in the meteorite is not known to occur on Earth.

YCG Public Speaking Event

27 September 2017

The Vic Branch YCG held a dinner event at the Coopers Inn in Melbourne. A public speaking workshop was facilitated by Dean Ferguson (Engineering Manager, Infracorr). The workshop involved both discussion and practical exercises, including an enlightening presentation on the merits of pineapple on pizza and what to do if you have 1 hour to prepare a talk with someone else's slides. The workshop was informative, entertaining and the YCG hopes to run more workshop-dinner events in the future.

Jess Lyndon

NEW PRODUCT SHOWCASE

The ACA does not officially endorse any of the products advertised in *Corrosion & Materials*.

Proceq Equotip UCI Hardness Tester

The Swiss-made Equotip 550 Portable Hardness Tester from Proceq is now even more impressive with the introduction of the Ultrasonic Contact Impedance (UCI) probe. Along with the range of Leeb probes and Portable Rockwell probe, the Equotip 550 offers the ultimate NDT solution to your hardness testing requirements.

The UCI Measuring Principle
The UCI (Ultrasonic Contact Impedance) method uses the same pyramid-shaped diamond as a conventional Vickers hardness tester. Unlike Vickers testing, no optical evaluation of the indentation is required, enabling fast and portable measurements. The UCI method excites a rod into an ultrasonic oscillation. The test load is applied by a spring and typically ranges from 1 to 5 kg of force (HV1 – HV5). As the diamond is forced into the material, the frequency of the rod oscillation changes in response to the contact area between the diamond and the material under test. The instrument detects the shift in frequency, converts it to a hardness value which is immediately displayed on the screen. While measurements are shown in Vickers, automatic conversions to Rockwell and Brinell can be displayed. The UCI method excels in testing of small and complex shaped parts comprised of fine-grained metals, while the rebound method is preferred for larger, coarse-grained forgings and castings.

The Equotip 550 Portable Hardness Tester from Proceq Switzerland is a complete all-in-one hardness testing solution which combines Leeb with portable Rockwell and now UCI (Ultrasonic Contact Impedance) methods. The Equotip 550 stands out with its new generation full colour, dual processor Touchscreen Unit packed with features. The instrument also has enhanced software with interactive wizards, automatic verification processes, personalized options, custom report functions and much more.

Advantages of UCI for NDT
- Measures only surface hardness
- Extremely fast with operator guidance when to apply and release
- Highly portable
- Test in any direction but must be perpendicular to the surface
- Can measure hardness of a coating, plating or case hardened surface
- Indentation is very small therefore non-destructive
- Small probe can access the HAZ of welds, gear teeth and splines for example
- Adjustable load for material hardness and coating with no need to change UCI probe

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ATG II Ultrasonic Thickness Gauge

The ATG II is an advanced ultrasonic thickness gauge, which uses a dual element transducer for internally corroded applications, as well as thru-coating and echo-to-echo functions. It features real-time A-scan trace as well as B-scan functions. The ATG II unit is lightweight and has a bright LCD display suitable for use in sunlight. It also has high impact ABS housing, and the silicon rubber cover provides extra protection for withstanding use in harsh industrial environments.

Features:

- Real time A-scan display.
- True colour TFT display with adjustable light intensity.
- Thickness, velocity and time-of-flight measurement.
- Differential mode and reduction rate mode.
- Pulse-echo and Echo-echo thru paint measurement.
- Single point and two point calibration.
- A-scan trace freeze and save.
- B-scan trace freeze and save.
- Automatic velocity measurement.
- Large capacity memory.
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- 32 bit Windows 7 and 64 bit Windows 8 report software.

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Flyability Elios Safe Drone For Inaccessible Places

NDT Equipment Sales has been appointed Authorized Reseller in Australia for Flyability, Switzerland, Manufacturer of the Elios Drone. Flyability is leading drone inspections in confined spaces, providing robotic solutions to various industries. Drone technology is steadily being incorporated as a sustainable practice for asset managers in the energy industries. Nonetheless, current solutions are unable to operate close to structures on in contact with operators, restricting effective inspection in complex environments.

While conventional methods are still required for maintenance, preliminary inspection can be performed at lower cost, risk, and infrastructure downtime. Flyability aims at becoming the leading technology provider in exploration and inspection of confined spaces and complex environments.

Lower Costs, Higher Safety:
Decrease downtime and inspection costs, avoid confined space entry and increase worker safety by remotely accessing boilers, tanks, pressure vessels, tunnels and other complex environments inside the plant.

Easy to Pilot, Instant Operation, Anywhere:
No piloting experience needed. Simply unpack, insert the battery and fly without the risk of collision, damage or injury. The drone is capable of taking off and landing in a variety of environments.

All-In-One Solution for High Resolution Imagery:
Elios is capable of delivering images up to 0.2mm/px, even in complete darkness. Along with its LED lighting and thermal imagery, it inspects and explores the unreachable.

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NEWS FROM THE ACA FOUNDATION

As I review the delegate list for the fast-approaching C&P2017 Conference , I find myself looking forward to meeting in person all of those ACA members who have welcomed me with valuable advice and personal warmth to the Foundation. Over the past 12 months, I have had numerous phone conversations and email exchanges with Branch Presidents, Treasurers and Committee members, and with many champions of the Foundation who continue to donate their time and energy as well as their financial support. There are still Foundation Board members who I have not met in person. Although email and teleconferencing have many advantages, they are not a substitute for the real thing.

The C&P2017 Conference will be a busy time for the Foundation. On the Monday evening, 13 November, we will host the inaugural fundraising event at the Watershed Hotel in Darling Harbour. Hopefully, Sydney's weather will be kind and we will have a balmy evening to enjoy each other's company in a relaxed setting, without the formality of some of the larger Conference events. At the time of going to press, the event may be sold out. However, there may be limited tickets available so please feel free to contact me for further information. Earlier that day we will conduct our AGM and hear a report from the Chair, Warren Green, on the Foundation's achievements and future challenges.

On the Tuesday evening, at the Conference Dinner, Scholarships will be awarded by the Foundation Chair and also by the Queensland and NSW Branches. Both of these Branches sponsored 2017 Scholarships in conjunction with the Foundation. Final bids for items in the silent auction, Galabid, will also be invited during the evening. There is a fantastic selection of items and leisure experiences in the Galabid catalogue which can be viewed online at www.galabid.com/acaf

Throughout the Conference, I aim to meet those Centurions attending and to personally thank them for their support and to distribute Centurion lapel pins. Please introduce yourselves. The Foundation will be sharing a table with the ACA in the reception area so we should be easy to find. We can also help you if you would like to join the Centurions or renew your membership.

This year the ACA Branches cast a 'vote of confidence' in the Foundation with their generous financial contributions resulting in a new level of management support. This has resulted in the growth of the Foundation's outreach to the education and wider communities and a sharper focus on fundraising. Through its ongoing Scholarship program, the Foundation continues to nurture young graduates, and encourage emerging leaders in the field. The Board will also consider the formation of a Scholarship Alumni or Ambassadors Group as part of its forward planning for 2018.

Lastly, this year has been one of change on the Foundation Board. Roman Dankiw who will be known to many ACA members, has resigned after many years of service. His valuable contribution is the subject of a separate article but I would like to say a personal thankyou to Roman for his support, particularly with regard to the Centurion program.

Two new members have joined the Board. In the previous issue of C&M, Christine Crawshaw was warmly welcomed. In this issue, we are pleased to introduce the most recent Director to join the Board, Sean Ryder, with a short profile. Profiles of all of our Board members are listed on the website https://foundation.corrosion.com.au/category/board-members/

The next issue of C&M will be published after Conference and, hopefully, the Foundation will be able to report on the success of fundraising efforts during 2017, together with priorities for the New Year ahead.

Linda Lawrie, Executive Officer, ACA Foundation
foundation@corrosion.com.au

Join the Thrill of an Online Auction

The Foundation is running an Online Silent Auction, hosted by Galabid, to raise funds to support its 2018 Scholarships and to develop exciting new science activities for Secondary School students. The auction is running now and will conclude with final bids at the Conference Dinner on 14 November, 2017. Using Galabid, bidders are able to register, bid on their favourite device, create a favourites list and receive a text notification when outbid. Winners will receive a text with a link to pay securely online. Winners can view and download their invoice from their phone. Bidders do not have to attend the Conference in order to participate. Why not take a look at some fabulous prizes and join in the fun www.galabid.com/acaf

GalaBid

An evening of fun at the Foundation's fundraising event at C&P Conference

All attendees at C&P2017 are welcome to join us for the ACA Foundation fundraising event on the evening of 13 November. Purchase your tickets when registering for the Conference and enjoy an evening of fun with DJ, deluxe beverages, premium canapes and the chance to catch up with friends and colleagues in a relaxed and welcoming environment. Located upstairs at the Watershed Hotel, Darling Harbour, Cohibar Lounge and Terrace offer panoramic views encompassing the city skyline and Cockle Bay. You can have a great evening of conversation, food, drinks and music and contribute to the Foundation's fundraising at the same time. More information available at https://conference.corrosion.com.au/registration-fees and-information/

NEWS FROM THE ACA FOUNDATION

Welcome to new Foundation Board Director

Sean Ryder - Director and Principal Consultant - Phoenix Solutions.

Sean is a Principal Consultant and Company Director of Phoenix Solutions, which specialises in all aspects of Cathodic Protection, Asset Management, Inspection and Remediation. He has over 12 years' experience in the Corrosion and Asset Management industry. Prior to starting at Phoenix Solutions in 2013 he was the National Materials Technology Manager for GHD in New Zealand.

Sean is currently engaged as the Senior Project Manager for NZ Transport Agency where he is responsible for delivering two bridge replacements. The blend of his technical knowledge and project management skills has seen his services requested by clients throughout New Zealand, Australia, USA, and Canada.

Roman Dankiw Steps Down

Mr Roman Dankiw, one of the long-standing members of the ACA Foundation Board, has recently resigned. Roman's contribution to the ACA includes periods serving as ACA Finance Director and as ACA President. In 2009-2010, Roman was closely involved with the transition of the Foundation to a new legal entity with its own independence, constitution and governance, including tax deductibility status for the Foundation's Scholarship Fund. Roman contributed to formalising the governance and financial arrangements between the ACA and the ACA Foundation which enabled the Foundation to embark on its program of leadership workshops, seminars and scholarships. Roman hopes to see the Foundation continue its valuable work and pursue the goal of supporting young corrosionists and urges all ACA members, "to get behind this great Foundation." Roman is leaving the Board due to other commitments, and to make space for another Board member. Roman thanked the ACA Board and ACA Foundation Board for their support over the years. The September meeting of the Foundation Board carried a vote of thanks to Roman for his service to the Foundation, particularly in its early stages and during times of transition and growth.

ACAF International Travel Scholarship Report *by Mark Dragar*

Having graduated from the University of New South Wales with a degree in Materials Science Engineering, I found myself working in the gas pipeline industry, predominantly in the corrosion and integrity fields.
As the corrosion engineer I had to manage design and operations for the cathodic protection systems and was responsible for coating specifications for over 2,500km of high pressure pipelines. Since then my role has moved from a purely technical one to managing a team of engineers responsible for the safety, reliability, integrity and life cycle cost of Jemena's AS2885 Pipelines asset class. My role is also accountable for driving asset class strategies that balance these requirements against Jemena's strategic and business objectives.

During my career I have been making active contributions to numerous Australian Standards committees, representing the gas industry and of particular relevance has been my work on the development of AS2832.1 and AS4853 both of which directly impact the cost of providing service, and are paramount to the safety and livelihood of the public and the gas utilities industry. So, when I was awarded the Australasian Corrosion Association Foundations International Travel Scholarship I was immediately drawn to attend the CEOCOR conference which is an international scientific not for profit association that brings together hundreds of specialists from:

- universities and research centers water, gas and oil distribution and transmission companies
- waste water companies; and
- pipe producers and manufacturers of coatings and equipment for cathodic protection systems.

This year, the CEOCOR conference was held in Luxembourg, with delegates from all over Europe attending, to present the latest developments regarding criteria for cathodic protection, stray current protection, AC corrosion and corrosion related risk based assessment techniques amongst other interesting topics. A total of 24 papers were presented over the course of 2 days with an unforgettable dinner cruise along the river Moselle which borders Luxembourg and Germany. The highlight of the cruise was the entertainment and certainly the fine white wine that Luxembourg's wine regions produce.

As the only Australian present at the conference I was also invited to participate in the working groups that occurred both before and after the conference presentation days. This opportunity was invaluable as it gave me greater insight into the differences between the ISO and Australian Standards. It was at these working groups where all the hard work occurred before taking the consolidated views to the standards committees.

They were conducted in an informal manner where participants spoke freely about the issues they face with satisfying the regulatory requirement of complying with the protection criteria in the ISO standard under particular circumstances.

One particular conversation outlined the gravity of the situation where Corrosion Engineers have been prosecuted in Europe for signing declarations that their pipelines complied with ISO 15589-1 whilst the pipeline's integrity still failed as a result of corrosion despite the fact that the criteria had been truthfully satisfied. The group had discussed potential solutions to this issue, of which brought into contrast the words found in the Australian Standard AS 2832.1 which provides a statement outlining that "while cathodic protection can prevent corrosion there are circumstances where it may not be effective, even if protection is indicated by potential monitoring techniques carried out at test points". Furthermore, the working group was astounded that we Australians were able to include the following statement, "the determination that cathodic protection is achieved is a risk based judgement dependent on an evaluation of a number of parameters" within our standard which has been accepted by the technical regulators. I had the feeling that they viewed this statement as an admission of being unable to truly understand the mechanism of corrosion

Mark and wife with Australian Supplier on river Moselle cruise.

Mark with CP telemetry agent.

Mark (centre) listening to Brian Wyatt Chairman of CEOCOR opening.

Mark looking at camera.

and that we substitute science for "gut feel" and experience.

As an active member of the MT-14-3 committee responsible for the development of AS 2832.1, I had expressed to the working group that this statement is there to explain to the reader that there are other threats of corrosion that CP cannot protect against (e.g. shielding) which people may not think about differentiating from the threat that CP is specifically used to mitigate against. It was not meant to be a "get out of gaol" card because we couldn't always be sure that our application of CP was effective.

Nonetheless, this got me thinking, "Could we do better?". Have we really provided the industry with clear and measurable protection criteria that are complete in all circumstances? Is our Standard clear, and does it provide appropriate guidance to the end user? These questions stayed with me throughout the conference and were my main focus during many presentations. In particular, the presentations given by Marcus Buechler, titled "An objective discussion of cathodic protection criteria based on literature data" and "Summary of recent developments". Marcus Buechler is the President of Working Group Commission 2 within CEOCOR and is CEO of SGK, a Swiss based company whose goal is to combine high end fundamental research with actual industrial problems.

Marcus' papers clearly presented the history of CP criteria and their derivation from both theory and empirical research. I found his presentations useful in explaining the potential deficiencies with each of the more common protection criteria. He cross-examined data from different parts of the world to test if any of the theories are completely underpinned by data collected from other researchers. It is through this meticulous analysis that he makes the case for reconsideration of the usage of the 100mV polarization criterion altogether, whilst presenting a robust case to promote the use of on-potential as the main type of criterion provided a pipelines bedding and backfill supports a pH build up to occur on the metals surface at coating defects through control of diffusion of ionic species.

It was from these presentations that I began to think about how much importance do we put on the backfill when constructing a pipeline. Usually, pipeline engineers talk about bedding and backfill particle size for the purpose of determining how much risk is expected from mechanical damage to the coating due to rocks impinging on the coating during laying and burial. On the other hand, corrosion engineers usually only talk about backfill when discussing the anode to soil resistance of the backfill around the CP ground bed. It seems that both main governing Standards mention backfill but fail to address the details needed to ensure that when designing and constructing a pipeline, that the backfill is conducive to the kinetics and diffusion of the polarisation film that protects the exposed steel wall. The closest reference can be found in AS 2885.1-2012 Clause 10.15.3 (d) Development of specifications and procedures which states "The properties, including resistivity, of the backfilling materials surrounding the pipe, shall permit the cathodic protection system to work effectively over the full surface of the pipe". This is a gap in both Standards and really should be addressed in the next revision of AS 2832.1.

On a similar note, Marcus' presentations demonstrated the importance the size of coating defects play in the relationship associated with satisfying the protection criteria. This is something that I feel is often not well understood or even forgotten about when talking to other pipeline engineers. The underlying assumption is that all coating defects will be protected regardless of their size, distance between each other and the type of backfill that they are sitting in. This is similar to another common assumption, that undertaking a Direct Current Voltage Gradient (DCVG) survey will inform them of the location of all the defects, and that the %IR rating will tell them which coating defect is physically larger, all with the intent to "manage" the risk of corrosion through prioritisation of dig up and repair. But when you consider that it took decades for the industry to both realise and accept that DCVG is good at detecting coating defects, but that there is no correlation between %IR and the physical size of the actual defect, it is no surprise that the industry has relied upon assumptions to reduce the grey area that is introduced when asking a simple question that is not so simple to answer "Is the pipeline cathodically protected?"

And this is all without even introducing other variables such as telluric or stray currents. Such concepts are questioned during the design phase of a pipeline, but cannot be answered until the pipeline is built and buried. This is where the operational experience of a designer begins to show merit. Their designs build in contingencies, also known as capital expenditure inefficiencies to all others, in an attempt to provide flexibility for operators to reduce the impact to the pipelines integrity, as any attempt to accurately predict such conditions during the design phase would be based predominantly on luck. This is simply the nature of stray currents, where operators are forced to compromise in order to maintain protection of the steel wall. In cases where operators can perform inline inspection of the pipelines steel wall they can satisfy themselves that the condition of their asset is being monitored.

However, in the case of pipelines that are not piggable, a paper presented by Dr Fumio Kajiyama from Tokyo Gas titled "Risk assessment of fluctuating stray current interference on buried steel pipelines with cathodic protection applied" was very interesting.

Dr Markus Buechler.

Dr Fumio Kajiyama.

He demonstrated a technique for undertaking a risk assessment of combined dc and ac stray current interference on buried pipelines with cathodic protection applied which used current probes in accordance with the British Standard BS EN 50162:2004. The technique explained how data acquired from probes every 2 seconds measuring the average, maximum and minimum ac & dc current densities along with probe on and instant-off potentials was used to assess the risk of stray current through the calculation of a corrosion rate in comparison to the allowable limit of 0.01mm/year in accordance with ISO 15589-1.

This paper demonstrated that despite the challenges presented with managing a pipeline with stray currents, there are people in the international community who are applying scientific methods and techniques to decrease their reliance on simply meeting criteria and focus on physically measuring corrosion rates combined with better information to determine the risk of corrosion from stray currents across an entire pipeline.

This paper, amongst others, truly highlighted the importance of educating ourselves in our respective fields. Not just through formal institutions or by undertaking courses to help "increase our understanding", but that we must take the responsibility of deeply educating ourselves in the mechanisms and the details of the problems we must solve as engineers and scientists. Without this deeper level of thinking how can we expect to make better decisions? This is why I consider attending such conferences where the quality of papers being presented and the discussions had afterwards are another important step in our education of the mechanisms of corrosion. It is because of associations like the ACA and CEOCOR that foster this kind of contribution and interaction between researchers, asset owners and designers. It is these associations that society benefits from even if they never really know what they do or that they even exist. But as members of such organisations and industries we must continue to advance our knowledge and we can only do so by participating and sharing with each other.

Based on my experience, I would highly recommend other individuals passionate about corrosion to apply for the ACA Foundation Scholarship. This scholarship genuinely provided me the opportunity to re-engage my former purist technical mindset, predominantly because this was a smaller and more intimate conference with quality technical presentations. This was also an opportunity to interact with new professionals who were sharing their way of doing things, an opportunity to network and extend my thinking beyond what I am used to within the confines of Australasia. But best of all, I found myself with like-minded individuals who also shared my passion for CP and felt that they had quickly accepted me as a valued contributing participant. By applying for an ACA Foundation Scholarship, you can expect to be rewarded with an experience of your own choosing and know that only few people get the opportunity to do such things on their own terms.

I look forward to sharing my new-found knowledge and seeing how I can continue to shape the industries I work within, all thanks to the ACA Foundation Scholarship. I would also like to thank the Australasian Corrosion Association Foundation Board for recognising my industry contributions by awarding me with this scholarship, and would like to thank my two industry sponsors Brian Martin and Geoff Cope for supporting my application.

Working Group Session presented by M. Buechler.

Mark (right) having lunch.

7–11 October

fib 2018

Melbourne, Australia

BETTER | SMARTER | STRONGER

CONCRETE INSTITUTE of AUSTRALIA | fib CEB-FIP

The 5th International Federation of Structural Concrete *(fib)* Congress is coming to Australia in 2018.

The Congress will focus on the theme "**Better – Smarter – Stronger**" and is dedicated to bringing together leaders and practitioners in the concrete industry from all over the world.

The multidisciplinary theme of the Congress provides an excellent forum for engineers, scientists, specifiers, concrete technologists, researchers, academic, practitioners and professionals to connect, and to share knowledge and learn about advances in the concrete world. Abstracts are now open for submission.

The Congress will run over 4 days, and will feature –

- A multi-streamed technical program
- 5 high quality keynote speakers
- The *fib* Concrete Excellence Awards Ceremony & Congress Dinner
- Exhibitors of concrete products & services from all over the globe
- Opportunities to connect with world leading concrete practitioners

A Congress of this type is an incredible opportunity for the Australian construction industry to show the world what we can do in our own backyard.

We look forward to seeing you at the *fib* 2018 Congress in Melbourne.

Professor Stephen Foster
Congress Chair

Key Dates

Abstracts Now Open

Abstracts Submission Deadline
13 October 2017

Registrations Open
November 2017

Full Paper Submission Deadline
8 February 2018

Author Notifications
April 2018

Early Bird Registration Close
7 June 2018

Congress Dates
7-11 October 2018

www.fibcongress2018.com

CERTIFICATION PROGRAM

Working toward Professional Development in Corrosion

The ACA's Certification program for ACA Corrosion Technicians and Technologists recognises those with education and experience in the corrosion industry. A Corrosion Technician has at least 4 years work experience and has attended a number of formal training courses, whilst those awarded Corrosion Technologist have at least 10 years work experience and have obtained further training. For a more detailed explanation of the eligibility criteria, please consult our ACA Certification Program brochure which is available on our website www.corrosion.com.au. A schedule of current ACA Corrosion Technicians and Technologists appears below and will be published in Corrosion & Materials in each November issue and will be continuously updated on the ACA's web site. All current ACA Technicians and Technologists have been issued a wallet card with their certification number and membership details.

Please note continued membership of the ACA is a requirement for certification and therefore all certified Corrosion Technicians and Technologists will have an expiry date which coincides with their ACA membership renewal date. 'Pending' expiry dates indicate that a membership payment is overdue.

Please note this list is current as at 29 September 2017

Corrosion Technicians		
Name	**Cert No:**	**Expiry Date**
Alan O'Connor	303	5/9/17
Belinda Jones	347	21/4/18
Bradley Jones	258	18/4/18
Bradley Slocum	357	12/4/18
Brendan McGuinness	343	23/8/17
Brendan Schapers	314	5/7/17
Christopher Butler	320	24/1/18
Clinton Watson	341	30/6/18
Courtney Campbell	352	10/4/18
Craig Clarke	246	25/3/18
Daniel Chambers	335	23/8/17
Dave Charters	261	21/1/18
David Fairfull	179	30/6/18
David Harley	291	17/12/17
David Parravicini	296	2/9/18
Elias Galanis	354	23/1/18
Gavin Telford	244	30/6/18
Geoff Farrant	253	30/6/18

Corrosion Technicians		
Gerrard Felix	333	23/8/17
Glenn Dean	280	10/4/18
Heath Boelen	306	4/5/18
Ian McNair	163	30/6/18
Ian Saunders	251	24/6/18
Justin Tanti	238	14/2/18
Luke Ellis	340	2/9/17
Marius Gray	327	26/9/17
Mark Watson	186	3/9/18
Nicholas Critchley	330	23/8/17
Nicholas Lange	353	23/12/17
Raed El Sarraf	305	25/9/17
Rodney Clarke	206	20/12/17
Ross Darrigan	174	31/3/18
Scott Wallbank	332	23/8/17
Sean Ryder	262	21/11/17
Stephen Brown	263	4/2/18
Venkatesh Coimbatore	192	30/6/17
William Guest	316	14/4/18

Corrosion Technologists		
Name	**Cert No:**	**Expiry Date**
Aaron Turner	345	18/4/18
Adrian Dundas	250	18/4/18
Alireza Kouklan	317	13/11/17
Allan Sterling	191	31/3/18
Andrew Smith	326	30/3/18
Antonio Carnovale	203	17/12/17
Arthur Austin	106	30/6/18
Barry Gartner	2	30/6/18
Ben Ward	351	23/8/17
Bernd Rose	252	1/5/18
Bill Gerritsen	18	30/6/18
Bill Lannen	111	1/1/18
Bill McEwan	32	1/1/18
Boris Krizman	169	17/12/17
Brad McCoy	178	14/7/18
Bradley Dockrill	241	15/7/18
Brett Hollis	88	30/6/18
Brian Hickinbottom	138	30/6/18
Brian Martin	60	1/1/18
Brian Smallridge	201	30/6/18
Bruce Ackland	82	30/6/18
Bruce Jewell	245	10/5/18
Calvin Ogilvie	17	19/1/18
Craig Hobson	349	20/7/18
Craig Hutchinson	249	26/10/17
Dale Franke	199	30/6/18
Daryl McCormick	1	17/12/17
David Blaby	336	19/5/18
David Nicholas	94	1/1/18
Dean Parker	108	5/7/17
Dennis Richards	180	1/1/18
Derek Avery	295	19/8/18
Derek Whitcombe	325	30/6/18
Dinesh Bankar	264	23/2/18
Dylan Cawley	224	29/6/18
Elio Monzu	159	30/6/18
Erwin Gamboa	339	31/8/17
Frank Hewitt	67	1/1/18
Frank Turco	309	14/4/18
Fred Andrews-Phaedonos	153	30/6/18
Fred Salome	231	1/1/18
Frederick Gooder	141	30/6/18
Gary Brockett	215	30/6/18
Gary Doyle	294	2/8/18
Gary Evans	271	16/6/18
Gavin Forrester	282	10/2/18
Geoff Cope	71	29/6/18
Geoff Robb	124	30/6/18

Corrosion Technologists		
Geoffrey White	182	1/7/18
Gordon Stewart	68	1/1/18
Graeme Gummow	318	20/9/17
Graeme Kelly	102	1/1/18
Graham Carlisle	281	19/5/18
Graham Sussex	136	30/6/18
Grant Chamberlain	334	30/6/18
Greg Moore	97	1/1/18
Harbhajan Khera	331	23/8/18
Harry Lee	19	1/1/18
Harvey Blackburn	10	1/1/18
Ian Glover	129	30/6/18
Ian Savage	259	14/4/18
Ian Stewart	155	5/9/17
Isaac Isakovich C	355	26/8/18
Janet Morris	256	16/12/17
Jeffrey Hurst	202	30/6/18
Jim Galanos	254	17/12/17
Jim Hickey	346	13/8/17
Jim McMonagle	56	1/1/18
Jim Steele	119	17/12/17
John Kalis	166	17/12/17
John Kilby	193	30/6/18
John Lane	188	20/1/18
John McCallum	59	30/6/18
John Mitchell	115	30/6/18
John Rudd	243	5/9/17
John Waters	121	30/6/18
John Watson	239	10/6/18
Keith Lichti	133	30/6/18
Kevin Woodland	323	30/10/17
Kim McCoy	350	28/7/17
Kingsley Brown	257	23/6/18
Leon Cordewener	44	30/6/18
Les Boulton	43	1/1/18
Liam Holloway	356	16/9/17
Luciano Ioan	228	30/6/18
Luis Carro	260	30/6/18
Mark Sigley	338	30/3/18
Mark Weston	149	1/1/18
Marshall Holmes	293	26/8/18
Max Fraser	283	16/3/18
Michael Boardman	30	12/7/18
Michael Johnstone	230	5/9/17
Michael Jukes	90	3/3/18
Mike Dinon	5	30/6/18
Morris Young	217	30/6/18
Murry McCormick	196	28/6/18
Narendra Tripathi	312	30/6/18
Neil Campbell	38	30/6/18
Nicholas Van Styn	229	25/2/18
Nizam Yusoff	302	9/2/18

Corrosion Technologists		
Paul Hunter	62	30/6/18
Peter Crampton	8	29/6/18
Peter Dove	210	29/3/18
Peter Hart	200	16/11/17
Peter Hosford	216	1/1/18
Peter Hunger	301	20/6/18
Peter Wade	190	30/6/18
Phil Harrison	145	1/1/18
Philip Bundy	209	30/6/18
Philip Schembri	198	17/12/17
Raymond Da Costa	342	5/6/18
Reg Casling	11	1/1/18
Rob Billing	12	30/6/18
Rob Francis	23	1/1/18
Robert Callant	106	30/5/18
Robert Cox	14	30/6/18
Robert de Graaf	154	1/1/18
Robert Freedman	147	1/1/18
Robert Mumford	33	23/6/18
Rodney Wubben	46	30/6/18
Roman Dankiw	208	29/6/18
Ronald Tan	308	30/6/18
Ross Antunovich	214	30/6/18
Ry Collier	344	21/7/18
Saeed Ali	328	15/12/17
Stephen Holt	348	28/2/18
Stephen Wargula	310	14/4/18
Steve Richards	110	30/6/18
Stuart Bayliss	236	7/11/17
Stuart McLaughlin	299	17/12/17
Tan Swee Hain	189	30/6/18
Thomas Wenzel	329	23/8/17
Tony Betts	74	1/1/18
Tony Murray	134	5/9/18
Ulf Kreher	304	11/9/18
Verne Linkhorn	39	30/6/18
Vic McLean	237	23/8/17
Wade Guye	313	9/8/18
Wayne Burns	100	1/1/18
Wayne Ferguson	242	4/9/17
Wayne Speer	337	17/12/17
William McCaffrey	142	30/6/18
Willie Mandeno	13	1/1/18
Xiaoda Xu	315	28/11/17
Yongjun Tan	194	30/6/18

Current as at 29 September 2017

ACA Standards Update Summary*

Welcome to the corrosion related standards report for November 2017.
The standards reporting for 2017 is scheduled against specific interests and as indicated below:

Issue 2017	Standards search for Specific Interests
February	Oil & Gas
May	Asset Management
August	Protective Coatings
November	Concrete & CP

This Standards report focuses on Concrete (corrosion related) and Cathodic Protection.

As previously this is in two stages, namely:

1. A global standards and publication focus at **21 September 2017**, searching through SAIGLOBAL Publications at https://infostore.saiglobal.com/en-au/Search/Standard/?sortKey=productName-asc&productFamily=STAndARD , for all current publications and standards relating to corrosion and its prevention for the topics of Concrete and Cathodic Protection.

These results are shown in Table 1a for 'Concrete and Corrosion' and Table 1b for 'Cathodic Protection'.

2. An SAI Global search at https://infostore.saiglobal.com/en-au/Search/Standard/?sortKey=productName-asc&productFamily=STAndARD for standards, published from 13 July - 21 September 2017, using the key words and key word groups:

- 'durability and corrosion'.
- 'corrosion' or 'corrosivity' or 'corrosive'; but not 'anodizing' or 'anodize(d)'.
- 'paint' or 'coating'; but not 'anodizing' or 'anodize(d)'.
- 'galvanize' or 'galvanized' or galvanizing'.
- 'electrochemical' or 'electrolysis' or 'electroplated' or anodizing' or 'anodize(d)'.
- 'cathode' or 'cathodic'.
- 'anode' or 'anodic'.
- 'corrosion' and 'concrete' or 'concrete' and 'coatings'.
- 'anodize' or 'anodizing'.

These results are shown in Table 2.

3. Summary

Through SAIGLOBAL for a search for current Standard Publications on:

a. 'Concrete and corrosion', there was a total of 132 current citations for current standards with eight AS/ NZS and one NZS, five ASTM, one ACI, and seven NACE; see Table 1a.

b. For "Cathodic Protection" (CP), there was a total of 200 citations with 10 AS/NZS, 1AGA, three API, two ASTM, one AWWA, two ISO and eight NACE; see Table 1b.

Across SAIGLOBAL online Standards Publications there was a total of 37 listings of new standards found that were issued from 13 July to 21 September 2017; two from AS AS/NZS;

- AS/NZS 4631.1:2017 Guide to hazardous paint management. Lead and other hazardous metallic pigments in industrial applications; and
- AS 5104:2017 General principles on reliability for structures.

All results are shown in Table 1b for 'Cathodic and protection' there were 200 standard citations with 10 AS/NZS, One AGA, three API, two ASTM, one AWWA, two ISO and eight NACE.

All results are shown in Table 2 in the full report for Members via Resources/**www.corrosion.com.au**.

Regards

Arthur Austin
(Arthur.Austin@alsglobal.com)

***For the full Standards Report, please visit www.corrosion.com.au**

nacecorrosion.org

CORROSION 2018
Conference & Expo

6500+
ATTENDEES
FROM 60
COUNTRIES

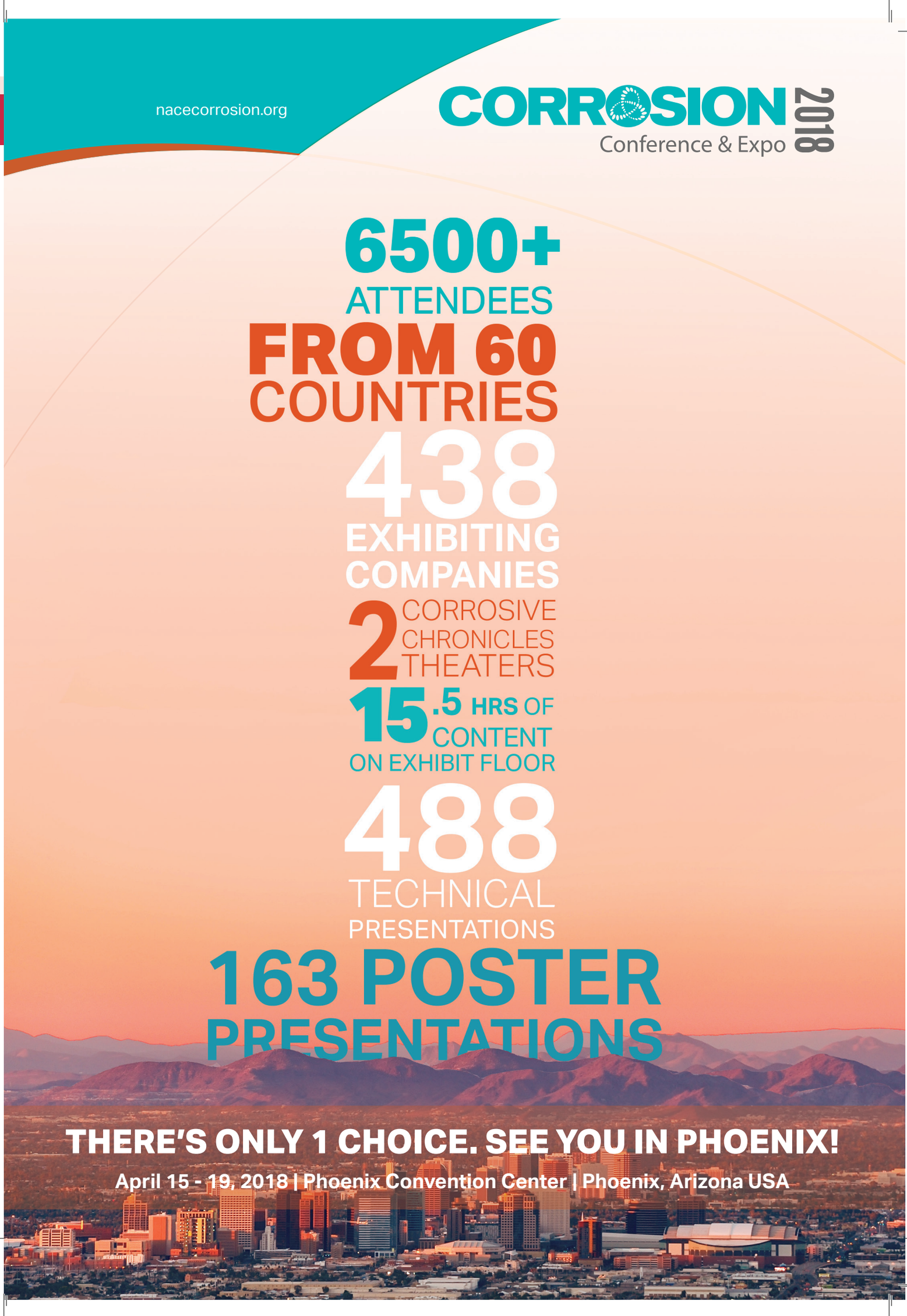
438
EXHIBITING
COMPANIES

2 CORROSIVE CHRONICLES THEATERS

15.5 HRS OF CONTENT
ON EXHIBIT FLOOR

488
TECHNICAL
PRESENTATIONS

163 POSTER
PRESENTATIONS



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CORROSION & PREVENTION 2017

PROUDLY PRESENTED BY:

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Corrosion & Prevention 2017 Program
ICC Sydney
Sunday 12 November - Wedneday 15 November 2017

The ACA reserve the right to exclude any paper and to alter without notice any of the arrangements, timetables and programs relating to the conference: Program accurate as of 11/10/2017

Sunday 12 November 2017

13:00-18:30	**Registration Desk Opens** Level 2 - The Gallery Foyer, ICC Sydney
17:30 - 18:30	**First Time Delegates Function** *Sponsored by Galvanizers Association of Australia* Doltone House - Jones Bay Wharf (South Pier), 26 - 32 Pirrama Road, Pyrmont Point
18:30 - 21:30	**Welcome Reception** *Sponsored by Dulux Protective Coatings* Doltone House - Jones Bay Wharf (South Pier), 26 - 32 Pirrama Road, Pyrmont Point

Monday 13 November 2017

8:30	**Conference Opening & Starting of Ed Potter Corrosion Clock** Cockle Bay Room 2, ICC Sydney
9:00	**Plenary 1 - Dr Brian Skerry, Global Director - Corrosion Programs** The Sherwin-Williams Company, USA Corrosion Prevention Coatings – From Noah's Ark to Nanotechnology Cockle Bay Room 2, ICC Sydney ***Chair: Bruce Hinton***
9:45	**Plenary 2 - Miles Buckhurst, Global Concept Director** Jotun, Norway The Advantages of Heat Resistant Composites Cockle Bay Room 2, ICC Sydney ***Chair: Bruce Hinton***
10:30	***Morning Tea***

The ACA will be launching its new C&P2017 App at this year's Conference in Sydney.

So make sure your mobile is fully charged and ready to go, to download the app.

Then you can search the program for your preferred sessions, presenters, locations and social functions.

We will produce a 'pocket program' for those who are still wedded to the paper version too!

	Concurrent Session 1A Cockle Bay Room 2 Steel Corrosion, Coating of Steel *Session Chair: Rob Francis*	Concurrent Session 1B Meeting Room 3.2 Concrete & General CP *Session Chair: Brian Cherry*	Concurrent Session 1C Meeting Room 3.3 Oil & Gas | Marine Structures *Session Chair: Rob Jeffrey*	Concurrent Session 1D Meeting Room 3.4 Non Ferrous Metal Corrosion *Session Chair: Laura Machuca*	Concurrent Session 1E Meeting Room 3.5 Asset Management & Stainless Steels *Session Chair: Katerina Lepkova*
11:00	Qualifying Tank Coatings for Broad Service Capabilities **S Bowditch** *A.W. Chersteron Co* 150	What Does CP Mean Now for Steel in Concrete? **W Green** *Vinsi Partners* 20	Marine Asset Protection Systems - Cathodic Protection and Marine Pile Wraps Working Together **W Thomson** *PFP Systems* 18	Case Study: Remote In-field Environment and Corrosion Monitoring **A Sudholz** *Defence Science and Technology Group* 131	Protecting Underground Structures Against Corrosion: The Role of Stainless Steels **L Boulton** *Nickel Institute* 12

11:30	Restoration of Corroding Metal Roof Structures **R Cardoso** *Andersal* 13	ICCP Advances for Major Wharf Repair **I Godson** *Infracorr* 122	An Overview of Techniques for Measuring the Interaction between Erosion and Corrosion **Y Xu** *IFM, Deakin University* 99	Comparison of Corrosion in Different Paint Defects, Material and Orientation Following Prohesion Salt Fog Testing **S Knight** *BAE Systems* 98	Impact of Path Dependence on Corrosion of Commercial and Military Systems **G Keller** *LMI/US DOD Corrosion Prevention & Control Program* 16
12:00	Novel Smart-Release Chrome-Free Inhibiting Pigments from Lab Investigation to Industrial Coatings **P Dodds** *Swansea University* 65	High-Current Pipeline Cathodic Protection Design - Achieving 0.35 OHM Loop Resistance Onshore **N Doblo** *APA Group* 106	Qualification of High-Temperature Protective Coatings on Offshore Pipelines **J Lim** *Shawcor* 100	Electropolymerisation of Aniline on Alkaline Pre-Treated Magnesium Alloy and Corrosion Evaluation **A Baloch** *James Cook University* 146	Experience of Stainless Steel as a Structural Material in Civil Infrastructure **J McCray** *Arup* 109
12:30	***Lunch***				
12:45	**ACA Foundation AGM** Meeting Room 3.2 (150)				
	Concurrent Session 2A **Cockle Bay Room 2** **Steel Corrosion, Coating of Steel** ***Session Chair: John Duncan***	**Concurrent Session 2B** **Meeting Room 3.2** **Concrete CP & Repair** ***Session Chair: Brad Dockrill***	**Concurrent Session 2C** **Meeting Room 3.3** **Oil & Gas Refinery Issues** ***Session Chair: Phil Fleming***	**Concurrent Session 2D** **Meeting Room 3.4** **Non Ferrous Metal Corrosion** ***Session Chair: Sarah Furman***	**Concurrent Session 2E** **Meeting Room 3.5** **Water Infrastructure** ***Session Chair: Simon Krismer***
13:30	In Situ Scanning Kelvin Probe Study of Cathodic Disbondment on Trivalent Chromium Coated Steel **J Edy** *Swansea University* 91	The Entrance Bridge: Deterioration and Remediation Challenges **M Karlaftis** *Marine & Civil Maintenance* 34	Deployment of Smart Sensors **N Sequera** *SN Integrity* 138	Natural Fresh and Salt Water Immersion Corrosion Trials of Composite Aluminium Syntactic Foams **I Chaves** *The University of Newcastle* 48	Case Study: Condition Assessment of Aged Utility Pipes in Underground Mines **V Afshari** *GHD* 134
14:00	Comprehending Coating Adhesion: Part 1: To Stick or Not to Stick? **R Francis** *R A Francis Consulting Services* 9	An Investigation into the Correlation between Half Cell, Current Injection Testing and the Current Required to Protection **J McLean** *Freyssinet Australia* 39	On the Hydrogen-induced Corrosion of AISI 410 **S Thomas** ***Monash University*** 111	Measurement of Aluminum Oxide Film in Situ During Anodization of Aluminum by Fabry-Pérot Interferometry **K Habib** *Materials Science and Photo-Electronics Lab* 7	The Influence of Soil Moisture on the Corrosion of Mild Steel in Clays **R Petersen** *The University of Newcastle* 35
14:30	Comprehending Coating Adhesion: Part 2: Pull-off Adhesion Testing **R Francis** *R A Francis Consulting Services* 10	Gippsland Water Factory – A Case Study over 3 Years **J Rigby** *REMEDY Asset Protection* 26	Gas Arrestors Trus & the Validity of Assumptions about Lighting Damage **G Gummow** *G Squared Solutions* 147	Long-term Marine Pitting Corrosion of AlMgSi Aluminium Alloys **M Liang** *The University of Newcastle* 52	Evaluation of the Surface Topography of Corroded Old Cast Iron Pipes **Z Soltani Asadi** *The University Of Newcastle* 92
15:00	***Afternoon Tea***				
	Concurrent Session 3A **Cockle Bay Room 2** **Steel Corrosion, Coating of Steel** ***Session Chair: Peter Dove***	**Concurrent Session 3B** **Meeting Room 3.2** **Concrete Repair** ***Session Chair: Warren Green***	**Concurrent Session 3C** **Meeting Room 3.3** **Oil & Gas Refinery Issues** ***Session Chair: Maria Forsyth***	**Concurrent Session 3D** **Meeting Room 3.4** **High Temperature Corrosion** ***Session Chair: David Young***	**Concurrent Session 3E** **Meeting Room 3.5** **Water Infrastructure** ***Session Chair: Greg Moore***
15:30	Fast Curing Polycyclamine Cured Tank Linings **M O'Keefe** *Akzo Nobel* 143	A New Class of Polymer Linings – Commonly Used Systems Become Outdated in Favour of Instant Gratification and Reliable Restoration **N Subotsch** *Peerless Industrial Systems* 135	Artificial Intelligence Assisted Condition Assessment **W Nash** *Monash University* 80	Effect of Ni-Re Diffusion Barrier on Ni-Al Coating Structure and its Oxidation in Dry CO_2 Gas at 650 °C **M Li** *University of New South Wales* 84	Polarisation Resistance and Corrosion of Steel in Soil Media **J Cull** *Elorane Geophysical Surveys* 23

16:00	A Review on the Passivation Ability of Nanostructured Steel Surfaces Created by Nanocrystallization Treatment **M Laleh** *Deakin University* 71	Gamification of Training for Specifying Inspection and Remediation of Concrete Structures **W Ward** *Papworths Construction Testing Equipment* 19	A Novel Flow Loop for Testing the Susceptibility of Materials to Stress Corrosion Cracking **R Rihan** *Kuwait Institute for Scientific Research* 77	Effects of Ti and Al on Corrosion of Ni-20Cr and Ni-30Cr Alloys in Dry CO_2 Gas **T Nguyen** *University of New South Wales* 41	Blue Green Water Corrosion of Copper Piping - 15 Years On **S Furman** *AECOM* 94
16:30	Challenges and Opportunities for Chromium Free Inhibitors for Galvanized Steel **O Gharbi** *Monash University* 67	IRATA Unleashed - Growth in the Use of Rope Access in Corrosion Mitigation and Repair **A Caddy** *Absafe* 127	Infrastructural Health Monitoring Using Corrosion Sensors: Past, Present and Future **M Y Tan** *Deakin University* 17	Effect of Water Vapour on Oxidation Behaviour of Ni-Cr Alloys in CO_2 Atmosphere at 650°C **Y Xie** *University of New South Wales* 38	Condition and Risk Assessment of Griffith G4 Sewer Rising Main **A Hackett** *KBR* 58
17:00	Epoxy Based Materials for Elevated Temperature End Uses: What Do We Really Know? **M O'Keefe** *Akzo Nobel* 142	Strategic Inspection and Repair Procedure Formalised for Repairs to a Major Marine Complex **I Khan** *BCRC* 103	Approaches to Overcoming Ongoing Pipeline Corrosion Monitoring Challenges **K Wang** *Deakin University* 88	Electrochemical and Static HPHT Study of Porphyrin Derivatives as Effective Corrosion Inhibitor for N80 Steel in a Sweet Corrosion Environment **A Singh** *Southwest Petroleum University* 43	The Use of Epoxy and Polymer Modified Cementitious Coatings to Re-Line Old Concrete and Brick Manholes and Sewer Structures **D Johnstone** *Akzo Nobel* 133
17:30 - 19:00	**Exhibition Opening** The Gallery, ICC Sydney				
18:30 - 21:30	**Young Corrosion Event** *Sponsored by Galvanizers Association of Australia* The Watershed Hotel, 198 Harbourside, Darling Harbour				
19:30 - 23:00	**ACA Foundation Networking Event** The Watershed Hotel (Cohibar Lounge & Terrace), 198 Harbourside, Darling Harbour				
Tuesday 14 November 2017					
9:00	**Plenary 3 PF Thomson Lecture: Professor Maria Forsyth, Australian Laureate Fellow Chair Electromaterials and Corrosion Sciences, Deakin University, Australia** Controlling Corrosion with Chemistry Cockle Bay Room 2, ICC Sydney ***Chair: Matt Dafter***				
9:45	**Plenary 4 - Professor Peter Robery, Director Robery Forensic Engineering Ltd** Effective Corrosion Management of Reinforced Concrete Assets Cockle Bay Room 2, ICC Sydney ***Chair: Matt Dafter***				
10:30	***Morning Tea***				
	Concurrent Session 4A **Cockle Bay Room 2** **Steel Corrosion, Coating of Steel** ***Session Chair: Rob Freedman***	**Concurrent Session 4B** **Meeting Room 3.2** **Concrete Reo & Deterioration** ***Session Chair: Igor Chaves***	**Concurrent Session 4C** **Meeting Room 3.3** **Oil & Gas - CP Pipelines** ***Session Chair: Wayne Thomson***	**Concurrent Session 4D** **Meeting Room 3.4** **Non Ferrous Metal Corrosion** ***Session Chair: Les Boulton***	
11:00	Water-borne Inorganic Zinc Silicate: Two NZ Bridges **W Mandeno** *Opus International Consultants* 32	An Overview of Corrosion Protection Provided by Carbon Fibre Reinforced Polymer Bonded on Reinforced Concrete **A Wei** *Deakin University* 86	DC Traction Electrolysis Modelling of a Reinforced Concrete Retaining Wall **A Vinnell** *Aurecon* 130	An Investigation into the Atmospheric Corrosion of Brass Using Sodium Chloride-Containing Water Droplets **A Neilson** *Swansea University* 66	

11:30	Hot Dip Galvanizing of Quench and Tempered Structural Grade Specialty Steels **W McLean** *Galvanizers Association of Australia* 110	Concrete Durability Assessment of a Concrete Gravity Structure on Australia's North West Shelf **A Peek** *GHD* 24	Traction Stray Current Mitigation Systems **R Brodribb** *M. Brodribb* 59	Determination of the Long-Term Corrosion Resistance of PEO-coated Magnesium Alloys: A Review **D Northwood** *University of Windsor* 69
12:00	Using Intumescent Coatings to Achieve Building Code Compliance on Steel Structures **C Partington** *Akzo Nobel* 120	Findings of a 7 Year Field Study of Concrete Sewer Pipe Corrosion **T Wells** *The University of Newcastle* 30	Stray Current Corrosion Detection – the Use of Penetration Probes **B Sandberg** *3C Corrosion Control Company* 62	Improving Corrosion Resistance of Monel 400 Alloy by CVD Graphene Coating **S A Patwary** *Monash University* 45
12:30	***Lunch***			
	Concurrent Session 5A **Cockle Bay Room 2** **Coatings Forum** ***Session Chair: Justin Rigby***	**Concurrent Session 5B** **Meeting Room 3.2** **Reo Corrosion** ***Session Chair: Allan Sterling***	**Concurrent Session 5C** **Meeting Room 3.3** **Oil & Gas - CP Pipelines** ***Session Chair: Bruce Ackland***	**Concurrent Session 5D** **Meeting Room 3.4** **Steel Marine Environments** ***Session Chair: Ian MacLeod***
13:30	Introduction & Nominations for ACA Coatings Group Committee **J Rigby** A Review of Recent Changes to Thermal Spray Coatings Standards: ISO 2063 and NACE No.12/AWS C2.23M/SSPC CS-23 **W Mandeno** *Opus International Consultants*	Judiciously Classifying Exposure Environments for Concrete and Steel **N Tripathi** *Roads and Maritime Services* 79	Challenges with Designing Retrofit Cathodic Protection Systems in Petrochemical Complexes **C Chan** *SMEC Australia* 72	Studies of the Microbiologically Influenced Corrosion of Stainless Steel Alloys by Sulphate Reducing Bacteria **S Wade** *Swinburne University of Technology* 64
14:00	How Do We Improve the Image of Coatings in the Oil and Gas Sector? **M Buckhurst** *Jotun* TBA **D Johnstone** *Akzo Nobel*	Modelling the Electrokinetics of Concrete Steel Reinforcement Corrosion **H Flitt** *QUT* 31	Corrosion Mechanism for Stray Current Affected Cathodically Protected Pipelines **B Martin** *Brian Martin & Associates* 29	Comparative Marine Immersion Corrosion of Ship Construction Steels Exposed in Arctic and Temperate Waters **B Chernov** *The University of Newcastle* 51
14:30	Description of Victor Nightingall Award & Open Forum		Cathodic Protection Criteria for Stray Current Affected Pipelines **B Martin** *Brian Martin & Associates* 28	Using Thermoplastics for Infrastructure Protection in Marine and other Challenging Environments **T Davison** *Alocit & Enviropeel Services* 61
15:00	***Afternoon Tea***			
	Concurrent Session 6A **Cockle Bay Room 2** **Applicators Forum** ***Session Chair: Justin Rigby***	**Concurrent Session 6B** **Meeting Room 3.2** **Concrete Forum** Infrastructure Protection Solutions for Discussion ***Session Chair: Warren Green***	**Concurrent Session 6C** **Meeting Room 3.3** **CP Forum** ***Session Chair: Bruce Ackland***	**Concurrent Session 6D** **Meeting Room 3.4** **Steel Marine Environments** ***Session Chair: Willie Mandeno***
15:30	Networking Opportunity & Introduction to ACA Applicators Group **J Rigby & M Rutherford**	Civil Infrastructure Diagnosis and Solutions for Protection, an Industry Reflection **M Dacre** *AECOM*	Alternative Cathodic Protection Criteria **B Martin** *Brian Martin & Associates*	Importance of Accurate Pipeline Corrosion Diagnosis for Optimized Corrosion Management **S Loftus** *ROSEN UK* 76

16:00	Certificate 3 in Surface Preparation – The Australian Nationally Recognised Trade Level Qualification for Applicators and Blasters **I Squire** *TAFE NSW* A Description of the Benefits Available to Applicators within Existing ACA Training Streams **R Boucher** *ACA*	Patch Repairs: the Current Perspective **R Reeves** *Sika*	Challenges with DCVG Surveys **J Wu** *Jemena*	Addressing Sheet Pile MIC Fresh Water Corrosion on Ohau Diversion Wall **R El Sarraf** *Opus International Consultants* **125**
16:30	Pitfalls in Trying to Reach the Top **A Caddy** *Absafe* ***Open Discussion***	Tunnels Protection Including Fireproofing **C Partington** *Akzo Nobel*	Activities of the NSW Electrolysis Committee and General Discussion	The Effect of Coastal Seawater Temperature on Corrosion of Steel with Different Carbon Contents **R Jeffrey** *The University of Newcastle* **36**
19:00 - 24:00	**ACA Annual Awards Dinner** *Sponsored by Denso Australia* Grand Ballroom B3, ICC Sydney			

Wednesday 15 November 2017

	Concurrent Session 7A **Cockle Bay Room 2** **Steel Corrosion, Coating of Steel** ***Session Chair: Geoff White***	**Concurrent Session 7B** **Meeting Room 3.2** **Research Forum** ***Session Chair: Brian Kinsella***	**Concurrent Session 7C** **Meeting Room 3.3** **Oil & Gas - CP Pipelines** ***Session Chair: Mike Tan***	**Concurrent Session 7D** **Meeting Room 3.4** **Steel Marine Environments** ***Session Chair: David Nicholas***
9:30	Corrosion Inhibition of HY80 with La(trans-4OHCin)$_3$ & Imidazolinium-trans-4OHCin **R Catubig** *Deakin University* **63**	Research Integrity in Corrosion Research **A Betts** *Dublin Institute of Technology* **85**	Corrosion Mitigation of Ageing Buried Steel Pipelines in Metropolitan Sydney **J Galanos** *Corrosion Control Engineering* **95**	Long-Term Marine Immersion Corrosion Field Trials of Simulated Steel Weld HAZ **S Krismer** *Bureau Veritas* **50**
10:00	Effectively Capture In-Field Data – a New Way Forward for Protective Coatings Projects **J Rigby** *Docopro* **25**	Exposing Patent Myths **M Repacholi** *FB Rice* Corrosion of Steel Induced by Sulphate Reducing Bacteria **T Tran** *Charles Darwin University, Australia*	Cathodic Protection at Australia's Largest LPG Storage Facility **D Sunjaya** *Corrosion Control Engineering* **108**	Corrosion of Steels Under Low D.O. Concentration and Elevated Temperature **R Melchers** *The University of Newcastle* **33**
10:30	Lifecycle Cost Study for Maintenance Painting at Coal Export Terminal **M Rutherford** *Conspectus (Qld)* **11**	Microbial Communities in Oil Production Systems: Understanding the Risk of MIC by Thiosulphate-reducing Bacteria and Associated Consortia **L Machuca Suarez** *Curtin University* Effects of Fluid Flow on Bacterial Attachment and Microbiologically Influenced Corrosion of Copper **A Osman** *Swinburne University of Technology*	Modelling a Retrofit CP System for an Above Ground Tank, a Methodology and Implementation **S Mostafavi** *STORK* **124**	Addressing the Challenges of Accelerated Low Water Corrosion at The Port of Melbourne **J McLean** *Freyssinet Australia* **54**
11:00	***Morning Tea***			
11:30	**Plenary 5 - Professor Nick Birbilis, Woodside Innovation Chair, and Head, Department of Materials, Science and Engineering, Monash University, Australia** Corrosion of Emerging Materials Cockle Bay Room 2, ICC Sydney ***Chair Rob Melchers***			

12:15	**Plenary 6 - Professor Jing-Li Luo, Department of Chemical and Materials Engineering, University of Alberta, Canada** The Synergism of Electrochemical and Mechanical Factors in Materials Degradation Cockle Bay Room 2, ICC Sydney ***Chair: Rob Melchers***			
13:00	***Lunch***			
	Concurrent Session 8A **Cockle Bay Room 2** **Steel Corrosion & Infrastructure Degradation** ***Session Chair: Paul Vince***	**Concurrent Session 8B** **Meeting Room 3.2** **Research Forum** ***Session Chair: Brian Kinsella***	**Concurrent Session 8C** **Meeting Room 3.3** **Oil & Gas Forum** ***Session Chair: Fikry Barouky***	**Concurrent Session 8D** **Meeting Room 3.4** **Asset Management** ***Session Chair: Jessica Lyndon***
14:00	Corrosion Behaviour of Pipes in Soil and in Simulated Soil Solution **C-Q LI** *RMIT University* **139**	Accurate Assessment of Instantaneous Corrosion Rates **A Betts** *Dublin Institute of Technology* **46**	Accurate Diagnosis and Management of MIC: Current and Evolving Approaches **L Machuca** *Curtin University*	Practical Examples for the Management of Assets with Corrosion **T Pape** *AECOM* **136**
14:30	Investigation of Corrosion Effect on Underground Metal Pipes **W Wang** *RMIT University* **144**	Corrosion of Steel in Soil **C Tan** *Charles Darwin University* Developments in Organic Corrosion Inhibitors for Mild Steel **A Summers** *Deakin University* Microbial Community Investigation Associated with Corrosion Failures of Submarine Seawater Piping **J Wood** *Defence Science and Technology Group*	An Overview of Research Conducted at Deakin University on Assessing the Performance of Coating & Cathodic Protection **M Tan** *Deakin University*	Remaining Life Estimates Using Monte Carlo Simulation & Weibull Survival Analysis **A Spark** *AECOM* **81**
15:00	Assessing the Origins of Corrosion on Stainless Steel **G Sander** *Monash University* **53**	Advances in Investigating Corrosion Inhibition using In-situ Analytical Methods **K Lepkova** *Curtin University* Corrosion Inhibition of AS1020 Mild Steel by Rare Earth Carboxylate Compounds **Y Peng** *Deakin University*	Spread of Corrosion Assessment on Flexible Elastomeric Insulation Systems in Continuous Salt Water Environment **L Zhen Hue** *Armacell Engineered Systems*	Pitting in Wind Turbine Gearboxes: Corrosion or Fatigue? **A Spark** *AECOM* **102**
15:30	Influence of Biodiesel on Corrosion by Bacillus Megaterium **J Pusparizkita** *Bandung Institute of Technology* **89**	Corrosion Testing of Thermal Spray Metal Coatings for Marine Applications **Scott Wade** *Swinburne University of Technology* Where is the Value in Cost of Corrosion Studies? **J Colwell** *Defence Materials Technology Centre*	Corrosion Under Insulation: The Development of Best Practice to Assess, Evaluate and Rehabilitation Approaches - Update and Open Discussion **F Barouky**	Surface Preparation Applied to Shipyards Using Desiccant Dryers. Design and Energy Considerations. **G Lacey** *DST Dryer* **105**
16:00	**Closing Session** Cockle Bay Room 2, ICC Sydney			
16:30 - 18:30	**Farewell Function** *Sponsored by AIWC* Cockle Bay Room Foyer 2, ICC Sydney			

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Originally established over 40 years ago to provide technical consulting, BlastOne has grown to become a single source supplier of blasting equipment, abrasives and know-how to customers all over the world. BlastOne operates internationally from several offices across Australia, New Zealand, North America and UK.

We stand behind our brand claim of Superior Performance. It's something we define as 'Performance3' – the result of combining superior know-how with superior abrasives and superior equipment. In short, it's something that delivers greater cost-efficiencies for our customers.

Jim Gooden | Global Technical Director – Corrosion Control
Phone Number: +61 8 8292 2000
Email Address: jim.gooden@blastone.com

WIRELESS INTERNET SPONSOR

3C CORROSION CONTROL COMPANY

www.3ccc.se

With a strong international focus and an extensive know-how in cathodic protection and sea water applications, 3C is a highly specialized company with strategic partners on a global level.

Focusing on Power Generation, Oil & Gas and Desalination industries, our mission is to offer practical solutions that secure highest operational reliability. We build long-term partnerships with international industrial contractors to whom we offer our expertise and reliability.

3C develop a range of products for cathodic protection, such as Switch Mode rectifiers, remote controls and monitoring systems, customized MMO anodes and probes for corrosion detection.

Strong customer focus, highest quality and extensive know-how. That's 3C.

Bjorn Lindell
Phone Number: +46 418 411 900
Email Address: bjorn.lindell@3ccc.se

APP SPONSOR

PACIFIC CORROSION CONSULTANTS (A DIVISION OF LTH LTD)

www.linetech.co.nz/services/asset-inspection/

Pacific Corrosion Consultants (PCC) is a division of LTH Ltd, the parent company for a group of specialist consultancy teams with its foundations in the power engineering field circa 1994. We have New Zealand's largest NACE certified independent coatings inspection and condition assessment team. We can also develop procedures, specifications, training materials, and maintenance strategies.

Where there are protective coating issues, we can provide coating failure investigations. Our transmission tower climbing capability together with rope access (IRATA), confined space, and high-resolution UAV (drone) capabilities allow us to get access to challenging structures throughout NZ, Australia, and the Pacific.

Mike Boardman | Director | Principal Consultant
Phone Number:+64 421 906 684
Email Address: mike.boardman@pacific-corrosion.com

EXHIBITORS

3C CORROSION CONTROL COMPANY

Booth Numbers: 12 & 15
www.3ccc.se

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Bjorn Lindell
Phone Number: +46 418 411 900
Email Address: bjorn.lindell@3ccc.se

ABSAFE

Booth Number: 26
www.absafe.com.au

Absafe is a specialist contractor that provides diagnostics, repair and maintenance to all forms of the built environment. Our forte is difficult access; whether it be at height, confined space, or otherwise extreme conditions. Highly experienced, triple accredited and award-winning.

Engineering
- Diagnostic and remedial
- Design
- Fabrication

Coatings
- Industrial Steel
- Commercial Facades
- Abrasive Blasting

Concrete Repair
- Patch Repairs
- Shotcreting
- Crack Injections

Access
- Rope Access
- Rigging
- Environmental Protection

We also operate a retail division: Absafe Specialist Equipment, which provides world-class equipment solutions to meet even the most rigorous demands in the field.

Andy Caddy | Director
Phone Number: +61 3 9486 3777
Email Address: andy@absafe.com.au

ABSS

Booth Numbers: 67 & 68
www.abss.net.au

ABSS are industry leaders in the surface finishing sector throughout Australia. Our offices are located in Melbourne and Sydney with distributors located all over Australia, Canada & USA.

We are an Australian Manufacturer of quality Shot Peening Equipment, Shot Blast Machines, Turbine Wheel Blasting Machines, Abrasive Sandblasting Cabinets, Sandblast Pots and Sand Blast Rooms. We carry a large range of Sandblasting Abrasive Media including Steel Shot, Steel Grit, Glass Bead, Garnet, Ceramic, Plastic, Aluminium Oxide and Organic Blast Media.

We also hold a large range of accessories including Sandblast Hoses, Sandblasting Nozzles, Operator Sandblast Helmets and Abrasive Media Feed Valves.

AEGIS

Booth Number: 27
www.aegis.net.au

For more than 80 years Aegis has designed and manufactured test equipment for utility companies worldwide. Aegis strives to maximise the life of a utility network, seeking continuous reliable operation and performance. From contractors to network owners, Aegis provides test and measurement solutions for daily use.

Aegis is transforming the corrosion protection industry by providing 24/7 monitoring of your protection systems. You no longer need to wonder whether your network is being protected, let the DataCell product range do it for you. View your network on any smart device, react to alarms only as required, and proactively maintain your asset efficiently.

Matthew Mitchell, Steve Watt
Phone Number: 1300 723 447
Email Addresses: m.mitchell@aegis.net.au, s.watt@aegis.net.au

The ACA will be launching its new C&P2017 App at this year's Conference in Sydney.
So make sure your mobile is fully charged and ready to go, to download the app.
Then you can search the program for your preferred sessions, presenters, locations and social functions.
We will produce a 'pocket program' for those who are still wedded to the paper version too!

AERIS ENVIRONMENTAL

Booth Number: 22
www.aeris.com.au

Aeris Environmental brings 'clean, green technology' to drive measurable improvements and changes in the performance of key assets in climate controlled environments.

Australian made and patented technology with a long pedigree in health care and hospitals, Aeris solves real world problems more effectively than conventional toxic technologies. It is uniquely based on validated clean-tech solutions.

AerisGuard™ Corrosion Protection Plus demonstrates superior technical benefits:

- Salt spray resistance 20,000+ hours more than three times that of our nearest competitor
- Extend asset life
- Repairable Coating – Blue or Clear
- Applied to new or existing assets
- 5 year warranty when applied by trained applicators
- 10 year warranty when applied by OEM

AIRBLAST AUSTRALIA

Booth Number: 32
www.airblastaustralia.com.au | www.blastrac.com.au

For more than 40 years, Airblast has been the world leader in providing blasting and painting solutions to the anticorrosion industry. With an unparalleled network of offices around the world Airblast works closely with our customers and distribution partners providing field proven equipment as well as developing customised solutions for your specific application. With world class products come class leading solutions, with an unparalleled arsenal of surface treatment products including, Airblast Abrasives, Airblast blast room facilities, Airblast high production wheel blasting machines, Dust management, abrasive recycling, Blastrac grinding/scarifying and Graco.

With branches and Agents located across the country ready to help with all your surface preparation and coating application solutions, we have the best products to achieve the best results.

David Pocock or Ian Beets | Blastrac Surface Prep Equipment
Phone Number: +61 8 9271 2265 or +61 407 945 694
Email Address: david@airblastwa.com.au
or ian.beets@blastrac.com.au

AZKONOBEL – INTERNATIONAL

Booth Numbers: 2 & 3
www.international-pc.com

AkzoNobel creates everyday essentials to make people's lives more liveable and inspiring. As a leading global paints and coatings company and a major producer of specialty chemicals, we supply essential ingredients, essential protection and essential colour to industries and consumers worldwide. Backed by a pioneering heritage, our innovative products and sustainable technologies are designed to meet the growing demands of our fast-changing planet, while making life easier. Headquartered in Amsterdam, the Netherlands, we have approximately 45,000 people in around 80 countries, while our portfolio includes well-known brands such as Sikkens, International, Interpon and Eka. Consistently ranked as a leader in sustainability, we are dedicated to energizing cities and communities while creating a protected, colorful world where life is improved by what we do.

Karen Palin | Marketing Support Specialist
Phone Number: +61 7 3727 5148
Email Address: karen.palin@akzonobel.com

ANODE ENGINEERING

Booth Number: 5
www.anodeengineering.com

Anode Engineering Pty Ltd is a specialist product and service provider to the wider Australian, New Zealand and Pacific Rim asset integrity industry. Our long standing association with the industry has seen us develop relationships and corresponding expertise in providing cutting edge products, services and technology in corrosion management and prevention. With offices in Brisbane, Melbourne, Auckland and Wellington, our team are able to lead the industry in design, installation, commissioning and management of corrosion management and sytems including:

Anodes – CP systems, Instrumentation & Materials – Coating Assessments, Equipment & Services – Survey Services & Equipment – Remote Monitoring Systems – Corrosion Monitoring – Earthing/Surge Equipment – CP Backfills – Exothermic Welding – Holiday Detectors – MIJ's & Flange Isolation – Pile Protection & Anti-fouling – Nut & Bolt Protection – Staff Training – Vapour Phase Corrosion Inhibitors – Pipe Supports.

Wayne Burns | Managing Director
Phone Number: +61 7 38015521
Email Address: sales@anodeengineering.com

With thanks to our Media Partners:

AMAC

Booth Number: 45
www.amacgroup.com.au

Since 1974, we have been manufacturing cathodic protection systems in Melbourne. We specialise in producing the highest quality Aluminium, Magnesium and Zinc sacrificial anodes as well as impressed current anodes and related cathodic protection materials and equipment. Our continued accreditation to ISO9001 (since 1997) is testament to our product quality.

We continue design and manufacture products to suit every application and industry, while providing customers with a friendly and sincere service. Nothing is impossible for our diverse manufacturing team, and we welcome your enquiries.

Please come and have a chat at our stand in the exhibition.

Mark Rigg | General Manager
Phone Number: +61 3 9729 8888
Email Address: markrigg@amacgroup.com.au

ANTI CORROSION TECHNOLOGY

Booth Number: 43
www.anticorrosiontechnology.com

Anti Corrosion Technology (ACT) is an Australian-based engineering company that specializes in providing sustainable solutions in materials engineering and corrosion control by senior specialists for the oil & gas, water, mining, marine and power generation industries. ACT is also the authorised and sole distributor of STOPAQ systems in New Zealand and Australia offering unique and cost effective solutions for external pipeline corrosion protection including field joint coating, factory applied mainline coating, flange and valve protection, HDD, steel pipe casings under road & rail crossings as well as corrosion protection of tank bottoms and offshore/submerged structures such as platform risers, wharf piles and jacket legs.

Simon Ghobrial | Managing Director
Phone Number: +61 7 3344 4434
Email Address: info@anticorrosiontechnology.com

AUSTRALASIAN INDUSTRIAL WRAPPINGS & COATINGS PTY LTD

Booth Number: 44
www.aiwc.com.au

AIWC is a manufacturer and distributor of Petrolatum, bitumen, butyl, elastomeric and epoxy coatings.

After 19 years of manufacturing for the pipeline and corrosion industry, AIWC have further diversified and for over the last decade the company have been providing one stop shop solutions to the pipeline and marine industry.

Amongst some of the agencies AIWC represent are Viscotaq with their world renowned elastomeric tape coatings and Tinker & Rasor with their holiday detection equipment and corrosion monitoring products.

These products complement AIWC's pipeline and marine coatings which ensure AIWC are one of the market leaders with our worldwide distribution network.

AWS SERVICES

Booth Number: 72
www.awsservices.com.au

AWS Services is a multifaceted company based in Boronia, Melbourne with over 20 years of experience. Our expertise covers civil, commercial and residential sectors, and we offer a long range of services such as remedial works, waterproofing, caulking, plastering, painting, general construction etc.

Carlos Abreu
Phone Number: +61 425 720 268
Email Address: office@awsaus.com.au

BLASTONE

Booth Numbers: 36, 37 & 38
www.BlastOne.com

Originally established over 40 years ago to provide technical consulting, BlastOne has grown to become a single source supplier of blasting equipment, abrasives and know-how to customers all over the world. BlastOne operates internationally from several offices across Australia, New Zealand, North America and UK.

We stand behind our brand claim of Superior Performance. It's something we define as 'Performance3' – the result of combining superior know-how with superior abrasives and superior equipment.

In short, it's something that delivers greater cost-efficiencies for our customers.

Jim Gooden | Global Technical Director – Corrosion Control
Phone Number: +61 8 8292 2000
Email Address: jim.gooden@blastone.com

BLYGOLD OCEANIA

Booth Number: 56
www.blygold.com.au

Blygold prevents and stops corrosion in air conditioning & refrigeration systems with our unique anti-corrosion coating products. Blygold Oceania is part of Blygold International, being established for over 40 years with a reputation for excellence and quality of products and services. Blygold services many clients such as retail, airports, hospitals, hotels, oil & gas, mining and many other industries.

Blygold Treatment Benefits:
- save up to 20% on energy
- triple the lifespan
- increase reliability
- provide cleaner air

Specifications Blygold treatment:
- salt and acid resistant over 11,000 hours
- coating 25 to 30 microns
- full coverage, fins, copper tubes plus the connection between the fins and tubes
- metal pigmentation, conductivity stays high
- can be applied and maintained on site

Mark Weir | Managing Director
Phone Number International: +61 7 3807 0660
Phone Number Australia: 1300 271 115
Email Address: admin@blygold.com.au

BRISTLE BLASTER AUSTRALIA PTY LTD

Booth Numbers: 52, 53 & 54
www.bristleblaster.com.au

Bristle Blaster® Australia Pty Ltd is the proud Monti Partner for Australia, New Zealand, Papua New Guinea and New Caledonia. Monti is the manufacturer of Bristle Blaster® Surface Preparation Technologies.

Bristle Blaster® Australia Pty Ltd supplies and supports the Bristle Blaster® throughout a variety of industries, including pipeline, oil & gas, marine / shipyards, bridge maintenance, mining and construction, to mention a few. Based in Melbourne, we work closely with select local partners throughout the region to provide on-site service, training and support.

Contact the team at Bristle Blaster® Australia today to find out more about products and services.

Phone Number: + 61 3 9737 2800
Email Address: info@bristleblaster.com.au

CARBOLINE

Booth Number: 30
www.carbolineaustralia.com.au

Carboline is dedicated to supplying high performance coatings, linings and fireproofing products around the world through continuous technological improvements and superior service.

Our commitment to provide excellence in service and in product means our customers have access to the best possible coatings and solutions for superior corrosion and asset protection.

Altex Coatings is part of the Carboline global network. Since 1954 Altex has become one of the largest privately owned manufacturers of high performance coatings in Australasia. Supplying a wide range of coating types and systems for almost every major industry sector, with a strong focus in technology, training, staff and customer education. Altex Coatings Limited is a Resene Group company.

Ricky Collins
Phone Number: +64 075 411 221
Email Address: ricky@carboline.co.nz

CATHODIC ANODES AUSTRALASIA

Booth Number: 71
www.cathodicanodes.com.au

Since commencing manufacturing in 1984, we have established ourselves as Australia's largest galvanic anode manufacturer. Our foundry is designed based on Lean Manufacturing principals, where work flow efficiency gains and minimal down time has led to significantly shorter lead times and reduced energy use.

Our anodes protect billions of dollars' worth of infrastructure throughout Australia, the South Pacific and South East Asia including industrial anodes for offshore oil rigs, floating FPSOs, mining, construction and pipelines as well as for the protection of infrastructure such as ports, wharves, sheet pile walls and desalination plants. Our anodes also protect ships, yachts, marine motors, tanks and hot water systems.

Brent Linde | Business Development Manager
Phone Number: +61 7 5476 9788
Email Address: brent@cathodicanodes.com.au

The ACA will be launching its new C&P2017 App at this year's Conference in Sydney.
So make sure your mobile is fully charged and ready to go, to download the app.
Then you can search the program for your preferred sessions, presenters, locations and social functions.
We will produce a 'pocket program' for those who are still wedded to the paper version too!

CATHODIC PROTECTION CO LIMITED

Booth Number: 50
www.cathodic.co.uk

Cathodic Protection Co Limited, founded in 1950, was one of the first companies in the United Kingdom set up specifically to provide equipment and engineering services for the cathodic protection of pipelines, storage tanks, well casings, and marine structures for the oil, gas, petrochemical, water and power industries.

Following several successful years of growth, the company continues to expand its operations in Australasia, with its full range of cathodic protection and marine anti-fouling services and materials.

CERAMISPHERE

Booth Number: 59
www.ceramisphere.com

Ceramisphere is a micro-encapsulation company based in Sydney, Australia. We manufacture a series of new smart anticorrosive pigments: Inhibispheres™. This innovative and patented technology brings a range of unique benefits: the potential for metal free and environmentally friendly corrosion protection, the simplification of the paint system by reducing the number of coatings required for optimum protection, the ability to formulate inhibitors otherwise incompatible with the paint and the extension of the corrosion protection in time. In addition, Inhibispheres™ are very easy to incorporate in a wide range of paint formulations with no impact on the final (mechanical, optical and chemical) paint properties.

Ron Cozijnsen | Business Development Manager
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Mobile Number: +61 414 029 382
Email : roncozijnsen@ceramisphere.com

CHEMCO SPECIALITY COATINGS AUSTRALIA

Booth Number: 64
www.chemcosc.com.au

Chemco Specialty Coatings Australia is a world leader in innovative coating solutions. Our wide range and product adaptability covers many different industries, with our products used extensively in heavy industrial applications and challenging conditions. We focus on providing long term corrosion solutions, coating inspection and refurbishment of corroded equipment.

Our capabilities in industrial coatings specification, design review, project management and protective coatings application have been refined from over 30 years of experience.

Our expertise encompasses workshop based repairs or rehabilitation of industrial equipment and mobilisation to site, to reduce costs due to the onset of corrosion and improve operation efficiencies in the long-term.

CORROSION CONTROL ENGINEERING

Booth Number: 39
www.cceng.com.au | www.cceng.co.nz

Corrosion Control Engineering (CCE) is Australasia's leader in Cathodic Protection engineering, field services and materials supply. CCE has more NACE certified CP Specialists than any other company in Australia and operates 7 regional offices across Australia and New Zealand which are managed by Principal Engineers, each of whom have in excess of 30-40 years' experience in the corrosion control industry.

The CCE team consists of qualified professional engineers and technicians who have specialised in the field of corrosion prevention and Cathodic Protection for many years, and who are certified with the ACA and/or NACE International. CCE also supplies a wide range of CP and pipeline related products and materials to the industry.

CCE specialises in the design, supply, installation and monitoring of cathodic protection systems for:

- Pipelines, plants & facilities
- Ports, wharves and jetties
- Storage tanks & reservoirs
- Steel reinforced concrete
- Marine vessels
- Offshore structures

Jason Paterson
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DECORA GROUP PTY LTD

Booth Number: 35
www.decora.co.nz

The Decora Group has been manufacturing and distributing anti corrosive coatings for over 30 years. Located in Auckland, New Zealand the manufacturing facility produces an extensive range of decorative and industrial coatings. It is ISO 9001 and APAS certified, assuring quality coatings are produced to the most stringent quality control standards.

The Decora Group distributes ZRC, Camrex Camovin and Procoat ranges of anti-corrosive coatings to Australia, New Zealand and the Pacific Islands. For over 30 years our industry leading anti-corrosive coatings have been specified by architects and engineers for thousands of corrosion protection projects.

The Decora Group offers superior service, experienced technical back up, combined with industry leading product performance for extended longevity of corrosion protection.

Derek McClelland
Phone Number: +64 9813 5900
Mobile Number: +64 274 940 721
Email Address: derek@decora.co.nz

DENSO AUSTRALIA

Booth Numbers: 40 & 47
www.densoaustralia.com.au

Denso Australia is an industry leader in corrosion prevention and sealing technology and has been manufacturing and supplying corrosion prevention solutions to the Australian market since 1961.

The Denso range of global brands include Protal, SeaShield, Denso, PCS, Archo Rigidon and Sylglas.

Denso's extensive product range is suitable for use in a wide range of highly corrosive environments with operating temperatures ranging from sub-zero to 250 degrees celsius, across the pipeline, marine, tanking and structural markets. Denso will be showcasing a range of corrosion prevention products at its stand.

DETECTION SOLUTIONS

Booth Number: 19
www.detectionsolutions.com.au

Detection Solutions is a supplier of essential locating and specialist equipment to various industries such as plumbing, gas, power, construction, and also to local councils and government departments.

The Company has been in operation for over 25 years, hence enjoys an excellent reputation, with much repeat business from satisfied clients.

Our equipment works! Call us now to discuss your specific needs.

Phone Number: 1300 885 383
Email Address: info@detectionsolutions.com.au

DIRECT CONNECTIONS

Booth Number: 28
www.directconnections.com.au

Direct Connections is an innovative R&D company, designing and manufacturing equipment to support the corrosion mitigation industry.

We have engineered and produced numerous devices, although our main focus has been on Dataloggers for monitoring CP Systems.

Our new range of BLE Loggers allows unsurpassed flexibility with wireless control, using Smartphones, Tablets, Laptops, or even remote monitoring from anywhere in the world.

Minimising maintenance costs and downtime, the dataloggers are totally field-serviceable and field-calibratable. Their IP67 rated enclosure permits effortless access to the standard AA batteries, which power the datalogger's continual use for up to 2 years.

Nick Papas
Phone Number: +61 419 711 701
Email Address: nick.p@directconnections.com.au

DOCOPRO

Booth Number: 33
www.docopro.com

Docopro, an online document generation service, is now offering quality assurance and specification templates for industrial use. The initial template sets, which include Inspection and Test Plans (ITP) and Product Inspection Forms (PIF), are designed for the protective coatings industry and comply with coating systems standards in Australia, the U.S. and internationally.

The templates are downloadable on the company's website, docopro.com, in a format for electronic entries or as printouts for manual entries. The templates can be personalized with a company's name and logo, project name and description, and contact information.

Email Address: info@docopro.com

DST DRYER

Booth Number: 61
www.dstdryer.com.au

DST is one of the world's leading suppliers of desiccant dehumidifiers, represented in more than 40 countries. With strong ties to the Corrosion, Grit Blasting, Military, Museums and Power Stations, DST strives to maintain high standards of quality and level of humidity. DST has been using dry air as a method of preventing corrosion during surface preparation and coating, during the grit blasting process and to ensure readiness in military and power stations. Using dry air as a preventative method of reducing corrosion and mould is a cost-effective way of ensuring high standards of product and stable humidity conditions.

DEHUMIDIFICATION TECHNOLOGIES

Booth Number: 62
www.RentDH.com

DeHumidification Technologies, LP provides humidity and temperature control solutions to multiple industries in the US, Canada, Australia and Thailand. In addition to the highest quality equipment for every job, DH Tech is proud to have the most experienced and highly trained technical staff in the industry. Owners, Ken Armstrong and Brian Battle work closely with employees to deliver unparalleled customer service.

Ken Armstrong
Phone Number: 1-800-Rent-DH (736-834)
Email Address: karmstrong@rentdh.com

DULUX PROTECTIVE COATINGS

Booth Number: 55
www.duluxprotectivecoatings.com.au

Dulux Protective Coatings provides protection against corrosion, chemical attack, abrasion and impact damage in diverse, harsh and corrosive environments with our broad range of products. Heavy duty inorganic zinc silicate and zinc-rich epoxy primers, high build epoxies, chlorinated rubbers, epoxy-acrylic and polyurethane topcoats, micaceous iron oxide coatings, polyurea and heat resisting product lines are available from over 230 outlets across Australasia.

Dulux Protective Coatings' experienced technical consultants provide tailor made solutions for whatever your project demands, even for the most demanding and difficult conditions.

Call your local Dulux Protective Coatings Representative or Dulux Customer Service on 13 23 77. Contact us today at www.duluxprotectivecoatings.com.au.

Phone Number: 13 23 77

DUOGUARD AUSTRALIA

Booth Number: 17
www.duoguard.com.au

DuoGuard Australia are the sole distributors for Concrete Preservation Technologies range of DuoGuard and PatchGuard range of Hybrid and Galvanic anodes for complete leading edge corrosion solutions.

DuoGuard Australia also rely upon the Technical support provided by CPT research and development of new technologies for the treatment, assessment and monitoring of steel reinforced concrete structures and assets.

With over 40 years experience in corrosion management, we offer an innovative and flexible range of cutting edge products designed to effectively treat steel reinforced structures such as Wharves, Bridges, Bridge supports, culverts, high rise apartments and many more. We have installed our products into over 250 projects in 15 countries around the globe.

David Hadley | General Manager
Phone Number: +61 419 632 241
Email Address: david.hadley@duoguard.com.au

DURATEC AUSTRALIA

Booth Number: 63
www.duratecaustralia.com.au/

Duratec Australia is a solutions-based contractor specialising in the protection and remediation of steel and concrete structures.

With ten branches across Australia, we service the defence, mining, oil and gas and marine industries, along with government assets and commercial infrastructure.

Duratec's team of specialist structural, civil and corrosion engineers are committed to providing clients with best practice methodologies, material selection and innovative solutions to maximise the life of our clients' assets.

Our services:

- Concrete repair
- Flooring systems
- Cathodic protection
- Waterproofing
- Blasting & painting
- High performance coatings
- Structural strengthening
- Precision grouting
- Joint sealing
- Acid protection
- Specialist access systems
- Technical surveys

FAVCOTE | REZITECH SERVICES

Booth Number: 24
www.favcote.com | www.rezitech.com.au

Rezitech Services in alliance with Favcote are please to present the Belzona range of wear and chemical resistant metal, steel, rubber concrete coatings. Our companies supply and apply Belzona protective coatings which have many uses in all process industries including cold curing, wear resistant coatings providing similar wear rate to basalt tiles. Belzona protective coatings are used for internal lining of pipes, tanks, separators, production vessels, pylons and pumps for protection against erosion, corrosion and abrasive attack. Favcote are an experienced coatings applicator and abrasive blasting contractor experienced in the use of Sponge-Jet low dust abrasive blasting equipment. Sponge-Jet technology reduces the level of airborne particles typically experienced with more traditional dry blasting methods by up to 98%.

Bruno Favretti | Graeme Norris
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FOSROC

Booth Number: 48
www.parchem.com.au

Fosroc is an international leader in delivering Constructive Solutions for projects across a broad range of market segments. Our commitment to customer service and technical support is second to none.

We work closely with architects, structural engineers, contractors and owners to best understand their requirements and develop a bespoke solution for a construction project, adding value and becoming more than just a materials supplier.

Parchem Construction Supplies is a leading manufacturer and supplier of products and equipment to the Australian and New Zealand concrete and construction markets and is the sole licensee of the Fosroc brand in Australia and New Zealand.

Phone Number: 1300 787 737
Email Address: sales@parchem.com.au

FREYSSINET

Booth Numbers: 8 & 11
www.freyssinet.com

Offering integrated technical solutions in construction and structural repair, Freyssinet possesses an unparalleled array of civil engineering expertise in construction methods, post-tensioning, cable-stayed structures, structural accessories, repair, strengthening, cathodic protection, earthquake protection, and structural maintenance – on assets including bridges, tunnels, stadiums, power plants, LNG tanks, buildings, wharves, water tanks, and more.

Freyssinet offers extensive in-house design and technical capabilities with professional engineers and corrosion specialists including NACE and ACA certified Corrosion Technologists and Technicians – the most widely recognised qualifications for personnel demonstrating experience in designing, installing, commissioning, monitoring and maintaining CP systems.

HUMISCOPE

Booth Number: 25
www.humiscope.com.au

At Humiscope, we provide customised air treatment services to a diverse range of industries. Our key product lines are commercial and industrial dehumidifiers/humidifiers.

Humiscope strive to set standards of excellence in our industry in all aspects of selection, design and customer service. We accomplish this through quality work and clear communication between all team members including clients, mechanical contractors and consultants. Our wealth of technical expertise and over 20 years' experience help us to deliver the best possible solution to our customers and their budgets.

Melissa Le Roux
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Email Address: melissa@humiscope.com.au

IMATECH

Booth Number: 51
www.imatech.com.au

Imatech is one of the most innovative solution providers in the area of industrial wear protection solutions.

With over 30 years of combined practical experience with the best available products in the world, we have successfully expanded our presence in international markets and gained a reputation for continually delivering ground-breaking technological solutions in Asia-Pacific, South Africa, the Americas and Canada.

Our main area of operation is the mining & minerals processing Industry, where we provide a diverse range of solutions including engineered reinforced polymer composites, rubber-ceramic wear liners, rubber repair solutions, engineered abrasion resistant pipelines and pump efficiency solutions.

Phone Number: +61 2 8853 3000
Email Addresss: info@imatech.com.au

INTERPROVINCIAL CORROSION CONTROL

Booth Number: 46
www.rustrol.com

Interprovincial Corrosion Control features the most certified DC-Decoupling Device with the most extensive range of protection. The fail-safe, maintenance-free Rustrol® Model: DCD & Model: SSP are certified under the ATEX Directive, IECEx Scheme and KCs Marking for intended use in Gas & Dust explosive atmospheres, and bear the CE marking. The Rustrol® Model: SSP & Model: DCD effectively block the DC needed for cathodic protection, while simultaneously providing an effective AC continuity grounding path for AC fault current, lightning protection, mitigation of induced AC voltages, and also reduce and/or prevent the potential shock hazard to personnel and equipment, and AC Corrosion.

Please visit www.Rustrol.com to review the extensive range of Corrosion Control Products offered by ICCC.

JOTUN

Booth Numbers: 9 & 10
www.jotun.com

Jotun is one of the world's leading manufacturers of paints, coatings and powder coatings with over 9,600 employees with 68 companies and 33 production facilities on all continents. Jotun has agents, branch offices and distributors in more than 90 countries. Jotun Australia Pty Ltd supplies: Protective, Marine, Fire Protection Coatings and Powder Coatings nationally, providing a high level of local service, manufacturing locally while supported by Jotun's global strength to provide best practice solutions. Industries supported include Offshore Oil & Gas Production, Hydrocarbon Processing Industries (HPI), Energy, Mining, Infrastructure, Pipelines and maintenance. Marine Dry Dockings, Marine Vessel New Builds, Tank Coatings & Linings.

Ted Riding | Technical Manager
Phone Number: + 61 3 9314 0722

KK&S INSTRUMENTS

Booth Number: 60
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KK&S INSTRUMENTS
Quality is a necessity

The Best in Quality Service and Products for Non destructive testing. As an Australian owned company, KK&S Instruments established itself as a leader in materials analysis and has been providing Australian Industry with state of the art Non-Destructive Testing Technologies since 1977.

KK&S specialize in Coating Thickness Measurement & Analysis along with; Ultrasonic Thickness Gauging, Eddy Current Testing, Material Analysis, Ultrasonic Testing, Ferrite Measurement, Hardness Testing, Borescopes, Magnetic Inspection, X-ray, as well as Energy Dispersive x-ray fluorescence on a wide variety of products from base metals & Plastics through to Gold Assay.

Products provided through KK&S Instruments are on an exclusive basis from worldwide leaders in their field. Companies such as Karl Deutsch, Institute for Dr Foerster, Helmut Fischer, Henke Sass Wolf, Parker Research Corporation, Technisonic, Gilardoni, to name a few.

Our qualified staff has for over 35 years conducted Demonstration, Training and Service support on our wide range of NDT products to expand our business throughout Australia and regionally to incorporate New Zealand, Papua New Guinea, New Caledonia and Fiji.

Continuing with our long history in Non-Destructive Testing KK&S has completely updated our website, in order to provide the complete overview of our product range and the areas in which they are applicable. KK&S hopes the information contained on our website will assist you in contacting us and be a useful evaluation tool for now & in the future.

Phone Number: +61 2 8850 3755
Email Address: contact@kks.com.au

LET'S CLEAN PTY LTD

Booth Number: 65
www.letsclean.com.au

let's Clean
Heim Surface Technologies

Supplier of Innovative Equipment, Products and Techniques to the Restorative, Conservation and Heritage Cleaning Industry as well as other Specialised Cleaning requirements. We are now manufacturing, here in Australia, the New "CAPTIVE HEAD WASHING SYSTEM" for Reducing Salt Loads in porous materials like Brick – Masonry – Concrete – Timber – Sandstone to a depth of up to 150 mm, and it's proven it works.

The principle is that the hand held wash head contains a low pressure (70psi) spray nozzle which is connected to a water supply. A 'flexible' skirt encloses the head and seals the unit against the surface so that the attached vacuum system creates a negative pressure within the wash head which is greater than the capillary effect of the substrate. Waste water is collected into the vac tank which enables the operator to analyse for soluble salts by electrical conductivity.

With over 25 years in business we have become experts in paint stripping, removing sealers & varnish, removing mould, brick colouring, old fashioned corrosion control, efflorescence removal, façade cleaning, fire damage restoration cleaning, anti-graffiti coatings and designing special purpose cleaning tools techniques.

Products & Equipment includes "Blue Vac System", "JOS" , "Heritage No1" natural paint removal poultice, "Soy Gel", "Wonder Strip", "Super Strip", Mastic remover, "Rustmasters" and accessory Products.

To help with your projects we can send our experienced staff to carry out on site testing, producing as many test patches as required, using equipment & products which would be used to carry out the actual job. This service has proved invaluable in drawing up accurate specifications and costing at the pre-contract stage of a project.

Phone Number: +61 2 9451 8422

MARINE & CIVIL MAINTENANCE

Booth Number: 13
www.marineandcivil.com.au

MCM Marine & Civil Maintenance

Marine & Civil Maintenance Pty Ltd (MCM) is an engineering rehabilitation specialist. We rejuvenate critical ageing infrastructure such as wharves, bridges, buildings and industrial facilities by re-engineering and extending the asset's life through optimised Whole of Life solutions.

Over the last 16 years, MCM has built an enviable record of delivering high-quality engineered solutions in concrete repairs, cathodic protection, protective coatings, structural strengthening and other specialist activities. Embedded within our workforce, we bring this essential expertise and experience to ensure the successful completion of complex rehabilitation projects, whatever the location or scope.

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MRJ INDUSTRIAL SERVICES

Booth Number: 28
www.mrjindustrial.com.au

MRJ
Industrial Services Pty Ltd

MRJ Industrial Services provide services and products in the construction industry and are a company built on over 25 year's industry experience.

MRJ have partnered with leaders in the industry bringing the latest technologies to the Australian market from many corners of the globe.

MRJ offer supply, supply and install, training (on or offsite) and full specification services to architects, engineers, asset owners and end users with service based integrity, leaning on the vast experience of our international product partners.

MRJ's technologies are spread over a wide variety of market sectors including but not limited to mining, construction, marine, civil, commercial and residential.

Phone Number: +61 3 6268 6027 or +61 419 348 846
Email Address: admin@mrjindustrial.com.au

MUNTERS

Booth Number: 16
www.munters.com.au

Munters

Munters is a global leader in energy efficient air treatment solutions based on expertise in humidity and climate control technologies. We can deliver state of the art dehumidification equipment for short-term or long-term climate control to any location throughout Australia and New Zealand.

For over 60 years, Munters has engineered and manufactured equipment to solve humidity and climate control problems. Our technicians will install, set and monitor equipment throughout the duration of your project. Our technical expertise enables us to advise you on your optimal requirements, giving you reassurance that the job will be completed efficiently and cost-effectively.

We provide:

- Corrosion Control
- Surface Preparation & Protective Coating
- Utilities (Oil & Gas, Power Stations)

Khalid Shaikh | National Project Manager
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Email address: Khalid.Shaikh@munters.com.au

MURPHYS SPRAY & BLAST EQUIPMENT

Booth Number: 66
www.sprayandblast.com.au

MSBE MURPHYS SPRAY & BLAST EQUIPMENT

Murphys Spray and Blast Equipment was incorporated in 1984 and currently employs 17 staff. Now part of the Wagner Group of companies, the head office is situated in Wangara Western Australia, with representation in Victoria and New South Wales.

MSBE is the Authorised Australian distributor for Blast Vision products, Titan Speeflo spray equipment and Torbo Engineering Wet Abrasive Blasting equipment. Additionally MSBE is a Diamond distributor for Carlisle Finishing Brands which includes brands such as DeVilbiss, Binks, Samson, Arnold & Ransburg. Through their extensive distribution network, customers can access many leading brands covering all your spray and blast needs.

Brendan Murphy | General Manager
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Email Address: sales@sprayandblast.com.au

NACE INTERNATIONAL

Booth Number: 49
www.nace.org

NACE INTERNATIONAL

NACE International, The Worldwide Corrosion Authority, serves more than 36, 000 members in 130 countries and is recognized as the premier authority for corrosion control solutions. NACE International's global membership includes: engineers, inspectors, technicians, scientists, business owners, CEOs, researchers, educators, students, and other corrosion professionals. Located in Houston, Texas, with offices in the U.S., China, Malaysia, Saudi Arabia, and Brazil, the organization serves all industries impacted by corrosion.

NACE International is the key resource for corrosion prevention and mitigation, technical knowledge and information, conferences and exhibitions, industry standards, reports, publications, and the most specified technical training and certification programs worldwide.

Phone Number: +1 281 228 6200
Email Address: firstservice@nace.org

NATIONAL FACILITY FOR PIPELINE COATING ASSESSMENT

Booth number: 42
www.deakin.edu.au/ifm/our-facilities/national-facility-for-pipeline-coating-assessment

NFPCA National Facility for Pipeline Coating Assessment

The National Facility for Pipeline Coating Assessment (NFPCA) is an independent and NATA accredited testing facility jointly developed by the Energy Pipelines Cooperative Research Centre and Deakin University. It provides the technical capability and capacity required to perform a wide range of standard and custom-designed materials performance tests such as:

- Assessing the performance and failure of pipeline coatings;
- Evaluating the environmental degradation of materials such as plastic pipes;
- Testing corrosion susceptibility and behaviour of metals and alloys;
- Research on protective coatings, cathodic protection, corrosion monitoring, corrosion inhibitors etc.

NDT EQUIPMENT SALES

Booth Number: 57
www.ndt.com.au

ndt EQUIPMENT SALES

NDT Equipment Sales has been trading since 1992 and is a leading supplier of equipment for the inspection of valuable plant assets, including the detecting of Corrosion Under Insulation (CUI). Our extensive range of products include: gamma and x-ray equipment, radioactive sources, ultrasonic equipment, hardness testers, eddy current systems, magnetic particle equipment and consumables. We are proud to be distributors for a range of manufacturers, including: QSA Sentinel (OpenVisionTM), Lixi Inc. (The ProfilerTM), NOVO DR (Digital Radiography), Flyability (Elios Drone) and Elektrophysik, amongst others.

Rod Martin | Manager
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NMT ELECTRODES

Booth Number: 41
www.nmtelectrodes.com

NMT® Electrodes is a well-established name in providing high quality, cost effective solutions and products in the field of Cathodic Protection. NMT® Electrodes' Mixed Metal Oxide (MMO) and Platinised titanium Anodes are the products of choice and are used and specified worldwide for use in concrete, underground storage tanks, pipelines, offshore and marine installations among numerous other applications. NMT® Electrodes' full range of tubular, wire, ribbon, rod, mesh, mesh ribbon and plate anodes are available from its Australian and South African facilities.

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Email Address: kim@nmtelectrodes.com

OLYMPUS

Booth Number: 70
www.olympus-ims.com

Olympus is a world-leading manufacturer and distributor of high-quality optical, electronic and precision engineering products, for scientific, medical and industrial applications. The Olympus industrial leading edge testing technologies include remote visual inspection, microscopy, ultrasound, phased array, eddy current, eddy current array, X-ray fluorescence and diffraction.

The Olympus products include ultrasonic flaw detectors and thickness gages, videoscopes, borescopes, microscopes, high speed video cameras, in-line and advanced nondestructive testing systems, XRF and XRD analyzers, interferometers, and a large selection of industrial scanners, probes, software programs, and instrument accessories.

Phone Number: 1300 132 992
Email Address: info@olympus.com.au

OMNIFLEX

Booth Number: 4
www.omniflex.com.au

Omniflex has been designing and manufacturing electronic products and systems for the automation and control industry since 1965. We specialise in providing solutions to industry in the fields of Remote Monitoring and Cathodic Protection (CP) Systems for both galvanic and impressed current applications.

Omniflex's PowerView CP system integrates world leading technology in distributed CP systems with full web-based remote monitoring, testing and control to provide significant cost saving in both installation and ongoing monitoring.

The PowerView CP system harnesses our depth of experience in harsh environments to bring reliable enterprise wide solutions to the challenges associated with installing and managing cathodic protection systems in difficult locations spread over remote locations.

PAPWORTHS CONSTRUCTION TESTING EQUIPMENT

Booth Number: 18
www.pcte.com.au

PCTE specialises in the sale and hire of testing equipment for construction materials. That includes field testing equipment (non-destructive testing equipment), laboratory test equipment as well as geotechnical and structural monitoring sensors.

For corrosion investigations on concrete structures, they carry a broad range of equipment vital to determining the extent of corrosion such; as cover meters, potential mapping equipment and resistivity meters. PCTE also supply a range of corrosion activity monitoring probes and data logging equipment.

Finally, PCTE supply coating inspection equipment for use over ferrous or nonferrous metals, or with a concrete substrate.

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PHILLRO INDUSTRIES

Booth Number: 20
www.phillro.com.au

Founded in 1971, Phillro Industries have grown to be a respected specialised supplier of high quality products and equipment including:

- NDT (Ultrasonic Non Destructive Testing)
- Enterprise training Coatings fluid transfer pumps
- Spraying and Finishing Guns, Hoses and Systems
- Spray Booth Filtration
- Associated Safety products
- Solvent Recovery
- Food and Pharmaceutical Fluid Transfer
- Coatings Inspection
- Concrete Inspection
- Metal Detection

They are also trained and authorised service and repairers of Major Brands such as Graco & Ciemme. As the Principal Australasian/ Oceania Importer Distributor for Elcometer Ltd, Phillro are the only Elcometer authorised Service centre in the region.

Phillro's activities include focussed Product Training, Sales, Service and Hire of Equipment manufactured by the world's most respected Brands.

Paul Jenkins
Phone Number: 1300 503 610
paulj@phillro.com.au

PPG

Booth Number: 6
www.ppg.com

We protect and beautify the world™

PPG Protective & Marine Coatings (PPG) has products that protect customers' assets in the world's most demanding conditions and environments. Our exceptional heritage has resulted in a range of brands that are tried and trusted to deliver consistent performance in their given markets.

All brands have PPG Protective & Marine Coatings as an endorsement, benefiting from unparalleled levels of experience and expertise in coatings technology. Working closely with our customers, we blend technical and business skills creating solutions to meet the constantly changing demands in all sectors.

As part of PPG Industries, we are uniquely placed to offer a complete service, so you will enjoy the resources, stability and capability of a worldwide organization. Our business is built on firm foundations, enabling us to provide not only market-leading products and services, but also a level of support unmatched in the market.

Graeme Gunston
Phone Number: +61 417 717 937
Email Address: gunston@ppg.com

PRODIGITEK

Booth Number: 29
www.prodigitek.com

ProDigitek

As the Australian representative for BioLogic Science Instruments, ProDigitek, based in Seven Hills NSW, offers the most cost effective Potentiostats to the scientific community involved in Corrosion and Coatings research, aimed toward developing products to improve corrosion prevention. Whether in the Laboratory or the field, solutions provided by ProDigitek include high end research equipment to Universities, Government and Industry.

When you buy from ProDigitek you don't just buy the equipment but also over 30 years of expertise in the use of such equipment which is also supported by a global support team with several years of field experience.

The ACA will be launching its new C&P2017 App at this year's Conference in Sydney.

So make sure your mobile is fully charged and ready to go, to download the app.

Then you can search the program for your preferred sessions, presenters, locations and social functions.

We will produce a 'pocket program' for those who are still wedded to the paper version too!

RUSSELL FRASER SALES | RFS

Booth Number: 14
www.rfsales.com.au

RFS NDT Russell Fraser Sales inspection & testing equipment

Russell Fraser Sales (RFS) has served Australia's inspection and testing community since 1993 and along with its team of 10 staff, RFS has sustained its position as Australia's most trusted NDT equipment supplier by staying ahead of the changing needs of industry. For the corrosion mitigation industry RFS supplies 3D Laser Scanners for pipeline integrity assessment, Ultrasonic Thickness Gauges, Ultrasonic Phased Array, Holiday Detectors, Thermal Imagers, Videoscopes and more; many of which will be showcased on stand #14. RFS has also launched an innovative approach to NDT product video reviews on YouTube with the series "unboxing NDT" offering a detailed look at precisely what's in the box.

Phone Number: +61 2 9545 4433
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SAVCOR PRODUCTS AUSTRALIA

Booth Number: 58
www.savcorproducts.com.au

SPA
SAVCOR PRODUCTS AUSTRALIA PTY LTD

Savcor Products Australia (SPA) is one of the leading distributors of brand name corrosion products in Australia.

The company provides expert technical support for a wide range of corrosion products including materials for cathodic protection systems.

SPA also focuses on fast responses to enquiries, and can often deliver various products directly from stockpiles, which substantially reduces the waiting time for customers.

SIKA TECHNICAL EXCELLENCE

Booth Number: 7
www.sika.com

Sika®
BUILDING TRUST

With 84 ICRI awards in 16 years, Sika is the global company with the most concrete repair projects awarded by the International Concrete Repair Institute (ICRI).

Sika is a global leader in speciality chemical product supply for the building and construction industry, Sika Australia prides itself on being technically driven and project-motivated. Our product line features high-quality concrete repair mortars, Latest technology corrosion control solutions including corrosion inhibitors and sacrificial and hybrid anodes, concrete admixtures, specialty grouts, sealants and adhesives, structural strengthening systems, industrial flooring as well as roofing and waterproofing systems.

SN INTEGRITY PTY LTD

Booth Number: 69
www.sensornetworkscorp.com

SN Integrity

SN Integrity Pty Ltd has been established as an engineering company in Australia to provide smart solutions for asset integrity. We are Australian and New Zealand business partners for USA Company Sensor Networks Inc. We offer the very best minds in the highly specialized fields of ultrasonic and remote visual technologies. We deliver smarter solutions with a refreshingly personalized approach to the world's critical asset management applications. We specialize in the design and fabrication of industrial ultrasonic transducers and tooling for demanding in-situ test and inspection applications.

Telephone number: +61 8 7220 6670
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SVENIC

Booth Number: 21
www.svenic.com.au

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The Complete Solution Since 1984

Svenic will be exhibiting its Coating and Foam (CAF) Spray System. This portable and lightweight system sprays paints, coatings, sealants, adhesives, foams, polyurethanes, and polyureas using 2 part cartridges and static mixers. It is excellent for use in confined spaces, repair jobs, and smaller applications. Material wastage is significantly reduced. CAF requires minimal set up time, training, clean up and machinery maintenance. More expensive 2 part pumps are not required.

Svenic also provides filling, labelling, and assembly of two part cartridges, syringes, and other containers filled with sealants, adhesives, coatings and foams.

We also supply:

- Crack Injection Components and Accessories
- Manual, Air and Battery Operated Dispensers
- Advise, testing and package suitability
- 2 part cartridges and static mixers

Contact Person: Peter Coundouris
Phone Number: +61 7 5539 2255
Email Address: peter@svenic.com.au

TECHNOSEAL

Booth Number: 34
www.tecnoseal.it

TECNOSEAL

Tecnoseal is one of the world's leading suppliers of sacrificial anodes for cathodic protection in the leisure boat market, and for shipping, offshore and industrial applications. With over 30 years of experience, we produce and supply from our foundry in Grosseto (Tuscany) zinc, aluminum and magnesium anodes with our own peculiar passion for seeking top quality perfection of the product and the customer service.

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UNIVERSAL CORROSION CONTROL

Booth Number: 1
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wattyl®
Protective Coatings

Wattyl Protective Coatings is a leading paint and coatings manufacturer in Australasian, specializing in high performance protective and marine coating solutions across a vast range of industries. Markets we operate in are: oil and gas, mining. water and waste, power, marine, OEM, as well as infrastructure and fireproofing. Wattyl's engineered solutions are designed to optimize the life of our customers' assets, provide maximum cost effectiveness, and deliver brilliant aesthetics. Wattyl's Epinamel® epoxies, Poly U™ polyurethanes, Galvit® zinc primers and, Seapro® anti-fouling range are well known brands that have been protecting major assets for over 40 years, a testament to the enduring performance of our product capabilities. As part of the Sherwin Williams group, Wattyl is committed to bringing the latest technologies, expertise and experience from the world's largest coatings company – straight to you.

Jasmine Moey | Marketing Manager
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DULUX
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WE'RE HERE.
Protecting assets across Australasia for over 80 years, Dulux Protective Coatings' experienced consultants provide tailor made solutions for whatever your project needs, even for the most demanding and difficult conditions. Dulux Protective Coatings supplies a premium range of coatings for protection against corrosion, chemical attack, abrasion and impact damage in diverse, harsh and corrosive environments from over 230 outlets across Australasia.
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Dulux®
PROTECTIVE COATINGS
Protecting Australasia's Assets
City Beach Shade Structure WA ©Dulux® Protective Coatings

Eptec

Q: In what year was your company established?

A: Eptec Group was established in 1997 when the co-founder, Enrico Piccioli, left his role at Transfield to set up his own business. In September this year, Eptec will be celebrating our 20th anniversary!

Q: How many employees did you employ when you first started the business?

A: When Eptec first started, we only employed a grand total of 3!

Q: How many do you currently employ?

A: Currently, Eptec Group employs approximately over 200 direct employees.

Q: Do you operate from a number of locations in Australia?

A: Eptec has had a national presence since 1998 when we commenced services in WA. The business currently has permanent offices in NSW, SA and WA, but operations can occur wherever the job takes us.

Q: What is your core business? (e.g. blasting and painting, rubber lining, waterjetting, laminating, insulation, flooring etc.)

A: Eptec's core business is the Preservation and Rehabilitation of Assets. We have developed the full range of capabilities to meet the requirements of asset owners, irrespective of whether we are dealing with steel, concrete or GRE/GRP structures. Blasting & Painting, Concrete Remediation and Waterproofing are the typical services provided, but we have a broad engineering capability to address most forms of asset degradation.

Q: What markets do you cover with your products or services? e.g. oil & gas, marine, chemical process, general fabrication, tank lining, offshore etc.

A: Our markets can be broken down into 5 broad sectors:

- Buildings & Facilities
- Energy & Resources
- Naval Defence & Marine
- Transport & Infrastructure
- Water & Wastewater

Our expertise is however, in our ability to preserve and protect assets and includes a diverse range of structures from ships, to bridges, to tanks.

Q: Is the business yard based, site based or both?

A: We are a site operator and have built a flexible, multi-skilled workforce designed to rapidly mobilise anywhere in Australia. Indeed, some of our most interesting work has been in the most remote parts of the country.

Q: What is your monthly capacity or tonnage that you can blast and prime?

A: As a site based contractor, we have never failed to meet a client's requirements and will rapidly scale to meet most demands.

Q: Do you offer any specialty services outside your core business? (eg. primary yard based but will do site touch up etc.)

A: We pride ourselves in our ability to find innovative solutions to rehabilitate assets. Whether this is development of specialist equipment for Trench Breakers, Sewer Pipe Lining, or underground soil consolidation structures using chemical injection, it is our ability to think outside the square which often brings the greatest benefits and satisfaction to our clients.

Q: What is the most satisfying project that you have completed in the past two years and why?

A: The most recent project is the blasting and painting of Albert Bridge in Queensland, Australia. This one is particularly significant due to it being Eptec's first rail bridge rehabilitation work completed under live power and operating conditions. Our innovative solution ensured no disruption to the running rail line, paving a precedent for future infrastructure projects.

Eptec has recently been awarded the rehabilitation of Peats Ferry Bridge, North of Sydney. At the time of construction, Peats Ferry Bridge was designed with the largest steel trusses for road bridgework in Australia at 438ft (133.5m). The rehabilitation project is forecasted to be completed in late 2018, and is one of Eptec's larger projects.

Q: What positive advice can you pass on to the Coatings Group from that satisfying project or job?

A: As with every job, fully understanding the client's requirements is essential, both in terms of quality but also program and management of risk.

Q: Do you have an internal training scheme or do you outsource training for your employees?

A: We utilise both internal training as well as third party external training. The industry expects far greater capability from its contractors and internationally recognised qualifications and certifications such as NACE and PCCP are now our benchmark. These can only be achieved through structured external training sources. We are also working closely with equipment suppliers who frequently organise specific training on the latest equipment and products on the market. Our overriding aim is to ensure that we can offer our clients the most advanced and appropriate solution to meet their needs safely, on time and on budget.

Contact:

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Fax: +61 2 9034 6970
Email: eptec@eptec.com.au
Web: www.eptec.com.au

The University of Newcastle

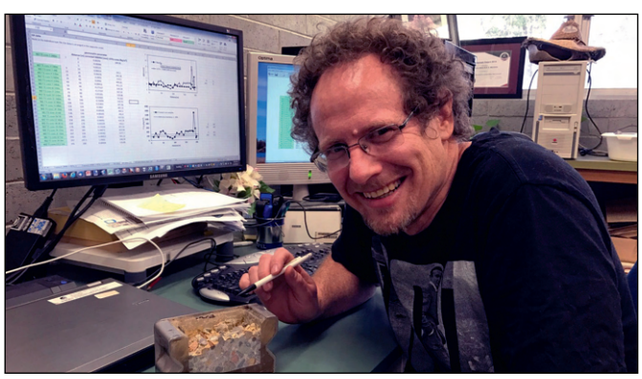
The corrosion research team at The University of Newcastle continues to focus strongly on infrastructure related research and applications projects. These are funded by the Australian Research Council and by industry. The main background of the group is on marine corrosion of steels, such as in immersed, tidal and splash zone, and also in coastal and other atmospheric conditions. More recently attention has turned also to marine corrosion of structural aluminium alloys, corrosion of cast irons and steel buried in the ground, such as for cast iron water mains and bridge piers of older rail and road bridges, and the corrosion of offshore facilities such as Floating, Production, Storage and Offloading (FPSO) platforms and maritime vessels. A short summary of the main on-going (and new) projects follows.

1. Atmospheric corrosion of steels in a variety of exposure conditions, including the potential effect of microbiologically influenced corrosion. This project, nearing completion after substantial ARC funding, and in the process of being written-up comprehensively (although there are several conference papers) has considered the orientation aspects of exposed surfaces and their respective corrosion losses over several years. It also has found the presence of quite different species of microorganisms in the varied exposure environments. Prof Rob Melchers and Dr Robert Jeffrey are the main investigators in this project. It also involved Dr Laura Machuca from Curtin University for DNA-related analyses.

2. Marine corrosion related to offshore oil production systems. FPSO platforms are major maritime assets for the international oil and gas industry. The UoN corrosion group acted as the corrosion researchers for a major JIP (named SCORCH – seawater corrosion of ropes and chains) managed by Melbourne based consultant AMOG. Nearly all the international oil majors funded the project, together with various equipment and service suppliers. Some information is available on the web and a few papers describe overviews of the project but details are still subject to IP restrictions. Subsequent developments include the oil-industry-funded Deepstar Joint Industrial Project on MIC of mooring systems project that involved UoN (Rob Melchers) and researchers from the University of Oklahoma (Prof Iwona Beech, Dr Jan Summer and their teams), with whom the UoN corrosion group continues to have research interactions. Also in the offshore research area, Research student Daniel Wang recently completed studies of the corrosion of water injection pipelines used in the oil and gas industry to increase reservoir yield. He tested the corrosion of the mild steels typically used in the industry under deposits of debris typically found in the pipes and under stagnant, very low DO water conditions, including with high nutrient contents to boost microbiological activity and corrosion. Studies by Dr Mukshed Ahammed of the pitting corrosion of those pipes using data supplied by Statoil are showing that the conventional ideas of extreme value analysis need some revisiting. This has been presented at international conferences such as the International Society of Offshore and Polar Engineers.

3. In-ground corrosion of cast iron water mains. This is a very significant research project with funding provided by Australian, UK and US water utilities, led by Sydney Water. There are extensive networks of cast iron water mains in all major cities and their apparently unpredictable failure is a major concern for water utilities world-wide. The project is run in conjunction with Monash University and with UTS. The Newcastle work has focused on the development of analytical, physical chemistry based models for the prediction of the corrosion and pitting of cast iron water supply main pipes buried in various soils and potentially subject to microbiologically influenced corrosion. The models are now being calibrated to real-world data. Much of the detailed work for this is being done by Dr Tony Wells and Dr Robert Petersen. They have been processing much field data and also designing and running specialist tests to try to elucidate some aspects currently not well understood. These include the precise effect of moisture in soils on corrosion in clays, and the (slow) transport of moisture, most likely with chemical composition, along the soil-metal interface. The project team, with the water utilities, was awarded the International Water Association Award for Innovation in the Applied Research Category.

4. Interior corrosion of offshore wind farm pods. This new project builds on the very successful research and practical outcomes from the Accelerated Low Water Corrosion research, that was part of coastal marine corrosion studies funded by the ARC. For this new project Rob Melchers and Robert Jeffrey obtained ARC funding to investigate the interior corrosion of the tall towers used to support offshore wind energy generators. This project is using field trials at several locations and will build models for prediction. It is supported by Igor Chaves.



Tony Wells with a sectioned, very heavily corroded concrete surface of one sample of the many coupons exposed for up to 7 years in working sewers.

Igor Chaves examining some of the concrete samples used in the reinforcement corrosion study.

5. Marine corrosion at the steel-sand interface. This also is a recently commenced project funded by an ARC Discovery grant awarded to Rob Melchers and Igor Chaves (UoN) and Associate Prof Bobby Mathan (James Cook U). It was one of a very few new Discovery grants awarded in the latest round. This project is concerned with the short and the long term corrosion of steels in contact with seawater and with marine sands, and considers the possibility of microbial corrosion being fostered by such contact, both short term and long term. Research student Md. Maruf Hussain and Dr Robert Petersen are contributing to the project.

6. Maritime assets subject to extreme loads, fatigue and corrosion. This, the latest project for the corrosion group, commenced during 2017. It is industry-driven and funded by an ARC Linkage project. It focusses on the long-term prediction of deterioration of ships and maritime assets under various sea-states and with corrosion and fatigue contributing to deterioration. The Linkage grant was awarded to Prof Rob Melchers (UoN) and Prof Chongmin Song (UNSW), with Pacific ESI as the major industry partner and with the support of Defence Science and Technology (formerly DSTO). Research Associate for the project is Bruce Cartwright, who has much practical experience in industry.

7. Corrosion of welds. Initially proposed by industry contacts, this project focused on the welds of steel pipelines exposed to seawater immersion environments. The publications have been widely quoted and are of much interest in applications. The work is now being extended by research students Simon Krismer and Jeremy Rosen working with Igor Chaves and Rob Melchers. They are considering various steels and weld electrodes and examining the influence of steel microstructure as well as the possible influence of microbiological corrosion around the weld zone. Its outcomes are anticipated to feed into the project on maritime assets.

8. Reinforcement corrosion. Occasionally researchers have the opportunity to do some really long-term experiments, and this is one of them – running now for more than 15 years. It is investigating, experimentally in real-time and under real conditions, the corrosion of reinforcement when the concretes are made with seawater, even though this has long been prohibited. Current outcomes of the project were reported at the Brian Cherry Concrete symposium in Melbourne recently. In brief, they show that the role of chlorides is widely misunderstood. New mechanisms are proposed based on actual observations, not theory. A somewhat related project is the corrosion of brick-ties used extensively in housing. Research student Barbara Jardim Do Nascimento has commenced working on this with Igor Chaves and Associate Prof. Mark Masia.

Members of the UoN corrosion research group continue to be active in presenting papers at various conferences. Almost all presented papers at the annual ACA 2016 Corrosion and Prevention conference and many will do so again in Sydney in 2017. Recent highlights include that one of our 4th year Engineering students, Dylan Pearce, received the 2016 ACA Foundation first time attendee award while Igor Chaves was awarded the prestigious ACA Brian Cherry International Travel Award for 2016. He has used it for an intense study trip to leading corrosion institutes and organizations, mainly in France, including presenting 2 papers at the European Corrosion conference in Prague and technical seminar presentations at DCNS (now Naval) in Cherbourg (F), LaRochelle University (F) and at the Institut de la Corrosion in Brest (F). Also during 2017, Rob Melchers gave keynote lectures on corrosion modelling relevant to the oil industry at the San Diego meeting of the International Symposium on Applied Microbiology and Molecular Biology in Oil Systems, a forum composed largely of microbiologists and molecular biologists as well as oil industry participants. He also gave keynote talks at the International Symposiumon Life Cycle Civil Engineering conference in Delft, where Dr Tony Wells and Dr Robert Petersen also gave technical papers, at a marine corrosion seminar at the Antwerp Maritime Academy, and at the Brian Cherry Concrete symposium in Melbourne.

Our technical staff, both in the School of Engineering and in Central Services, contribute much to the success of the corrosion group. We much appreciate their support - and they really deserve a special public 'thank you'.

The Corrosion group has access to all the usual equipment, including microscopes, SEM-EDS, XRD, Raman, electrochemical gear, field testing gear and, most recently, up-graded its digital scanner to a much more accurate model and applicable to measuring pit depths after realistic exposure periods. A major asset for the group is the dedicated sea water testing facility at Taylors Beach where natural seawater as well as nutrient-dosed and sterile seawater is available for longer term testing. This facility has been mentioned already in numerous papers published in the major corrosion journals.

Finally, if you want to see how many papers our team members have published, the research grants they obtained and the industry-related projects they are involved in, just look up the UoN website – it is all there.

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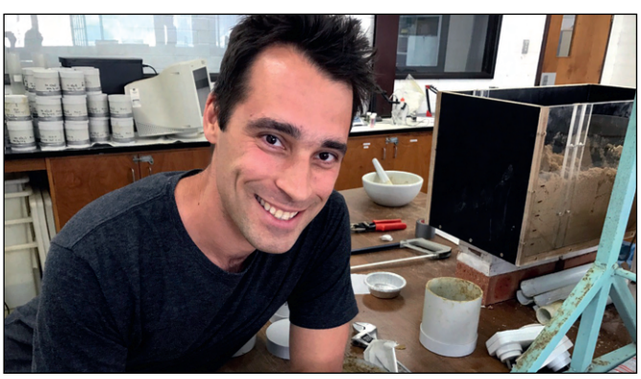


Robert Petersen with one of his experimental samples for the study of clay soil corrosivity.

Part of a 76 mm diameter steel mooring chain link showing some of the severe corrosion found as part of the SCORCH project.

Water Leaks in Multi-storey Buildings & Corrosion Problems

The world was going crazy over Panama leaks. The scale of this leak is the largest that the world has come across to date. Yet there is another even bigger leakage problem that the Construction world needs to be concerned about – water leaks. These are exceedingly detrimental to the health of high rise buildings. Water can enter the building envelope through many different paths – from damp construction materials during the building phase, through leaking roofs, basements, wet areas and leaking water installations. Concrete being a semi-permeable material, water can find its way in and it can readily spread. If the source of the water leakage is left unattended it can cause significant structural damage that often needs very expensive rectification to structural elements.

Many reports and studies identified water leaks as the most common defect in buildings, regardless of country or location. Water leakage is the major cause of early onset of corrosion and concrete deterioration. Initiation of corrosion and depassivation of reinforcement is only possible in the presence of water, oxygen and corrosive agents such as chlorides and carbon dioxide. Leaking water in reinforced concrete acts as a perfect medium to bring electrolytes to corroding interfaces and is well documented. Water leakage in buildings results mainly from inadequate construction design, inferior materials, poor workmanship and deterioration of building materials.

A Double Edged Sword Effect: Water leakage in multi storey buildings not only initiates corrosion problems in private residential multi-storey buildings but it also leads to a serious threat to hygiene. Wong and Hui, (2005), revealed that the failure of sanitary fittings, inadequate maintenance of sewer piping system and defects to waterproofing membranes in wet areas can cause dampness and seepage inside the buildings. In Hong Kong, the Department of Health identified water seepages in buildings as the possible source of the outbreak of the severe acute respiratory syndrome (SARS) epidemic in 2003. Water leakages in the buildings due to poor maintenance and building defects can lead to growth of toxic moulds that can cause serious health and safety issues for the occupants. There is also established evidence of the relationship between water leaks in buildings and respiratrory symptons in occupants.

Wet Areas and Roof Water Leaks: Ceiling leaks from bathrooms of the upper floors is the last thing one would like to experience. The water leak makes its way across the ceilings below causing damp patches and even worse when it starts to drip steadily. One of the main reasons of leakages in bathrooms, toilets and other wet areas is due to the failure of waterproofing membranes. Their installations in wet areas should be designed to allow prompt detection of leaking water and easy access for repair.

Leaks in wet areas of high-rise buildings, has resulted in a high number of defects in most countries around the world. The annual maintenance cost for wet areas is about 40 per cent of the total maintenance cost of a building (Chew and De Silva, 2004). With growing maintenance costs of existing buildings and facilities, researchers worldwide emphasize the importance of awareness of the root cause of the failures. Interestingly, a few studies revealed that the damage in these areas occurs when the bathrooms are relatively new, implying that the damage is not mainly due to poor maintenance; rather incorrect workmanship and use of inferior materials are the main culprits. In addition, it is a failure of the contract management system that did not detect the defects before it was too late to make corrections.

Bathroom ceiling corrosion problems in multi storey buildings.

Water seepage from leaking bathroom to external building facade.

Roof leakage causes severe corrosion.

Delamination of paint due to roof leakage.

The aggressive effects of external weathering on roofs make them more vulnerable due to deterioration. Roofs suffering from leaks could not only cause serious damage to structures but also pose a great risk of injury. Symptoms such as dripping water, damp patches, paint peeling-off, rust stains on the ceiling indicate that the roof waterproofing system is not performing. Due to a combination of lack of awareness and expediency, the ceiling is normally cosmetically repaired with 'masala mortar' without addressing the source of leaks. Consistent leaks from top roofs and wet areas of the upper levels can initiate corrosion of the reinforcement causing concrete spalling, which can turn into a soffit collapse.

A large percentage of seepage and moisture related defects in buildings originate from rain. Roof leakage in the buildings result in seepage to the flats below that causes discomfort to the occupants and frequent disputes between the landlord and the tenant in regard to the liability to repair. A research conducted by Lo, Leung and Cui (2005), on roof construction defects highlighted that the root cause of failure of the roof waterproofing membrane stems from the cracks in the roof parapet walls. It further concluded that the design and choice of material for roof parapet walls is critical to avoid failures of the waterproofing membrane on the roof slab.

Leaking Balconies Syndrome – External balconies form an integral part of multi storey apartment buildings. Water leaks in balconies can easily trigger the electrochemical corrosion process because these are subjected to more aggressive environments, resulting in damaged and spalling concrete. Balcony blunders can be classified into issues associated with a lack of understanding of the nature of the site, such as wind-borne salts and the normal seasonal changes in temperature and relative humidity. The more manageable issues include factors such as leakage due to failure of waterproofing membrane, inadequate drain slope, poor design, inadequate detailing, poor workmanship or a combination of these factors. The affected balconies, if they remain unattended, present both a danger to the structural integrity of building and the health and safety of the occupants. Inferior quality waterproofing membrane is one of the contributing factors of balconies failure. The use of a thin film instead of a robust tenacious waterproofing membrane to waterproof balconies must be discouraged.

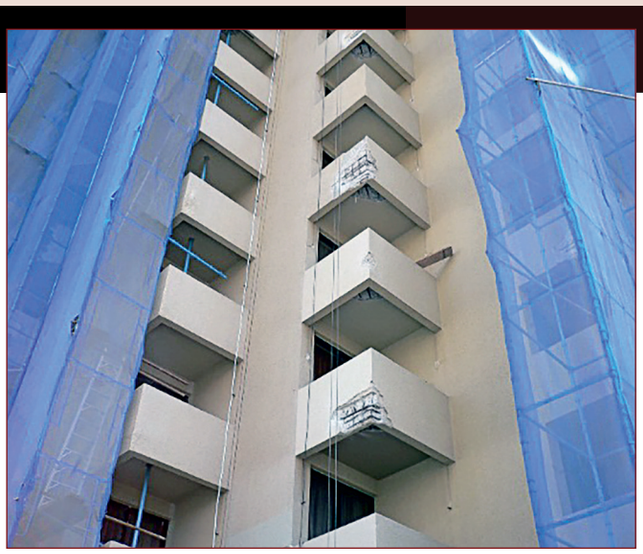
Concrete being the first line of defence, the cantilever structural element should be cast with high quality concrete. If screed is used to form slopes, it should have additional waterproofing properties using rubber latex emulsion. Water resistant tile adhesive and tile grouts should be specified to fix the final finish tiles with an adequate slope and drainage details.

Working Backward Approach – Avoid Swimming in Basements: Leakage into basements may be attributed to many factors such as poor selection of the waterproofing system, inadequate detailing for joints and other critical locations, inadequate drainage design, poor concrete quality and workmanship, damage to waterproofing membrane, ground water level rise to name but a few factors. An interesting analogy by Chew and De Silva (2003) suggests that water seepage signs appear from the basement ceiling are not always related to the above factors but could also originate from the non-basement features of above ground landscaping, water features, swimming pools or water ponding. Insufficient slope or clogged drainage of the planter structures can result in moist patches that, if unattended, lead to seepage and algae growth on basement ceiling finishes. (Chew and De Silva, 2003).

Rising levels of the ground water table in urban areas can have serious implications to basements. The rise of ground water level (GWL) could be due to seasonal rise, capillary action or closure of dewatering activity in the surrounding neighbourhood construction sites. The structures designed without considering the obvious risks of GWL rise and the resulting hydrostatic pressure associated with water leakage is a serious risk. With sea water leakage, the structural integrity of basements is seriously compromised, as the chloride content of the concrete may rise above the threshold level resulting in severe corrosion problems. The challenges of soil mechanics and groundwater conditions need to be considered during design stage and a site specific waterproofing system should be selected for the structure against ground water infiltration.

There is a saying that 100 steps backward are as good as 1000 steps forward. (Busch, 2013). Suppose, a manager of a newly opened restaurant is suddenly given a task to take-action to cause the restaurant business to fail. Key factors that could lead to the failure of the newly set-up venture? Some methods guaranteed to induce failure include serving rotten food in dirty chipped plates by non-professional staff, or the dining area is greasy and dirty. The end result would be the failure and closure of the restaurant. Now, if the restaurant needs to succeed, then working on the lessons learned from the backward approach, the manager would need to avoid the above failure factors. By inverting the process, the manager would recruit trained and qualified staff, use only good quality crockery, adopt the best hygiene practices and so on.

Similarly, working backwards is the best approach to avoid basement leaks. In other words, it means injecting error proofing in waterproofing activity. Most contractors and engineers have a



Balconies concrete spalling.

Damage from leakage in balconies.

linear way of thinking to perform their tasks. Engineers appreciate rationality, consistency, the common sense, one-step-forward-at-a time approach (Busch, 2013) to perform site activities and it all makes good sense but at the same time reversing the order of one's approach has its advantages too, as it challenges the brain to think in an unconventional way. Assume, if a project manager at a new construction site wants his basement to leak. It sounds weird, but the argument is what actions would lead to the failure of the basement? The answer is simple – the project manager on site would ensure they avoid using waterstops in construction joints, use poor quality concrete, select the wrong or a poor quality waterproofing membrane, omit pile head waterproofing, appoint inexperienced waterproofing installation companies and so on. The worst action is to use multiple suppliers for waterproofing that rules out a single point of responsibility. The project manager can now self-question and develop a check list of what factors need to be considered to have a leak-proof basement. This is possible by addressing and countering all the above pitfalls by adopting a working backward approach.

The Way Forward: Water leaks can cause significant structural damage, inconvenience, trouble and litigation issues. Water leaks usually result from a combination of the above highlighted failure factors, rather than an individual element be liable for the failure. Most of the buildings that start showing early signs of deterioration during the first ten years of their service life, are alarming in this age where asset owners expect a longer maintenance free design life. Water leakage is the main culprit for the early initiation of corrosion and concrete deterioration in multi storey buildings and commercial towers. To help minimize leakage nuisance and potential hazard to life and property, robust construction practices should, therefore, be practiced during building planning, design and execution stages. It is also suggested a working backward approach be adopted as this leads to the adoption of 'system based waterproofing approach'. It is important that the waterproofing in basements, roofs and wet areas, are not driven by waterproofing membranes only; rather it should be based on 'a complete waterproofing system'. The designers and controlling authorities should further improve processes of building plans approvals, inspection of construction works, and quality control procedures regarding waterproofing aspects. A stich in time, saves nine. Prevention using a backward approach is always better than cure.

Leakage through retaining wall construction joint.

Basement leakage showing early signs of corrosion.

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HOLIDAY RUST SNAP COMPETITION

As rust nerds we might find ourselves on holiday in beautiful surroundings only to be mesmerised by the flourish of rust around a monument, or a peppering of pits down by the seaside. Don't deny it, we all do it. For the chance to have your beautiful patina pictures published in C&M February 2018 Issue, and the opportunity to attend an ACA Technical Group Event of your choice FREE in 2018, **send your holiday rust snaps (high resolution over 300 dpi) plus a caption to Tracey Winn at the ACA twinn@corrosion.com.au by Thursday 18 January.**

Here's what we're after, starting with **Jess Lyndon** / ACA VIC Branch and Junior Vice President

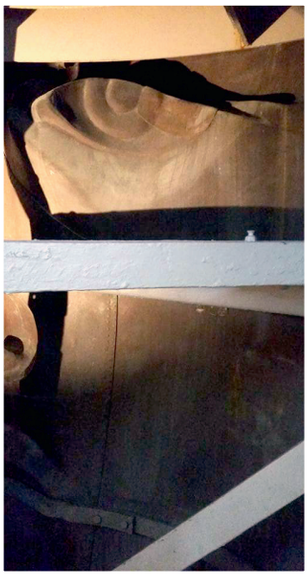
In 2016 I was lucky enough to go to a conference in Montreal to present a poster for my PhD, being so close to the USA who could resist a trip to New York, where I was extremely lucky to get a ticket to ascend to the crown at the Statue of Liberty (being summer these limited tickets usually book out months in advance).

All the original struts were replaced due to serious corrosion between the iron and copper after 100 years. Some of the support struts had lost 50% of their thickness. Only 4 struts could be removed at a time, as the copper is draped over the struts in order to give the statue flexibility to wind - the copper is only about 2 mm thick. Some extraordinary engineering for the time, that was attributed to Gustav Eiffel, who 10 years later would start construction on the Eiffel Tower.

Liberty Enlightening The World.

Original torch was replaced due to severe corrosion in 1986.

Struts inside the statue.



Inside Liberty's head.

Tabula ansata showing corrosion.

Choosing the Right Abrasive to Maximise Productivity and Surface Quality

One of the critical construction and maintenance challenges faced by many industries globally is corrosion.

Research findings by NACE International, a corrosion-control standards and certification association, revealed that the global cost of corrosion is estimated to be US $2.5 trillion. This is equivalent to 3.4% of the global Gross Domestic Product (GDP) 2013. In addition, these costs exclude work safety and environmental consequences.

In the energy sector for example, thousands of industrial facilities are constructed primarily of carbon steel and these structures, when unprotected, are vulnerable to corrosion.

The application of industrial protective coatings is generally the most economical and effective corrosion protection available for carbon steel.

However, prior to this procedure, the surface needs to be cleaned and free from contaminants with the right surface profile (roughness) for effective paint adhesion. This is actually the most expensive part of the coating job, but this step is crucial to minimise coating failure and to maximise the life of the coating system.

Although there are multiple surface preparation methods such as pickling (acid etch), sanding and wire brushing, the most cost-effective method is abrasive blasting.

Abrasive blasting is preferred due to several reasons. It efficiently:

- Removes contaminants from the surface to be coated, including mill scale, rust, old coatings and linings.
- Produces an anchoring surface profile to improve coating adhesion.
- Achieves significantly higher productivity than other cleaning methods.

The next key factor to look into is the blasting medium. There are a wide variety of options available in the market, ranging from soft abrasives like baking soda to hard abrasives such as garnet. Selecting the right abrasive for the job should not be based solely on price per ton or habitual practices. Instead, the main criteria should be on achieving the correct anchor profile and required surface cleanliness to ensure effective adhesion and long-lasting coating life, as well as achieving the highest productivity rates. The overall cost per square metre cleaned should be a prime consideration, not just price per tonne of abrasive. Cheap inferior abrasives generally require more tonnes per unit area of cleaned, more clean-up and disposal handling, and often yield more dust. Other considerations that are equally important are safety risks of the workers at site and the environment.

In order to compare different blasting abrasives, it is important to understand their physical properties and how they impact on blasting performance.

Size

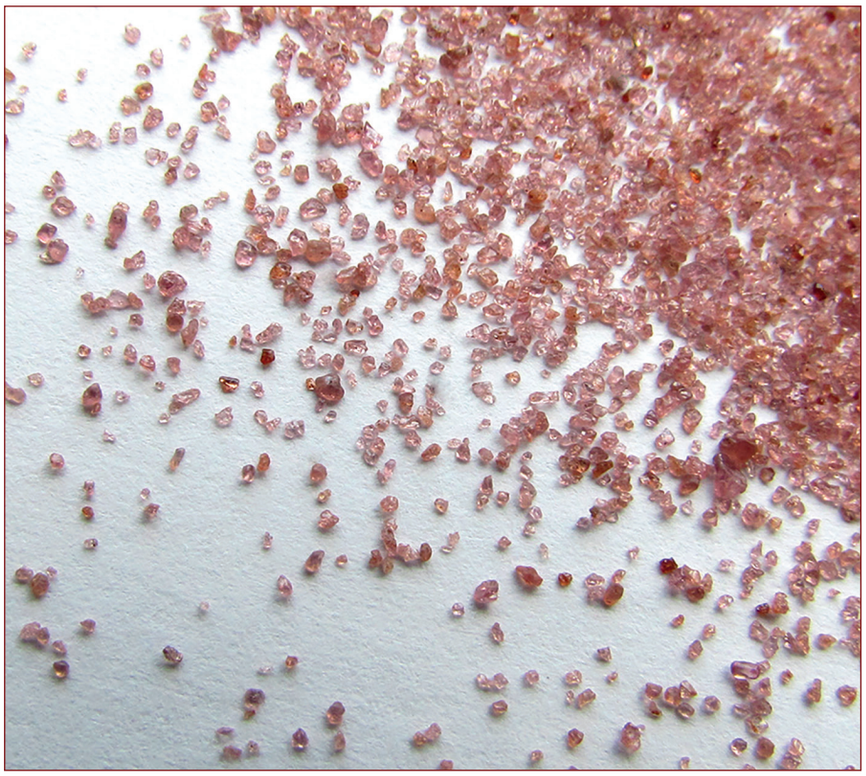
Larger particles will produce a bigger indentation. However, they produce less impacts per unit area than the same volume of smaller particles, which work faster. Smaller particles also produce a more uniform surface profile and a cleaner surface. In addition, smaller particles can increase the density of peaks produced , which can create more surface to adhere to than a deeper surface profile. Therefore, the most efficient approach is to use the smallest particle size necessary to achieve the required anchor profile.

Shape

Abrasives are classified in three different shape types: rounded, sub-angular and angular. Rounder particles without cutting edges will pound or ‘peen’ a surface, while sharp particles with points and edges remove surface material on impact by a chiseling action. Both angular and sub-angular abrasives will also create angular profiles. As for sub-angular particles, they present a larger surface area for contact with the surface while still maintaining sufficient angularity for cutting. Moreover, sub-angular particles are more resilient to breaking down than angular particles and less likely to cause impingement (abrasive splinters embedded in the metal surface).

Hardness

A harder particle will generally be more aggressive in cleaning the surface and imparting a deeper profile. However, if the particle is friable (the tendency of a solid substance to break into smaller



pieces) and shatters on impact, the force on the surface will be reduced.
A good example is a diamond which is extremely hard but is also brittle.

Toughness

Abrasives that are both hard and tough (opposite to friable) provide the best means of transferring energy to the surface during blast cleaning. Tough grains are resistant to breakdown upon surface impact and hence there is better conversion of energy from the blast stream into surface cleaning and profile formation. Minimal breakdown also means lower dusting. This improves operator visibility and reduces possible occupational health and environmental impacts.

Density

The higher the density (specific gravity) of an abrasive particle, the more energy it will carry to the surface compared to a less dense particle of the same size. This is due to KE = ½ mv^2 whereby kinetic energy is proportional to mass (determined by density) and velocity (provided by air stream) squared. This means that finer grades of higher density abrasives can achieve the same surface profile as coarser grades of lower density abrasives. The added advantage is that finer abrasives clean faster than coarser abrasives due to exponentially more particle impacts per unit area per second.

In addition, higher density particles are more likely to fall to the ground after blasting, rather than becoming airborne, so there is less dust and abrasive dispersion making it is easier to clean up.

Toxicity

Traditional blast cleaning abrasives such as silica sand, are outlawed in Australasia and some smelter slags are known to be potentially harmful to human health. Heavy metals from some slags are also an environmental hazard, particularly in waterways and marine environments. Free silica dust (from quartz sand) is a known human carcinogen which can cause lung silicosis when inhaled, which is why the process is not used in Australasia. Heavy metal toxicity has proven to be a major hazard and there are several health risks associated with it. Avoid such abrasives wherever possible.

Metallic vs non-metallic

Metallic abrasives such as chilled iron grit or steel shot or cut wire should not be used for sweep blasting galvanizing or for profiling aluminium or stainless steel as any embedded particles will result in galvanic corrosion. Non-metallic abrasives such as garnet and aluminium oxide should be used instead, and these are also preferred as the abrasive media for wet abrasive blasting.

Recommendation

Choosing the right abrasive directly impacts on maximizing productivity and producing good surface quality to achieve a coating application that lasts. The best results can be obtained by taking into consideration the following points:

- Select the smallest particle size necessary to achieve the required anchor profile for the coating system being applied. The smaller the particle size, the faster the cleaning rate.
- Sub-angular particles provide cutting combined with a greater surface area for impact, providing more efficient coating removal. They are also less likely to cause impingement.
- Select an abrasive that is both hard and tough (low friability) to impact the substrate more aggressively, maximise profile generation and minimise dust formation.
- Select an abrasive with a higher specific gravity (density) that will result in each particle applying more energy to cleaning and profile formation.
- Ensure that equipment and settings are adjusted to achieve optimal abrasive flow rate and blasting pressure for the abrasive being used.
- Avoid hazardous abrasives.
- Price per ton of an abrasive is no indication of the overall cost of a blast cleaning job. Cheap abrasives are often more expensive overall due to inferior cleaning rates, high consumption rates and high material handling, clean-up and disposal costs. The quality of cleaning in terms of surface cleanliness and profile uniformity is also often inferior with lower cost abrasives vs. the high performance abrasives.

ABOUT THE AUTHOR
Martin Taylor, Garnet International Resources Pty Ltd

Martin Taylor is the Emeritus Group Technical Manager of Garnet International Resources and has been instrumental in developing and testing garnet abrasives for over 40 years. A qualified geologist with a Bachelor of Science in geology, with honors, he has spent decades building his knowledge of key properties of minerals and how they can affect a blasting application.

Lucinda Bulk Sugar Terminal

The iconic 5.7km long jetty of the Lucinda Bulk Sugar Terminal (LBST) stretches off towards the horizon from the small coastal town of Lucinda in Far North Queensland. The structure was built in 1979 to allow bulk loading of sugar onto vessels that were becoming too large to enter the shallow Hinchinbrook channel, where the old wharf still stands. The impressive length of the structure puts the wharf into naturally deep water, avoiding the sandbanks that regularly catch out recreational boaters at low tide. The jetty and wharf are constructed of steel piles and headstocks supporting pre-stressed concrete decks. The tropical marine environment is very corrosive to these steel elements and is an ongoing challenge for the engineering team at Queensland Sugar Limited (QSL), who are the operators of the facility, along with five other bulk sugar terminals along the Queensland coast.

The original coating on the piles and headstocks was a coal-tar epoxy. This coating has lasted remarkably well and is generally still providing great protection to the bulk of the structure. In the past, maintenance of this coating was carried out by spot abrasive blasting of any corroded areas and overcoating with epoxy mastics. However, such maintenance is no longer practical at LBST for a number of reasons.

Firstly, over the years, community expectations and regulations around environmental performance and health and safety of workers have improved enormously. Years ago, maintenance of this structure would have consisted of abrasive blasting without encapsulation, while using access systems that would be entirely deficient by today's standards.

Abrasive blasting today requires full encapsulation and recovery of spent abrasives and paint while operating from a properly engineered and constructed access system – typically scaffolding. What might be a minor spot repair, therefore, requires a major investment to treat. Secondly, with the age of the structure, the original coating is reaching the end of its useful life and spot repairing is likely to have diminishing effectiveness as the coating starts to break down in a more widespread manner. In a traditional paint coating approach, the steel piles now require a full removal of the original coating, and this is what was embarked upon in 2010.

In the 2010 project a total of 78 piles (and associated 39 headstocks) were refurbished by full abrasive blasting and application of a high build epoxy. A breakdown of the projects costs are shown in Figure 1. The analysis shows that a large portion of the costs were for scaffold access, welded repairs to corroded areas of the pile and stand-down due to poor weather. The cost of a typical pile bent, with 2 piles, was around $50,000, and there are over 800 piles on the whole structure. The coating applied in 2010 is performing very well to date, but is only expected to have a life of around 15 years, with some coating breakdown having already been observed.

When the program was continued in 2013 (after being postponed for repair of extensive damage caused by cyclone Yasi), the opportunity was there to apply some innovations that could save millions of dollars over the life of the structure.

QSL's engineering team has reduced long term costs for the program through improving the corrosion protection systems used, reducing requirement for structural welded repairs and through improved access techniques.

FULL BLAST AND PAINT COST BREAKDOWN

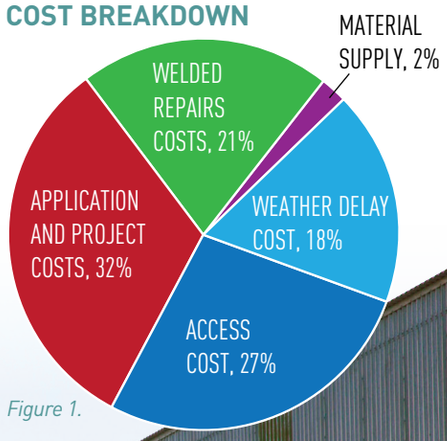


Figure 1.

Photo Credit: Matthew Murray

Photo Credit: David Edelman

Petrolatum Tape Jacket Systems

Instead of using a paint coating on the round piles, QSL are using the Denso 2000FD system consisting of a petrolatum grease primer and tape and a HDPE protective jacket applied down to the mid-tide level. Using a petrolatum tape system, in preference to a paint coating, gives a number of advantages including:

- Long life – the life of the system is expected to be at least 30 years – compared to 15 for a paint coating.

- Reduced requirement for welded repairs – With a paint coating any corrosion pitting must be rectified to give a smooth surface before coating, to avoid coating breakdown. With petrolatum systems, assuming the corrosion is not affecting the structural integrity of the pile, the pitted area is simply filled with the primer during application.

- Reduced weather standdown cost – due to the fast application of the system and ability to apply in wet weather.

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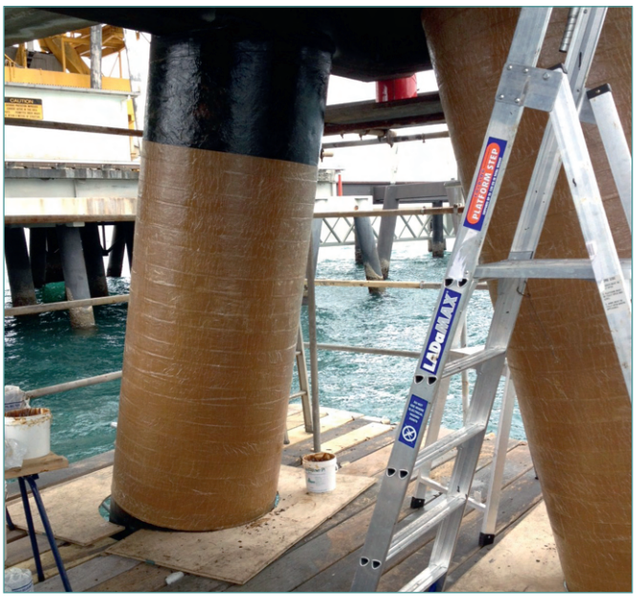


System application before installation of jackets.

Completed system.

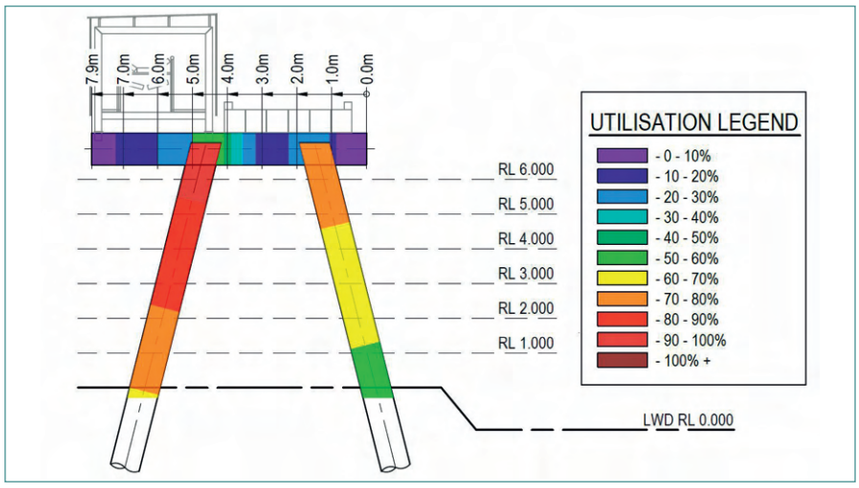
PETROLATUM TAPE WRAPPING OF UNDERSIDE OF GALLERY

Lucinda bulk sugar terminal has a long history of using petrolatum tapes, such as Denso Tape, which are composed of cloth impregnated with grease or wax compounds, typically used in the pipeline industry. Petrolatum tape has been used to protect the hollow sections of the underside of the conveyor gallery along the jetty, as seen in this photo. This system has been in place for over 30 years in some locations and is still in excellent condition. Treating a 20m 'span' with this method takes 2 workers around one week to complete and is therefore a fraction of the cost of scaffolding, encapsulating, blasting and painting. However, care must be taken to use petrolatum tapes where appropriate and failures have occurred through use without protection in areas that are too exposed to the elements or where intimate contact between the tape and the steel has not been ensured, such as in the corners of open sections.

Petrolatum jacket systems were previously seen as being an expensive option. However this is only true of the actual material cost, which is more than 10 times the cost of the paint material. With the reduced welded repairs and standdown, however, QSL found the total project cost to be less when petrolatum jackets were used.

Structural Welded Repairs

Where deep pitting occurs, there is a risk that the structural integrity of the element has been compromised. Often engineers use a rule of thumb to decide on allowable corrosion loss and 10% loss of the cross-section area is a typical figure used. To ensure the structure is kept in sound order and to optimise the budget spend for structural repairs, QSL engaged Aurecon Australia to carry out a utilisation assessment on the Jetty and wharf. This investigation used sophisticated modelling techniques to understand the stress experienced by the structure in operation and in a 1-in-500 year weather event. The output of the investigation was a process that allowed contractors to determine whether the corrosion measured in a particular location would require a structural repair. In general, piles located closer to the shore can tolerate a far greater degree of corrosion loss compared to those located offshore, due to greater depth and wave action offshore.



CORROSION ZONES

The underdeck structure at LBST can be classified into four distinct corrosion zones:

- The atmospheric zone - where the steel typically stays dry but is subject to high levels of salt spray.
- The splash zone – above the high tide mark, where the steel is constantly wetted by wave and spray. This is where the highest corrosion rates are seen at LBST.
- The tidal zone – between low and high tide. A cathodic protection (CP) system provides full protection up to mid-tide, and likely up to the 'barnacle line' closer to high tide.
- Low water and submerged zones – without a CP system it is likely that the piles would suffer from accelerated low water corrosion caused by microbial action around the low tide mark. This corrosion mechanism can cause rapid steel thickness loss so it is very important that the CP system is well designed and maintained. In deeper water, the lower levels of oxygen typically result in lower corrosion, though this section is also protected by a CP system.

Improved Access

In order to remove the reliance on scaffolding, QSL modified and refurbished their old underbridge access unit. This machine was custom built for the Lucinda Jetty, with the ability to reach over the top of the conveyor gallery and down to the water. It was previously used for spot coating repairs, but had only been used intermittently since the spot repair program was ceased. A new work basket added some fold-down platforms that allow operators to access three sides of a pile simultaneously. Having access to three sides allows the operators to wrap the pile with petrolatum tape and apply the protective jacket – something not possible from a regular, rectangular basket. The machine was also brought up to modern safety standards and re-certified through a rigorous design registration process.

With this machine a team of three operators can clean, prepare and wrap more than 1 pile per day, without any scaffold required. The system also allows the engineers to be more selective about targeting of works. For example, one pile of a pilebent can be worked on while leaving the lower priority piles or headstock for another time. With scaffolding it is most sensible to treat the whole area at one time, due to the significant investment in scaffold incurred.

The combination of these improvements has resulted in enormous projected savings over the life of the structure. However, there are still opportunities for further improvement. For example, the headstocks are a shape that does not lend itself easily to petrolatum tape wrapping. A number of trials are currently in progress testing a range of adhesive tape systems. If these systems prove to last longer and are more easily applied than a paint coating, then further savings may be realised.

The benefit of working on such a large structure is that any savings made through innovation are multiplied hundreds of times, so the investment in new techniques, equipment and trials is well worth the effort.

David Edelman, *QSL*

Underbridge access unit with modifications to allow pile wrapping.

Long Range Ultrasonics – Long shot or Ultra useful?

Introduction

Industry has consistently highlighted the need for cost-saving solutions for asset integrity assessment NDT (Non-Destructive Testing). However, industry decision makers have split opinions about the latest advancements in NDT. Most are aware about the developments in advanced NDT technologies; yet they are hesitant to apply these solutions on their assets. Why?

If the industry is aware of the "published merits" of the advanced NDT technologies, which are actively promoted by the equipment manufacturers and service providers, then why are many Australasian key asset owners reluctant to employ advanced NDT on their assets? Based on the author's experience, many of these decision makers have previously applied some form of advanced NDT on their ageing assets. The unfortunate feedback is that most were not satisfied with the outcome. There could be several reasons for this:

- Lack of readiness of technology still at the inception stage, leading to ineffectual outcome
- Early versions of the NDT equipment software not able to adequately interpret the acquired data
- Limited experience of the test personnel resulting in poor or conservative interpretation with excessive false calls
- Overseas service providers not giving adequate support or assistance to interpret data acquired in Australasia
- Service providers overselling the technology without clearly disclosing the limitations

In the last decade, software and hardware development has progressed exponentially. Ease of use and output format of the latest equipment has enhanced the experience for both NDT personnel and the asset owners. Some of the developments in the advanced NDT systems (LRUT, PEC, ECA, CRT, DRT, AE, MFL, PAUT, TOFD, MMM) are mind blowing even to an NDT specialist. Moreover, these advanced NDT technologies are cost effective solutions that can save the industry thousands, if not millions, in operating and maintenance costs. Regrettably, the owners of ageing assets have not exploited these latest developments due to bad memories or ghosts from the past.

Does this mean that we should persist with basic NDT, or is there a need for the decision makers to learn more about the latest developments in NDT? Do decision makers compare and weigh-in the limitations of advanced and conventional NDT, by employing or engaging industry-recognised, ISO 9712 Level 3 NDT experts in their teams? The author's observation is that most cases, the answer is no. Essential training, qualification and experience in the variety of NDT methods would ensure selection of the best and most appropriate inspection solution.

There are countless examples wherein tens of thousands of dollars could have been saved by asset owners by using an advanced NDT solution. A classic example is the lack of awareness of the benefits of the latest LRUT technology to detect piping degradation and corrosion. This article illustrates the benefits and limitations of this particular technology.

What is LRUT?

Long Range Ultrasonic testing (LRUT), also known as Guided Wave testing (GWT), is an inspection method wherein low frequency ultrasonic waves are transmitted along the pipe (guiding) wall. A set-up of an LRUT inspection unit is shown in Image 1 (Images are edited by LMATS Australia with permission from Olympus Scientific Solutions).

LRUT enables rapid examination for integrity assessment of pipelines, locating potential degradation or engineering concerns and gross discontinuities for targeted assessment and inspection. It is especially useful for non-piggable buried lines, encased piping, vertical or inaccessible piping (such as overhead pipe racks) or insulated / epoxy coated pipelines.

While conventional NDT methods enable localised inspection underneath or near sensors, LRUT can inspect 100% of pipe circumference along the pipe length from a single contact location. The guided ultrasonic waves are generated into the pipe body, 360° around the pipe circumference, on both sides of the LRUT transducer assembly. The waves continue to propagate axially along the pipe wall until the entire energy is attenuated or dissipated or reflected. The waves reflect towards the sensors wherever they intercept a cross sectional change, such as a butt weld, pipe support, elbow, flange or gross discontinuity, such as severe corrosion, erosion or clusters of pitting. Signals at multiple frequencies are acquired simultaneously and evaluated and the time-of-flight and dominant frequency for each reflection is analysed.
The location of each indication is determined by the distance from the sensor as well as the circumferential quadrant. The signal amplitude determines the defect significance - and relative loss of cross section (LCS).

The chief application of LRUT is for pipelines with limited or only localised access. In such cases, LRUT can avoid unnecessary excavation, coating removal or extensive scaffolding, while enabling assessment of the entire pipeline. Thus, the use of LRUT significantly reduces maintenance costs. The interpretable scanning range from a single test location in ideal conditions - above ground or encased pipelines - is up to 90m in each direction (180m bi-directionally). Generally, the inspection range depends on the defect size sought (sensitivity) and the attenuation of sound. The interpretable scanning distance is affected by the following parameters:

- Pipeline layout such as bends, attachments, supports, branches, joints, clamps
- Highly viscous liquid deposits on the internal or external pipe wall.

- Severely corroded entire pipelines - rapid attenuation of ultrasound and excessive noise reduces interpretable lengths of pipeline
- Coating type - viscous coatings like bitumen dampen the signal
- Excessive thickness and very large diameter
- Joint type and the material type

LRUT is currently applicable for piping diameters from 38mm (1.5") to 1200mm (48"). Larger diameter pipes can be tested with additional effort. Testing can be performed on in-service pipelines operating between 0°C to 100°C. Testing at higher temperatures and as low as -30°C is possible with exceptional risk management plans.

There are very few LRUT equipment manufacturers, with varying positions on sensitivity. One manufacturer is Olympus Scientific Solutions. To date, their literature states that 3% is the minimum total LCS (loss of cross sectional area) that can be confidently detected. These are based on statistical data; however the detection limit also depends on the application. For example, the figure for buried pipes may be closer to 7-10%. LRUT is equally sensitive to indications on both ID and OD of the pipe. The absolute defect size limit depends on the pipe size (for large diameters and wall thickness, 5% can be a penetrating defect). The signal amplitude depends on the discontinuity shape, whether spread over the circumference or an encroached depth in the wall.

Although LRUT can be applied to various materials and different pipe diameters up to 40mm thick, ASTM E2775 outlines a procedure for testing tubular carbon steel or low-alloy steel products with nominal pipe size (NPS) 50 – 1200mm and wall thickness 3.81 –25.4 mm.

Ideal use of LRUT:
LRUT is an exceptionally cost effective advanced NDT test method for high speed inspection of in-service piping to detect corrosion and areas of concern. Some of the applications wherein LRUT can deliver significant cost savings:

- Buried pipelines at the excavation locations or at level crossings
- Inaccessible pipe sections in encased (through-wall) pipelines or culvert line or jetty lines
- HDPE / PE / Epoxy coated or insulated pipes, without the need for removing coating or insulation from the entire pipeline
- Vertical pipes or structural circular columns, without the need for scaffold erection to access upper sections
- Inaccessible piping, e.g. overhead piping racks, without the need of scaffolding or mobile EWP (elevated work platform). Only 30mm gap is required between pipes on a pipe rack to apply LRUT
- Risers and offshore topside pipe work without the need of scaffolding or jetty or a barge

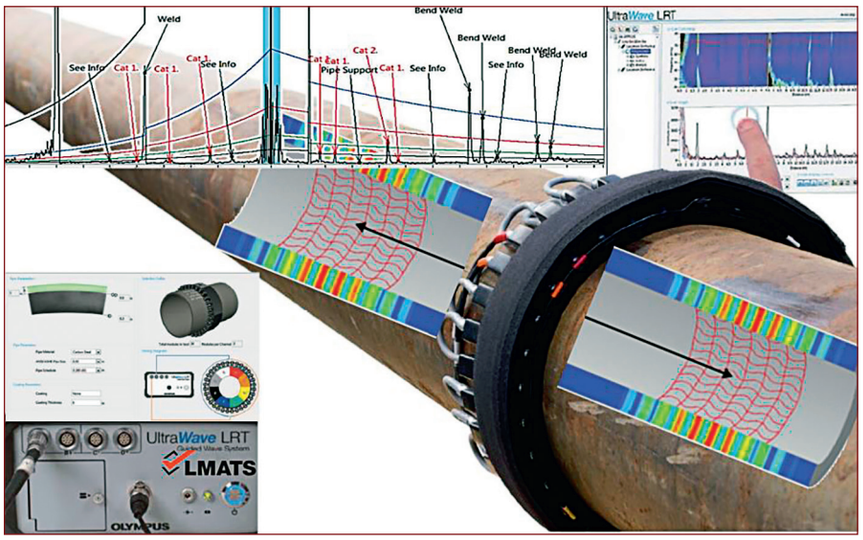


Image 1 – Pipeline test set-up, simulation of ultrasound, typical A-scan and F-scan display (Image used with permission from Olympus Scientific Solutions).

A significant application of LRUT is for the corrosion detection at pipe supports, clamps and pipe racks. LRUT can also detect significant weld root erosion (including flow accelerated corrosion or FAC) or incomplete penetration at welds. Refer to Image 2, showing a spike in the A-scan display and cluster in the lower frequency range in the F-scan display.

Advantages of using LRUT:
In today's cost driven economy, the industry may not accept a solution without associated cost and time saving features. Fortunately, LRUT can save both on-site time and maintenance/operations costs by eliminating or reducing the need for scaffolding, coating/insulation removal, surface preparation, or an EWP to access 100% of the surface to be examined. Moreover, it is a non-intrusive test method that can be applied on in-service pipelines whenever intelligent pigging may not be an option. LRUT provides the following distinct advantages in comparison to other methods:

- In-service inspection without production losses or downtime. (Pigging may not be feasible on some in-service pipelines)
- Reduction in onsite inspection time - high speed testing at 180m per hour in ideal conditions
- Up to 180m pipe length can be assessed from a single test point
- 100% of the pipe circumferential wall can be examined from a single test point

Although there is no need for insulation removal or abrasive blasting along the entire pipe length, access is required to the LRUT test location, where the transducer assembly is positioned for testing. At this location, a 500mm band must be clean, uninsulated, and may require abrasive blasting or grinding if the coating is of unacceptable quality.

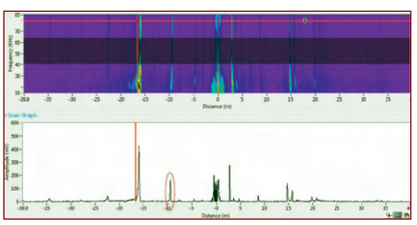


Image 2 – LRUT signal from Weld Root Erosion. (Image used with permission from Olympus Scientific Solutions).

Corrosion under pipe supports and clamps is not detectable by most other NDT methods. LRUT has a significant advantage here, as it can successfully detect the otherwise hidden corrosion or loss of cross section (LCS). Refer to Image 3, showing distinct indications in the higher frequency range in the F-scan display.

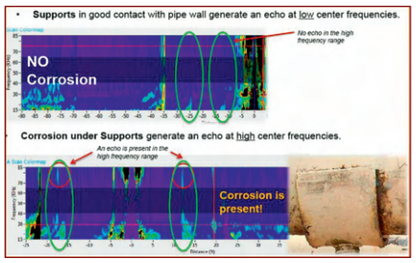


Image 3 – LRUT signal from pipe support
(Image used with permission from Olympus Scientific Solutions)

Another major advantage is that LRUT enables in-service pipeline inspection wherever pigging is not feasible or possible. Similarly, LRUT can inspect for degradation on inaccessible pipelines. Systematic or random spots can be exposed or excavated, from which tens of metres of in-service pipeline can be assessed.

Compared to pigging equipment or digital radiography through insulated systems, LRUT offers the advantage that it is portable, carry-on equipment that can be operated by a single technician.

A further benefit is that LRUT does not require couplant to transmit ultrasonic waves. This increases inspection speed and avoids residual dry couplant, which can become future corrosion nucleation sites.

Limitations:

LRUT is a rapid screening test method, and does not provide precision measurement of wall thickness. After LRUT has detected an area of concern or degradation in the form of LCS, wall thickness can be measured by another rapid technology such as Pulsed Eddy Current Testing (PECT). For precise wall thickness measurements, Phased Array Ultrasonic testing (PAUT) is recommended. For localised wall thickness measurement, conventional compression (longitudinal) wave ultrasonic test can be applied. The primary limitations of LRUT are:

- Testing of a pipeline having several bends or fittings is a challenge. However, data for up to two bends or branches can be interpreted depending on the attenuation of the ultrasound
- Isolated defects such as pits cannot be detected
- Testing of cryogenic pipes is possible but very difficult. Heavy condensation occurs on the exposed piping, and the transducer may not detach from the frozen pipe wall surface.
- Bitumen-coated pipelines, pipelines buried in wet soil or silt, or severely pitted pipelines attenuate sound severely and hence they are difficult to inspect. If the cause of heavy attenuation can be confirmed, it can be used to identify severely corroded pipelines
- Cannot assess 100% of surface area around fillet welds
- Currently not applicable for pipes less than 38mm diameter
- Minimum pipe length of 5m for cost effective application

Required expertise:

Compared to conventional ultrasonic testing or other advanced NDT methods, the LRUT instrument, transducers and software are complex and expensive. This technology requires highly trained, skilled and experienced personnel. There are very few trained, certified and experienced technicians to perform LRUT in Australasia.

Conclusion:

NDT can be performed on almost anything and anywhere. The need or level of NDT is dependent on the outcome sought. A proven NDT procedure is a compromise of several essential variables that can affect test results. With every advanced NDT technology there are limitations or disadvantages. But if the industry can save time and money, and if the asset owners can receive some useful data instead of no data or guesses on the basis of "She'll be right mate", then LRUT has several applications in the industry as a cost-saving NDT method, even with its few limitations.

Considering the unique advantages, LRUT can deliver significant benefits and should be considered as an "Ultra good", efficient technology, rather than pessimistically being considered as a "long shot" or inadequate technology for testing inaccessible pipelines.

The author will welcome discussion about the Guided Wave LRUT. For more information about LRUT or knowledge sharing, you can contact the author at LMATS Australia via email at pranay@lmats.com.au, or Olympus representative via email at ibdinfo@olympus.com.au

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Microbiologically Influenced Corrosion of Copper and its Alloys – a Review

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1. Introduction

Microbiologically influenced corrosion (MIC) refers to how the presence and activity of microorganisms (e.g. bacteria, algae, fungi and archaea) can influence corrosion [1]. Microorganisms can initiate, accelerate, and/or inhibit corrosion processes through various mechanisms, including modification of the localised environment at the metal/solution interface, destabilisation of protective films or corrosion products on the metal surface, or by causing pitting attack where microbial adhesion takes place on a metal [2]. The corrosion rates that have been observed in relation to MIC can be on the order of several mm/year, which is much greater than what would normally be expected for corrosion in the associated environment without the involvement of microorganisms [3]. This rapid attack has the potential to cause significant structural damage before identification during routine maintenance. If not properly managed, MIC can result in considerable increases in maintenance and repair costs, and could possibly have disastrous consequences for a wide range of industries including for example maritime, power generation, oil and gas, chemical processing and water distribution [1, 4].

Copper (Cu) and its alloys are widely used in range of applications where MIC can be a potential problem, due to their high corrosion resistance combined with mechanical workability, excellent thermal conductivity and resistance to macro-fouling [5]. Some of the typical areas in which Cu and its alloys are used are in household and industrial water distribution/piping systems, heat exchangers, intake screens, sheathing for splash zones, off shore structures as well as chiller and fire sprinkler systems [5-7]. In aqueous systems, the corrosion of Cu is strongly influenced by the physico-chemical properties of the water including the pH, level of oxygenation and the presence of certain anions such as carbonate, chloride, and sulphate, or iron cations [8-10]. Various oxide layers can form on the surface of Cu which can help to reduce corrosion rates, however these films can breakdown by either mechanical, chemical or biological processes [11-14]. The addition of elements such as nickel and a small amount of iron has been shown to improve the corrosion resistance of Cu alloys. Studies have shown, for example, that Cu with 30% or more nickel has superior corrosion resistance for seawater applications [15]. The presence of sulphides in seawater, for example due to pollution, however may lead to higher corrosion rates and pitting of these alloys, as discussed in detail in references 16 to 18.

Copper and its alloys are vulnerable to MIC despite their general good corrosion resistance and antibacterial properties. Cu alloys exposed to natural seawater were reported to be colonised by bacteria within 3 weeks, independent of alloy composition [19]. Numerous studies have also reported the susceptibility of Cu alloys to MIC induced pitting and crevice corrosion [20-23]. While the role of microbes in the pitting corrosion of Cu alloys is not entirely clear, it appears that the presence of biofilm contributes to corrosion by maintaining enhanced local ion concentrations and/or by creating differential aeration cells [1]. The areas under a biofilm can become depleted of oxygen due to the respiration of microbes relative to the surrounding non-colonised areas. This gives rise to a potential difference between the two sites, and consequently to corrosion. In addition to oxygen concentration cells, the metabolic activities of microorganisms within the biofilm can also result in ion concentration cells. Microorganisms within the biofilm are capable of maintaining an environment that is radically different from that of the bulk medium in terms of pH, organic and inorganic species. The formation of differential aeration/ion concentration cells can cause rapid pitting or corrosion of the metal surface under the biofilm [24]. In addition, microbial by-products including carbon dioxide, hydrogen sulphide, ammonia, organic, and inorganic acids are some of the other reported causes of MIC of Cu alloys [5, 25].

The impact of sulphides on the corrosion of Cu alloys in seawater has also received a considerable amount of attention. Several studies reported localised corrosion of Cu alloys by sulphate-reducing bacteria (SRB) in estuarine environments [22, 26, 27]. The SRB reduce sulphate into sulphide ions which react with Cu ions to form a layer of cuprous sulphide [1, 28]. Copper ions migrate through the layer, react with more sulphide, and form a thick black scale on its surface. The cuprous sulphide film formed on the surface is fragile and poorly protective. The breakdown and loss of the surface film, the emergence of pits, and the heterogeneity of the local environment produced by the biofilm bring about inter-granular and/or pitting corrosion attack [28]. Accelerated corrosion of Cu alloys in seawater in the presence of SRB is reported to be likely due to the lack of tenacity of microbiologically produced sulphide films on the surface of the Cu alloys [29]. Another possible explanation for an accelerated microbial corrosion of Cu alloys might be the binding of metal ions by the extracellular polymeric substances produced by bacterial cells [30, 31]. Metal ions bind to the anionic functional groups, such as carboxyl, glycerate, pyruvate and succinate groups, which are common in the protein and carbohydrate components of the exopolymers. Beech and Sunner [32] proposed that metal cation binding by extracellular polymeric substances (EPS) promotes the anodic dissolution of the metal surface via a cathodic depolarisation. Results from several studies suggest that Cu is sensitive to wide range of exopolymers including those produced by some biofilm forming bacteria that colonizes Cu tube [33-36].

The use of chlorination to reduce the pitting corrosion of Cu tubing in potable water systems has also been extensively studied [37-39]. Chlorine is commonly used as a disinfectant in potable water to kill bacteria and viruses, which normally grow in water pipelines and storage tanks [40, 41]. However, the chlorination process has been found to be ineffective in cases of pre-existing biofilms as chlorine is unable to penetrate and kill bacteria underneath the biofilm [42, 43]. In addition to bacterial biofilms, there are many other factors that can affect the efficiency of chlorination process and in turn the corrosion of Cu pipelines including high pH, chloride, sulphate, alkalinity and orthophosphates (corrosion inhibitors) levels present in the water [44-46].

A number of studies have reported MIC of Cu and its alloys in seawater and potable water applications. A few examples of case studies on MIC of Cu alloys in seawater and potable water system have been provided later in the paper. Whilst it is not possible to list all the studies found in literature on MIC of Cu and its alloys, a number of articles worth considering for further information are cited in Table 1.

Table 1. List of studies found in literature on MIC of Cu and its alloys in seawater and potable water system.

Topic	References
Copper corrosion mechanisms	Syrett [16], Little and Mansfeld [47] Little and Lee [48], Gaylarde and Videla [49], Beech [50]
MIC of copper in seawater	Alhaji et al. [51], Little et al. [22, 26, 29, 52], Mansfeld and Little [19], De Saravia et al. [53], Pope et al. [54], Powell et al. [15], Schiffrin and Sanchez [55], Schleich [56], Sun et al. [11], Chamberlain and Garner [57], Jacob et al. [58]
MIC of copper in potable water	Bremer et al. [59], Calle et al. [60], Critchley et al. [61-63], Fallowfield et al. [64], Fischer et al. [65], Keevil [66], Boulay and Edwards [67], Oliphant [68], Pavissich et al. [69], Wagner et al. [70, 71], Wagner and Chamberlain [20], Webster et al. [72]

This review article is aimed at providing information on the different mechanisms proposed for MIC of Cu and its alloys, toxicity of Cu towards microorganisms and its role in MIC, and a few case studies of MIC failure of Cu alloys in seawater and potable water systems. In addition, the results of some recent experiments on MIC of pure Cu and copper-nickel (CuNi 90:10 and CuNi 70:30) alloys are also presented.

2. Toxicity of Copper (II) Ions to Microorganisms

Copper is a required trace element in most living organisms, however at sufficiently high concentrations it can become toxic [73, 74]. Cu and Cu-containing compounds are widely used as bactericides and fungicides. For example Cu sulphate has historically been added to lakes to control algal blooms [73], while systems which release Cu ions into seawater pipework via an electrolytic process are used to prevent biofouling [75]. The antimicrobial action of Cu is believed to result from the ability of Cu ions to deactivate cells enzymes, denaturing proteins, and by competing with essential cations [74, 76]. The concentration of Cu ions in a system required to inhibit microbial activity can be affected by a number of physico-chemical factors, e.g. pH and redox potential [73]. This may account for the wide ranges of inhibitory levels reported for certain bacteria. For SRB, for example, 50% inhibitory levels of Cu varying from 0.84 mg/L to 200 mg/L have been reported [74]. Studies have shown that Cu in the dissolved form is more effective for bacterial killing. In an example of a Cu ion/MIC investigation, Unsal et al. [77] studied the effect of Ag and Cu ions on the microbial corrosion of 316L stainless steel in the presence of *Desulfovibrio sp*. They found that the presence of Ag/Cu ions in the test media delayed the growth of bacterial cells, changed the structure of the biofilm formed as well as decreased the corrosion rate of the stainless steel tested. It is important to mention here that SRB are not the only microbes relevant to MIC of Cu, indeed it is likely that there are a range of microbes that can affect Cu corrosion either with or without the presence of SRB [66]. This is important as simply testing for the presence of SRB alone is not sufficient in itself, as a diagnostic to determine if microbes are playing a role in Cu corrosion.

The bactericidal action of Cu is dependent on the concentration of free Cu ions. It was reported that the toxicity of Cu to the estuarine microbial community was a quantitative function of free Cu ion activity [78]. Many studies have shown that binding of Cu ions to environmental constituents, such as organic materials, has considerable effect on the availability of Cu and can reduce the toxicity of Cu towards microorganisms [79-81]. As already mentioned, Cu ions can form soluble complexes with anionic functional groups, such as carboxyl, glycerate, pyruvate and succinate groups, which are common in the protein and carbohydrate components of the exopolymers. Menkissoglu and Lindow [82] studied the relationship of free Cu ions and toxicity to bacteria in solutions of different organic compounds. They found that the toxicity of Cu ions to bacteria was reduced ~30 times in the presence of different organic compounds tested. In addition to a reduction in the toxicity of Cu, the Cu bound exopolymers can also promote the anodic dissolution of the metal surface via a cathodic depolarisation [32]. Little et al. [6] investigated a correlation between localised anodic areas and biofilm on Cu substrate in the presence of marine bacterium *Oceanospirillum*. They found that the bacteria produces copious amounts of exopolymer when grown on Cu surfaces, binds Cu ions from the substratum and produces local anodic regions on the Cu surfaces as detected with a scanning vibrating electron microscope.

Copper, due to its toxic nature, has also been used as an alloying element in stainless steels in order to improve their resistance to bacterial attachment and subsequent MIC. Nan et al. [83] studied the MIC characteristics of a 304L-Cu stainless steel exposed to *E. coli* in comparison with 304L SS as a control. The results showed that the presence of Cu in the 304L SS resulted in less dense *E. coli* biofilm coverage which inhibited the pitting corrosion due to MIC. They concluded that Cu_2O/CuO at the metal/biofilm interface tended to result in a more MIC-resistant passivation film. Similarly, Sreekumari et al. [84] studied the effect of bacterial attachment and MIC on stainless steel with different alloying elements. They concluded that the presence of sulphur and nitrogen as alloying elements increased the susceptibility of stainless steel to MIC, whereas the presence of toxic elements like Cu and Ag decreased microorganism attachment and reduced MIC attack. Kielemoes and Verstraete [85] investigated the bactericidal influence of Cu-alloying of stainless steel on microbial colonisation. They found that the presence of Cu in the steel matrix inhibits the attachment bacteria during an initial period (48 h), whilst this bactericidal effect disappears after longer incubation periods. They suggested that the application of Cu-alloyed stainless steels for bactericidal purposes should be used only for regularly-cleaned surfaces.

Further examples of literature on the toxicity of Cu and its effect on bacterial attachment and MIC are summarised in Table 2.

Table 2. Examples of studies found in literature on toxicity of Cu toward microorganisms and its effect on MIC.

Topic	References
Cu (II) ions in solution	Zarasvand and Ria [86]; Pizzaro and Vargas [87]; Unsal [77]; Grass et al. [88]; Fang et al. [89]; Ilhan-Sungur et al. [90]
Cu as alloying element	Lou et al. [91]; Ni et al. [92]; Zhang et al. [93]; Kawakami et al. [94]; Wagner and Little [95]; Li et al. [96]; Dan et al. [97]; Hong and Koo [98]

3. Case Studies

A number of case studies of MIC of Cu and its alloys used in different industries are summarised below. These case studies show different examples of potential MIC failures with different causes, details of the methods used to investigate the failures as well as potential solutions to the problems.

3.1. Case 1 – Failure of copper tube in residential cold water lines [99]

The first case study involves pinhole leaks that were reported in Cu water lines used for municipal drinking water in Santa Fe, New Mexico USA. The age of the affected pipelines ranged from 15 to 20 years old, and the majority of the leaks occurred in domestic cold water lines. Older Cu pipelines within the same location, receiving the same water supply, have not experienced the same number of leaks compared to these newer pipelines. The observed pitting matches the description of Type I pitting of Cu, historically attributed to water chemistry and contaminants on the Cu tubing surface.

An investigation was carried out to find out the potential causes of the Cu tubing failure. A typical pinhole leak found on the Cu tubing was shown in Fig. 1a. The inner surface of the tube was covered with green corrosion products and tubercles (Fig. 1b). A detailed analysis of the corrosion products and pits was carried out using a scanning electron microscope (SEM), energy-dispersive spectroscopy (EDS). The results showed the presence of bacteria deep inside corrosion pits which might be responsible for the pitting corrosion attack in these Cu tubing.

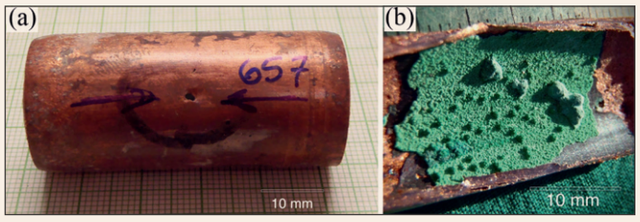

Figure 1. (a) A typical pinhole leak in the Cu tubing. (b) Green corrosion products (tubercles) inside the Cu tubing. Reproduced with permission from Materials an open access Journal [99].

The authors have suggested that residual films (i.e. lubricating oils, degreasing compounds etc) used in the manufacturing of Cu tubing, for example in the extrusion process, might be responsible for microbial pitting corrosion of Cu tubing. The bacteria were able to attach and grow on the surface of Cu tubing in the presence of the residual organic films. This possibly explains why the newer pipelines experienced more pitting and leaks compared to older pipelines, despite having the same chemical composition and the same municipal water following through them. The lubricants used in the extrusion of Cu tubing are continually changing over time and it is possible that a new residual oil or lubricant compounds is promoting the microbial attachment and growth on the surface of Cu tubing. Oliphant [68] has reported similar observations that the presence of organic/carbon rich films could (i) attract microbes and assist colonisation and/or (ii) form a galvanic corrosion couple resulting in an accelerated corrosion of copper pipelines.

3.2. Case 2 – Failure of copper water service pipe [100]

The second case study again involves pinholes leaks reported in a Cu water service pipe, this time used in a water distribution system. A detailed investigation was carried out into the causes of the failure. A number of possible corrosion factors were investigated including susceptibility to MIC. A visual analysis showed greenish tubercles and areas of greenish film on the interior of the corroded pipes (Fig. 2a). Pits were found underneath the tubercles (Fig. 2b). The pits progress to a pinhole through the exterior of the pipe (Fig. 2c). In addition, corroded and non-corroded sections of the pipes were subjected to microbiological analysis. No microorganisms were observed on non-corroded pipe samples, while a microbial biofilm was identified in the pitted areas and debris of the corroded pipes. The paper also discusses how the ozonation process, used for primary disinfection, may have actually resulted in an increased nutrient supply for microbes including those involved in MIC. Work was performed to improve the disinfection process, including implementing a unidirectional flushing process, which appears to have remedied the problem.

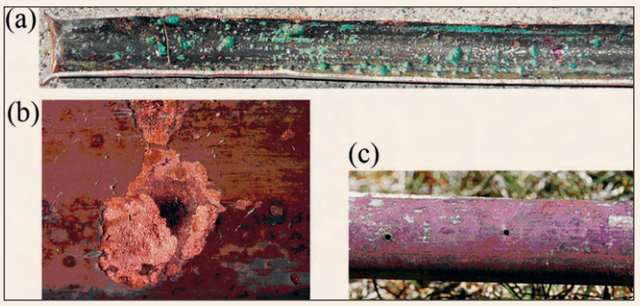

Figure 2. Typical corroded Cu water service pipes. (a) Tubercles found on the interior of corroded Cu pipes; (b) underneath tubercles, pipe interior patterns of sharp-edged pits; (c) interior pits break through the pipe exterior as pinholes. Reproduced with permission from NACE International, Houston, TX [100].

3.3. Case 3 – Failure of copper-nickel tubing in marine heat exchanger tubes [101]

Nicklin [101] reported the failure of CuNi heat exchanger tubes used in Royal Navy (UK) submarines, where seawater was used as a coolant (Figure 3). Severe pitting corrosion attack was observed in the CuNi alloy tubing used in the heat exchangers which resulted in the loss of 8 months operational availability across two submarines. It was reported that through wall pitting occurred after just 6 months of service, indicating a corrosion rate of 2 mm/year as a result of MIC attack. Detailed investigations have been undertaken on the causes and possible mitigation. Despite tests showing similar bacterial populations, cooling systems mainly operated in non-tidal basins or in warmer waters experienced accelerated pitting failures, whereas those operated in nominally clean and cold tidal waters didn't have such failures. Short-term solutions adopted include the complete exclusion of dockyard water from heat exchangers whilst in upkeep, instead using "sacrificial" interface coolers, closed loop circulating rigs or even total loss fresh water. Other solutions for investigation included the development and use of improved cooler conditioning chemicals to make the system alloys more tolerant to microbial attack.

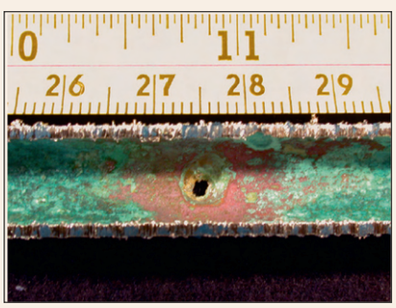

Figure 3. Defective CuNi 70:30 tube sectioned during metallurgical examination showing through wall pit linked to MIC. Reproduced with permission from IMarEST, London [101].

3.4. Case 4 – Failure of a copper chiller tube due to changes in water supply [102]

The final case study involves a Cu chiller tube that experienced a leak after six years of service, and four years after recycled water had been introduced as cooling water tower makeup. The

recycled "grey" water was treated with Cu corrosion inhibitors and for bacteria control by free chlorine. Green colour deposits and scaling were found throughout the inside of the tubes. Localised pitting corrosion was observed under the deposits (Fig. 4). EDS analysis of corrosion products showed very high concentration of calcium and phosphorus as well as other elements typically found in water scale. It was discussed that phosphorus rich deposits might indicate bacterial activity. Analysis of treated cooling tower water and untreated water was also performed, which included relatively high chlorine levels being detected. The author theorised that in this case the chlorine was ineffective as a biocide, and that the corrosion inhibitor may have increased bacterial growth. Overall the conclusion was that the poor water treatment was the cause of the MIC that led to the piping failure. Additionally, once a biofilm is present on the tubes, the chlorine is unsuccessful in controlling bacteria growth within the biofilm. The use of certain inhibitors, for example orthophosphate in this case, has been reported as acting as nutrient and can further stimulate bacteria growth. Consequently, the bacteria protected from chlorine under the biofilm and benefited from the presence of orthophosphate inhibitor led to MIC failure of Cu tubes.

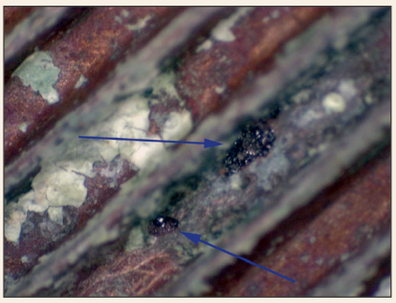

Figure 4. Pits that were beneath the adhered deposits on the Cu tube, 32× original magnification. Reproduced with permission from NACE International, Houston, TX [102].

4. Studies of MIC of Pure Copper and Copper-Nickel Alloys

4.1. MIC of pure copper in the presence of *Escherichia coli* bacteria

MIC for pure Cu was investigated in the presence of E. coli bacteria [103]. Finely polished coupons were exposed to *E. coli* bacteria in a minimal salts (M9) medium for 21 days. A range of techniques including 3D optical profilometry, light microscopy and SEM were used to study initial bacterial attachment and MIC of pure Cu coupons. The results showed significantly increased corrosion of Cu under biotic condition (i.e. in the presence of bacteria) compared to abiotic condition (i.e. in the absence of bacteria). The observed corrosion rate under biotic condition (~43 µm/y) was ~3 times more than in the abiotic condition (~15 µm/y). Figure 5 shows examples of SEM images of the corrosion products/biofilm formed on Cu surface after 21 days of immersion in the minimal medium under abiotic and biotic conditions.

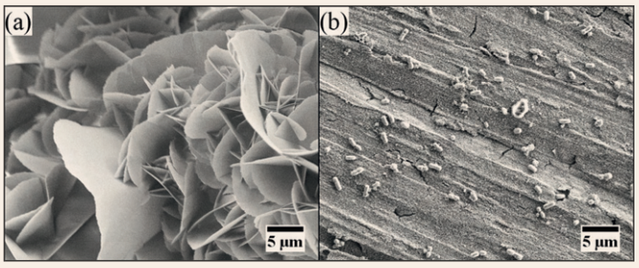

Figure 5. SEM images of corrosion products/biofilm formed on 99% pure Cu after 21 days of immersion in M9 medium under (a) abiotic and (b) biotic conditions.

To reveal the extent of corrosion damage, the metallic coupons were cleaned as per ASTM standard G1-03 [29] using 10% sulphuric acid solution and analysed via SEM. The results showed relatively less attack on the surface of Cu coupons immersed in the abiotic M9 medium (Figure 6a) compared to the coupons immersed in the biotic M9 medium (Figure 6b).

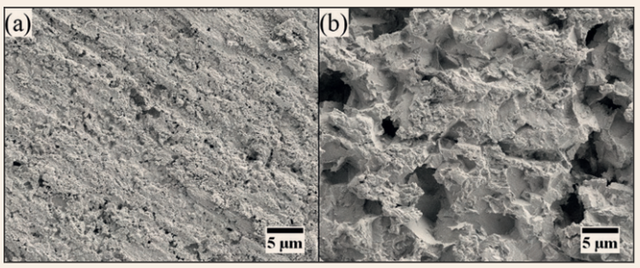

Figure 6. SEM images of extent of corrosion damage on the surface of 99% pure Cu after 21 days of immersion in M9 medium under (a) abiotic and (b) biotic conditions.

The increased corrosion rate of Cu under biotic conditions could be due to the production of acidic by-products by the bacteria due to the presence of glucose in the minimal salts medium [41]. The bulk pH of the medium was monitored at the end of immersion test. The results showed a significant drop in the pH value of the biotic M9 medium (~ 5.7) compared to abiotic test medium (~ 7.4), indicating that the bacterial cells produced acidic by-products in the presence of the glucose carbon source. The number of viable bacterial cells was measured at the start and end of each test. The results showed a significant decrease in the number of viable bacterial cells in the bulk solution from ~2.8×10^8 cells/ml (start) to ~7×10^6 cells/ml (end). This might be due to the toxic effect of Cu ions on the bacteria in the test medium [104].

4.2. MIC of copper-nickel alloys in the presence of sulphate reducing bacteria

Laboratory studies were carried out on CuNi alloys (90:10 and 70:30) to investigate MIC susceptibility of these alloys [105]. Polished coupons were exposed to the SRB (*Desulfovibrio desulfuricans*) in modified Baar's (MB) medium for 90 days. SEM images of the two alloy surfaces before and after cleaning following immersion in abiotic MB medium for 90 days are shown in Figure 7. A thin adherent corrosion film formed on both CuNi 90:10 (Figure 7a) and CuNi 70:30 (Figure 7c) under abiotic conditions. A relatively low level uniform attack on the surface of both alloys was observed after removal of corrosion products (Figures 7b and d).

Figures 8a-d show SEM images of alloy surfaces immersed in the SRB inoculated MB medium for 90 days. Unlike the samples in the abiotic test medium, bacteria and a dense black biofilm accumulated on the surface of both of the alloys tested. The black corrosion products observed on the alloy surfaces were suspected to be iron sulphide and/or copper sulphide formed during the metabolic activity of SRB. Previous studies have shown that SRB cells produce iron sulphide corrosion products in media containing soluble ferrous ions [106, 107]. An EDS analysis of the black corrosion products (data not shown) revealed high content of iron, Cu and sulphur, indicating the presence of FeS and/or Cu_2S. After the removal of biofilm/corrosion products, SEM results showed attack along the grain boundaries on the surface of CuNi 90:10 (Figure 8b) whereas a localised pitting attack was found on CuNi 70:30 (Figure 8d).

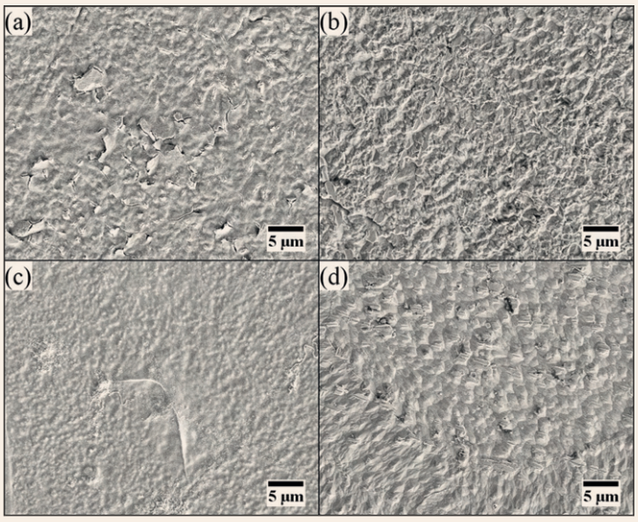

Figure 7. SEM images of CuNi alloys before (a, c) and after (b, d) removal of corrosion products immersed in abiotic MB medium for 90 days. (a, b) CuNi 90:10 and (c, d) CuNi 70:30.

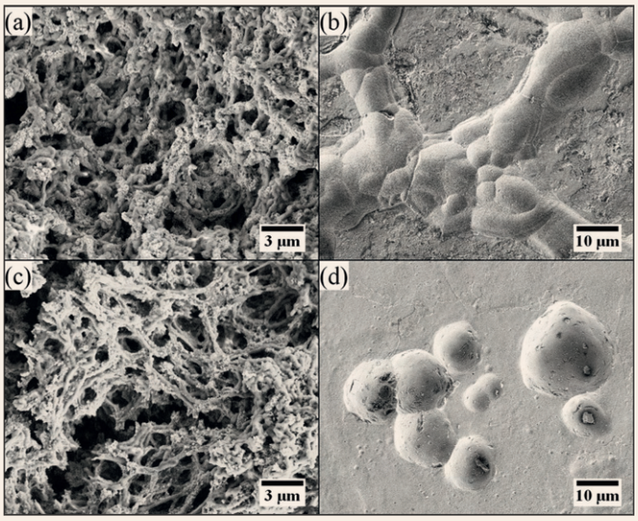

Figure 8. SEM images of CuNi alloys before (a, c) and after (b, d) removal of biofilm/corrosion products immersed in MB medium inoculated with SRB for 90 days. (a, b) CuNi 90:10 and (c, d) CuNi 70:30.

Pit depth analysis was performed on both of the alloy surfaces using a 3D optical profilometer. The result showed a relatively high pit density for CuNi 70:30 (~8.5×10^8 m^{-2}) compared to CuNi 90:10 (~0.5×10^8 m^{-2}). The average pit depths of ten deepest pits were found to be 20 ± 1 µm and 11 ± 0 µm for CuNi 90:10 and CuNi 70:30, respectively. The corrosion rate, calculated from weight loss, for both of the alloys was found to be significantly higher under biotic conditions, compared to abiotic conditions. A significant difference was also observed between the corrosion rate of CuNi 90:10 (65 ± 4 µm) and CuNi 70:30 (11 ± 1 µm) under biotic conditions. Weight loss is a measure of the average corrosion rate and does not provide information on material degradation due to pitting attack. Maximum pit penetration rates from biotic tests were calculated from the average pit depths of the ten deepest pits found on the surface of the coupons using 3D profilometer. The results showed that the maximum pit penetration rate for CuNi 90:10 (~82 µm/y) was approximately two times more than CuNi 70:30 (~43 µm/y).

The bulk pH and redox potential (E_h) of each individual test medium was measured every two weeks, prior to medium replenishment, to determine whether there was any relationship between these parameters and corrosion. Under abiotic condition, the pH and E_h of the test media (~6.5 and ~ –20 mV vs SCE, respectively) remained relatively unchanged throughout the experiment. Under biotic conditions, after two weeks, the pH values increased to slightly more alkaline values (~7.7) with a decrease in the E_h values (~ –100 mV vs SCE) which then remained relatively constant throughout the rest of the experiment. It is also important to note that under both abiotic and biotic conditions no significant change was observed in either the bulk pH or E_h of the tests medium at any time interval during the corrosion test duration.
The number of viable bacterial cells in the test media was measured every month, prior to medium replenishment. The microbial population was determined as a function of time to provide insight into (i) possible population size effects on the corrosion behaviour of the different alloys used in this study and (ii) whether any ions (e.g. Cu) released into the test media as a part of corrosion process affected bacterial levels. The results showed no significant change in the number of viable bacterial cells in the test medium with different alloy types over the course of the 90 day immersion studies.

While the exact mechanism responsible for pitting corrosion attack in CuNi alloys is not entirely clear, it appears that the presence of biofilm contributes to corrosion by either (i) maintaining enhanced local ion concentrations and differential aeration cells [1], (ii) microbiologically produced copper sulphide [28, 42, 108] and/or (iii) the binding of metal ions by the EPS produced by bacterial cells [31, 30].

5. Conclusions

This review discusses the microbial mechanisms that can lead to accelerated corrosion of Cu and its alloys, the toxicity of Cu ions towards living microorganisms and its role in MIC, and provides some examples of case studies of MIC of Cu alloys in seawater and potable water systems. Overall, it is worth re-stating that copper and its alloys are susceptible to MIC despite their good antibacterial properties. In this work we have also shown that different types of Cu based alloys i.e. CuNi 90:10 and CuNi 70:30 presented different forms of corrosion attack i.e. intergranular and pitting attack respectively, after exposure to similar MIC test conditions. The case studies and other references provided may be a useful source of information for those undertaking Cu MIC research and/or those studying failures of Cu and Cu alloy systems. Further work is currently underway to gain a better understanding of MIC of Cu and its alloys due to the presence of different types of microbes and also to determine the type and extent of attack for different alloys. It is envisaged that these studies will ultimately assist in the design of better MIC inhibition and mitigation strategies for Cu-based systems.

6. Acknowledgements

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7. References

For the full list of references go to the conference proceedings at www.corrosion.com.au (for members only)

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