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CORROSION & MATERIALS

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Inside this Issue:

60 CELEBRATING 60 YEARS 1955 – 2015
AUSTRALASIAN CORROSION ASSOCIATION INC.

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Corrosion & Materials
Corrosion & Materials is the official publication of The Australasian Corrosion Association Inc (ACA). Published bi-monthly, *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 *Corrosion & Materials* publishes original, previously unpublished papers under the categories 'Research' and 'Professional Practice'.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 Brendan Pejkovic at bpejkovic@corrosion.com.au with a copy to bruce.hinton@monash.edu

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 Brendan Pejkovic at bpejkovic@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.

Vision Statement
Reducing the impact of Corrosion.

THE WORLD CORROSION ORGANIZATION
The ACA is a founder member of the World Corrosion Organization

Front Cover Photo:
Corrosion protection on an oil & gas platform.
Photo Courtesy Rhino Linings.

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The ACA celebrates 60 years in 2015.

Mohammad Ali
President

ACA Director Call for Nominations 2015

The ACA Council invites all interested ACA members to nominate themselves to serve on the ACA Board.

The ACA Board has undertaken a review of the skills that the Board should desirably possess and has determined that key areas in candidates' skills that would supplement the skills of the continuing Board members are:

- **Corporate Governance and Risk**
- **Corporate Strategy**
- **Corrosion Related Industrial Experience**
- **Finance and Accounting**
- **Legal**
- **Professional Education and Training**
- **Marketing and Communication**
- **Previous Board Representation**

The Board has defined these skills on pages 4 and 5 of the Board Nomination Form – which can be accessed on the ***About Us*** page at www.corrosion.com.au.

Nominations must be made and seconded by a member of The Association and shall be accompanied by the Board Nomination Form as well as statements by the candidate describing their relevant skills, qualifications and attainments which fit them for election as well as a CV.

Nominations are called for three ACA Board positions for a three year term commencing 15 November 2015. Three current Directors retire by rotation, and two of them are eligible for re-appointment and have indicated they will seek re-appointment.

To nominate for an ACA Board position, please return your completed application via nominations@corrosion.com.au no later than COB on Wednesday 16 September 2015.

All nominations will be provided to ACA Council members who will elect to fill the Board vacancies during the ACA Council meeting on Sunday 15 November 2015.

For answers to any queries, please contact the ACA Executive Officer, Wesley Fawaz via email at wesley.fawaz@corrosion.com.au

Kind regards

Mohammad Ali
ACA President

ACA 2015 Events

Part of the role of the ACA is to organise events that bring together industry experts to present on new technologies, updates to standards, and share knowledge and experiences via case studies on a variety of projects. Here are the events for the remainder of 2015.

Event Title	Event Date	Event Location
Corrosion in the Oil & Gas Industries	27 August 2015	New Plymouth
Concrete Corrosion	17 September 2015	Sydney
Protective Coatings	1 October	Perth
Corrosion & Prevention 2015 Conference	15 – 18 November 2015	Adelaide

ACA members will receive further details on each event as appropriate throughout the year, but for now, please include these in your 2015 diary. For further information on these events for 2015 please don't hesitate to contact Brendan Pejkovic (bpejkovic@corrosion.com.au) in the ACA office on +61 3 9890 4833.

Branch Events

Each of the 8 ACA Branches will conduct regular technical events throughout 2015. To enquire, you may contact your local Branch at the following email addresses:

New South Wales: nsw@corrosion.com.au
New Zealand: nz@corrosion.com.au
Newcastle: ncl@corrosion.com.au
Queensland: qld@corrosion.com.au
South Australia: sa@corrosion.com.au
Tasmania: tas@corrosion.com.au
Victoria: vic@corrosion.com.au
Western Australia: wa@corrosion.com.au

YCG Events

Targeting individuals under 35, new to the corrosion industry and/or interested in the corrosion industry, the ACA Young Corrosion Professionals conduct regular events. For further details email ycg@corrosion.com.au or go to www.corrosion.com.au

ACA YCG
THE AUSTRALASIAN CORROSION ASSOCIATION INC
YOUNG CORROSION GROUP

Please refer to **www.corrosion.com.au** for up to date details on all ACA activities.

Wesley Fawaz
Executive Officer

Expanding our training offerings is a key strategy for the ACA's future growth and I thank all those who participated and provided valuable feedback of your training needs. Results of the recent corrosion training survey are currently being analysed. This research will allow the ACA to develop a formal framework for existing and new training offerings by providing a diverse training program through development of new courses as well as introducing existing courses with international partners.

The ACA has continued to enhance its governance processes and operational procedures with Council approving its Charter which sets out the core roles, how it is structured, and how it works. The Board now has a Charter for its subcommittees and a Branch Operating Manual has been reviewed by Branch committees and approved by the Board. Following the Constitutional change last year, this now completes Action Plans 2.1, 2.2 and 2.3 of the Strategic Plan.

The 10-15% per annum growth in membership that we have experienced in recent years has now slowed to a more steady pace but I am delighted to announce that membership is now above 2,200 for the first time. A new membership recruitment and retention strategy is being developed to ensure we continue our growth and further develop and service new and existing membership market segments. I certainly believe there is more growth to come.

The ACA will trial offering webinars starting next month. If there is sufficient interest from members and industry for this convenient web based style of learning, this service will be offered on a regular basis.

The ACA has been focusing on raising corrosion awareness with the implementation of it's PR strategy this year which has resulted in 67 articles being published in the first half of the year in a wide cross section of industry publications from New Zealand Construction News, to Australian Mining, to Australian Hospital Engineer.

The Board recently approved to undertake a Cost of Corrosion study with the aim to further raise the awareness of corrosion and to influence government. The scope is being developed and a call for a working committee will be released.

Building relationships with other Associations is another key action plan for the ACA. I was recently involved in a meeting with a group of similar member Associations to discuss the concept of collaborating on common issues so that by working together we will be able to achieve greater results compared to individually. An immediate outcome of that meeting was providing a letter of support to the Australian Steel Institute's submission into the Australian Senate Enquiry into non-conforming Building Products.

A joint event was trialed in July with the Australian Pipelines and Gas Association in Brisbane and with over 90 delegates, this enabled the ACA to reach a wider audience and offer members a greater networking opportunity. The ACA is also partnering with Engineers Australia to develop an Introduction to Corrosion online eLearn (thank you to Rob Francis and Graham Sussex for their support) and this should be announced shortly. We also welcome the Australasian Institute of Surface Finishing into our offices in Melbourne next month as another example of Associations working together.

By implementing all these activities, the ACA is working toward its vision of reducing the impact of corrosion.

Wesley Fawaz
Executive Officer
wesley.fawaz@corrosion.com.au

THE AUSTRALASIAN CORROSION ASSOCIATION INC. | TRAINING

ACA Training Calendar 2015

ACA/ACRA Corrosion and Protection of Concrete Structures

Member $1060 Non-member $1330

Adelaide August 20 – 21

Perth October 13 – 14

ACA Coating Inspection Refresher

Member $605 Non-member $740

Adelaide November 14

Wellington December 4

Cathodic Protection Monitoring

Member $1485 Non-member $1810

Adelaide August 31 – September 2

Perth October 5 – 7

Melbourne October 26 – 28

Cathodic Protection Advanced

Member $2220 Non-member $2600

Auckland September 14 – 18

Perth November 30 – December 4

All Australian course fees listed are GST inclusive. All NZ course fees are exempt from GST.
To calculate the fee pre-GST, divide the fee by 1.1

Corrosion Technology Certificate
(Also offered as Home Study)

Member $2220 Non-member $2600

Melbourne September 21 – 25

Sydney November 23 – 27

CTC Home Study

Member $2220 Non-member $2600

Start any time

NACE CIP Level 1

Member $3740 Non-member $4275

Melbourne October 12 – 17

Adelaide November 2 – 7

NACE CIP Level 2

Member $3740 Non-member $4275

Perth August 24 – 29

New Zealand October 5 – 10

Melbourne October 19 – 24

Adelaide November 9 – 14

NACE CIP Level 3 Peer Review

Member $1470 Non-member $1725

Adelaide November 9 – 13

By appointment only. Duration: 2 hour oral exam in front of a 3 member review board. Pre-requisites apply go to Training at www.corrosion.com.au for more details

Protective Coatings Quality Control

Member $1485 Non-member $1810

Perth September 14 – 16

IN-HOUSE TRAINING

Did you know that you can have ACA's suite of courses come to you?

'In-house training' offers your company the opportunity to have your employees trained at your own facility whilst eliminating travel expenses and minimising downtime.

'In-house training' also gives you the flexibility to choose the ACA training that best fits the needs of your company with flexible scheduling options.

Please contact the ACA's training department on +61 3 9890 4833 or aca@corrosion.com.au

Australian Academy of Science Honour for Maria Forsyth

Professor Maria Forsyth, Deakin University, has been elected a Fellow to the Australian Academy of Science.

Only around 500 Australian scientists have received this lifetime honour, since the Academy was established in 1954 by Australian Fellows of the Royal Society of London. The Academy's mission is "to champion Australian scientific excellence, to promote and disseminate scientific knowledge, and to provide independent scientific advice, for the benefit of Australia and the world." Members are selected by Australian and international peers from within their discipline.

The appointment recognises Maria's work as a leader in the fields of advanced materials for new energy and infrastructure technologies, including fuel cells, battery designs and new ways to prevent corrosion.

Professor Forsyth is Chair in Electromaterials and Corrosion Science at Deakin, and Associate Director for the ARC Centre of Excellence for Electromaterials Science (ACES), which is based at the University of Wollongong and is helping to lead Australian innovation in areas such as energy storage and bionics.

4Subsea gets research grant for corrosion in flexible pipes

SMEDSVINGEN, Norway -- The Research Council of Norway has through the 'Petromaks 2' program awarded 4Subsea funding for a research initiative on corrosion in flexible pipes. The initiative aims at developing new and improved ways of assessing structural integrity, and close the industry's technology gaps on understanding of corrosion mechanisms within flexible pipes.

The analysis work will enhanced by laboratory testing with IFE (Institute for Energy Technology), a key partner, and is supported by Norske Shell, ExxonMobil Norway and Statoil as participating industry partners. The duration of the research work will be two years.

"With the current track record and failure rate of flexible pipes in the North Sea and the rest of the world, this project will contribute to more safe and cost effective operation of flexible pipes"; says Nils Gunnar Viko, head of the Flexible Pipe Technology department in 4Subsea. "We see this initiative as a direct continuation of many years' effort on understanding the complex mechanisms that drive the integrity of flexible pipes. We look forward to working with our partners in enhancing this knowledge base," Nils Gunnar Viko adds.

The increased knowledge of the diffusion and corrosion processes in the annulus of flexible pipes is important for the development of improved 4Subsea services and products, including the annulus monitoring system AMOS.

New professorship for nanotechnology research

Women in Engineering Day got off to a good start with the announcement of the Shell/Royal Academy of Engineering Research Chair for Professor Mary Ryan.

Professor Ryan leads Shell's programme for Materials and Corrosion at Imperial's Department of Materials in London.

The programme was set up to help industry develop new ways to manage and protect equipment by providing a better understanding of how to predict the behaviour of materials. Finding ways to reduce corrosion is a serious challenge for industry, estimated to cost the global economy upwards of $2.2 trillion annually.

Professor Ryan's new chair is for Interfacial Nanoscience for Engineering Systems, to carry out the underpinning research to link what goes on at the nanoscale to large-scale corrosion – ultimately to make industrial processes safer, more predictable and more efficient.

Rodney Glocer – Steel Mains

Australia's leading manufacturer and supplier of steel pipeline systems for the water and wastewater industry has recently changed its name to Steel Mains. Formerly part of Pentair Water Solutions and prior to that Tyco Water, the company has been spun off into a separate entity.

As part of these changes Rodney Glocer has been appointed to the capacity of Sales & Marketing Director. Rodney has worked for the Company for over 13 years and has over 20 years' experience in the water industry in various roles in product development and management, standards, and technical marketing.

Steel Mains and its forerunners have traditionally been at the forefront of developments in the water industry for more than 125 years of manufacturing pipelines in Australia. Over that period steel pipeline design, manufacturing processes and technology have evolved into the SINTAKOTE® steel pipeline system.

Further details can be found at www.steelmains.com

Pumpline now Airblast Australia

Pumpline are proud to announce an exciting change to their business name and product offering. Their new trading name is Airblast Australia effective from 1st July 2015. Last year they became a part of the Airblast group of companies which operates from offices in many countries around the world.

Airblast offer world leading products and solutions for the surface treatment industry and are a world leader in dustless blasting, and combined with the Blastrac range of products they now have some of the best products available to bring to the Australian market. Together with Graco, Ecoquip, Gema and ABSS products they now believe their range is both comprehensive and of outstanding quality.

Pumpline would like thank all their customers that have been a part of the Pumpline journey and look forward to enjoying continued support and success as AIRBLAST AUSTRALIA.

New research to realise the sensor 'pipe dream'

Three new research projects funded by Australia's energy pipeline industry have been initiated at Deakin University. The projects aim to develop a world-first pipeline health monitoring system that will be based on a high tech sensor developed by Deakin researchers.

The Deakin Corrosion Research Centre has been granted about $1 million by the Energy Pipelines Co-operative Research Centre to progress the sensor technology through a three-year development phase - leading to commercialisation. The researchers will also use the funds to undertake extensive modelling of corrosion under disbonded coatings.

Co-Director of the Deakin Corrosion Research Centre, Professor Mike Tan, explained that the unique sensor-based pipeline health monitoring system should help the industry to extend the lifespan of pipelines by decades.

"Pipelines are a multi-billion dollar asset within Australia," said Professor Tan. "They were designed to last for 30 to 40 years, and many of Australia's oil and gas pipes are near the end of that timeframe, but the companies would face huge difficulties and expenses if they were to replace them."

"The energy pipeline industry has a 'dream' to economically extend the safe operational life of their pipelines to 100 years. I believe that our technology will help them to achieve it."

"High pressure underground pipelines are typically protected against corrosion with a combination of barrier coatings and cathodic protection systems," he explained.

"When their coatings become 'disbonded,' due to the effects of various chemical, electrochemical, electrical and environmental factors, pipelines become susceptible to corrosion that can eventually lead to leaks or catastrophic failure."

Professor Tan explained that currently a common method to detect corrosion is 'smart pigging,' where a testing device (known as a pig) is inserted into the pipe and carried along by the fluid flow. However, this is expensive and is usually only carried out at intervals of at least five years.

"The sensors will play an important role in complementing that technique, with a focus on the outside of the pipes, where most of the underground pipeline corrosion tends to occur," he said.

The sensors will be able to be placed in the ground, near the outside of existing pipes, and will provide continuous, real-time monitoring of the efficiency of cathodic protection, coatings and corrosion. They will allow the monitoring, modelling and prediction of when and where corrosion damage would likely occur in years ahead, to enable better and more efficient maintenance practises (and cost savings).

They will use wireless or satellite technology to alert companies when issues occur.

"The sensors will be highly versatile," said Professor Tan. "They can be designed to be suitable for oil and gas pipelines, underwater pipes, desalination plants, bridges, large structures, or even submarines."

CCE appoint new Group Business Development Manager

Corrosion Control Engineering (CCE) has announced Jason Paterson as the company's new Group Business Development Manager. Mr Paterson has over 25 years' worldwide experience in the oil, gas, water and wastewater industries and is a familiar face on the ACA event circuit, having held a senior position at Mears for the past three years.

As CCE continues to expand its operations in the corrosion control and cathodic protection industry, Mr Paterson said:

"As we all know, the effect corrosion can have on infrastructure can be detrimental and in some cases devastating. Corrosion professionals and asset owners continue to face their single biggest challenge... How do I ensure I am doing everything possible to minimise the risk of corrosion on my critical assets?

One essential component of the corrosion prevention process is the use of Cathodic Protection, and CCE continues to lead the way in this field. At CCE, we use our experience to provide engineering solutions for the industry. CCE are also heavily involved in educating the next generation of corrosion professionals, to ensure Australasia's essential infrastructure remains safe and protected for many years to come".

For more information about Corrosion Control Engineering's Services and Products visit www.cceng.com.au

A Rubber That Stops Corrosion? NRL Research May Extend Life of Amphibious Assault Vehicle (AAV)

The U.S. Naval Research Laboratory (NRL) has found that some types of rubber provide corrosion protection—and potentially better ballistic protection—for amphibious assault vehicles (AAVs). This is important to the U.S. Marine Corps (USMC) as they look to extend the AAV, introduced in 1972, through 2035. "Innovative sustainment concepts, like those NRL is investigating, enable us to avoid the cost of new design, development, and production of new components," says Tim Bergland of the USMC Advanced Amphibious Assault (AAA) office.

Dr. Mike Roland and Dr. Ray Gamache led the research for NRL. "What makes [AAVs] unique is they can go on water and land," says Roland. "They give the Marine Corps a capability that no other service has."

Since the 1990s, the USMC has been bolting armor onto their AAVs. "The armor itself is a laminate of high tensile hard steel, which by itself is good for ballistics; a rubber layer; then there's another soft steel layer in the back," says Roland. The problem is that the armor gets corroded with intense use and exposure to salt water.

Roland and Gamache found rust and corrosion start at cracks in the paint. "You've got steel, rubber, steel—and these things are thermally expanding and contracting differently," says Roland. "In addition to which, AAVs aren't driven like expensive Volvos; they're banging into stuff—and now you've got a way for water ingress."

NRL showed that certain types of rubber, called polyureas, could better protect the armor from corrosion by stretching with it, instead of cracking like brittle paint.

They also showed polyurea coatings slow bullets and blast fragments. "They take kinetic energy from the bullet," says Roland. "So the bullet, to keep penetrating, it's meeting an increasingly resistant medium. And if it slows down enough—it always makes it to the steel plate, but it doesn't have enough velocity to get through it."

NRL's research could help extend the life of today's AAVs, and may also guide the next generation of ship to shore connectors. "We solved the corrosion problem," says Roland. "And with a negligible increase in weight, we also provided a higher payload capacity and the potential for better ballistic protection."

Dr. Ray Gamache (left) and Dr. Mike Roland (right) of the U.S. Naval Research Laboratory (NRL). Photo: U.S. Naval Research Laboratory/ Jamie Hartman.

Amphibious assault vehicles (AAVs) demonstrated ship to shore connector capabilities in Feb 14 at Camp Pendleton. Photo: Lance Cpl. Ricardo Hurtado/USMC.

Army researchers develop batteries that don't corrode

New lighter batteries for soldiers are under in-house development at the Army Research Laboratory in Adelphi, Maryland. "We help to develop new battery materials that are lighter and last longer for the soldier, so he doesn't have to carry so many batteries," said Cynthia Lundgren, a chemist and Chief of the Electrochemistry Branch of the Power and Energy Division in the Sensors and Electron Devices Directorate.

To create a better battery, Lundgren and her team experiment with small ‘button cells,’ such as what one might find in a watch. A ‘cell’ consists of two electrodes: an ‘anode,’ which is the side marked with a ‘minus’ sign; and a metal oxide or phosphate cathode, which bears the ‘plus’ sign. Between these two electrodes is a liquid electrolyte soaked separator that facilitates the transfer of lithium ions to transfer charge. One or more of these ‘cells’ is used to construct a battery pack. The team tinkers with the different materials that make up both the cathode and the anode. They also tinker with the chemistry of the electrolyte of the battery. Lundgren said that one way to make a battery lighter is to use electrodes that increase its cell voltage.

"If we could raise the voltage of a single cell -- energy density is a direct function of the voltage -- we could make the battery lighter," she said. "The problem is, as you go up in voltage, the electrode becomes much more energetic, and so it reacts with the electrolyte." The reaction of electrodes with the electrolyte is one of the key problems Lundgren and her team have proven successful at tackling.

"The electrodes are very corrosive, and they react with the electrolytes," said Von Cresce, a chemist at the lab. "So what ends up happening as you cycle the battery back and forth is that the electrolytes are degraded by the cathode because of the voltage at the cathode."

For the types of rechargeable batteries that Lundgren and her team are developing, that degradation means fewer charge/discharge cycles. Additionally, as the cells are charged and discharged, they retain less of their ability to hold a charge.

To prevent such degradation in a cell, the team created a solution called HFiPP -- short for "tris (hexafluoroisopropyl) phosphate," which they use to enhance the electrolyte to make it more stable in high-voltage situations. "It's a corrosion inhibitor," Lundgren said. "You just add it to the electrolyte that any manufacturer would put in. It's a little bit of pixie dust."

In the lab at Adelphi, the team is experimenting with a higher voltage iron-doped lithium cobalt phosphate cathode developed in the lab by fellow Army chemist, Jan Allen.

Cresce said the $LiCoPO_4$ cathode is particularly high voltage, at 4.9V. "It seems to be more reactive towards the liquid electrolyte," he said. "This is a common problem among many varieties of experimental high voltage cathodes. It really seems to behave badly against unprotected liquid electrolyte."

But with the HFiPP solution added to the electrolyte for corrosion protection, the team was able to develop a battery that has both a higher voltage cathode, but at the same time is more stable. It can be charged and recharged many times, while maintaining its capacity and not corroding.

Lundgren said she believes what they have developed at the Army Research Lab will make batteries lighter and last longer.

ACA Welcomes New Members

Corporate Gold

Marine & Civil Maintenance Pty Ltd
www.marineandcivil.com.au

Marine & Civil Maintenance is a specialist remedial contractor which is focused on fully-engineered repair, strengthening and protection of infrastructure such as wharves and jetties, bridges, seawalls, buildings and industrial facilities throughout Australia. MCM was founded in 2001 and is now recognised nationally as a leading D&C provider of all types of cathodic protection and concrete repair in challenging situations.

Cryoprep (Aust)
www.cryoprep.com

Cryoprep uses a blast process which employs a combination of dry ice and a range of conventional grit media. Dry ice sublimates on contact with a surface leaving it dry, clean and paint ready. A significantly reduced amount of selected abrasive media is used to create the specified profile suited to the coating system being applied. We are surface preparation and coating specialists.

Corporate Bronze

Advanced Cathodics, a division of Liquid Gas Services
www.lgs.co.nz

Advanced Cathodics is a new division of Liquid Gas Services, specialising in Cathodic Protection, including design, installation, auditing, repair and supply of hardware. Advanced Cathodics has two full time staff based out of Auckland, but cover all of New Zealand, and the Pacific Islands.

Eddysonics Pty Ltd
www.eddysonics.com

Asset Integrity Testing & Inspection

- Industrial Rope Access
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- Visual Inspection
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- Non Destructive Testing
- Thickness Surveys
- Corrosion Mapping
- Coating Inspection

Eddysonics provides proficient & highly qualified asset integrity inspectors specialising in the Offshore Energy industry with experience in Construction & Maintenance. They intuitively seek out new technologies, updated industry standards & learning outcomes to exceed their clients' expectations in a timely manner.

VALE: The Missing Man Formation: A Tribute to Mark S. Schilling by Friends

On 7 December 2014, Mark S. Schilling, our good friend and collaborator in the technical community, suddenly and tragically passed away. This tribute will focus on a few salient aspects of the great man and the many contributions he made to the fields of corrosion and materials science.

Mark Schilling visited Australia a number of times and delivered some of the more memorable technical presentations ever witnessed at several ACA and BCCA Conferences.

Mark's depth and breadth of knowledge on a wide range of topics including but not limited to corrosion science, metallurgy, protective coatings, plastics, elastomers, fireproofing, and materials testing was remarkable. He had, quite simply, a brilliant mind. His encyclopedic grasp of so many complex scientific and engineering principles in the areas of polymer chemistry, thermodynamics, materials performance properties, analytical techniques, and failure analysis was unparalleled by anyone else we knew or know. When we thought we knew the answer to a particular problem, or conversely weren't sure which way to turn, we would call Mark. Usually, with his counsel, the path to resolution of that specific problem-solving quandary would become well illuminated. Often, we had missed the obvious and looked too far. On other occasions, we hadn't considered all of the contributing factors. In nearly every scenario in which his counsel was sought, he set us on the right course. Mark was generous to a fault with his time, sharing in-depth, insightful guidance along with the technical reference sources necessary to back-up the conclusions.

Using his apparently bottomless vessel of a learned, incisive mind, and solid technical writing skills, Mark authored and co-authored numerous technical papers and standards through SSPC, NACE, and other technical associations. He is perhaps most widely known for his popular series of articles in the JPCL called Truth and Consequences.

Mark led the Standards Committee at SSPC for a number of years and ensured the scientific accuracy and clarity of language used in many important documents. In short, Mark's leadership and steadfast determination for SSPC and NACE to achieve technical efficacy and defensible veracity in publications provided invaluable contributions and advancements to the profession. With his remarkable intellect and seemingly photographic recall of scientific principles and facts, he made our industry better.

Mark was adamant about getting to the truth in all technical matters. His unyielding dedication to precision made him a highly valued ally, a formidable technical adversary, and a tough reviewer of all written words.

One of Mark's greatest crusades was his fundamental disdain with the junk science of the salt frenzy brigade who, over many years, had been peddling the untruths that soluble salt, particularly sodium chloride, could regeneratively form acid in corrosion pits, and that this needed a proprietary 'salt extraction agent' that would allegedly dislodge these "insidious and dangerous" materials that had now, somehow, become chemically attached to the substrate or were ingrained and were mostly insoluble. Mark repeatedly and fluently demonstrated that the corrodent in atmospheric corrosion was oxygen, that chloride was potentially a corrosive (in some situations) and that 'soluble' actually meant soluble, i.e., all that was needed to dissolve these materials off the surface was water. Mark, almost singlehandedly, stopped or curtailed the many untruths about soluble salts being written into industry tests, textbooks, standards and published papers.

His campaign of truth against the salt frenzy junk science earned Mark the title of 'The Detriment', a handle he wore with much pride, indeed for many years he signed his correspondence so.

Mark could be confrontational, contrary, argumentative and unyielding. Those with thin skin and unsupported claims didn't enjoy Mark's challenges, nor did he suffer fools gladly. Thus, he challenged friend and foe alike. And he did so to seek, find and articulate the truth.

At our last night at the 2015 SSPC National Conference, the undersigned along with a few other old comrades of Mark's enjoyed a special dinner together in Las Vegas. At Mark Dromgool's wise suggestion, we who were seven, booked a table for eight. In aviation, as Dromgool explains, it's called the 'missing man formation'. We reminisced about prior conferences, debates, backpacking trips, and many years of laughs. It was our way of continuing to enjoy Schilling's brilliance, insistence on the truth, and love of levity.

To close it would be remiss not to mention another salient matter, very typical of Mark Schilling. For many decades, Mark's email address was WELBYTOAST. When asked why this was so, he declared that, "one day, we'll be toasting our lives, our achievements and our legacy."

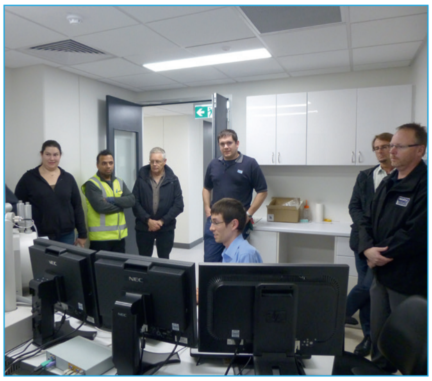
Mark S. Schilling; WELBYTOAST; MSS; MS2; The Detriment; we, your long-held friends, admirers & colleagues, toast you.

Goodbye, Dear Friend, until we greet again.

Signed by: Mark Dromgool, Randy Nixon, Mike O'Donoghue and Russell Spotten.
(Excerpt from the original article which appeared in JPCL March 2015).

SA Branch

Here are two photos from the recent visit to Adelaide Microscopy, University of Adelaide. The visit went very well; 8 participants went on the tour, and were treated to the first images of the new Titan TEM which was being commissioned. The images were of actual gold atoms and their arrangement, which was very exciting to see.



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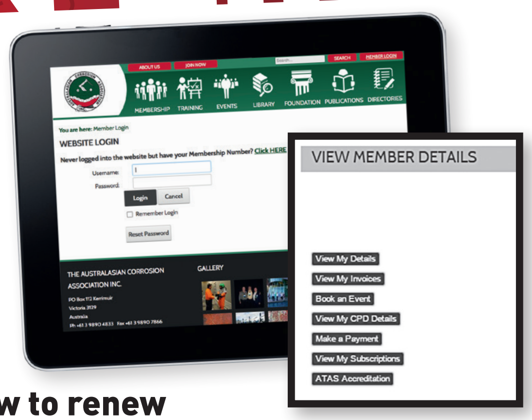

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ACA Auckland Dinner Meeting

June 2015

ACA Auckland held a meeting at The Landing Hotel in Onehunga on 17th June with speaker Les Boulton of Les Boulton & Associates Ltd, addressing the subject of '*Forensic Engineering – Who Dunnit*'. The presentation opened with an overview of the cost of corrosion due to the failure of important infrastructure, sometimes due to corrosion. The failure of assets and infrastructure often results in civil court action to determine who was responsible and who faces any liability costs. Forensic engineers contribute to the civil or criminal legal processes that can ensue by assisting an asset owner, legal counsel and the civil court to determine 'who dunnit'.

A number of recent high profile global infrastructure failure cases were presented, including a major gas pipeline explosion and structural steel failures of plant and a carpark, which resulted in death and destruction. In these cases criminal charges were subsequently laid against management and engineering staff, which is now more likely to become a global trend. However, tort law applies in most asset corrosion failure cases. An outline was then given of how the insurance industry deals with various aspects of asset losses due to corrosion. As a rule insurers treat corrosion as "wear and tear" and the insured have little redress, unless "corrosion" is specifically included in an all-risk insurance policy. 'Perils of the sea' were then described, these being asset losses due to misadventure at sea. Several cases were then outlined to illustrate how insurers deal with losses at sea including cases where corrosion of cargo or ships is involved.

The recent case of the disastrous failure of an 8-lane federal highway bridge called Interstate I35W in Minnesota, USA, was then outlined. The 40-year old steel truss bridge failure that occurred in 2007 highlighted how important the role of inspection and monitoring is on ageing infrastructure that has possible structural deficiencies. The failure of the bridge showed that inadequate design and poor maintenance can result in tragic consequences, which also create huge psychological stress in the affected community. Forensic engineers assist the authorities and the courts to determine the cause of critical infrastructure failures and also assist in the legal process to discover who is liable and how large any punishment should be for the perpetrators.

Chairman Bruce Fordyce then thanked Les for his presentation and the attendees retired to The Landing restaurant for fellowship and an excellent dinner with wine provided by ACA. At the commencement of this Auckland ACA meeting Bruce had presented three attendees with a bottle of wine each for attending their first ACA meeting.

Attendees at the mid-year dinner meeting.

Dinner at The Landing restaurant.

Les Boulton (speaker) and Bruce Fordyce (Chairman).

Guests David Gifford, Grant Chamberlain and Sean Ryder.

Corrosion Technology Course

Manukau, June 22-26 2015

The ACA's respected 5-day Corrosion Technology Course (CTC) was recently held at HERA House in Manukau, Auckland. There were 8 students attending and the CTC course lecturer was Dr Geoffrey Will from the Queensland University of Technology (QUT), Brisbane.

Successful CTC students will be able to use the points gained from completing the CTC course towards becoming an accredited ACA Technician and ACA Technologist, which are recognised ACA qualifications throughout Australasia.

The pictures show the student group at work during their week studying many aspects of corrosion and its control.

ACA Annual Trade Shows

The ACA again hosted its annual Trade Shows, this year in Hobart, Newcastle and Melbourne in June and July. Demand for exhibition tables was high with 19 in Hobart, 13 in Newcastle and 24 in Melbourne. Registrations were over 250 in total and numbers were bolstered by a fair number of walk ins at each event. Businesses represented included a cross section of asset owners, protective coating specialists, blasters, applicators, equipment specialists and more. Great food, beverages and door prizes featured at each networking event. Thanks to those businesses that participated, visitors that attended and Branches that organised and supported these local events.

After my first round of ACA Trade Shows in 2013 (Bris, Syd & Adel), I was a little sceptical about whether, they would actually help my business in any way?

Then I decided to commit to the second round in 2014 (Adel, Tas & Melb) and for a small company like APPS the costs were adding up with little to show.

In early February 2015 I received a call from an extremely large company asking me to look at a massive job on a significant piece of equipment in South Australia.

When I flew down to assess the job, I asked how they had found out about APPS and to my surprise the guy said that he had spoken to me at the Adelaide Trade Show.

So I guess as the saying goes 'it only takes one'!

Richard Raper
Australian Pickling and
Passivation Service Pty Ltd
www.picklingandpassivation.com.au

WA Branch Event - May

Continuous non-intrusive remote monitoring for erosion and corrosion within cryogenic to high temperature service condition.

Presented By Sameer Pal on Thursday 21st May 2015

The presentation of the technology that allows the non-intrusive monitoring of erosion and corrosion over a large variety of temperatures was a result of BP requesting Imperial College London to design a sensor that met a number of key requirements. These requirements included the ability to install these in difficult areas, a relatively low cost, and low maintenance. BP also provided live facilities to field trial the transducers.

The problem with ultrasonic measurements is that they are limited in the temperature they can be successfully deployed. The key to the technology was to locate the sensitive electronics remote to the surface being monitored at a more realistic temperature, and coupling the transducers via a waveguide which is used to send and receive the ultrasonic signal.

Work on the sensors began in 2006, and the by 2008, transducers were available for installation in BP Refineries. By 2010, the technology was commercialised and made available to other companies.

The requirements of the brief for monitoring to be done in difficult locations meant they would require to communicate wirelessly, be battery operated, and be suitable for installation in hazardous areas. Both the units and batteries are hazardous area rated and these can the changed out on site in hazardous areas. The battery life is typically 6 to 8 years. They are also IP67 which allows for their installation in splash zones although no data is transmitted whilst the unit is under water.

One key difference in the use of these transducers is that traditional UT measurements measure spot locations when the measurements are taken. Whilst the area covered by each transducer is limited, they are providing constant data at nominally two readings per day, or a maximum of one reading every 15 minutes. The readings are also delivered to the desktop which allows a number of benefits.

- The number of readings allows for filtering the data to increase the accuracy over time.

- The large number of readings also allows for trending of the data to quickly determine if corrosion is occurring on the inside of the pipeline, and adjusting process conditions if required

The system comprises of the following components, these being the wireless gateway, the transducers, and the software package.

The wireless gateway provide an access point for each transducer to communicate with the software to transfer the data. The gateway can be provided with either a proprietary protocol, or an industry standard Wireless HART system already available in many plants and used for other transducers. Each gateway can handle up to 100 transducers.

The transducers themselves include a transmitter / receiver which communicates with the gateway. Whilst the maximum range of individual transducers (and the gateway) is limited to 50 metres, each transducer can relay data from surrounding units. A string of up to 8 transducers can relay information back to the gateway, giving a theoretical maximum spacing from the gateway of 400 metre radius.

The transducers can be installed using either studs welded directly onto the pipe for high temperature application, brackets bolted around piping or magnetic clamps for lower temperature applications and offshore.

Once set up, the transducers form a 'mesh' whereby they find a suitable path back to the gateway. If that link is broken, an alternate path is found back to the gateway provided there are alternate paths within radio range.

The software is installed on a server and can be accessed via a web interface, by anyone with the correct permissions/ access rights. Various data is made available including summary data and exception data where readings fall outside certain limits.

Two case studies were presented where these units have been installed. In the first example, these units were installed to monitor the corrosion/ erosion occurring on a multiphase flow line where they suspected flow was turbulent.

The second example was of monitoring corrosion on a refinery where they were using blended crudes. This helped identify the corrosive effect of one of the crudes and enable action to be taken to prevent high corrosion rates and eventual failure of the piping. The ability to monitor and view the data in real time allowed for correlating the data with the changes in conditions, allowing the cause of the problems to be identified.

CORROSION & PREVENTION 2015

Adelaide, South Australia
15–18 November 2015

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C&P2015 Plenary Lecturers Abstracts

P F Thompson Memorial Lecture – 2015

Percival Faraday Thompson (1885-1951) is recognised as Australasia's pioneer in the science and technology of metallic corrosion and its mitigation. In recognition of this singular distinction the Australasian Corrosion Association inaugurated the P F Thompson Memorial Lecture in 1951. The Lecture is the Association's premier dedicated Lecture and the Lecturer is encouraged to mark P F Thompson's distinction by referring to or emulating the academic and technical qualities for which Thompson became known, particularly his prowess with practical demonstration.

Robert Francis has been selected to be the 2015 P F Thompson Memorial Lecturer.

Robert Francis
R A Francis Consulting Services, Australia

Who Rusts First? Galvanic Corrosion Revisited

Galvanic corrosion has been studied for over 200 years, but is still the subject of misunderstanding and misuse. It arises when dissimilar metals are joined in a common electrolyte. The more active metal will corrode while the more noble metal will be protected. However, there are many factors other than electrochemical potential which influence the severity of the galvanic action, including area ratio, the nature of the surface of the more noble metal and the environment. After providing a brief history, this presentation reviews investigations which have been carried out into practical aspects of galvanic corrosion. It looks at the factors that influence this form of corrosion, how they are inter-related and how galvanic behaviour can be better predicted than simply reference to a Galvanic Series.

Plenary Lecturers

Markus Büchler
Swiss Society for Corrosion Protection, Switzerland

Sponsored by FREYSSINET

A Discussion of the Mechanisms Involved in Cathodic Protection and their Consequences on Protection Criteria

Cathodic protection has proved to be an efficient way to control corrosion and increase the service life of pipelines. While there is general agreement on the effectiveness of cathodic protection, there is a widespread discussion with respect to the mechanism of protection, the significance of the protection criteria, the methodology of their assessment and their interpretation. Moreover, there are significant differences in the application of these criteria, despite AS2832.1 and ISO 15589-1 that describe clear and strict requirements. The physical-chemical meaning of the protection criteria is discussed and a model for the mechanisms involved in cathodic protection is proposed.

The fundamental applicability of the model concept is validated based on the comparison with extensive field data. The extension of the concept allows explaining the mechanisms involved in a.c. and d.c. interference. The consequences on protection criteria under these conditions are elaborated and compared to experimental data. Based on this analysis a possible explanation for the failure of cathodically protected structures is presented and a new methodology for assessing protection is proposed.

Miles Buckhurst
Jotun, Norway

Sponsored by JOTUN

The True Cost of Paint, A Life Cycle Philosophy

How much does it cost? How often do we ask that question, or are asked by others? What does it mean? Certainly not the same to two different individuals, with different tasks, in the same company. Ask a finance manager, and they will often believe it is the cost of materials to do a certain job. Ask an Engineer and it will be cost of materials and maybe energy. Ask a Paint man and it will be ´depends'. Depends upon what, that is the critical question, but without the answer we neither get it right or get it wrong.

This paper explores Life Cycle Cost calculator, in the traditional manner, and the cost of understanding the reality of testing vs lifetime vs profit and loss. We consider the question of what is lifetime, expectations, maintenance and the cost of reduced production or out of service costs. A challenging approach that even if we cannot have a precise answer or a rule book, should be in the back of our heads when deciding upon, how we shall approach a coating project and choosing the best paint system, the methodology for preparation and application.

Frank Collins
Deakin University, Australia

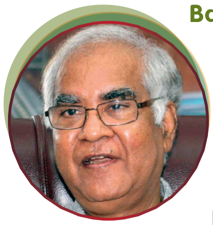
A Hitchhikers Guide to 3D Visualisation of Reinforcement Corrosion within Concrete Structures

Predictive models for corrosion initiation and resulting damage to reinforced concrete structures are primarily 1- or 2-dimensional rather than 3-dimensional and there is a lack of good correlation with the behaviour of field structures. This paper focuses on corrosion damage modelling in 3D and residual life, while visiting the damage on a journey from the microstructure to the damaged structural component.

Srdjan Nesic
Institute for Corrosion and Multiphase Technology, Ohio University, USA

Localized Corrosion of Mild Steel in a CO_2 Aqueous Environment - An Overview

Localized corrosion is a non-uniform loss of metal from the pipe wall which can lead to a loss of containment. Types of CO_2 localized corrosion considered here include: pitting corrosion and so called mesa attack. The most common causes have been grouped into four categories, those related to: flow, chemical causes, metallurgical causes and biological causes. Localized CO_2 corrosion mechanisms identified here include loss of protective layer, galvanic coupling, local water chemistry changes and bio-catalytic effects. Loss of protective corrosion product layer or inhibitor film leading to high (bare steel) corrosion rate is the most common mechanism; galvanic coupling between protected and unprotected areas might lead to even higher corrosion rates; often accompanied by local changes of water chemistry which stabilize localized attack propagation and or the bio-catalytic effect.



Baldev Raj
National Institute of Advanced Studies, Bangalore, India

Corrosion Mitigation, Monitoring and Inspection Technologies

Design, Materials, Manufacturing coupled with life cycle management plays a key role in the development and deployment of technologies for a better quality of life in society. Towards ever increasing temperature, pressure and concentration of chemicals in the industrial processes towards achieving higher efficiency; newer and better materials with higher performance are being demanded. Among the various degradation mechanisms, considered from life cycle perspective, corrosion is one of the major causes for the failure of engineering components in service and also influences total economic and reliable service life of operating components. For understanding the manifestation of corrosion and mitigating degradation with advanced materials and corrosion control technologies; extensive R&D is performed worldwide.

The author advocates the pursuit of corrosion mitigation thorough understanding of a complete spectrum of basic science to testing, evaluation, monitoring, modeling, quality, human resources and best practices to have confidence in authentic and substantial paradigm changes in corrosion mitigation and management. For understanding corrosion issues with deep and clear insights for applications to various engineering components in several critical environments; including liquid sodium, steam-water system, sea water, marine atmosphere, nitric acid, molten chloride and nuclear high level waste storage medium; significant efforts with successful outcomes have been made.

In this presentation, an overview is presented with a focus on the development of nitrogen alloyed stainless steel, nitric acid grade stainless steel, Cr-Mo steels, titanium and its alloys, zirconium and its alloys, nano structured ceramic coatings, thermal barrier ceramic coatings for various applications related to high performance components. The author is of the view that the corrosion processes can be understood and mitigated by pursuing sustained comprehensive R&D for realizing solutions to challenging applications. The approaches to learning and successes are demonstrated through case studies related to robust technologies in those of the application where corrosion is a life limiting parameter influencing reliability, safety and economics in high performance components.

60 years on, the ACA still fights the good fight

PART TWO

As our Association starts its seventh decade, it is interesting to reflect on the achievements and advances the ACA has made in the continuing fight to minimise the impact of corrosion.

The ACA: Training to win the Corrosion fight

The founders of the Australasian Corrosion Association (ACA) recognised that corrosion would only be beaten through the coordinated efforts of industry and academia working together to study the causes and remedies of all forms of material degradation. In his 1958 address—published in full in the previous edition—Milton Speedie stated that "What is more important in my view is the need to stimulate continual improvement in the education of engineers...so leading to a better standard and wider scope of corrosion protection."

As a result, the training and education of engineers and scientists in the field of corrosion has changed over the years. To help achieve this, part of the remit of the Association is the development and presentation of training courses and technical seminars. The level of the courses ranges from introductory for teaching people new to the industry about the fundamentals of corrosion through to advanced for continuing professional development for experienced technicians and engineers.

Research into all aspects of corrosion has been conducted at private laboratories and public institutions for many years by a great many people, but corrosion education in Australia is generally considered to have started with the work of Percival Faraday Thompson, who is often referred to simply as 'PFT' within the industry. Thompson began his Australian career when, in 1906, he took up a lectureship at the institution that would become RMIT.

During the early decades of the 20th Century, ad hoc short courses had been run in conjunction with the ACA by colleges and universities in Brisbane, Auckland, Melbourne, Sydney and Perth, but it was not until the 1970s that there was concerted effort to get consistency and coherence between all the courses offered by institutions throughout the region. "It was a huge task to co-ordinate public colleges and universities, private companies and government bodies," said Les Boulton, Principal Consultant at his own corrosion management company in Auckland and Life Member of the ACA. "All this was made more difficult by the tyranny of distance. They were spread from the Indian Ocean to the Pacific and we had no mobile phones or Internet back then."

In addition to supporting training by other organisations, the ACA also hosts an extensive range of its own courses and events throughout the year, sometimes running four or five different courses in the one month at locations in both Australia and New Zealand. Several of the courses form part of the education requirements if an engineer or technician wants to attain accreditation by the ACA as a Certified Corrosion Technician and Technologist.

While Australia and New Zealand have been at the forefront of a large amount of corrosion research, the countries do not have the population to support formal, tertiary-level corrosion engineer courses. Professor Brian Cherry, from the Faculty of Engineering at Monash University, Melbourne, said “In contrast, Cambridge University appointed a Reader in Metallic Corrosion in the late 1930s.” However, today there are at least a dozen university research schools offering corrosion studies at an advanced level (Masters and Doctorates) which offer higher degree training to Australasian students and an increasing number of international students.

One major area of research and training is cathodic protection (CP). While CP had been known about since the early 1800s, it wasn't until the middle of the 20th Century that scientists and engineers were seriously studying the processes involved and applications of the technology, but there were still no formal courses in the subject. Wayne Burns, Director of Anode Engineering in Brisbane, stated that in the mid-1980s, “there was no way for corrosionists to become formally trained in the art of cathodic protection.” To remedy this, the ACA organised a group of CP specialists from many disciplines to begin drafting the first CP courses which have become one of the mainstays of the Association's education and training program.

Dissemination of information about the principles and practice of corrosion and protection has been supported by the preparation and publication of Standards by the Association. Cathodic Protection is one of the many issues that ACA members have been particularly concerned with as part of their service on Standards Committees.

Another area of corrosion research that developed during the latter half of the 20th Century involved plastics. Members of the ACA have been at the forefront of this research and have developed some of the definitive texts on the subject, including Arthur Kennett's ‘Degradation of Plastics’ that was published in 1984.

In Australia, there used to be approximately 300 independent testing labs in Australia but this number has dropped to closer to 10 today. Bill McEwan, Associate, CTI Consultants Pty Ltd and Honorary Life Member of the ACA added “When I joined the Board of Works in the 1960s it, and most other government departments, had their own research divisions but these have now all been closed down.” Staff at the labs would often discuss corrosion issues at conferences, but with the closure of many labs, the ACA's training courses on particular subjects have effectively filled the knowledge transfer gap.

Many of these research departments were part of the network of institutions that provided the training in different aspects of corrosion. In addition to training their own staff, they were often open to anyone else interested in the subject.

Despite the closures and consolidations—and other restrictions—the ACA continued to support the research and education. “The Association had something special going for it,” Boulton added. “Dedicated and disciplined people who really cared about beating corrosion.”

As an adjunct to its training courses and technical seminars, the ACA also sponsors publication of a number of text books and journals. In 1965, Gordon Langslow, a teacher at the Auckland Technical Institute, published a booklet entitled “Fundamentals of Metallic Corrosion” that became the standard text used by schools in Australia and New Zealand for many years. Despite becoming out-dated, the continuing demand for the book prompted the ACA to commission a revised edition that was prepared by Les Boulton and Graham Wright and published by the ACA in 1979.

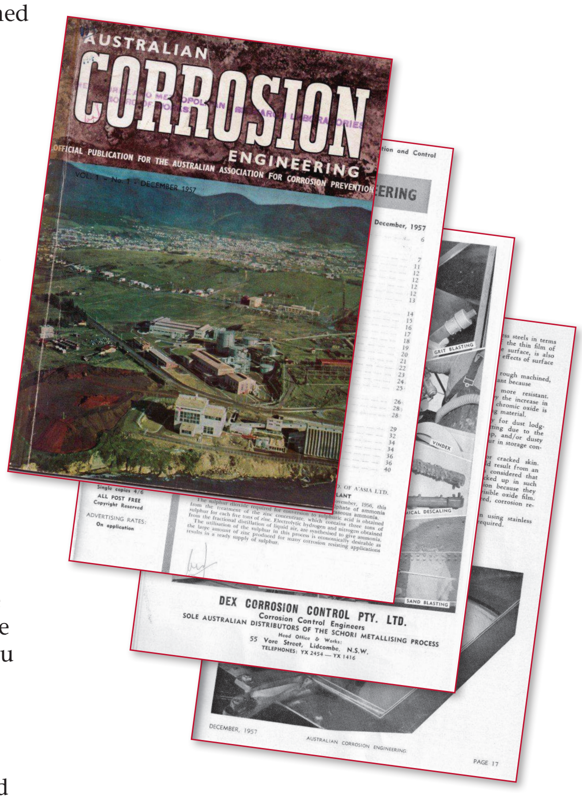
Association members originally published papers in a commercial magazine called ‘The Australian Corrosion Engineer,’ but in 1976 the ACA established its own journal “Corrosion Australasia.” This was first edited by John Moresby who was succeeded in the late eighties by Graham Sussex. The Association's own journal developed further through the 1990s, under the direction of David Whitby, to become the ‘Corrosion and Materials’ that you are reading now.

In addition to printed material for teaching purposes, the ACA New Zealand branch produced a film titled ‘The Corrosion Problem’ in 1980 as part of the celebrations for the Silver Jubilee of the Association in 2005. This film, as well as one titled ‘Turning Back Time’ continue to be a useful training aids for engineers and technicians.

The ACA has been, and continues to be, a hub for discourse and discussion for corrosion workers in Australia and New Zealand and their counterparts around the world. Boulton stated that several members of the Association have also become accredited lecturers for some of the certificate courses offered by the American-based organisation, NACE International, which was originally called the National Association of Corrosion Engineers. This recognition allows the ACA to offer some of the courses offered by NACE International without the expense for attendees having to travel to America for the training.

The ACA continues to work with industry and academia, to support research into all aspects of corrosion, to develop an extensive knowledge base that supports best practice in corrosion management. Through this process, the Association ensures all impacts of corrosion are responsibly managed, the environment is protected, public safety enhanced and economies improved.

With thanks to Wayne Burns, Brian Cherry, Bill McEwan and Les Boulton for their contribution to this article.



P F Thompson – Australia's Pioneer in Corrosion Research and Education

Figure 1. P F Thompson, circa 1949. (courtesy of Graham Thompson, eldest grandson of PFT)

W K Green[1] & B R W Hinton[2]
[1]Vinsi Partners, Sydney and Deakin University, Melbourne,
[2]Monash and Deakin Universities, Melbourne

Percival Faraday Thompson (P F Thompson, PFT), (1885-1951), (Figure 1), a metallurgist and chemical analyst, is widely considered as Australia's pioneer in corrosion science and education. Each year at the annual ACA Conference, the P F Thompson Memorial Lecture is presented by a person who has made a most significant contribution to corrosion science and engineering in Australia. While each presenter usually gives a few details of the work of PFT for the benefit of Conference attendees, the entire body of his work and details about his life are not provided due to the limitations on the lecture duration. A review of Thompson's life and some of his work is available in the '*Australasian Corrosion Engineering*' publication which was the ACA publication in the early 70s, and is one of the precursors to the current ACA publication Corrosion & Materials (Potter, 1972). However this publication is not widely available to the ACA membership, and certainly not in electronic format. The purpose of this paper is to provide readers with some of the history of the PFT Lecture, and to acquaint readers of '*Corrosion & Materials*' and the broader corrosion prevention community with the breadth of the scientific work of PFT and his enthusiasm for describing corrosion science through practical public demonstrations of experiments of the basic principles of corrosion.

THE P F THOMPSON MEMORIAL LECTURE

Dr Edmund C Potter, after which the Corrosion Clock at the ACA Conference is so named, delivered the first P F Thompson Memorial Lecture in 1971 (Figure 5), and it has been delivered every year since, refer Table 1.

Year	Location	Memorial Lecturer
1971	Melbourne	Dr Edmund Potter
1972	Adelaide	Brian Casling
1973	Brisbane	*
1974	Hobart	Prof H Muir
1975	Sydney	**
1976	Auckland	Prof A L Titchener
1977	Newcastle	*
1978	Melbourne	J W Thompson
1979	Perth	***
1980	Adelaide	Prof Mattsson
1981	Brisbane	Prof L E Lyons
1982	Hobart	J C Scully
1983	Sydney	Prof G R Wallwork
1984	Rotorua	Dr Graham A Wright
1985	Newcastle	Prof E O Hall
1986	Adelaide	Dr Graeme Kelly
1987	Melbourne	Prof Brian Cherry
1988	Perth	Dr Ian MacLeod
1989	Gold Coast	Brian Byrne
1990	Auckland	Dr John Duncan
1991	Sydney	Jerry McAuliffe
1992	Hobart	Graham Robilliard
1993	Newcastle	Les Boulton
1994	Adelaide	Dr David Nicholas
1995	Perth	Dr Peter Farinha
1996	Melbourne	Prof Brian Cherry
1997	Brisbane	Dr Paul Schweinsberg
1998	Hobart	Prof Brian Cherry
1999	Sydney	Dr Bruce Hinton
2000	Auckland	Dr Tony Betts
2001	Newcastle	Brian Martin
2002	Adelaide	Dr Ian MacLeod
2003	Melbourne	Mark Weston
2004	Perth	Robert de Graaf
2005	Gold Coast	Dr Bruce Ackland
2006	Hobart	Ivan Baxter
2007	Sydney	Fred Salome
2008	Wellington	Keith Lichti
2009	Coffs Harbour	Prof Robert Melchers
2010	Adelaide	Dennis Richards
2011	Perth	Dr Ian MacLeod
2012	Melbourne	Dr Graham Sussex
2013	Brisbane	Arthur Austin
2014	Darwin	Warren Green

Table 1. The List of P F Thompson Lecturers since 1971.

**no details found   **(was ICMC 6)   ***1st Asian Pacific Corrosion Control Conference*

Eminent Australasian corrosion practitioners and researchers who have delivered the lecture include Greig Wallwork (in 1983), Graham Wright (in 1984), Graeme Kelly (in 1986), Brian Cherry (in 1987), Ian MacLeod (in 1988), John Duncan (in 1990), Les Boulton (in 1993), David Nicholas (in 1994), Peter Farinha (in 1995), Paul Schweinsberg (in 1997), Tony Betts (in 2000), Brian Martin (in 2001), Bruce Ackland (in 2005), Rob Melchers (in 2009) and Graham Sussex (in 2012). It is not by coincidence that many of these eminent PFT Lecturers have also been past ACA Presidents, Operations Committee Members, Branch Presidents, Corrosion & Materials Journal Editors and Associate Editors, Conference Paper Reviewers, etc. This is a clear demonstration of their giving something back to the corrosion profession. As a form of appreciation, the ACA have also afforded many of these past PFT Lecturers Life Membership not just for their contributions to the practice of corrosion and the research thereof but also as recognition of their volunteer contributions to the ACA.

The gaps in Table 1 are not because the PFT Lectures were not given, but because in those days hard-copies only of proceedings were produced and there are no copies of the proceedings for the 1972, 1973, 1975, 1977 & 1979 Conferences in the ACA Library.

The 1978 P F Thompson Lecturer is significant. J W Thompson, John (Jack) Thompson, was the eldest son of PFT. Like his father, J W Thompson was also a metallurgist. It was Jack Thompson's eldest son Graham Thompson (also a metallurgist) that was entrusted with PFT's files and from which so much more information on PFT has been able to be gleaned.

THE CAREER OF P F THOMPSON

In 1906 at age 20, P F Thompson was appointed to lecture chemistry at the Melbourne Working Men's College (now RMIT University), (Figure 2). He published his first scientific paper in 1912. In 1918 he moved to Melbourne University. At this time, research as a university activity was still in its infancy and most academics spent much of their time on 'scholarship' and teaching, but PFT continued his experimentation, much of it involving electrochemistry. In 1925, he became President of the Society of Chemical Industry of Victoria and published his evidence attributing the passivity of stainless steels in certain aqueous media to a surface film of mixed oxides.

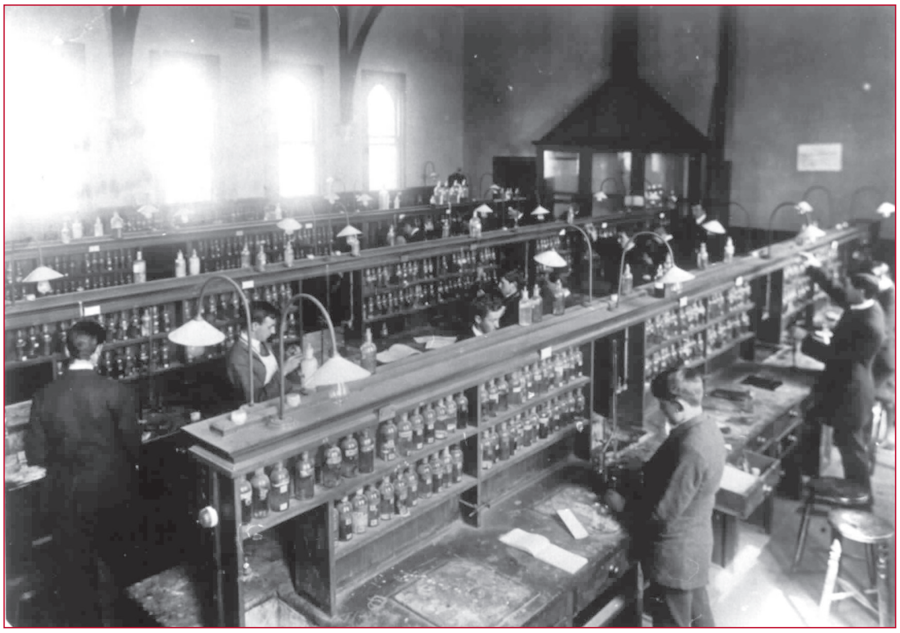


Figure 2. Melbourne Working Men's College Chemistry Laboratory, circa 1914 (courtesy of RMIT Archives).

Figure 3. G.B. O'Malley (Demonstrator), A.J. Roennfeldt (E.Z. Co Research), E.G. Thurlby (Bage Scholar), Professor J.N. Greenwood, P F Thompson, Melbourne University, 1927 (courtesy of Graham Thompson).

In 1928 PFT was promoted to Senior Lecturer, (Figure 3), and in 1932 was Acting Professor of Metallurgy.

In the early 1940's PFT returned to Melbourne Working Men's College and in 1942 joined the Division of Aeronautics at the Council for Scientific and Industrial Research (CSIR), (the forerunner of the CSIRO), where he worked for the RAAF on corrosion problems related to the cooling water for Spitfire aircraft engines. Potter (1972) reports that Thompson pursued and advised upon a wide variety of corrosion and metallurgical problems with enviable success whilst at CSIR. He preferred investigation to administration, and remained a keen student-examiner and critic in the subjects he had taught at Melbourne Working Mens College and Melbourne University for over 30 years. It is interesting that the CSIR Division of Aeronautics later became the Aeronautical Research Laboratory (ARL) and then the Defence Science and Technology Organisation (DSTO).

Nearly 50 years after P F Thompson's death, the aircraft corrosion related work initiated by him at ARL in 1949 is still continuing at DSTO. It says something about his foresight, that he knew it was important to establish such a capability within the old Department of Supply. Defence aviation has clearly been the beneficiary of P F Thompson's foresight and legacy.

P F THOMPSON - RESEARCH

From an examination of P F Thompson's published reports and papers, it is possible to appreciate the diverse range of scientific research in which he was involved at various stages of his career. Thompson was also a well-respected consultant and a highly sought after lecturer by professional groups. His publications and lecture transcripts indicate that he was not afraid of changing direction in a particular line of research and he delighted in a scientific challenge.

When Thompson began to publish his work, he was primarily interested in analytical chemistry, mineral dressing and assaying, and over the years he became more interested in corrosion. In the following section the publications of Thompson are summarised, with his work on analytical chemistry briefly and his work on corrosion in more detail. The reports and papers of PFT are a delight to read. They are well written, easy to understand and show excellent use of the English language. Electronic copies of all publications are available from the authors and from the ACA.

Analytical Chemistry

In a very informative and entertaining paper written in 1934 (Thompson, 1934a) PFT traced the development of analytical chemistry from the work of ancient alchemists in the Greek and Roman eras, to the efforts in the middle east by Persians and Arabs, the discoveries of Boyle, Priestley and Cavendish and the potentiometric techniques of Bottger in the late 19th century.

He strongly argued against adoption of standard methods of chemical analysis and was sceptical of the use of machines for automatic and mechanical analysis (Thompson, 1932a). His view was that "standard methods indicate a loss of that independence of thought which should be the most sacred possession of the professional man". PFT was always keen to deliver lectures to learned society members on a range of topics, an example of which is his lecture to the Victorian branch of the Australian Chemical Institute in 1930 on "A Sense of Proportion in Analytical Chemistry" (Thompson, 1930). This lecture was about sampling techniques to ensure representative proportions of all constituents are taken from samples of ores, chemical mixtures etc., the use of significant figures and the consistency of use of scientific units in written documents.

PFT also developed and published new techniques for chemical analysis (Thompson, 1926), as well as new indicator formulations for use in chemical analysis (Thompson, 1931a and 1933a).

Mineral Processing and Assaying

During his time at the University of Melbourne and later at CSIR, PFT developed an interest in mineral processing and assaying. These interests lead to his development of a new volumetric method for the determination of iron (Thompson, 1922), a new rapid technique for determining the levels of lead in ore samples (Thompson, 1929), and a method of using potassium hydroxide as a fusion agent for use in nickel crucibles when assaying pyritic ores for sulphur and antimony (Thompson, 1932b). This method allowed lower temperatures to be used as the melting temperature of potassium hydroxide is 380°C. In 1934, Thompson reviewed the principles of flotation and ore dressing (Thompson, 1934b).

He was always keen to optimise the gold winning process from ores, and in 1933 he published a paper that described the influence that telluride solubility has on that process (Thompson, 1933). Much later in his career at CSIR, he put his considerable electrochemistry knowledge to use to explain the mechanism through which gold is dissolved from cyanide solutions (Thompson, 1947) when he contributed on the subject to the General Meeting of the American Electrochemical Society in April 1947 (Potter, 1972). He was to show that the "dissolution of gold in the presence of cyanide and oxygen was "… an electrochemical process essentially similar to corrosion" (McCarthy 2001). One of the other contributors at the 1947 American Electrochemical Society meeting was U R Evans (1889-1980) of Cambridge University fame, the publisher of several corrosion science books and described in the Biographical Memoirs of Fellows of the Royal Society as the "Father of the modern science of corrosion and protection of metals". Both Thompson and Evans had their respective papers presented by distinguished American proxies and, not leaving their home countries, the two men never met. They certainly knew each other, however (Potter, 1972).

PFT developed a new high temperature furnace which could reach temperatures of 1600°C in a few minutes. The standard muffle furnace used for assaying in those days took considerable time to reach a maximum of 1200°C. The rapid rise to the higher temperatures was achieved using ash less gas carbon as a fuel in conjunction with blasts of air provided by an electric motor. This was a revolutionary approach and resulted in more rapid assaying of ores (Thompson, 1932c).

In assaying, the maintenance of furnaces and refractories in particular is very important. PFT reviewed refractories and their uses in a paper delivered to the Melbourne University Metallurgical Society and published in 1931 (Thompson, 1931b). In that paper he discussed the nature and properties of refractories, the physical changes they undergo during heating and cooling, their reaction with various gases, and methods for testing their high temperature mechanical properties. In the 1930s the study of ceramic as a material was in its infancy. PFT concluded his paper by saying, "one may be sure that in time a fuller understanding, rivalling that of metals will grow out of the slough of empiricism in which the study of refractory materials has long been struggling".

Corrosion

P F Thompson began to publish on the topic of corrosion in 1932. Many of his publications were transcripts of his lectures to various learned societies. Thompson's view at the time in 1932, was that the engineering community was largely ignorant about the nature and mechanisms of corrosion. To quote PFT, "Around no subject of technical interest have prejudice and wrong thinking in the past, so wrapped a web of obscurity as that of the corrosion of metals" (Thompson, 1932d).

In the following section, the detailed summaries of the published corrosion work of PFT are presented in chronological order.

Corrosion of Metals (Thompson, 1932d)

The quotation in the previous paragraph was the opening statement of PFT's lecture to the Australasian Institute of Mining and Metallurgy in

1932. He announced that the definition of corrosion was "the dispersion and waste of the useful solid metal by conversion into a useless compound which may or may not be retained on or near the metal remaining".

He stated that corrosion is "a matter which has primarily concerned the engineer, but the paucity of his training in chemistry and electrochemistry has been a stumbling block to a better understanding of its mechanism".

This is a very entertaining paper to read. It sets out the electrochemical nature of corrosion, the role of anodes and cathodes, the hydrogen evolution reaction and the oxygen reduction reaction. He describes in great detail an experiment involving the corrosion of a piece of iron in a jelly containing potassium chloride, and how the visual formation of the various corrosion products of iron (with different colours) form as the ferrous irons come into contact with hydroxyl ions, then the oxidation of the ferrous ions to ferric ions and the formation of ferric hydroxide.

In conclusion PFT indicated that the way to prevent corrosion was to (i) Exclude water from the metal surface, (ii) Avoid differences in potential, (iii) Avoid depolarisation of the metal by excluding oxygen, (iv) Form protective films at an anode site, and (v) Reduce hydrogen ion concentration by the addition of alkali. This advice remains correct to this day.

Corrosion of Chemical Lead (Thompson, 1932e)

In the 1930s, the chemical resistance of lead and its ease of fabrication made it a metal with potential for use in various process industries, in particular the manufacture of sulphuric acid. PFT therefore studied the corrosion behaviour of lead in that acid. It was known that iron as an impurity in lead would induce corrosion. He considered that the measurement of electrochemical potential with time could be a means of identifying suitable corrosion resistant lead samples. He measured the potential of three lead alloys containing 0.00026, 0.00036 and 0.0007% iron in 63% sulphuric acid solution. Unfortunately, his work showed no correlation between potential and iron content. He used a spot test to identify the presence of iron on the surface of the lead samples, but not the location of the iron, which he thought to be at grain boundaries. However this test was not quantitative.

Corrosion of Metals: The Effects of Electrolysis and Oxidation (Thompson, 1934c)

This paper is a presentation PFT gave to the Victorian Institute of Refrigeration in 1934. Even in those days as now, there was concern over the cost of corrosion. He informed the audience that "It has been estimated that 6,000,000,000 pounds is spent annually to replace the wastage by corrosion and on anti-corrosion devices". The audience were told that the corrosion of iron is inevitable in the presence of an environment to revert to its original form of iron oxide. He introduced the audience to the concept of the formation of local anodes and cathodes on a metal surface when exposed to a corrosive environment, and how the presence or absence of oxygen at the cathode and local pH changes affect the rate of the anodic and thus the corrosion reaction. It was during this lecture that PFT first discussed the concept of passive films of oxides of atomic thickness forming on metal surfaces under specific conditions, and the ability of such films to affect the initiation of corrosion.

Lubrication and Corrosion (Thompson, 1935)

This paper was the result of an investigation by PFT of corrosion of a crank pin in a large refrigerator. The contacting bearing surface between the pin and its journal was supposedly lubricated. The lubricating oil was meant to prevent water from coming in contact with the metal surfaces, where it could cause corrosion of the bearing surfaces. In order to prevent water access, PFT reasoned that a substance should be added to the oil which would lower the surface tension of the oil to below that of the surface tension of the water, and that such a substance should contain polar groupings. He investigated the surface tension of a number of oils with various additions of fatty acids which contained those groupings. He found that Lanolin contained certain polar groupings which gave it the power to exclude water and thus to promote a better bond between the oil and metal. He suggested that in general oils with good lubricating properties and with good water displacing properties could be designed to provide not only lubrication but also corrosion protection. Although he warned that some fatty acids may not be suitable for use in this application because of their reactivity with the gases used in the refrigeration process.

Corrosion of Metals (Thompson, 1943)

Eight years later PFT gave another lecture to the Victorian Institute of Refrigeration in the Metallurgy School of the Melbourne Technical College. The content of that lecture was consequently published in Refrigeration, Cold Storage and Air Conditioning. He began by addressing the audience as follows "I am not going to deal with your troubles specifically, since you will realise that when the principles of corrosion are understood, you will have no difficulty with your own troubles"! He then proceeded with a lecture to make those principles better understood.

The lecture included various examples of corrosion which included components of refrigerator compressors, nails from ancient artefacts, and a piece of stainless steel which had corroded in tap water. The last example, PFT claimed "shattered the illusion as to the impeccable nature of stainless steel". The types of corrosion were outlined, and the thermodynamic basis of corrosion was summarised. He used elaborately hand drawn diagrams to illustrate the corrosion of a metal in the presence of oxygen, "oxygen- water type corrosion" as he termed it. He contended that the "corrosion problem had been solved during the last few years by the application of many of the ideas he had been discussing, and it remained one of the mysteries as to why chemists, presumably understanding the laws governing electrolysis ever came to regard corrosion as a problem"!

Failure of an Hydraulic Brake System (Thompson, 1945)

During his time at the CSIR, PFT carried out many failure investigations. This one involved the failure of a component in a truck braking system. The piston in the brakes was made from an Al-Cu-Zn-Si die cast alloy. A rubber plunger in the system had failed due to degradation by the brake fluid. This had allowed water to enter the brake fluid, and had subsequently caused corrosion of the piston. The pitting and build-up of corrosion product had seized the piston and the brake failed. PFT using a combination of potential measurements and metallography showed that severe corrosion could occur in an apparent mild environment of brake fluid and water. He advised that a more corrosion resistant alloy should be considered for this application in future.

Some Aspects of the Corrosion of Aluminium (Thompson, 1946a)

Because of his work at CSIR Division of Aeronautics, PFT was interested in preventing corrosion on aircraft components. In this paper he discussed the protective nature of the oxide film that forms on aluminium alloys. He also outlined how that film could self-repair in the presence of oxygen and water through the formation of aluminium oxide/hydroxide. He showed using potential versus time curves for aluminium in a glycol water solution that in the absence of oxygen, corrosion can take place with hydrogen evolution as the accompanying cathodic reaction. He drew attention to the possibility of these conditions developing in close fitting aluminium surfaces as in joints on aircraft structures which are subject to fretting and chaffing.

The Corrosion of Metals – Metal in Aircraft Engine Cooling Systems (Thompson, 1946b)

In a sense, this report by PFT gathered together all of his thoughts on corrosion and its prevention at the time of 1946. His aim with this report was to "put the results from his investigations into a more or less readable form for the benefit of all concerned with corrosion problems".

The report outlined how electrochemical techniques can be used to understand and solve corrosion problems, and the parameters controlling the corrosion process. In this report PFT discussed the breakdown of the protective oxide film on the corrosion of aluminium. He introduced what he termed a "Corrosion Chart" for aluminium, which summarised the areas of stability of the oxide film as a function of electrochemical potential and temperature. Charts such as this were very advanced thinking for the times.

PFT concluded by stating that in relation to engineers, it was difficult for them to not to have anything but misconceptions regarding corrosion, largely because of the very little knowledge they were given in relation to the electrochemical basis of corrosion. At the time engineers were very quick to look for sources of acid to blame for corrosion when the availability of oxygen and the accompanying electrochemical reduction of oxygen to hydroxyl ions was the most active agent in the corrosion process. This was a continuation of the message he was sending to engineers back in 1932.

Corrosion of Condenser Tubes (Thompson, 1950, Parts 1, 2 and 3)

As part of his consultancy work at CSIR, PFT was engaged by Victorian Railways to investigate the failure of condenser tubes in the then new 34 megawatt turbo generator at the Newport A Powerhouse Station in Melbourne. The condensers were multi tubular cooling devices used in steam power plants in the 1940s. As a result of this investigation, CSIR and PFT undertook a lengthy research program which produced three large reports dealing with the corrosion of copper based alloys from which condenser tubes were typically made.

Part 1 of his report of this investigation covered the electrochemical characterization of the copper, zinc, brasses, Admiralty Brass, Aluminium Brass and Muntz Metal. This work looked at how the electrochemical potential of these alloys and the visible corrosion behaviour changed with time in various waters over a temperature range from 20 to 100°C. The report also investigated the effects of "impingement corrosion" as it was termed in the day, or the result of a corrosion environment and the impact of a stream of bubbles on the oxide film on these metals.

In Part 2, the report outlined the results of PFT's study on the effects of cuprous ions in the water and the effects of NaCl concentration on the corrosion of those copper based alloys. He found that cuprous ions had sufficient oxidising power to corrode brass in particular.

In one of the very early studies of microbiologically influenced corrosion (MIC), PFT in Part 3 of his report investigated the effects of deposits of organic matter and the bacteria they contain on the corrosion of the copper based condenser tube alloys. The organic matter included seaweed, mussel, crab, and prawn segments generally found in the condenser tubes at the power station. This report also looked at the effects of grain boundaries in the microstructure of the alloys on susceptibility to localised corrosion, in particular how the grain boundary chemistry affected susceptibility.

This work on the corrosion of copper based alloys produced an enormous volume of data and knowledge. However, because it was never published in the open literature it has never really been appreciated and referred to by the wider corrosion science community.

The Fundamentals of Corrosion of Metals under Stress: Aluminium (Thompson, 1950)

At the time of publication of this report, "the old idea that the intrinsic tendency of a metal to ionise was materially increased by stress" was used to explain the phenomenon of stress corrosion cracking (SCC). PFT was of the belief that it was the electrochemical process taking place on the metal surface which lead to stress corrosion. He monitored the potential of aluminium specimens with time with and without increasing levels of stress. He observed negative transient excursions in the potential with increasing stress, with the frequency increasing as the fracture stress approached. The effects on these transients of aeration and deaeration in tap and salt water, and the effects of aluminium strength level were also studied. PFT postulated that the negative transients were due to rupture or breakdown of the oxide film on the specimen surface. Film regrowth was indicated by the potential curve becoming more positive. He proposed that SCC initiation was the result of dissolution of aluminium at grain boundaries where oxide and undisclosed ions concentrated, and that the applied stress opened up cavities at these locations where corrosion progressed by differential aeration. He concluded from the studies that stresses are only contributory factors in so-called 'stress-corrosion.' These observations proved to be important in the future mechanistic understanding of SCC.

This work is another example of the forward thinking by PFT at the time. Unfortunately, this work was never cited in the open literature during discussions on SCC. Several authors since have shown the effects of stress on potential. The lack of recognition of this work is probably due to the fact that it was only ever published as an Aeronautical Research Laboratory Note.

Filiform Corrosion Products on Iron Immersed in Brine (Thompson and Lorking, 1955)

Filiform corrosion where worm like filaments of corrosion product develop beneath paint coatings had been reported by others several years earlier. This paper identified a new type of filiform corrosion, pustule, which was observed on uncoated steel specimens immersed in commercial refrigerating brine that contained chromate as a corrosion inhibitor. At first the filiform growth was observed to start from a central corrosion pustule and grow continuously from corrosion product extruded through the pustule. Growth then continued up and away from the metal surface into the surrounding solution. This paper was published after the death of P F Thompson in 1951. Dr Ken Lorking was a co-worker of PFT at ARL.

Methods for Assessing the Corrosion of Iron in Soils: Preliminary Experiments (Thompson and Lorking, 1956a)
This work used measurements with platinum electrodes to show that the potential of neutral sandy soils varied from +0.2 V under aerated conditions to -0.5 V under deaerated conditions. Using those potential measurements, the authors were able to deduce the depths of boundaries between aerated and deaerated soils. With similar measurements using iron electrodes and by measuring the currents between the electrodes placed at various depths, they showed that it was possible to determine the likelihood of corrosion occurring at these depths and the effectiveness of protective treatments on steel. The maximum corrosion in sandy soils, due to large-scale differential potential, was found at depths between 300 mm and 600 mm. Corrosion lessened with increasing depth, being negligible at 1500 mm. Rainfall did not affect the potentials but some increase in differential currents occurred at 300 mm and 600 mm with increased rainfall. The maximum current obtained between the electrode at 300 mm and those buried at lower levels confirmed the belief by the authors that the maximum amount of O_2 for the cathodic reaction exists at 300 mm. They were of the opinion that the O_2 concentration may be appreciable to a depth of 3000 mm in sandy soils, to 1200 mm in clay soils, but is not sufficient to support corrosion below 600 mm.

Some Aspects of the Corrosion Processes of Iron, Copper, and Aluminium in Ethylene Glycol Coolant Fluids (Thompson and Lorking, 1956b)
The reason for this work was to develop an understanding of how the triethanolamine phosphate (TEAP) inhibitor used for glycol-water coolants used in aircraft radiators inhibited corrosion. There was some thought at the time that this inhibitor may actually cause corrosion. The authors measured corrosion potentials of aluminium, iron, and copper, the principal metals in coolant systems, in glycol-water solutions with and without the inhibitor using a microelectrode method described in an earlier publication. Weight loss tests were also carried out in order to determine the effects of inhibitor addition on corrosion rates. From the results the authors concluded that TEAP caused accelerated corrosion of the copper by stabilising the copper cations in solution. These cations were then able to diffuse through the glycol water mixture to aluminium and iron surfaces where copper deposited and induced corrosion of both metals.

The sections above demonstrate PFT's ability for innovative thinking, and the volume and breadth of his research indicate that he was able to apply that level of thinking to many different fields of scientific endeavour. Most importantly he was able to effectively communicate those ideas through public lectures, scientific demonstrations and publications.

PERSUASIVE IMPACT OF EXPERIMENTS

Thompson, like Evans, knew the persuasive impact of simple practical experiments in the corrosion field and, with the eager help of his sons and daughters, developed ways of presenting corrosion phenomena to audiences, both students and professional, (Figure 4). He had 7 children – 4 sons and 3 daughters, so he had plenty of eager help. Interestingly 3 of his children became metallurgists, another became a "process engineer" and another a "design engineer".

Figure 4. P F Thompson experimenting, circa 1920s, Melbourne University (courtesy of Graham Thompson).

Magnesium alloys have been used widely in the aircraft industry mainly for gear box and generator housings, predominantly because of their low density and the weight savings. However, their use also presents an enormous problem, because magnesium alloys are very susceptible to corrosion especially in marine environments. P F Thompson was always keen to demonstrate to his students the basic principle of corrosion, and one of his favoured live experiments was to show that hydrogen evolution is an accompanying cathodic reaction to the dissolution of metals. A simple experiment is to take some magnesium alloy and immerse it into a solution of sodium chloride. Within minutes bubbles will be observed coming from the alloy. This is hydrogen gas which is being evolved at cathodic sites on the alloy surface. An experiment similar to this was a favourite of Thompson.

Thompson's love for simple practical experiments is the reason why the P F Thompson Memorial Lecture at ACA Conferences always contain experiments or demonstrations. The first P F Thompson Lecture by Ed Potter in 1971, (Figure 5), included a demonstration in Thompson's style, of the film passivity of a 13% chromium steel, (Figure 6).

Figure 5. Dr E C Potter delivering the first P F Thompson Memorial Lecture in 1971 (Potter, 1972).

Figure 6. Dr E C Potter assisted by his son Keith in 1971 re-enacting P F Thompson's experiment showing the existence of a passive film on stainless steel (Potter, 1972).

MICHAEL FARADAY

The second name of P F Thompson is also important when it comes to electrochemistry. When his parents chose the name Faraday, were they wanting their son to be an experimentalist and corrosion scientist? More likely they were reflecting sentiments of a time when great scientific achievements of men like Michael Faraday (1791-1867), (Figures 7 and 8), still caught the imagination of the public, (Figure 9).

Figure 7. Michael Faraday, 1791-1867 (http://en.wikipedia.org/wiki/Michael_Faraday).

Figure 8. Michael Faraday (http://www.nndb.com/people/571/000024499/?.

Faraday was of course a most gifted experimentalist and is famous for a phenomenal variety of work, but it was his discovery and experimental proof of the electrochemical equivalence between current and corrosion (or "electro-chemical decomposition") (Faraday's Law) that made a particularly huge impact for corrosionists (Ackland, 2005). Faraday's work enabled the calculation of how much metal will be consumed for a given electrical current and time. Faraday (1834) also defined words such as electrode, anode, cathode, electrolyte, anion and cation.

As an aside, Ackland (2005) advises that it was Sir Humphry Davy (Figure 10 and 11), the founder of cathodic protection, who discovered Michael Faraday. Faraday was at one stage in his career a bookbinder's assistant and presented Davy a fine bound copy of his notes taken during one of Davy's lecture series. Davy first recommended that Faraday stick with bookbinding, but around that time Davy injured an eye making NCl_3 and so took Faraday on as a temporary assistant. Faraday turned out to be extremely competent, was made permanent and the rest is history (Ackland, 2005).

Davy postulated in January 1824 (Davy, 1824a), that it would be possible to prevent corrosion of copper sheathing on ships by connecting it to zinc, tin or iron (Ackland, 2005). This was based on his observations and conclusions from over two decades of working with galvanic couples and he certainly considered the beneficial effects for the more positive metal in the couple at least as early as 1812 (Ackland, 2005). The copper sheathing on the ships was needed to reduce fouling and prevent attack on the timber by worms. Davy then reported on full-scale trials in June 1824 (Davy, 1824b) and showed the complete effectiveness of zinc and iron in protecting the copper (Ackland, 2005). He also published in June 1825 (Davy, 1825) the influence of ship movements on the efficiency of the protection action and the effects on fouling (Ackland, 2005).

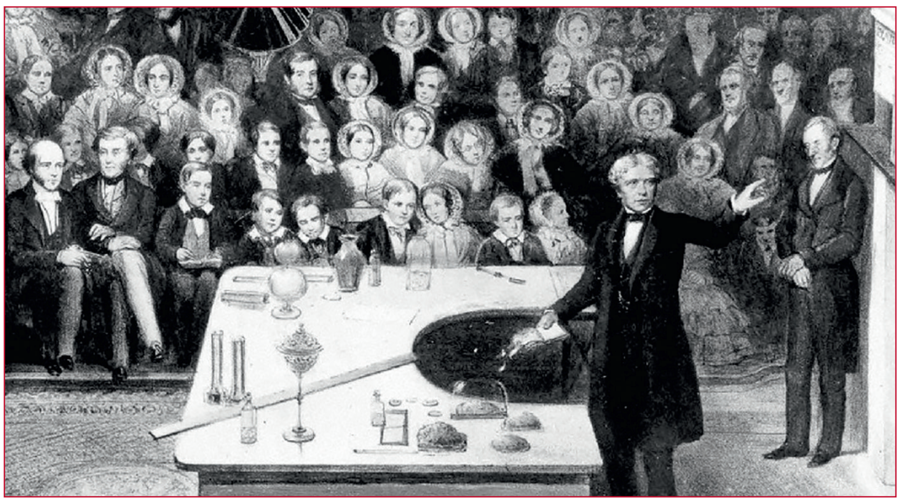


Figure 9. Michael Faraday, 1791-1867, delivering a corrosion lecture to the Royal Society, London (http://en.wikipedia.org/wiki/Michael_Faraday).

Figure 10. Humphry Davy, 1778-1829 (http://www.famousinventors.org/humphry-davy).

Figure 11. Humphry Davy, (https://sites.google.com/site/acidsandbaseschemistryproject/3).

CONCLUDING REMARKS

Percival Faraday Thompson, (1885-1951), a metallurgist and chemical analyst, is generally considered a corrosion research pioneer in Australia. The P F Thompson Memorial Lecture at the annual ACA Conference celebrates P F Thompson. This paper attempts to provide some of the history of PFT, his career and the breadth of his research achievements. It is clear that the man was much ahead of his time, in terms of his innovative thinking in the areas of analytical chemistry, mineral processing and assaying, and his ability to convey with such clarity his ideas through many lectures and publications. Potter (1972) who delivered the first PFT Lecture in 1971 notes that "yet in separate perverse ways, both international acclaim and conscious retirement eluded PFT, and he enjoyed no more than a languid waning of technical toil".

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NEW PRODUCT SHOWCASE

Correction and Clarification:

It has come to the attention of the *Corrosion & Materials* Magazine that information in the June 2015 New Product Showcase included a snippet of email correspondence between a writer and the publisher in the ***Rhino Linings limiting leaks*** article. This should not have been included in the article and was an oversight.

Permasense Wireless Corrosion Monitoring Systems

Corrosion Control Engineering (CCE) has announced it is representing Permasense in Australia, New Zealand and Papua New Guinea. Permasense is the world leader in online integrity monitoring systems for oil and gas production assets. Whether onshore or offshore, hydrocarbon processing facilities and other industries continue to suffer from corrosion and erosion.

Permasense systems use battery operated wireless sensors mounted strategically in the facility that deliver unparalleled quality and frequency of wall thickness measurements directly to the desks of the asset owners, to assist them in making better-informed operational decisions.

Users can monitor and analyse how the metalwork is coping with ever-changing demands, quickly detecting loss of metal due to corrosion or erosion, thereby facilitating the online optimisation of corrosion or erosion mitigation strategies, in even the most inhospitable environments. Permasense customers enjoy improved asset integrity management and online process optimisation - enhancing safety, reliability and ultimately profitability.

For further information please contact CCE on:
02 9763 5611
www.cceng.com.au
www.permasense.com

New FLIR C2 Pocket-Sized Thermal Camera

FLIR Systems has launched the new FLIR C2 compact professional thermal camera. The C2 is a fully-featured thermal camera, yet it is small enough to comfortably fit in your pocket. Designed to help identify heat patterns that indicate where hidden problems may exist, the FLIR C2 is this year's must-have inspection tool for builders and NDT operators.

Featuring FLIR's patented MSX® real-time image enhancement and a simple-to-use touch screen with auto-orientation, the camera creates thermal images with stunning clarity. MSX adds key details captured by the onboard visible camera to the C2's thermal images so numbers, letters, texture and other characteristics are clearly recognizable without compromising the thermal image.

The C2's 4800-pixel resolution, high sensitivity detector captures and displays subtle thermal patterns and small temperature differences and a wide 41° field-of-view frames in more of the scene. Plus, the C2 includes a built-in work light and flash that helps illuminate poorly lit work areas.

With a simple point-and-shoot operation, the C2 can store radiometric JPEGs with the push of a button. The images can be downloaded later using the free FLIR Tools software that allows the user to adjust thermal image levels, isolate and add temperature measurements, change color palettes, and create persuasive reports.

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Concrete Assets – Experiences with Repair & Maintenance

PROUDLY PRESENTED BY:

AUSTRALASIAN CORROSION ASSOCIATION INC.

Perth
25 June 2015

The Concrete Structures & Buildings Technical Group of the ACA held a technical event on Thursday 25 June at the Mercure Hotel in Perth. Forty delegates representing a cross section of the industry sectors were in attendance. The event looked at real life case studies, exploring both successes and failures. The presenters shared their experience and the lessons they have learnt. At the conclusion of the event an open floor forum was held which provided much discussion on the issues within the industry.

The ACA would like to thank all speakers and delegates who attended this event and for making the day a huge success!

Below is an overview and summary of the presentations provided by the speakers:

Concrete & Durability Planning

Rodney Paull, GHD

This presentation outlined the new Concrete Institute Australia (CIA) Recommended Practice Z7/01 'Durability Planning'. It was explained that this approach should be applied to all construction materials.

Durability planning is cost-effective selection and usage of materials, combined with design processes, construction methods and detailing to achieve the asset owner's intended service life without premature unexpected operational maintenance.

Testing for Corrosion in Concrete – A Practical look at the Pitfalls of Interpreting Data

Reuben Barnes, PCTE

There are a variety of test techniques in the Engineer's toolbox for the investigation of concrete structures for corrosion damage. They all fit together to create a picture that demonstrates not just the extent of the problem but also the mechanism by which it is proceeding and the best repair method. Techniques include Half-Cell Potential Mapping, Covermeter Surveys, Resistivity, Linear Polarisation Resistance and Visual Inspections. The biggest challenge is using each technique correctly and of course interpreting what it all means. Having set criteria by which to compare resulting data is the ideal scenario. It gives an iron clad pathway forwards. Unfortunately life is not that easy and set criteria followed blindly leads to incorrect outcomes for investigations. This presentation looked at the main test techniques and highlighted the pitfalls of each in relation to collecting data and interpreting it. Of particular focus was the misguided use of ASTM C876-09 in interpreting Half Cell Potential measurements in all circumstances by a large portion of the concrete inspection industry. CIA Z7/01 provides information on durability planning during design, construction and operational service life phases for all concrete construction stakeholders. It was intended to inform and inspire designers about the benefits of durability design so they can inspire asset owners to elevate durability planning to a position alongside structural and architectural design.

Project Case Studies in Concrete Remediation

Deane Diprose, Duratec

Each year industry loses millions of dollars to the destructive effects of corrosion and chemical attack on reinforced concrete structures in a variety of environments and causes. As our infrastructure ages, the costs of this corrosion will continue to escalate, placing increasing importance on asset remediation and protection and ongoing maintenance. This presentation took us on a journey highlighting some of Duratec's projects that have been focused on extending the life of concrete assets.

Crystalline Technology: A Solution to Repair and Rehabilitation of Concrete Structures

Farhad Nabavi, Xypex

Premature deterioration of concrete structures has become a worldwide problem due to excessive cost effect, environmental impact, and safety issues. According to case studies, many of reinforced concrete (RC) structures exposed to severe environmental conditions need to be repaired and rehabilitated after 15 to 20 years of construction. Nonetheless, based on many standards, design service lives of such structures have been considered as at least 50 years. Therefore, repair and rehabilitation operations are inseparable operations for the RC structures. There have been numerous research, studies, and innovations to provide proper methods and systems in this regard. Prevention of cold joint, obtaining the strength as close as possible to the existing concrete, lower shrinkage, and durability performance are the main challenges in producing repair materials. In this presentation, Crystalline Technology was introduced and investigated as a solution to repair and rehabilitation of RC structures. Crystalline materials can diffuse to the concrete and become an integral of the substrate. Crystalline structure blocks the pores and heals the cracks in the existing concrete permanently. Results from laboratory tests and field investigations as case studies indicated that formation of crystals in pores and cracks can reduce the diffusion rate of aggressive substances into concrete and enhance the durability of the repair concrete significantly.

What is the Effective Approach to Corrosion Prevention in Marine Structures

Ali Sarandily, AECOM

Corrosion affecting the durability of marine structures is rather a complex phenomenon and there is no single approach to the corrosion prevention of marine structures. This presentation outlined that effective corrosion prevention is a combination of the following:

1. Understanding of mechanism of corrosion and corrosion issues;
2. Good detailing, offsite fabrication with good quality control; and application of an appropriate coating system that forms an impregnating type barrier against the passage of seawater to the surface of the carbon steel structure.

The common factor in all the above is the 'prevent the formation of corrosion cell principle' which relies on the designer having an understanding and awareness of the mechanism of corrosion and corrosion cell formation. The designer must consider the 'prevent the formation of corrosion cell principle' while formulating carbon steel design details for marine structures.

The occurrence of corrosion in marine structures is as simple as:

A +B =C

Where:

A: Aggressive Marine Environment;
B: Bad Design/detailing/workmanship; &
C: Concentrated Corrosion.

Evolution of Repair Solutions for Concrete Structures

Grant Dowling, Sika Australia

This presentation looked briefly at early concrete and the introduction of steel reinforcement along with the issues that have arisen as a result. The ever increasing demands being placed on these concrete structures along with the advancements of modern concrete today and the issues that can arise from these harsh environments and demands being placed on these structures were discussed. An explanation of the modes of deterioration in new and existing concrete structures and the advancements in repair methods and materials available and requirements based on the advancements in technology, material science, investigation and the diagnosis of these structures was also investigated.

Remedial Technologies – Long Term Enhancement for Concrete Structures

Mike Rutherford, Freyssinet

The presentation covered the challenges in determining the deterioration mechanisms present in concrete and evaluating remedial product types and systems to reinstate structural durability for concrete structures where common deterioration mechanisms are present. We need the capability to assess the cause of the problem to develop a remediation strategy and design and implement an effective remedial solution. We should be committed to the philosophy that all structural remediation methods must be founded upon thorough investigation of the cause and extent of the deterioration and distress. Once this stage is complete we can then proceed to produce a complete specification for the required monitoring, remediation and/or strengthening work. As part of the investigation and analysis stage, asset owners can be provided with preliminary cost estimates, feasibility proposals including monitoring and investigation techniques, repair methods and types of products available. Asset owners spend hundreds of millions of dollars every year to remediate deteriorating concrete structures. The deterioration and remediation of concrete structures has emerged as a most severe and demanding challenge for the owners of concrete assets.

Whilst most asset owners recognise the need for visual inspection of these types of assets, detailed inspection, testing and sampling is not always initiated until after widespread deterioration is discovered. Often this approach eliminates the possibility for preventative maintenance strategies, with the extent of subsurface corrosion activity being much more extensive than visually apparent.

Nothing Lasts Forever - The Repair & Maintenance of Heritage Listed Concrete Assets

Liam Holloway, Mend Consulting

Liam's presentation focused on several case studies from projects involving the investigation and restoration of heritage listed structures. Highlights of the presentation were discussions on Monier bridges constructed by Monash and Anderson during the early 1900's, Ornate building façades including large balconies and adornments constructed with coke breeze concrete; and examples of post war construction with geometric form and early example of precast concrete construction.

Remote Inspection & Identification of Hidden Corrosion for the Oil & Gas Industries

PROUDLY PRESENTED BY:

SPONSORED BY:

21 May 2015 | Melbourne

The ACA's Petroleum & Chemical Processing Industry Technical Group (PCPI TG) held a technical event on Thursday 21 May at the Marriott Hotel in Melbourne. Over 50 delegates representing a cross section of the Oil & Gas Corrosion Industry were in attendance. The event looked at the latest challenges and developments in the materials engineering and corrosion control for both Onshore and Offshore environments. The event focused on the remote inspection and the identification of hidden corrosion within the Oil & Gas industries.

At the conclusion of the event an open floor forum was held which provided much discussion on the issues within the industry.

The ACA would like to thank all speakers, sponsors and delegates who attended this event and for making the day a huge success!

Below is an overview and summary of the presentations provided by the speakers.

Detecting Corrosion Under Disbonded Pipeline Coatings Using In-Line MFL Inspection Tools

Alan Bryson, APA Group

Not all pipelines are suitable for in-line inspection, as the in-line tool (pig) must be able to freely travel through the internal pipeline. However APA considers this the most reliable method of ensuring the ongoing safety and integrity of their pipelines by detecting anomalies including corrosion under disbonded coating. External corrosion control using a combination of coatings and cathodic protection has successfully mitigated corrosion on oil and gas steel pipelines for nearly a century. However, the monitoring of the ongoing effectiveness of this system has some short comings and corrosion can still occur with catastrophic results. Typical methods of CP monitoring and coating anomaly methods rely on the assumption there is a clear, uninterrupted electrical path between the pipeline steel and the surrounding environment, and this is not always the case. The most significant issue facing pipeline operators today is cathodic shielding due to failed pipeline coatings that 'disbond', or lift from the steel surface, allowing the ingress of moisture while the coating itself remains intact and is an effective electrical insulator. Pigs, or 'in line tools' have been used for many years for cleaning and separation of fluids. In the mid 1960's intelligent pigs were developed which could detect metal loss using magnetic flux leakage (MFL). This technology has developed in accuracy and resolution over the last 50 years and has now become a very effective tool in detecting pipeline corrosion, including corrosion under disbonded coating.

Techniques for Ultrasonic Inspection for Corrosion

Richard Nowak, Olympus

Ultrasonic detection of corrosion continues to develop, as the requirements for more information, more accuracy and faster inspection grow. This presentation looked at the latest in the application of various techniques: Guided Wave Ultrasonics as a screening tool, Phased Array scanning for general and isolated corrosion including MIC, weld root corrosion using Time of Flight Diffraction, and detection of flange face corrosion.

The Aims of a Downstream Oil & Gas Plant

Curtiss Hood, Coogee Energy

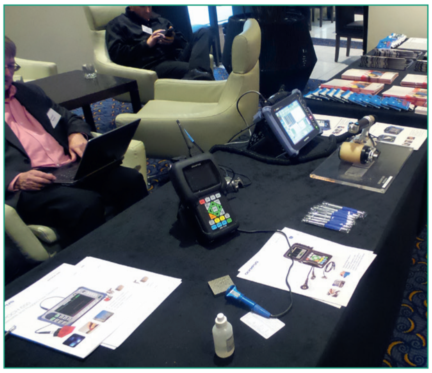
As a designer and operator of plant, there is an obligation to ensure that the plant is designed, constructed and operated to be safe and without risk to health when properly used. The presentation outlined how an operator adopts an Asset Integrity Management (AIM) philosophy to achieve safe operation and mitigate risk through maintenance. The objectives of the presentation were to:

- Describe at high level what AIM is for an operator and design of a chemical plant downstream of oil and gas.
- Provide an overview of an AIM
- Develop an understanding of what elements build an AIM's system and where an operator will engage with the industry to ensure that this is achieved.
- Illustrate a process which shows how a maintenance management system develops into an inspection work pack that can be carried out by an employee or nominated contractor
- Establish a process where there is verification and validation on the results and ensures that the risk to integrity on an asset is controlled.
- Reinforce the above objectives with case studies experience on the Coogee Methanol plant

Global Inspection Techniques (Including Seeing CUI)

Malcolm Oakey, ATTAR

This presentation was an overview of available techniques to detect 'invisible corrosion' in Plant and structures, and covered techniques such as laser scanners, long range UT, Pulsed eddy current and Acoustic emission. The presentation also included Risk based inspection and reliability of detection to highlight the need to provide accurate



inspection results in an affordable and effective manner.

Design, Application and Efficacy of Vapor phase Corrosion Inhibitors for Preservation of Aboveground Storage Tanks (ASTs): Field Report from Kingdom of Saudi Arabia

Phil Fleming, A.S. Harrison

This presentation looked at the soil-side corrosion of the bottom plates of above ground crude oil storage tanks as a major corrosion challenge in the Oil & Gas industry, especially when these tanks are constructed on oiled-sand pads. Severe corrosion was identified on tank bottoms at a crude oil tank farm in the Arabian Peninsula. Corrosion led to the costly replacement of bottom plates. The soil-side surfaces of the bottom plates were designed to be protected by a shallow anode impressed current cathodic protection (CP) system. The oily sand layer and air gaps under the bottom plates reduced CP effectiveness and resulted in severe corrosion. To reduce corrosion damage, a volatile corrosion inhibitor (VCI) was injected into the air gap between the sand pad and the underside of the tank bottom during a scheduled maintenance outage. An electrical resistance (ER) probe corrosion monitoring system was also installed underneath the tank. Effectiveness of the VCI treatment was monitored using the ER probe system. Corrosion rate data from ER probes during the first year after application indicated that VCIs were effective in mitigating corrosion on carbon steel bottom plates. VCI technology has good potential to reduce crude tank bottom corrosion, reduce maintenance costs, and provide extended service life.

Current Research Issues and Approaches To Infrastructure Life Extension And Structural Health Monitoring

Mike Tan, Deakin University

This presentation was an overview of Deakin's current research in the areas of infrastructural life extension, structural health monitoring and corrosion engineering, with particular focus on the energy pipeline and desalination industries. Currently the energy pipeline industry has an ambitious goal of cost effectively extending the safe operation life of energy pipelines to 100 years. An approach to achieving such a goal is the application of health monitoring and life prediction tools that are able to provide both long-term remnant pipeline life prediction and in-situ pipeline condition monitoring. A critical step is the enhancement of technological capabilities that are required for understanding and quantifying the effects of key factors influencing buried steel pipeline corrosion and environmentally assisted materials degradation, and the development of condition monitoring technologies that are able to provide in-situ monitoring and site-specific warning of pipeline damage.

One of Deakin's current research foci is the development of new sensors for monitoring, categorising and quantifying the level and nature of external pipeline and coating damages under the combined effects of various inter-related variables and processes such as localised corrosion, coating cracking and disbondment, cathodic shielding, transit loss of cathodic protection (CP). The basic principles that underpin the use of sensors to monitor localised corrosion are: that localised corrosion is not an accidental occurrence, it occurs as the result of fundamental thermodynamic instability of a metal in a specific environment. Therefore corrosion occurring on a pipeline will also occur on a sensor made of the same material and exposed to the same pipeline condition. Although the exact location of localised corrosion or coating disbondment could be difficult to pinpoint along the length of a buried pipeline, the 'worst-case scenario' pipeline sections and sites are predictable. Sensors can be embedded at these strategic sites.

Another research focus for Deakin is the development and application of new techniques for the quantification of the effects of major environmental factors affecting the effectiveness of coating and CP of pipelines. Currently the exact effects of some forms of stray currents on CP efficiency and corrosion have not been sufficiently understood primarily due to the difficulties in measuring these effects although they are known to be harmful to buried steel pipelines. Cathodic disbondment of protective organic coatings is another issue that has been a widely reported to cause pipeline coatings failure mode in the oil and gas pipeline industry, but current techniques have limitations in quantifying the effects.

Asset Integrity Services for the Oil and Gas Industries in Northern Australia

Margarita Vargas, Neptune

This presentation discussed the current development and construction related to the Oil and Gas industry in Northern Australia which is being supported by an extensive range of asset integrity services including: corrosion and coating inspections, non-destructive and mechanical testing for qualification of materials, welding and fabrication procedures.

This presentation provided examples of projects related to O&G industries such as microbiologically influenced corrosion in the Darwin Harbour, the assessment of structural and corrosion integrity in concrete and pipeline structures used in the transport of LNG, bespoke access facilities for inspection of O&G rigs, amongst others.

Living in the Zone I and II Hazardous Area. Impressed Current Cathodic Protection for the Oil & Gas Industry

Richard Brodribb, M Brodribb

Impressed cathodic protection systems may be required to be suitable for installation and operation in hazardous areas where there is a risk of explosion from gas or flammable liquids. As impressed current systems contain sources of energy which could cause a spark the CP system is often mounted in an enclosure which prevents a spark inside the enclosure causing an explosion outside it. The type of protection of the enclosure is determined by both the nature of the explosion hazard present and the practicality of achieving the certification requirements, for both the enclosure and the components inside it, necessary to satisfy the relevant standards. This presentation discussed the relevant standards and certification requirements, the types of protection used for impressed current, and issues faced in satisfying those standards while controlling costs and meeting delivery times.

ACA Standards Update

Welcome to the fourth corrosion related standards report for 2015.
The standards reporting for 2015 is scheduled against Technical Groups (TG) as indicated below:

Issue 2015	Standards search for TG interests
Feb	Concrete Structures & Buildings
April	Coatings
June	Petroleum & Chemical Process Industries

Issue 2015	Standards search for TG interests
August	Cathodic Protection
October	Mining Industry
December	Water & Waste Water

This Standards report focuses on the Cathodic Protection technical group.

As previously this report is in two stages, namely:

Stage 1

1. A global standards and publication focus, searching through SAIGLOBAL Publications at https://infostore.saiglobal.com/store, for all current publications and standards relating to one of the ACA technical Groups, with this editions group focus being the "Cathodic Protection" Technical Group.

Stage 2

2. A SAI Global search, as previously, at http://www.saiglobal.com/online/ for new standards, amendments or drafts for AS, AS/NZS, EN, ANSI, ASTM, BSI, DIN, ETSI, JSA, NSAI and standards and amendments for ISO & IEC published from **18 May 2015** to **15 July 2015**, using the key words and key word groups:

- 'durability'.
- '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'.
- 'cathode' or 'cathodic'.
- 'anode' or 'anodic'.
- 'corrosion' and 'concrete' or 'concrete' and 'coatings'.

Summary

Stage 1 Report

Through SAIGLOBAL Publications at https://infostore.saiglobal.com/store there were 414 Titles;

a. 8 from AS, AS/NZS (4 referenced in Australian Legislation), 1 ruling to AS 2832.1-2004 on cathodic protection interference levels; as shown in Table 1 below;
b. 23 from NACE as shown in Table 2 below;
c. 11 from ISO shown in
d. Table 3 below; and
e. 4 from ASTM shown in Table 4.

Stage 2 Report

Across SAIGLOBAL online Standards Publications there was a total of 38 listings of new standards, Drafts and Amendments, found issued from to **18 May 2015** to **15 July 2015**; with zero from AS, AS/NZS; as shown in below.

Reader feedback and interaction is welcomed to enable focus improvement and better minimisation of corrosion.

Stage 1 Report

Stage 1 Report on SAIGLOBAL Publications at https://infostore.saiglobal.com/store, for all current publications and standards relating to 'Cathodic Protection' for the Cathodic Protection technical group.

Table 1
Titles search 'Cathodic Protection"; result 414Titles, 8 from AS (4 referenced in Australian Legislation), 1 ruling to AS 2832.1-2004 on cathodic protection interference levels)

AS 2239-2003	Galvanic (Sacrificial) Anodes for Cathodic Protection
AS 2832.1:2015	Cathodic Protection of Metals - Pipes and Cables
AS 2832.2-2003	Cathodic Protection of Metals - Compact Buried Structures (Referenced in Legislation and Codes of Practice)
AS 2832.3-2005	Cathodic Protection of Metals - Fixed Immersed Structures Standards Australia (Referenced in Legislation and Codes of Practice)
AS 2832.4-2006	Cathodic Protection of Metals - Internal Surfaces (Referenced in Legislation and Codes of Practice)
AS 2832.5-2008	Cathodic Protection of Metals - Steel in Concrete Structures (Referenced in Legislation and Codes of Practice)
AS 4832-2007	Cathodic Protection - Installation of Galvanic Sacrificial Anodes in Soil
RUL ML.1-2008	Rulings to Metal Standards - Cathodic Protection Interference Levels (Ruling to AS 2832.1-2004) Standards Australia

Table 2
Titles search 'Cathodic Protection" for NACE Publications gave 23 publications

NACE 01102:2002	State-of-the-Art Report: Criteria for Cathodic Protection of Prestressed Concrete Structures
NACE 01105:2005	Sacrificial Cathodic Protection of Reinforced Concrete Elements - a State-of-the-Art-Report
NACE 01210:2010	Cathodic Protection for Masonry Buildings Incorporating Structural Steel Frames
NACE 10A392:2006	Effectiveness of Cathodic Protection on Thermally Insulated Underground Metallic Structures
NACE 1E100:2012	Engineering Symbols Related to Cathodic Protection
NACE 30105:2005	Electrical Isolation/Continuity and Coating Issues for Offshore Pipeline Cathodic Protection Systems
NACE 6A100:2000	Coatings Used in Conjunction with Cathodic Protection
NACE 7L192:2009	Cathodic Protection Design Considerations for Deep Water Projects
NACE 7L198:2009	Design of Galvanic Anode Cathodic Protection Systems for Offshore Structures
NACE RP 01 04:2004	The Use of Coupons for Cathodic Protection Monitoring Applications
NACE RP 01 93:2001	External Cathodic Protection of on-Grade Carbon Steel Storage Tank Bottoms
NACE SP 01 86:1986 (R2007)	Application of Cathodic Protection for External Surfaces of Steel Well Casings
NACE SP 01 96:2011	Galvanic Anode Cathodic Protection of Internal Submerged Surfaces of Steel Water Storage Tanks
NACE SP 02 85:2011	External Corrosion Control of Underground Storage Tank Systems by Cathodic Protection
NACE SP 02 90:2000 (R2007)	Impressed Current Cathodic Protection of Reinforcing Steel in Atmospherically Exposed Concrete Structures
NACE SP 03 88:2001 (R2014)	Impressed Current Cathodic Protection of Internal Submerged Surfaces of Carbon Steel Water Storage Tanks
NACE SP 04 08:2014	Cathodic Protection of Reinforcing Steel in Buried or Submerged Concrete Structures
NACE SP 05 75:1995 (R2007)	Internal Cathodic Protection (CP) Systems in Oil-Treating Vessels
NACE SP 06 07:2007	Petroleum and Natural Gas Industries - Cathodic Protection of Pipeline
NACE TM 01 01:2012	Measurement Techniques Related to Criteria for Cathodic Protection of Underground Storage Tank Systems
NACE TM 04 97:2012	Measurement Techniques Related to Criteria for Cathodic Protection on Underground or Submerged Metallic Piping Systems
NACE SP 01 00:2014	Cathodic Protection to Control External Corrosion of Concrete Pressure Pipelines and Mortar-Coated Steel Pipelines for Water or Waste Water Service
NACE TM 02 94:2007	Testing of Embeddable Impressed Current Anodes for Use in Cathodic Protection of Atmospherically Exposed Steel-Reinforced Concrete

Table 3
Titles search 'Cathodic Protection" for ISO Publications gave 11 publications

ISO/DIS 15257	Cathodic Protection - Competence Levels of Cathodic Protection Persons - Basis for Certification Scheme
ISO/DIS 13174	Cathodic Protection for Harbour Installations
ISO 12696:2012	Cathodic Protection of Steel in Concrete
ISO 13174:2012	Cathodic Protection of Harbour Installations
ISO/DIS 12696	Cathodic Protection of Steel in Concrete
ISO 12473:2006	General Principles of Cathodic Protection in Sea Water
ISO/DIS 12495	Cathodic Protection for Fixed Steel Offshore Structures
ISO/DIS 13173	Cathodic Protection for Steel Offshore Floating Structures
ISO/DIS 12954	Cathodic Protection of Buried or Immersed Metallic Structures - General Principles and Application for Pipelines
ISO 15589-1:2015	Petroleum, Petrochemical and Natural Gas Industries - Cathodic Protection of Pipeline Systems - Part 1: on-Land Pipelines
ISO 15589-2:2012	Petroleum, Petrochemical and Natural Gas Industries - Cathodic Protection of Pipeline Transportation Systems - Part 2: Offshore Pipelines

Table 4 Titles search 'Cathodic Protection" for ASTM Publications gave 4 publications	
ASTM STP1370-99	Designing Cathodic Protection Systems for Marine Structures and Vehicles
ASTM B843-13	Standard Specification for Magnesium Alloy Anodes for Cathodic Protection
ASTM G158-98(2010)	Standard Guide for Three Methods of Assessing Buried Steel Tanks
ASTM E1990-14	Standard Guide for Performing Evaluations of Underground Storage Tank Systems for Operational Conformance with 40 CFR, Part 280 Regulations

Stage 2 Report

Table 5 Corrosion Related Standards for AS, AS/NZS, EN, ANSI, ASTM, BSI, DIN, ETSI, JSA, NSAI and Standards and Amendments for ISO & IEC Published from 18 May 2015 to 15 July 2015.	
New standards, amendments or drafts for AS, AS/NZS, EN, ANSI, ASTM, BSI, DIN, ETSI, JSA, NSAI and Standards or Amendments for ISO & IEC PUBLISHED between 18 May 2015 to 15 July 2015	
Key word search on 'durability' and 'corrosion'.- 2 citations found related to corrosion but a 2012 Standard may be of interest	
UNE 83992-1:2012	Durability of Concrete - Test Methods - Chloride Penetration Tests on Concrete - Part 1: Accelerated Natural Method for Determining the Time to Corrosion
UNE 83989:2015	Durability of Concrete - Test Methods. Determination of the Free Chloride in Concrete
Key word search on 'corrosion' or 'corrosivity' or 'corrosive'; but not 'anodizing' or 'anodize(d)'- 13 citations in all – 0 from AS/NZS	
ISO 16701:2015	Corrosion of Metals and Alloys - Corrosion in Artificial Atmosphere - Accelerated Corrosion Test Involving Exposure Under Controlled Conditions of Humidity Cycling and Intermittent Spraying of a Salt Solution
ISO 17093:2015	Corrosion of Metals and Alloys - Guidelines for Corrosion Test by Electrochemical Noise
ISO 18069:2015	Corrosion of Metals and Alloys - Method for Determination of The Uniform Corrosion Rate of Stainless Steels and Nickel Based Alloys in Liquids
ISO 18086:2015	Corrosion of Metals and Alloys - Determination of AC Corrosion - Protection Criteria
ISO/FDIS 3160-2	Watch-Cases and Accessories - Gold Alloy Coverings - Part 2: Determination of Fineness, Thickness, Corrosion Resistance and Adhesion
IEC 60068-2-60 Ed. 3.0 (Bilingual 2015)	Environmental Testing - Part 2-60: Tests - Test Ke: Flowing Mixed Gas Corrosion Test
I.S. EN ISO 16701:2015	Corrosion of Metals and Alloys - Corrosion in Artificial Atmosphere - Accelerated Corrosion Test Involving Exposure Under Controlled Conditions of Humidity Cycling and Intermittent Spraying of a Salt Solution (ISO 16701:2015)
DIN EN ISO 15156-3 (2015-06) (Draft)	Petroleum and Natural Gas Industries - Materials for Use in H_2S-Containing Environments in Oil and Gas Production - Part 3: Cracking-Resistant CRAs (Corrosion-Resistant Alloys) and Other Alloys (ISO/FDIS 15156-3:2014); German and English Version FprEN ISO 15156-3:2015
DIN EN 16602-70-36 (2015-06)	Space Product Assurance - Material Selection for Controlling Stress-Corrosion Cracking; English Version N 16602-70-36:2014
DIN EN 16602-70-37 (2015-06)	Space Product Assurance - Determination of the Susceptibility of Metals to Stress-Corrosion Cracking; English Version EN 16602-70-37:2014
DIN EN ISO 28706-4 (2015-07) (Draft)	Vitreous and Porcelain Enamels - Determination of Resistance to Chemical Corrosion - Part 4: Determination of Resistance to Chemical Corrosion by Alkaline Liquids Using a Cylindrical Vessel (ISO/FDIS 28706-4:2015); German and English Version FprEN ISO 28706-4:2015
15/30301742 DC BS 7846	Electric Cables - Thermosetting Insulated, Armoured, Fire-Resistant Cables of Rated Voltage 600/1000 V for Fixed Installations, Having Low Emission of Smoke and Corrosive Gases when Affected by Fire - Requirements and Test Methods
BS EN ISO 16701:2015	Corrosion of Metals and Alloys - Corrosion in Artificial Atmosphere - Accelerated Corrosion Test Involving Exposure Under Controlled Conditions of Humidity Cycling and Intermittent Spraying of a Salt Solution

BS 3S 145:1996+A2:2015	Specification for Chromium-Nickel-Copper-Molybdenum Corrosion Resisting Steel (Precipitation Hardening) Billets, Bars, Forgings and Parts (1270 Mpa to 1470 Mpa)
Key word search on 'paint' and or 'coating'; but not 'anodizing' or 'anodize(d)' or corrosion– 19 Publications found; 0 from AS/NZS corrosion related;	
ISO/DIS 19396-1	Paints and Varnishes - Determination of pH Value - Part 1: pH Electrodes with Glass Membrane
ISO/DIS 19396-2	Paints and Varnishes - Determination of pH Value - Part 2: pH Electrodes with ISFET Technology
UNE 48281:2015	Paints and Varnishes - Determination of Water Content on Water-Reducible Paints by Gas Chromatography
UNE EN 71-7:2015	Safety of Toys - Part 7: Finger Paints - Requirements and Test Methods
15/30309731 DC BS Iso 19396-1	Paints and Varnishes - Determination of pH Value - Part 1: pH Electrodes with Glass Membrane
15/30309734 DC BS ISO 19396-2	Paints and Varnishes - Determination of pH Value - Part 2: pH Electrodes with ISFET Technology
ISO 27307:2015	Thermal Spraying - Evaluation of Adhesion/Cohesion of Thermal Sprayed Ceramic Coatings by Transverse Scratch Testing
ISO/DIS 19598	Metallic Coatings - Electroplated Coatings of Zinc and Zinc Alloys on Iron or Steel with Supplementary Cr(VI)-Free Treatment
DIN EN 16866 (2015-07) (Draft)	Metallic and Other Inorganic Coatings - Simultaneous Thickness and Electrode Potential Determination of Individual Layers in Multilayer Nickel Deposits (Step Test); German and English Version PrEN 16866:2015
DIN EN ISO 19598 (2015-07) (Draft)	Metallic Coatings - Electroplated Coatings of Zinc and Zinc Alloys on Iron or Steel with Supplementary Cr(VI)-Free Treatment (ISO/DIS 19598:2015); German and English Version PrEN ISO 19598:2015
AWWA C213:2015	Fusion-Bonded Epoxy Coatings and Linings for Steel Water Pipe and Fittings
15/30312397 DC BS En 16866	Metallic and Other Inorganic Coatings - Simultaneous Thickness and Electrode Potential Determination of Individual Layers in Multilayer Nickel Deposits (Step Test)
15/30325925 DC BS En 62631-3-11	Dielectric and Resistive Properties of Solid Insulating Materials - Part 3-11: Determination of Resistive Properties (DC Methods) - Volume Resistance and Volume Resistivity, Method for Impregnation and Coating Materials
Key word search on 'galvanize' or 'galvanized' or galvanizing' – 0 Standard Publications found	
Key word search on 'corrosion' with examination for concrete related standards - 0 Standard Publications found	
Key word search on 'cathode' or 'cathodic' -0 corrosion related Standard Publications found	
Key word search on 'anode' or 'anodes' or 'anodic' – 0 Standard Publications found	
Keyword Search on 'electrochemical' or 'electrolysis' or 'electroplated' – 2 Standard Publications found, 0 from AS or AS/NZS	
ISO 17093:2015	Corrosion of Metals and Alloys - Guidelines for Corrosion Test by Electrochemical Noise Measurements
DIN EN ISO 19598 2015-07) (Draft)	Metallic Coatings - Electroplated Coatings of Zinc and Zinc Alloys on Iron or Steel With Supplementary Cr(VI)-Free Treatment (ISO/DIS 19598:2015); German and English Version PrEN ISO 19598:2015
Keyword Search on 'anodize' or 'anodized' - 2 Publications found, none for AS AS/NZS	
15/30317616 DC DIN EN ISO 3210 (2015-07) (Draft)	Anodizing of Aluminium and its Alloys - Assessment of Quality of Sealed Anodic Oxidation Coatings by Measurement of The Loss of Mass After Immersion in Acid Solution(S) (ISO/DIs 3210:2015); German and English Version
prEN ISO 3210:2015 Bs Iso 3210	Anodizing of Aluminium and its Alloys - Assessment of Quality of Sealed Anodic Oxidation Coatings by Measurement of the Loss of Mass After Immersion in Acid Solution(s)

Arthur Austin
ACA Standards Officer

Rhino Linings Australasia Pty Ltd

Q: In what year was your company established?

A: Rhino Linings was originally founded in 1988 by Russell Lewis in the United States. The company first commenced trade in Australia in 2001 both manufacturing and distributing its range of polyurethane and polyurea protective coatings and training applicators in the use of the coatings for abrasion, corrosion and impact protection.

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

A: Rhino Linings Australasia's head office is based on the Gold Coast in Queensland. When the company first started we had two staff.

Q: How many do you currently employ?

A: Since 2001 Rhino Linings Australasia has grown to employ a group of 12 staff. All are highly knowledgeable in the field of protective coatings and employed specifically to meet the demands and needs of our dealer and approved applicator base. The head office team provides training, product and application knowledge, marketing and assist dealers when tendering for work.

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

A: We have a network of over 60 Rhino Linings dealers and approved applicators located throughout Australasia. All are independently owned and operated and trained in the specialised application of Rhino Linings polyurethane and polyurea coatings.

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

A: Applicator training, manufacturing and distribution of polyurea & polyurethane spray applied protective coatings for use in the automotive, commercial and industrial applications.

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

A: Rhino Linings protective coatings can be used for a diverse range of application requirements in the oil & gas, marine, water & waste water and mining industries. Our coatings provide resistance against chemical attack, abrasion, corrosion and impact. Some of our product range is even potable water approved for use in drinking water storage tanks.

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

A: Rhino Linings Australasia manufactures and distributes is polyureas and polyurethanes from its Head Office based on the Gold Coast. Our approved applicators provide both site and yard based services throughout Australia, New Zealand and South East Asia including Singapore, India and Korea.

Q: What is your monthly capacity or tonnage that you can manufacture?

A: Up to 50 tonne of both polyurethane and polyurea.

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

A: Our dealers and approved applicators complete a large number of projects each year. The most satisfying in the last two years have been the Orica Cyanide Plant located in Gladstone, Qld where the factory floor was coated with Rhino PP1195 to prevent leaching of cyanide waste products. The second being Melbourne Water Eastern Treatment Plant where again PP1195 pure polyurea was used for its chemical resistance and corrosion protective properties.

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

A: Positive advice we can pass on to those involved in the coatings industry is (if possible) be involved in the design from a very early stage by attending meetings and briefs. We have found direct involvement highly beneficial in understanding the potential clients requirements further helping to win the project. For the coatings applicator, always ensure correct surface preparation to prevent failure of coatings. Additionally, make sure your QA documents are fully completed and filed correctly for future reference.

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

A: All Rhino dealers and approved applicators are trained at RLA head office and onsite at the dealers premises in the safe application of our range of products. They are further backed by 24/7 technical advice and assistance from the RLA technical team. This ensures the coatings are applied correctly guaranteeing long term performance and cost savings for the customer.

Rhino Linings® PREMIUM PROTECTION

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Marketing: Michelle Gunn
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Corrosion protection on an oil & gas platform.

Melbourne Eastern Water Treatment Plant.

Orica Cyanide Plant, Gladstone.

Corrosion Research at the University of Adelaide

By Erwin 'Erk' Gamboa,
The University of Adelaide

The University of Adelaide (UoA) has been involved with corrosion research since 2005, having produced significant contributions to the pipeline industry and establishing a publishing track record in the area of Stress Corrosion Cracking (SCC).

A large portion of the pipeline research activities have been for the Australian Pipeline Industry Association (APIA), now recently rebranded as the Australian Pipeline Gas Association (APGA) and the Energy Pipelines Cooperative Research Centre (EP CRC). Some of the research areas have included gas pipeline girth welding consumables, pipe coatings, pipe metallurgy and pipe integrity, with a focus on high pH SCC of gas pipelines.

One successful APIA research project carried out in collaboration with ANSTO involved investigating how SCC cracks in a gas pipelines extended by fatigue due to operational cyclic pressures if the SCC could be rendered permanently dormant. Full scale tests showed that cracks formed initially by SCC could further propagate by fatigue, but that this growth was usually minute due to normal operational cyclic stresses within that pipeline's expected remaining lifetime. The results of the research work led to one company saving $8m in the first year after the research findings were applied, with further savings since then.

UoA is a participant in the Energy Pipeline Cooperative Research Centre, established in January 2010. The APGA Research and Standards Committee represented the industry members involved in the Energy Pipelines CRC.

UoA is a participant in the Energy Pipeline Cooperative Research Centre, established in January 2010. As part of the Energy Pipelines CRC activities, UoA's corrosion related research has been mainly concerned with investigating the role of the environment and cyclic operating stress regime on stress corrosion cracking in existing pipelines. The goal of this research is to cost effectively extend the life of our aging Australian pipeline infrastructure by mitigation of corrosion and environmentally assisted degradation.

Update on SCC Research at UoA

In the previous 'University Profile' article from the October 2013 issue of Corrosion & Materials, it was reported that X-ray tomography was a crack imaging technique that was adapted and developed by Dr Gamboa for imaging SCC cracks in pipeline steels. This technique has been used since then to further investigate and understand SCC cracks, especially unusual cracks with complex 3D shapes that interact underneath the pipe surface.

Aided by this technique, a number of observations were made that allowed the comparison of these unusual 3D cracks to others found internationally. These observations suggested that inclination of SCC cracks is not due to purely mechanical factors (such as shear planes, stress directions or stress intensity factors) or visible microstructural features (such as metallographic grain aspect ratios or inclusions). Instead, crystallographic orientation (sometimes called 'texture') seems to be a large driving factor for these unusual crack shapes.

Further work in this area has supported this hypothesis; comparison between inclined SCC samples, non- SCC affected samples and international inclined SCC samples has shown that there is a difference in crystallographic texture. The measured texture of inclined SCC samples is consistent with textures known to be susceptible to SCC, and the texture of non-SCC affected samples is consistent with textures known to be more resistant to SCC.

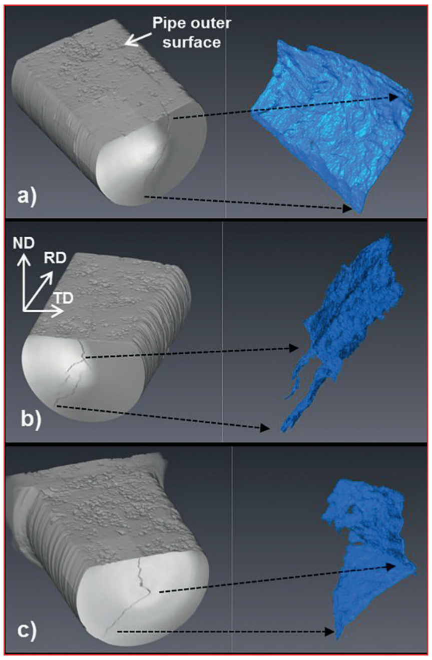


Figure 1- 3D observations of typical stress corrosion cracks showing non-straight through-wall propagation. The diameter of the truncated cylinder is 4 mm. ND, RD and TD are respectively the normal, rolling and transverse directions.

As work continues in understanding the role of texture on SCC resistance of pipeline steels, other projects at UoA are involved with investigating:

- the relationship between pipe manufacturing methods and SCC resistance
- modelling SCC crack interactions to determine crack growth rates and 'safe' interaction distances
- how does mechanical strain affect the electrochemical response of SCC cracks
- how do pipeline coatings deteriorate with time?

The University has also been involved with other research projects with industry in different fields, primarily focusing on

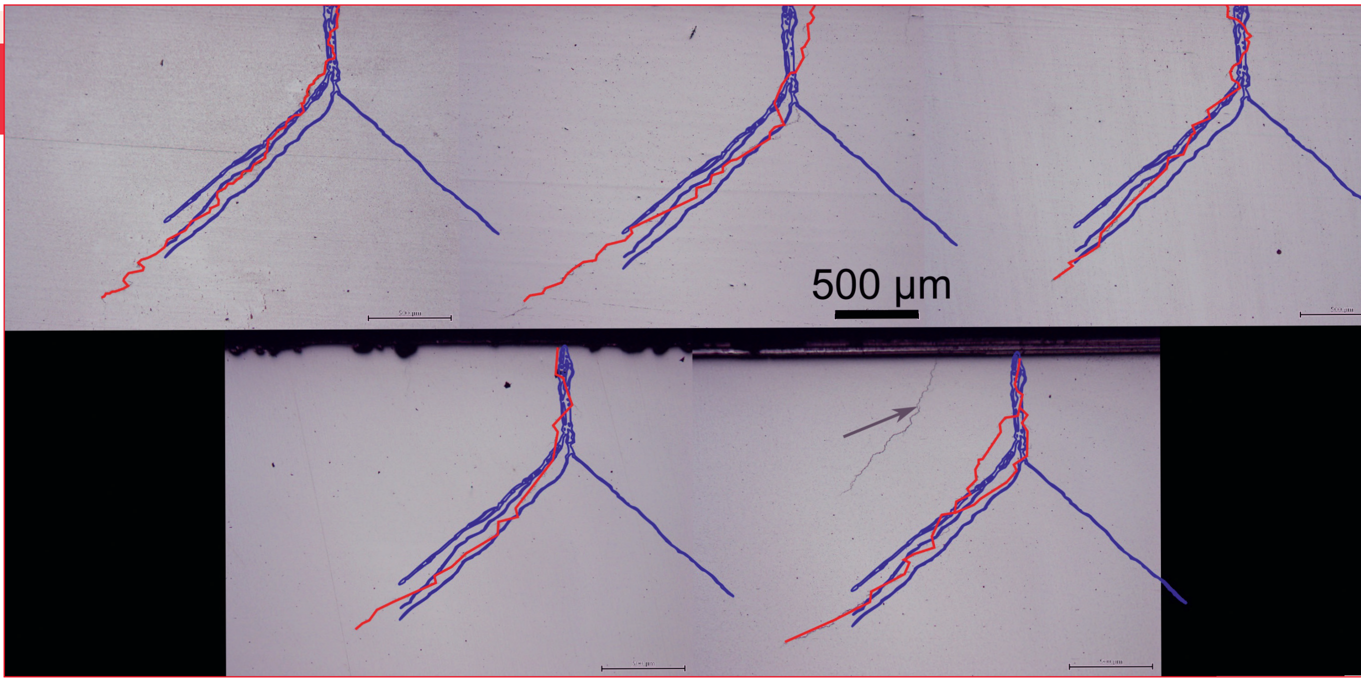


Figure 2 -Five different inclined SCC cracks with limited interaction from an inclined SCC colony in red, with modelled 0.5 grain aspect ratio crack paths in blue. Arrowed crack is not considered due to presence of interaction from adjacent crack. The fact that the 5 illustrated red cracks are leaning towards the same side is coincidental.

estimating relative corrosion resistant materials' performance in a range of environments, whether through contract work or as part of final year Mechanical Engineering student projects.

The final year mechanical engineering projects are shown at the end of every year to the public at Mech Expo in the largest of its kind exhibition in the country. A large majority of the projects have been done in collaboration with industry. The link http://www.mecheng.adelaide.edu.au/projectexhibition/ has many examples of projects and media coverage that the Mech Expo has attracted.

For more information on research opportunities, collaboration for final year Mechanical Engineering projects or past research work, please contact Dr Gamboa on Erwin.gamboa@adelaide.edu.au.

ACAF International Travel Scholarship Report

by Mike Rutherford
Part 3

The first section of my ACA Foundation International Travel Scholarship Report covered the Inaugural NACE European Corrosion Conference-Expo 2014 in Spain and the Corrosion Prevention and Protection System developed for the Chernobyl Sarcophagus Confinement Shelter Project in Ukraine.

The second section of my report covers site visits to projects and project offices of significance. In addition it covers meetings with key personnel to discuss challenging concrete cathodic protection projects.

The third section of my report covers market trends and experiences in France and the UK.

French Market Experience

The main standard that is referenced for cathodic protection of steel in concrete in France is EN ISO 12696: 2012 - Cathodic Protection of Steel in Concrete. Compliance with this standard means that when cathodic protection systems meet the performance criteria in the standard it is accepted you are preventing corrosion. This is aligned with relevant similar standards in Australia and the Middle East as all have similar criteria.

The selection criteria for cathodic protection systems in steel was discussed and they are aligned with the processes practiced in Australia. With discrete anodes the current is based on diameter and length whilst with ribbon anodes it is based on different widths providing different currents and for mesh anodes it is based on different grades providing different currents.

Following the determination of the cathodic protection system to be used, the total current for each anode zone, voltage requirements, required cable size based on the power requirements and cable lengths can be calculated. Once calculated, the number of anode zones and cabinets is determined.

Additional consideration is then given to how the cables will be run, the volume and configuration of cut in chases in the concrete that are to be made, the number of anodes that will be cast into new concrete or repair mortar, the volume of surface mounted conduits, the determination of the location of junction boxes and the location of power supplies.

Cathodic protection systems utilised for the protection of embedded reinforcement were overviewed to list their advantages, disadvantages and areas of application. The results of the CP System overview is as outlined below:

Conductive Coating:

The anodic coat is made of an organic resin with conductive additions of graphite (solvent or water based to 500 microns approx. thickness). The currents are distributed in the layer by a specially thin and durable wire that crosses the layer. A coloured overcoat may be used to restore the initial appearance of the structure.

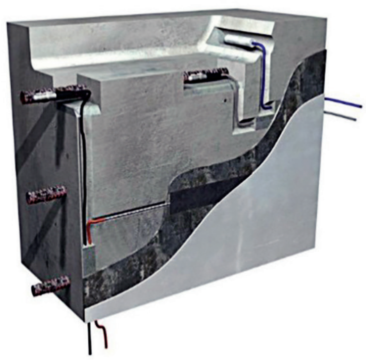


Figure 1 - Conductive Coating Application.

Advantages – ease of application - even on complex shapes, thin application thickness, provides uniform protection, no added weight and it can be easily re-applied.

Disadvantages – not appropriate for surfaces exposed to traffic or heavy weather, convenient for light rebar arrangement, provides design life of 10 to 15 years, staining may occur, can be applied to a dry substrate only and has limited resin pot life.

Applications – building facades, motorway and highway structures.

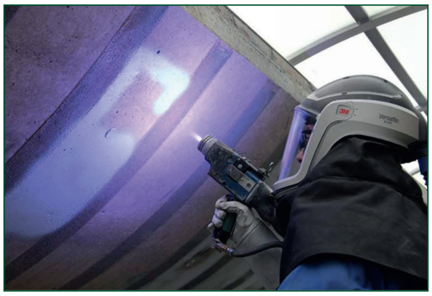


Figure 2 - Arc Sprayed Zinc Wire Application.

Discrete Coated Titanium Anodes:

The anode is made of a titanium tube and is coated by Mixed Metal Oxides (MMO) to prevent their passivation and to ensure their efficiency throughout their life time. They are inter-connected by titanium wires and are available in various diameters and lengths.

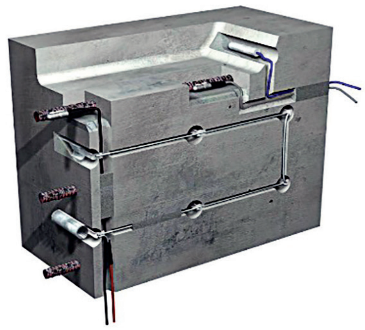


Figure 3 - Discrete Coated Titanium Tube Anode Schematic.

Advantages – consistent with any kind of aggressive environment, very long design life anode system, tolerant of a wet substrate during installation, protects rebar in the depth of the element, no added weight, no alteration of the geometry and provides a very high density of currents.

Disadvantages – uniformity of current distribution, risks of conflict between anodes and rebars when drilling, vibrations during installation, may modify the appearance of the structure, operates outside of NACE guidelines and require pH buffering grouts for installation.

Applications – not seen on structural elements.

Coated Titanium Ribbon Anodes:
The anode is made of Titanium, coated with MMO. Its width varies from 10 to 20 mm, so that it can be inserted in grooves. Spacing between anodes is usually less than 400mm but can be extended dependent on orientation.

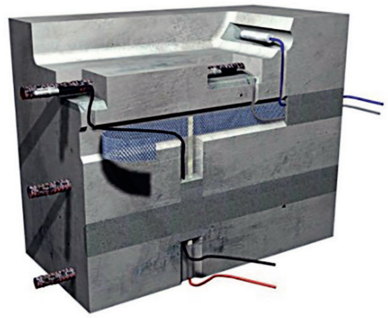


Figure 4 - Coated Titanium Ribbon Anode.

Advantages – consistent with any kind of aggressive environment, very long design life, tolerate wet substrate when installing, fast to install in grooves, no added weight, no alteration of the geometry and good adhesion.

Disadvantages – distribution of current not uniform (but better than discrete anodes), concrete cover shall be more than 20mm thickness (to avoid the risk of short circuit) and modifies the appearance (can be coated).

Applications – structures with no constraint regarding appearance and is convenient for new structures.

Coated Titanium Mesh Anodes:
The anode is an expanded Titanium anodic mesh coated with MMO and which is attached to the surface by plastic connectors and embedded in shotcrete (e.g. 20mm).

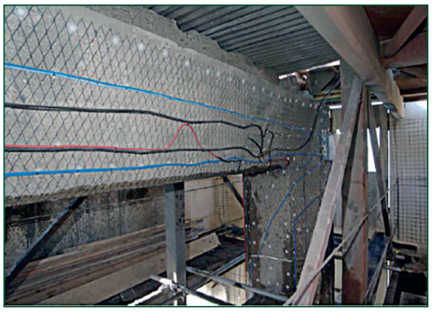


Figure 5 - Coated Titanium Mesh Anode Application.

Advantages – shotcrete application allows to re-profile and reinforce the element, uniform distribution of currents, high densities of currents (over-lapping), very long design life and solid track record.

Disadvantages – adds thickness (20-25 mm) and weight, modifies appearance, installation may prove to be complex, requirement to confine the overspray resulting from the shotcrete application and requires the relevant substrate preparation and skill in shotcreting. Potential for delamination of overlay.

Overview of Market Trends and Market Experience

For every cathodic protection project there must be an Inspection and Test Plan detailing material certification requirements, hold points, where the CP technician must measure and record data. Additionally it must say who is responsible for testing and approval to proceed and it must detail all the factory and site tests to be completed. Specific site check sheets are required for electrical continuity checks, negative connection installation, reference electrode calibration and installation, surface preparation, anode installation, checks for short circuits during concrete placement, junction box and cabling installation, testing and commissioning.

After commissioning, routine monitoring should be undertaken in accordance with EN12696:2012 providing for monthly functional checks for resistance, current and potential, quarterly performance verification and assessment for Instant Off Potential, 24 hour depolarization and annual system review and maintenance scheduling.

EN 15257: 2006 '*Cathodic Protection – Competence levels and certification of cathodic protection personnel*' requires designers and site staff to be qualified and hold certificates for specific fields e.g - (Concrete, Land, Marine, Internal structures): Level 1: Perform site measurements (technician), Level 2: Method statements, documentation etc and Level 3: For design & monitoring CP systems.

In the UK, project specifications now refer to this European standard, in Concrete Level 2 training and certification have existed since 2011 and in France, Concrete Level 1 training and certification started in October 2014. For many countries, NACE is the only recognized organization through which certification can be obtained. The standard is being implemented to keep assist uniform quality internationally within the cathodic protection industry.

UK and Ireland Market Experience

As outlined in the French Market Experience above, in the UK project specifications now refer to the European standard with practices aligned to a large extent with the French.

The trends in cathodic protection in the UK and Ireland are as outlined below:

Discrete Sacrificial Anode System –Where minimal cathodic protection is required, such as for patch repairs, the market favours discrete sacrificial anode systems.

Ribbon Mesh Anode System – Where chloride levels are high, the market seems to favour either ribbon mesh anodes (especially for joints) or discreet anodes where deeper penetration is required.

Hybrid Anode System – The hybrid anode system is quite prevalent in the market place and is meeting market needs where specified. It appears to be popular within the industry. In some cases the hybrid anodes are being used to replace impressed current cathodic protection systems.

Impressed Current System – Larger highly contaminated areas are largely the preserve of impressed current system utilising titanium mesh anodes. A trend for impressed current cathodic protection systems on steel framed buildings was evident and generally these are undertaken by technical centres (such as Taylor Woodrow) who are well placed to undertake the surveys, design the systems and install the systems via subcontractors.

Sprayed Coating Anode System – The UK sees little if no sprayed coating anodes (such as zinc spray). Conductive paint systems seem to be only used on car parks with little or no application of these system on the motorway links, although these systems were widely used in the 1990's and early 2000's.

There are also marine systems with the preference being for galvanic solutions which in general can be fitted by divers, designed by anyone with a cathodic protection design background.

It was noted through discussions that most port and marine facilities within the UK and Ireland were retro-fitting cathodic protection systems using galvanic anodes with impressed current cathodic protection systems being used for new ports or extensive upgrading. Impressed current systems were used in estuarine ports with high water resistivity or shallow water depths.

In conclusion an overview of the decisions between galvanic or impressed current cathodic protection system selection in the UK is based on the case for galvanic anodes being that no power supply is required and therefore there is no electricity bill, no cabling, less to go wrong and the requirement for less frequent inspection and monitoring.

The case for impressed current systems is the anodes provide longer life, 50% less capital cost for new build installations, provide accurate "Instant Off" potentials, less anodes to install, and that they are not affected by high seawater resistivity and if high bed level (close to mid tide).

I would like to sincerely thank the ACA Foundation for the extraordinary opportunity that the scholarship presented me. I was able in one trip to make connections with a wide range of colleagues and to see some extraordinary places. I can only recommend that other members of the ACA consider applying for a similar grant.
Thanks, **Mike Rutherford.**

Treatment Of Rusted Surfaces

R A Francis, R A Francis Consulting Services, Ashburton, Australia.

It is generally accepted that, for maximum protection, paints must be applied to surfaces which are entirely free from rust and other contamination. This is especially true of modern high performance coatings such as epoxies, inorganic zinc silicates, etc where abrasive blasting to a high standard is usually mandatory. There are, however, situations where it is not possible to completely remove all rust from the surface for design, economic, safety or other reasons. There has therefore been much research into treatments for rusted surfaces to avoid the need for such critical surface preparation. A large number of products have appeared on the market for such purposes although it is generally agreed that the protection achieved is nowhere near that attained if a rust-free surface is used. However, there is certainly a market for such products, especially in the consumer, or DIY market.

These can be arbitrarily divided into five categories:

1. Some of the products simply bind the rust particles together and to the steel surface, forming a barrier between the metal surface and the environment. There is no reaction between the rust or the metal substrate and the coating. Examples of this are penetrating primers such as PENETROL (OWATROL in other countries), ISOTROL and fish oils. Most of these are penetrating drying coatings (linseed oils or alkyds) and they may be overcoated for appearance or additional protection.

2. A second type, such as CORROLESS primers, contain a pigment which is claimed to convert rust into a more stable chemical compound (magnetite). These compounds also contain a conventional paint resin. They are usually overcoated with a top coat.

3. A third type are aqueous solutions of phosphoric or tannic acid or other tannin product, often in conjunction with wetting agents, surfactants, catalysts, etc. They are usually, but not always, water-based. Treatments are usually followed by a conventional primer and top coat. Some brand names which have appeared or are currently on the market include FERTAN RUST CONVERTER, GALMET IRONIZE and KILLRUST RUST-EETER.

4. A fourth kind is similar to type 3 in that it is based on the tannin products but also incorporates a latex emulsion compatible with the acidic tannin product. As well as providing the same form of protection as type 3 above, the presence of a binder means that a polymeric film is also formed so that these products act as a rust pretreatment and a primer. Examples of this type are CORROSEAL, NEUTRA RUST 661 and FERONITE RUSTY METAL PRIMER.

5. Industry will usually use a high solids epoxy coatings, generally called surface tolerant epoxies or epoxy mastics, such as AMERLOCK, JOTAMASTIC 87, Dulux DUREBILD STE and the International INTERPLUS and INTERSEAL range. These are epoxy coatings which have very good wetting and penetrating properties but can also be built up to quite high thicknesses, 300 microns or more. The epoxy resin provides excellent adhesion so they bind the rust particles together and bond it to the substrate. Furthermore, the thick film provides excellent barrier protection.

There are two problems with coatings applied to rusted surfaces. Firstly, the rust particles are not strongly bonded to one another, nor the substrate, so that any coating applied to loose, flaky rust will have poor adherence to the substrate. When moisture penetrates through the coating, the coating will lift and disbond from the surface. All products recommend removal of

Strait Shipping Strait Feronia (Jotamastic).

Roof refurbishment in Auckland (Jotamastic).

Tasport's Korimul Tug refurbishment over spot blasted surface with UHWJ.

as much flaky, non-adherent rust as possible to minimise this problem, but those with the best penetrating ability and strongest adherence will perform the best. The second problem is the salts such as chlorides, sulphates, etc., that are contained in the rust. The rust itself, hydrated iron oxides, is generally fairly innocuous chemically, and tends to grow due to the presence of new ferrous ions forming as a result of these salts reacting with moisture and oxygen. The salts aggregate at the bottom of the rust pits, so are generally not removed when the loose rust is removed. They remain under the coating and draw moisture through by osmosis, leading to blistering and coating failure.

The significant variations in rust, both in its adhesion and salt content, make it very difficult to scientifically evaluate the various rust treatments. It is impossible to compare results of one researcher to another because these two factors cannot be standardised. These will influence rates of breakdown far more than the small differences between the products. A poor quality product applied to a surface with almost all rust removed and no salts will show better performance than a better quality product applied to a surface with rust containing significant salts. A further problem arises because accelerated testing using salt spray is usually carried out. A salt spray solution on the surface of a coating placed over rust containing salts actually provides a *lower* osmotic pressure, therefore a slower rate of breakdown, than fresh water. Coatings over rusty surfaces should never be evaluated by salt spray or similar accelerated testing. Such tests may, in fact give results that are inversely proportional to life in actual exposure.

When all the above variables are considered it can be seen that it is very difficult to assess such products and the claims from manufacturers. As a result, while significant research has been carried out into their mechanism of protection, little work has been published on actual protection achieved by such products. DesLauriers (*Materials Performance*, Nov 1987, p35) did compare some tannin-based products and found poor performance. Generally speaking, those products based on soluble materials such as phosphoric and tannic acid (Types 2, 3 and 4 above) appear to provide least protection, probably because they are adding to the soluble content of the coating, leading to osmotic blistering. The inert materials (Type 1) probably provide superior protection to these, but the limited film build means that oxygen and moisture will penetrate fairly quickly, leading to eventual breakdown. The most successful treatments are the epoxy mastic type materials (Type 5) which have superior penetrating ability, adhesion and good film builds to minimise moisture and oxygen penetration. These are the usual treatments recommended in AS/NZS 2312.1 for poorly prepared surfaces.

According to AS/NZS 2312.1:2014, 75 microns of epoxy mastic (system EPM2) should provide 2 to 5 years to first maintenance in a moderate ISO C3 environments, while 200 microns of the same product (system EPM3) would provide 10 to 15 years in same environment and 2 to 5 years in a severe ISO C5 environment. The Standard also has a number of epoxy mastic primer systems, with a decorative topcoat for maintenance where blasting cannot be carried out. As mentioned above, the amount and salt content of the rust are significant factors in determining the life of such coatings and these figures must be considered as only a very rough guide. Any other rust treatment would be expected to provide significantly lower lives than these figures.

May 2015

Protective Coatings – a Guide to Project Delivery

J. Rigby
Remedy Asset Protection, Melbourne, Australia

This article aims to present a description of the asset maintenance industry and how the various intermediaries fit into the larger picture. Many of you are experienced in designing, engineering, protective coatings or project delivery, most professionals and contractors tend to operate in their own silos. The aim of this article is to discuss a description of the industry and how the various intermediaries fit into the larger picture.

By formalising the industry structure to describe how projects get delivered we can understand where an asset owner's project can fit into this industry structure.

The 'Guide for Project Delivery' will be discussed by working through the following topics:

- Assessing your project
- How we all fit in the bigger picture
- Provide real life examples of how differing projects fit into the existing industry structure

Assessing Your Project

So when focusing on 'Protective Coatings Projects' we most likely include the following parties;

- Asset Owner
- Engineering (Designer – Mechanical, Structural, etc.)
- Engineering (Corrosionists)
- Engineering (Materials Science)
- Consultant (Protective Coatings)
- Consultant (Project Management)
- Contractor
- Coatings Manufacturer
- Coatings Inspector

Where We Fit In

Lets discuss how we all fit within a project delivery model.

When an asset owner is appraising a project, they need to consider;

- capacity or function
- financial budgets
- asset life cycle
- time to first maintenance
- risk management

This sounds basic, but how many times have we been invited during the latter stages of a project where some of these items haven't been considered?

When presented with a coatings project – the asset owners need to properly evaluate how many elements are required to effectively manage their expected outcome.

Typical roles in a coatings project can include:

- Asset Owner
- Engineering (designer, mechnacal, structural etc.)
- Engineering (Corrosionists)
- Engineering (Material science)
- Consultant (Protective Coatings)
- Consultant (Project Management)
- Contractor
- Coatings manufacturer
- Coatings Inspector

Notice there are 3 engineers, 2 consultants, 1 contractor doing the work, 1 manufacturer supplying the paint and 1 inspector. The greater proportion is weighted at the pre start stages of the project being - **Project Appraisal**.

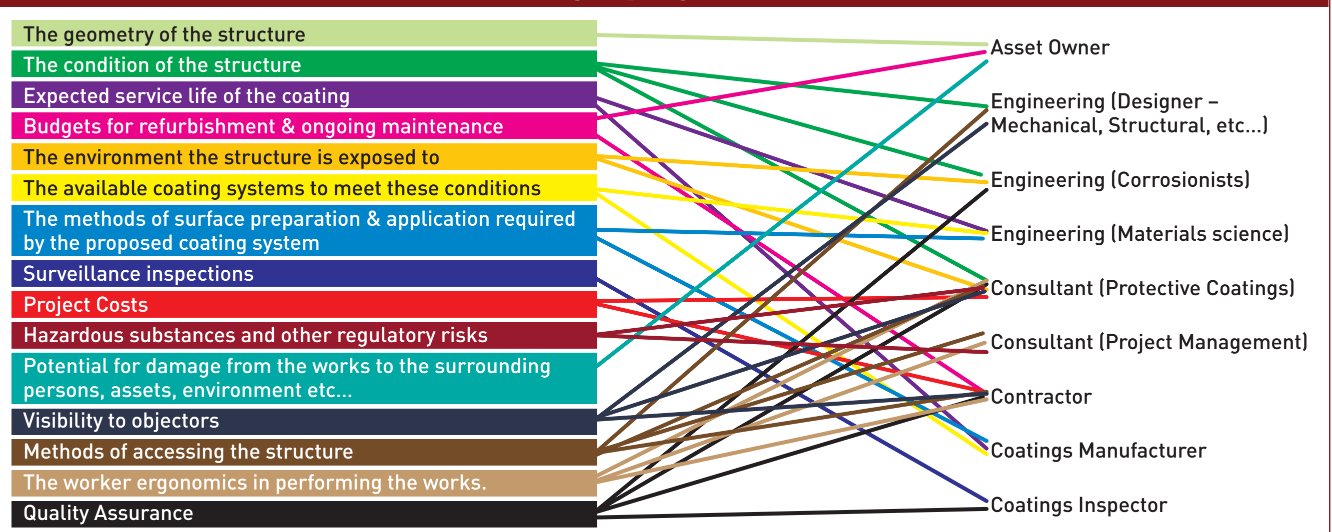
That's because expending the effort at the front end of the project saves time & money in the back end of the project.

A simple rule of thumb is, 'if you can't conceptualise the project, you need to surround yourself with people that can'.

It doesn't mean you need to stack the project with multiple layers of management. You just need to assess where your organisation's skills are lacking and get a professional third party provider to assist with that portion.

Let's now look at the major elements in a protective coating project.

Protective coatings, project considerations.



Organisations Capabilities.

Upper Levels of:

- Engineering Design
- Materials Science

Functional / Site Based Level:

- Consultants
- Contractors
- Coating Inspectors

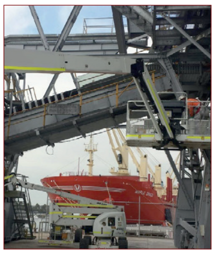
Project Case Studies

Case Study 1 Molasses Tanks:
A set of large silos on site that is overdue for a repaint.

Clients Request:	Need to repaint the silos.
Reasoning:	Because they look bad.
Risks:	■ Working at heights ■ Interruption to delivery flow.
Requests:	Low budget – long warranty
Solution:	■ Asset owners understanding of PC is limited. ■ They wanted the contractor to "Make it look good" ■ They recognised their lack of understanding and sought help. ■ They did not need designs or engineers as there were no alterations. ■ They needed a coating specification. ■ They needed a specialised approach to minimise the cost.
Outcomes:	These works were completed with a 6 year guarantee. A unique solution was developed in order to turn the project proposal into a job.

Case Study 2 Ship Loader:
This project involved refurbishment of a 1920's steel structure that had corrosion, lead based paints trapped under 7 defective coating layers.

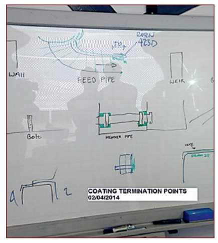
Clients Request:	To remove lead based paint, treat corrosion & apply a new protective coatings system.
Reasoning:	To protect the structure from corrosion
Risks:	■ Lead containing paint. ■ Damage to the Environment (Port of Melbourne waterway). ■ Working at heights (difficult geometry) ■ Interruption to shipping schedules.
Requests:	Upon going through the Project Appraisal Stage the client determined the required budget ($450k) was not suitable.
Solution:	A detailed coating survey was performed to determine the extent of the lead containing paint and also the extent of the defective coatings to help us tailor a solution. This involved: Low pressure water cleaning. Basic surface preparation performed to 90% of the surface area. This coupled with an aluminium pigmented epoxy mastic provided suitable protection for the next 5+ years before further evaluation. 10% of the remaining area had potential to disturb lead containing paint. For the short term these areas were coated to encapsulate lead and corrosion.
Outcomes:	In making their investment decision the owner was able to: 1. Contain corrosion to 10% of the structure 2. Effectively manage the lead containing paint. 3. Input a maintenance plan moving forward that will allow them to slowly treat the corrosion.



Project Case Studies

Case Study 3 Sewage Treatment Plant (STP) – Filter Cell:
This project was to strip defective coatings from a concrete tank and apply a new protective lining system.

Clients Request:	Detailed appraisal & specification to be developed by external Engineering & Consultancy CH2M Hill.
Reasoning:	Another coating failure would be unacceptable as it reduces the design capacity of the STP.
Risks:	■ Poor workmanship or materials. ■ Confined space entry & rescue. ■ Damage to downstream elements of the STP.
Intermediaries:	The Asset Owner engaged an external Engineering & consultancy firm to; ■ Provide mechanical engineering in appraising the environment for a new lining system. ■ Provide materials science principles in evaluating the range of coatings available. ■ Provide a detailed project specification. ■ Provide project management in selecting contractors and overseeing the works. ■ Engaged ***Remedy Asset Protection*** to provide site based consultancy & coating inspection duties.
Outcomes:	Successful removal of the old coatings & application of a new 4 layer resin based laminate coating. 1. Detailed work procedures were developed to deal with site specific issues. 2. Well documented site diary & inspection reports were completed to enforce contractor & manufacturer warranties. 3. Have been able to capture the learnings from this project to apply onto the other 11 cells.


Conclusion
Some suggestions to leave you with are;

Recommendations	Steps for failure	■ Not listening to recommendations from industry ■ Sacrificing quality for money (results in less longevity) ■ Accepting a lowest price bidder without properly checking their methodology. ■ Having a combative attitude to project delivery rather than a collaborative attitude.
	Steps for success	■ What is the project? ■ What is the outcome (includes standards)? ■ What is the risk? ■ What is the budget? ■ Use documentation.

Refurbishment of protective coatings involves many factors outside of simply applying coatings. These are projects that if managed well – work well and provide the desired outcomes. However when managed poorly they really expose the Owner to cost over runs and many risks that can make your head spin.

It is recommended spending some time with a professional at the evaluation stages to identify;

- Required outcomes
- Available budgets
- Key risks
- Skills that are not available in-house.

Then convince your boss (or client) to allocate some of the budget towards consultancy or inspection services where you have a skill deficiency.

Whether that is at the upper levels of;

- Engineering design & materials science

Or, at the functional site based levels of;

- Coatings consultant or coating inspector.

This additional expense at the front end of the project will;

- Save you grievances from your boss & your client.
- Make sure the job is done right
- Make you look good by having foreseen the likely risks and effectively managed them
- Protect & enhance your reputation for project delivery.

J. Rigby
Remedy Asset Protection,
Melbourne, Australia

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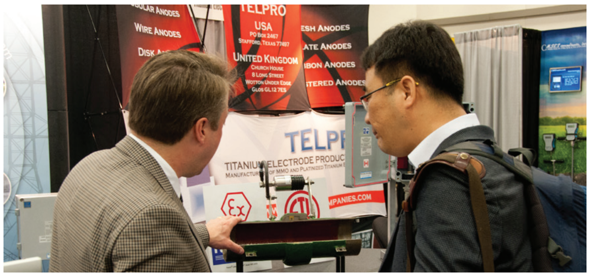

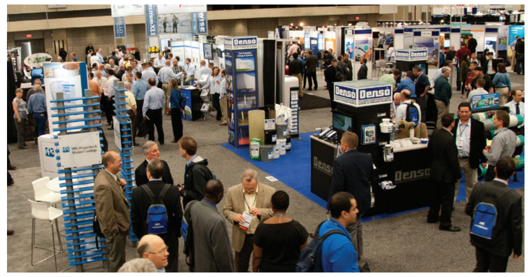

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