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CORROSION & MATERIALS

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Inside this Issue:

CELEBRATING 60 YEARS
1955 – 2015
AUSTRALASIAN CORROSION ASSOCIATION INC.

CORROSION & PREVENTION 2015

Proudly presented by:

Adelaide, South Australia
15–18 November 2015

Major Sponsor: JOTUN

Corrosion and Prevention is the annual conference of the Australasian Corrosion Association, it's a 4 day gathering of world experts on corrosion mitigation. This will be a premium networking event as well as a source for the latest information concerning corrosion mitigation.

Entitled Corrosion & Prevention 2015, the conference will feature a program of keynote speakers and presentations under a range of industry streams and is expected to attract approximately 450 - 550 delegates. Corrosion & Prevention 2015 also features an extensive exhibition of key industry suppliers.

In 2015 we invite you to the vibrant city of Adelaide, which is internationally regarded as a wine and food mecca, add in a temperate Mediterranean climate and Adelaide is the ideal place for mixing business with pleasure. All in all, this promises to be an enlightening, exciting and highly enjoyable conference.

Conference Committee

Conference Convenor Alan Bird

Technical Chair Erwin Gamboa

Conference Committee
- Mohammad Ali • Brian Hickinbottom • Peter Hosford
- Raman Singh • Dean Wall

The Destination

Nestled between the beautiful Adelaide Hills and the long white beaches of the Gulf of St Vincent, Adelaide is a picturesque city featuring wide boulevards surrounded by parklands around the city centre. Its position on the banks of the Torrens River amongst superb gardens also gives the city a relaxed atmosphere and a lifestyle that is the envy of all who visit.

Adelaide is internationally regarded as a wine and food 'destination' - offering locally produced world-class wines matched with fresh local produce; resulting in amazing dining experiences that are unforgettable.

South Australia is made up of spectacular regions, all of which offer a unique and exhilarating experience waiting to be discovered. Amongst the many reasons people visit South Australia are the spectacular scenery, fishing, fauna and national parks - wine and food are often at the top of the list. South Australia's wineries are legendary - the Barossa Valley, McLaren Vale, Clare Valley, Coonawarra and Adelaide Hills are sought out by many visitors.

www.southaustralia.com

Your Hosts

The Australasian Corrosion Association Incorporated (ACA) is a not-for-profit, industry association, established in 1955 to service the needs of Australian and New Zealand companies, organisations and individuals involved in the fight against corrosion.

The vision of the ACA is to reduce the cost of corrosion.

The Australasian Corrosion Association Inc
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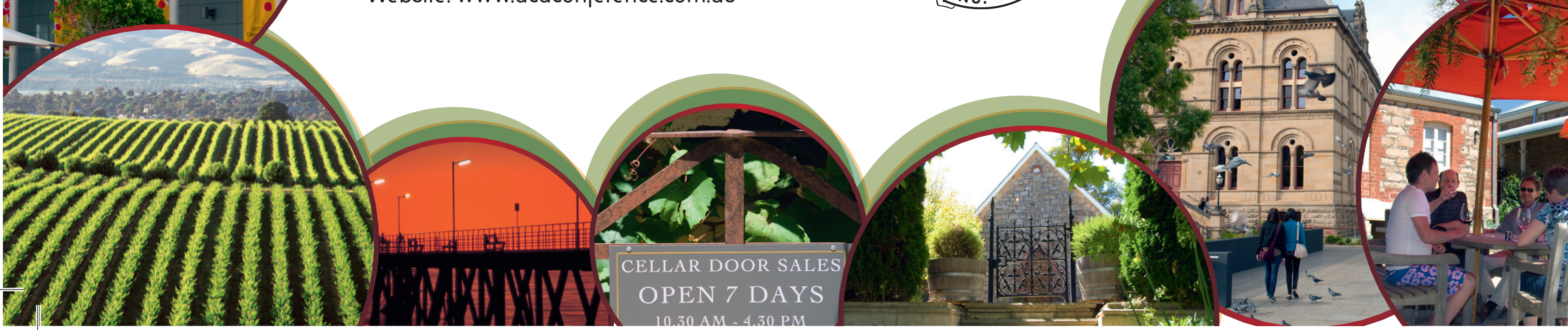

Protecting Infrastructure Against Corrosion

Durability Planning

14 May 2015 | Auckland

PROUDLY PRESENTED BY:

SPONSORS:

Overview

All structural materials will deteriorate over time, at different rates depending on the material used, the corrosivity of the environment and the deterioration mechanisms involved. Project design briefs typically require long design lives (50 to 100 years) of the assets, however, this is usually considered from a structural design point of view. Durability assessment, design and planning is an often misunderstood and/or underappreciated component of the design, which is important in minimising the risks of premature failure of structural materials, while maximizing its long-term performance over the design life of the structure.

During this event, the selection of the appropriate corrosion protection system, for the given environment, will be discussed. This includes different materials such as concrete, steel and other types of metals, plastics, and protective coatings. Durability design philosophy, the current provisions given in Clause B2 of the NZ Building Code, development of a maintenance plan, and case studies will also be discussed.

Venue

Crowne Plaza Auckland
128 Albert Street
Auckland, 1010, New Zealand

Contact

For further information on this event please contact Brendan Pejkovic on +61 (0)3 9890 4833 or bpejkovic@corrosion.com.au

Program

Time	Session	Speaker
8.30 – 8.55	Registration	
8:55 – 9:00	Welcome and Seminar Opening	
9.00 – 9.40	Durability and the NZ Building Code	Nick Marston, BRANZ
9.40 – 10.20	Durability Planning and Detailing for Optimum Material Performance	Raed El Sarraf, Opus International Consultants
10.20 – 10.50	Morning Tea	
10.50 – 11.30	Increasing the Longevity of Assets Through Risk Based Inspection and Coating Solutions	Kieran Nally, International Paint
11.30 – 12.10	Durability of Key Infrastructure – a Structural Engineer's Perspective	Stewart Hobbs, Proconsult
12.10 – 12.50	The Yanks Are Coming - Waikaraka Park Grandstand 72 Years On	Paul Ivory, Auckland Council
12.50 – 13.40	Lunch	
13.40 – 14.20	A Guide to AS/NZS2312.2 (2014) Hot Dip Galvanizing – What Is It & Why You Need To Tell Your Customers About It	Peter Golding, Galvanizing Association of New Zealand
14.20 – 15.00	Durability Planning: Optimising Materials Selection - a Strategic Asset Management Approach	Ian Martin & Miles Dacre, AECOM
15.00 – 15.30	Afternoon Tea	
15.30 – 16.10	Concrete Durability – A Practical Guide To Managing The Risks For NZ Infrastructure	Sue Freitag, Opus International Consultants
16.10 – 16.50	Ilico Apartments Case Study – Designing for Durability and Aesthetics using a Duplex Coating System	Duane Baguley, Perry Metal Protection
16.50 – 17.00	Seminar Close	
17.00 – 19.00	Cocktail Function & Exhibition	

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 cost of corrosion.

The ACA is a founder member of the World Corrosion Organization

Front Cover Photo:
Australia's first glow in the dark pedestrian pathway protective coating developed by Strini Industries 'Moon Deck' glow coating systems, Gosford NSW.
Images supplied by Strini Industries, courtesy of Transport NSW.

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The ACA celebrates 60 years in 2015.
A feature story will appear in the June
Issue of *Corrosion & Materials*.

Paul Vince
Chairman

Chairman's Message

G'day. Recently I attended the NACE Corrosion 2015 Conference in Dallas, USA. The ACA had a stand at the conference which promoted the ACA Conference in Adelaide in November. We also invited speakers from the US to submit abstracts for the technical sessions at our conference. The message was 'G'day, come on over to Australia and visit our conference in Adelaide.' The stand was a big success with over 250 delegates visiting the booth. Thanks to Jacquie Martin from the ACA Office for managing the stand. Many Australian members at the conference spread the message including Luke Thompson from Infracorr who was especially helpful. Thanks Luke. Folks from the US rate Australia highly as a tourist destination. I look forward to some of the delegates submitting abstracts and attending the conference.

The NACE Conference was also a good opportunity to meet with other international corrosion associations. The ACA met with delegates from NACE, SSPC, Institute of Corrosion (UK), European Federation of Corrosion (EFC), and World Corrosion Organization (WCO). Part of the ACA Strategic Plan involves expanding our training offerings to meet market needs and many of the discussions at the NACE conference revolved around training opportunities. I anticipate that the ACA will have some new courses for you before the end of this year. We recently ran the SSPC Concrete Coatings course for the first time in Melbourne and it was very successful.

Another meeting at the conference concerned the IMPACT Study. This study aims to look at corrosion practices around the world, identify best practice and develop tools for measuring effective management of corrosion. The study relies on input from surveys to be conducted in many countries over the next month. The ACA will be distributing surveys for Australian and New Zealand companies to complete. Please take the time to complete the survey and send it back. The results of the survey could make a big difference internationally. Locally, I hope to be able to use the results to make governments and large corporations aware of the impact of corrosion. At the same time it will be good to have examples of best practice in corrosion management so solutions can also be recommended.

The ACA Board met in February to discuss the strategic direction of the Association. The Board is continually looking at ways to improve the Association, its management and its service to members. There was some discussion about the changing economy in Australia and New Zealand. It was noted that investment in capital projects has decreased and many projects are transitioning to a maintenance phase. Addressing corrosion issues at any stage of a project is important. As such, the services of the ACA, and its members, remain highly relevant. The Board is working towards matching the training offerings with the industry needs and maintaining a broad base of services to meet member needs. At the same time we are looking at how to attract and keep new members.

Finally, if you have found the activities of the ACA to be valuable, tell a friend – it could help us all.

Yours Sincerely,

Paul Vince
ACA Chairman

ACA 2015 Events Calendar

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. 2015 will be no different, with the events listed below scheduled in our Calendar of Events.

Event Title	Event Date	Event Location
Durability Planning	14 May 2015	Auckland
Corrosion in the Oil & Gas Industries	21 May 2015	Melbourne
Concrete Corrosion	25 June 2015	Perth
APIA/ACA - Pipeline Corrosion Management	23 July 2015	Brisbane
Introduction to Corrosion	30 July 2015	Melbourne
Introduction to Corrosion	30 July 2015	Sydney
Protective Coatings	13 August 2015	Perth
Corrosion in the Oil & Gas Industries	27 August 2015	New Plymouth
Corrosion in the Power & Energy Industry	3 September 2015	Brisbane
Concrete Corrosion	17 September 2015	Sydney
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 (0)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

The ACA will soon be calling upon members and industry to participate in three different surveys. Participation in two of these surveys will allow members and industry to influence new training offerings and member services so as to better meet your needs. The third survey is targeted toward asset owners to participate in an International Measures of Prevention, Application, and Economics of Corrosion Technologies (IMPACT) study.

Training Needs
The ACA has a critical role to play in ensuring that there is sufficient corrosion and corrosion related training opportunities available in Australasia in order to ensure that there are well trained personnel within industry.

Via the ACA Education & Training Committee, the ACA is about to embark upon an investigation into the training needs of the corrosion mitigation industry in Australasia with the aim to provide further training and education services to meet those needs. This is a key action item of the current strategic plan.

Members and industry will be provided the opportunity via a survey to comment on how the current suite of ACA courses meet their needs, what they expect their training needs will be in the near future and if they see any gaps in the market where they would appreciate ACA offering training.

Member Services/Member Satisfaction
It is important that ACA meets the expectations of its members. Each member will receive an invitation to participate in our membership survey mid-year. I encourage you to complete the survey as it will provide valuable feedback to us to ensure we continue to evolve, respond to member needs and assist in planning future ACA strategies and activities.

IMPACT Study
The ACA is also currently contacting member asset owners to contribute data to the IMPACT Study. This study aims to determine the financial and societal impacts of corrosion on industry sectors including utilities, transportation, energy and infrastructure whilst looking at the effects of corrosion as related to: public safety, environmental impact, management planning and planning.

The study is being led by NACE International with participation from industry partners from over 15 countries worldwide.

The goal of ACA's involvement is to support the study by providing data for financial benchmarking, economic models, and best corrosion management practices, as well as any case histories demonstrating best-in-class corrosion management approaches in Australasia.

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

Melbourne April 28 – 29

Adelaide August 20 – 21

Perth September 1 – 2

ACA Coating Inspection Refresher

Member $605 Non-member $740

Adelaide November 14

New Zealand December 4

Cathodic Protection Monitoring

Member $1485 Non-member $1810

New Zealand April 29 – May 1

Sydney August 3 – 5

Adelaide August 31 – September 2

Perth October 5 – 7

Melbourne October 26 – 28

Cathodic Protection Advanced

Member $2220 Non-member $2600

Melbourne May 25 – 29

Perth November 30 – December 4

Coating Selection and Specification

Member $1485 Non-member $1810

Perth August 10 – 12

Corrosion and CP of Concrete Structures

Member $1060 Non-member $1330

Sydney June 10 – 11

Corrosion Technology Certificate

(Also offered as Home Study)

Member $2220 Non-member $2600

Brisbane May 18 – 22

New Zealand June 22 – 26

Melbourne September 21 – 25

Sydney November 23 – 27

Home Study

Member $2220 Non-member $2600

Start any time

NACE CIP Level 1

Member $3740 Non-member $4275

Melbourne May 4 – 9

Sydney June 15 – 20

Auckland July 6 – 11

Brisbane July 20 – 25

Perth August 17 – 22

Sydney September 7 – 12

Melbourne October 12 – 17

Adelaide November 2 – 7

All prices are in $AUD.
All courses listed include GST.
For NZ courses deduct 10%

NACE CIP Level 2

Member $3740 Non-member $4275

Melbourne May 11 – 16

Sydney June 22 – 27

Auckland July 13 – 18

Brisbane July 27 – August 1

Perth August 24 – 29

Melbourne October 19 – 24

Adelaide November 9 – 14

NACE CIP Level 3 Peer Review

Member $1470 Non-member $1725

Adelaide November 9 – 13

Protective Coatings Quality Control

Member $1485 Non-member $1810

Sydney July 1 – 3

Perth September 14 – 16

Metallurgy of Steels Introduction

Member $1485 Non-member $1810

Sydney July 22 – 24

CORROSION & PREVENTION 2015

Adelaide, South Australia
15–18 November 2015

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The Corrosion & Prevention 2015 Technical Committee in conjunction with a number of ACA members are delighted to announce the following distinguished Plenary Lecturers for this year's conference in Adelaide.

Plenary Lecturers

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

Rob Francis is a metallurgist and a corrosion and coatings specialist. He has over 40 years' experience in metals, materials and corrosion, especially regarding protective coatings. He is a regular presenter of a number of Australasian Corrosion Association and NACE training courses. Dr. Francis obtained a B.Sc. in metallurgy from the University of Melbourne and has a Ph.D. in corrosion science from the Corrosion and Protection Centre at the University of Manchester, UK. He is an ACA Corrosion Technologist and Coating Inspector, a NACE Certified Coating Inspector and is Chairman of MT14/2, which has developed AS/NZS 2312 on the selection and application of protective coatings. He is also Chairman of Committee MT 14/5 which produced AS 4312 on atmospheric corrosivity zones in Australia. He edited the recently-released revision of the ACA publication "Inorganic Zinc Coatings – History, Chemistry, Properties, Applications and Alternatives". He has been awarded the JPCL editor's award twice and was made a JPCL Top Thinker in 2012. He was awarded the ACA Victor Nightingall Award in 2014.

Markus Büchler
Swiss Society for Corrosion Protection, Switzerland

Markus Büchler is the Chief Executive Officer (CEO) of the Swiss Society for Corrosion Protection (SGK), Technoparkstr, Zürich, Switzerland. After joining SGK in 2000 as head of research and development, he took the position of CEO in 2006. His field investigations and research have contributed to the understanding of corrosion of buried structures. He has a M.S. Degree in Materials Science (Dipl. Werkstoffing (ETH), April 1994) and a Ph.D. in Technical Sciences (January 1998) from the Swiss Federal Institute of Technology (ETH), Zürich, Switzerland.

Miles Buckhurst
Jotun, Norway

Miles Buckhurst is a Global Concept Director at Jotun looking after Hydrocarbon Processing Industry. Miles has 26 years of experience within the industry starting life as a Polymer and Paint Chemist, further working in various technical roles before taking on coatings supplied in the HPI business area.

Frank Collins
Monash University, Australia

Associate Professor Frank Collins is currently Head of the Structures Group, Department of Civil Engineering at Monash University. His career has been different to most academics, including 19 years as a Chartered Professional Engineer. His grounding in durability of construction materials began when working with Harold Roper at the University of Sydney in the early-1980's. This led to 13 years work with Taywood Engineering in their London, Hong Kong, Sydney and Melbourne offices; involved with diagnosis and rehabilitation of infrastructure and applications of construction materials. In 1988, Frank was Lead Materials Engineer in the Sydney Opera House rehabilitation programme which entailed diagnosis of the roof shell elements and substructure, and development of remedial and preventative maintenance works. In 1995, Frank established the Bridge Testing and Rehabilitation Unit within the Ministry of Transport, Vietnam, allowing the Ministry to become self-sufficient in the management of bridge assets. During 1997-99, Frank undertook his PhD research at Monash, developing alkali-activated cements as an alternative to conventional Portland cements – it was the forerunner to what is now termed the "geopolymer". He then joined AECOM (Maunsell) and over 7 years as technical director he established and managed AECOM's Advanced Materials Group, including technical and commercial leadership, and providing high-level advice on many international infrastructure projects. Since 2007 he has been based at Monash and maintains a keen research interest in the areas of durability and ageing of infrastructure; utilisation of wastes as alternative construction materials; and improved construction materials for durable and stronger infrastructure.

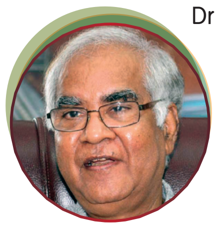
Srdjan Nesic
Institute for Corrosion and Multiphase Technology,
Ohio University, USA

Dr. Srdjan Nesic joined Ohio University in 2001 as a Professor and the Director of the Institute for Corrosion and Multiphase Technology. He has previously served as a research scientist at the Institute for Energy Technology in Kjeller, Norway and at the Vincha Institute for Nuclear Sciences, Belgrade, Yugoslavia. In addition, he has served on the faculties of the University of Oslo, Norway, and of the University of Queensland in Brisbane, Australia.

Dr. Nesic's research interests reside at the intersection of transport phenomena and electrochemistry. Specific directions lead to research projects in corrosion, erosion, computational fluid dynamics and multiphase flow.

In 2008, Dr. Nesic was appointed a Fellow of NACE, 2011 was appointed as Russ Professor of Chemical and Biomolecular Engineering at Ohio University and in 2012 was appointed as member of National Academy of Sciences (NAS) committee investigating pipeline transportation of diluted bitumen. Dr. Nesic has written and presented over 200 conference papers (locally and internationally), written over 100 peer reviewed papers published in leading international journals as well as published many other scientific reports, paper citations and book articles.

Baldev Raj
National Institute of Advanced Studies, Bangalore, India

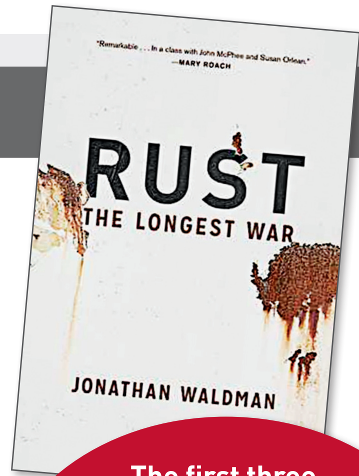


Dr Baldev Raj is the Director of the National Institute of Advanced Studies, Bangalore, an eminent multi-disciplinary institution of India. He is a distinguished scientist and Former Director of the Indira Gandhi Centre for Atomic Research in Kalapakkam. His work on corrosion relates to austenitic and ferritic steels. He has made pioneering contributions to super hydrophobic surfaces, biodegradation, and non-destructive evolution to mitigate corrosion. His work to understand corrosion mechanisms of archaeological objects, such as ancient bronze Icons, Delhi Iron Pillar, etc. is much acclaimed. He has advanced holistic corrosion management for strategic and infrastructure industries through policies, solutions and human resources development. His unique contributions relate to synergy of NDE with corrosion management. He was awarded three Lifetime Achievement Awards by National Association of Corrosion Engineers (NACE), India; Indian Society of NDT and Indian Nuclear Society. He is author of more than 970 academic papers in peer reviewed journals along with 75 books and special journal volumes; He has an h-index of 42; i10 of 278; substantial and arguably unparallel achievement considering his contributions to realise technologies and large mission programmes. He is distinguished Alumni of Indian Institute of Science, Bangalore. Dr Baldev Raj is a Fellow of all the four Science and Engineering Academies in India, German Academy of Sciences, The World Academy of Sciences, International Nuclear Science Academy, Academia NDT International, Honorary Member, Indian Institute of Metals and Indian Society of NDT and Distinguished Materials Scientist Awardee of Materials Research Society of India.

For more information, please go to www.acaconference.com.au

Rust The Longest War

By Jonathan Waldman



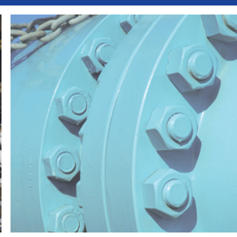
It has been called "the great destroyer" and "the evil." The Pentagon refers to it as "the pervasive menace." It destroys cars, fells bridges, sinks ships, sparks house fires, and nearly brought down the Statue of Liberty. Rust costs America more than $400 billion per year—more than all other natural disasters combined.

In a thrilling drama of man versus nature, journalist Jonathan Waldman travels from Key West, Florida, to Prudhoe Bay, Alaska, to meet the colorful and often reclusive people who are fighting our mightiest and unlikeliest enemy. He sneaks into an abandoned steelworks with a brave artist, and then he nearly gets kicked out of Ball Corporation's Can School. Across the Arctic, he follows a massive high-tech robot that hunts for rust in the Alaska pipeline. On a Florida film set he meets the Defense Department's rust ambassador, who reveals that the navy's number one foe isn't a foreign country but oxidation itself. At Home Depot's mother ship in Atlanta, he hunts unsuccessfully for rust products with the store's rust-products buyer—and then tracks down some snake-oil salesmen whose potions are not for sale at the Rust Store. Along the way, Waldman encounters flying pigs, Trekkies, decapitations, exploding Coke cans, rust boogers, and nerdy superheroes.

"Jonathan Waldman's first book, 'Rust' sounds like a building code violation. But don't let that fool you. This look at corrosion — its causes, its consequences and especially the people devoted to combating it — is wide-ranging and consistently engrossing. Mr. Waldman makes rust shine" Quote from Gregory Cowles in the New York Times.

The first three members to write a brief testimonial about an ACA event or course will win a copy of this book. Please email this to sbrave@corrosion.com.au

The result is a fresh and often funny account of an overlooked engineering endeavor that is as compelling as it is grand, illuminating a hidden phenomenon that shapes the modern world. Rust affects everything from the design of our currency to the composition of our tap water, and it will determine the legacy we leave on this planet. This exploration of corrosion, and the incredible lengths we go to fight it, is narrative nonfiction at its very best—a fascinating and important subject, delivered with energy and wit.



Upskilling Our Workforce

In 2013, the National Centre for Vocation Education Research (NCVER) conducted their biennial survey on workforce skills and training, and the results showed that employer satisfaction with training decreased between 2011 and 2013.

To address this problem, the federal government is assisting local businesses by providing access to a $476 million targeted training fund that will help boost productivity and competitiveness across the economy.

Applications are now open for the new $476 million Industry Skills Fund, which will offer up to 200,000 targeted training places and support.

This fund is targeted at small and medium sized businesses that need to upskill or retrain their workers so their business can diversify or take advantage of new market opportunities.

The fund includes a free service for eligible small businesses, to help them identify the skills they need to support growth and potential training solutions.

The Industry Skills Fund is a key element in the Australian Government's Industry Innovation and Competitiveness Agenda.

Further information about the Industry Skills Fund visit: www.business.gov.au. Applications will be accepted on an ongoing basis, throughout 2015.

QUT researcher takes out aviation award

Vanessa Lussini. Photo: Erika Fish

A Queensland researcher has taken home a huge gong at the Australian International Airshow and Aerospace and Defence Exposition in Victoria with a compound that detects potentially catastrophic paint deterioration.

Vanessa Lussini, from Queensland University of Technology's School of Chemistry, Physics and Mechanical Engineering, won the $10,000 young innovator scholarship on Tuesday at the annual Avalon show.

Ms Lussini took out the award for her use of organic compounds to develop sensors that alerted maintenance crews of issues that required repainting.

Without that repainting, mechanical strain, direct sunlight, varying temperatures, water, salt and other pressures cause dangerous corrosion which could result in potentially catastrophic failure.

"Corrosion is like a cancer to metal and paint acts like a sunscreen which needs to be re-applied before the structural integrity of an aircraft is compromised," she said.

"It's critical to know when to repaint an aircraft but we can also paint them too often simply because they are scheduled to be done and every new coat adds weight.

"Often only certain sections need to be painted because they are more exposed and degrade faster. Or one plane is used every day and another sits in a hangar for long periods.

"Free radical oxidative degradation is the main route to coating failure and my project aims to create new, more resilient sensors to detect deterioration."

That was done, Ms Lussini said, by using a group of compounds called profluorescent nitroxides that monitored the chemical character of the protective outer coating of an aircraft through a fluorescent emission.

"Longer lasting sensors that can cope with harsh environmental conditions will make it easier to monitor and maintain aircraft coatings," she said.

"The reapplication of these coatings is costly so utilising condition-based monitoring over basic periodic maintenance can maximise the potential lifetime of the product, optimise maintenance schedules and reduce costs."

Ms Lussini said her research could also be applied to other structures, such as bridges.

ACA Welcomes New Members

Corporate Silver

Waterway Constructions
www.waterway.com.au

Waterway Constructions is a specialist maritime contractor with the capacity to undertake construction, maintenance and refurbishment of maritime structures throughout Australia. Our experienced team of engineers and construction staff is committed to working with clients to optimise project outcomes. Established in 1993, Waterway Constructions has grown to become one of the largest specialist maritime contractors in Australia.

Corporate Bronze

Hychem International Pty Ltd
www.hychem.com.au

For nearly 30 years, Hychem international has been formulating and manufacturing polymer systems for the protection of concrete and steel. Their range offers Australian manufactured flooring solutions, epoxy grouts, marine pile encapsulation, and ultra-high build spray applied coatings for the water/chemical industry. Their expertise in design and innovation is backed up by technical staff available in each state. They have completed projects in a huge diverse market incorporating industrial, commercial, utilities/mining and residential.

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.

New Individual & Student Members

First Name	Surname	Company	Branch
Matthew	Aitken		Queensland
Rares	Badrea	Cooler Clean	New South Wales
Elliot	Baker	PFP Systems	Queensland
Justin	Beckwith		New South Wales
Thomas	Bettison	University of Adelaide	South Australia
Ross	Bezant	CAPE Australia	Western Australia
Arnold	Bouwer		Western Australia
Brian	Casson	Applus RTD	Western Australia
Vaughan	Chaffey	Ravensdown Fertiliser	New Zealand
Frank	Collins	Monash University	Victoria
Martin	Connolly	Murphy Pipe and Civil	Newcastle
Les	Connors	Project Painting Services (WA) Pty Ltd	Western Australia
Leisa	Cull	Queensland Sandblasting & Painting	Queensland
Mitch	Davey		Western Australia
Christopher	Evans	Outlaw Coatings and Conveyors	South Australia
Derek	Fagan		Queensland
Ross	Henderson		Queensland
Mark	James	UT Group Pty Ltd	Victoria
Phillip	Jans		New Zealand
Patrick	Jean	G.C.C.	New South Wales
Amr	Kholosy	ATCO Gas Australia	Western Australia
Marin	Leusink	Leusink Solutions	New Zealand

First Name	Surname	Company	Branch
Andrew	Lyle	McConnell Dowell	Western Australia
Gregory	Machen	WISE Consolidated	Victoria
Keith	Mather		Queensland
Colin	McCabe	CASMAC Pty Ltd	Queensland
Peter	Mcgregor	Vertech	New South Wales
Mark	Miller	MDM Consulting	Queensland
Reg	Neil	Electrical Safety Office	Queensland
Glen	Nolan		Australasia
Carl	Porritt	Electrical Safety Office	Queensland
Thomas	Prest	Cape PLC	Queensland
Dongzhu	Qi	WorleyParsons	Western Australia
Hooman	Shokoohi	Henkel Australia Pty Ltd	Victoria
Sindhunata	Sindhunata		Western Australia
See Leng	Tay	The University of Auckland	New Zealand
Mark	Thomson	ProjectMax	New Zealand
Leigh	Unsworth	Asset Rehabilitation Services Pty Ltd	Victoria
Todd	Velvin	Velvin Solutions Ltd	New Zealand
Peter	Walker	Pilbara Insulation	New South Wales
Adam	Walsh	Inline Systems Pty Ltd	New South Wales
Xiang	Wang	University of Newcastle	Newcastle
Pun	Wellappuli	Bechtel Australia	Western Australia

Introductory Corrosion Seminar

Protective Coatings & Cathodic Protection

Proudly presented by:

Sponsored by:

Thursday 30th July 2015

Melbourne - Hotel Mercure
13 Spring Street,
Melbourne VIC

Sydney - Engineers Australia
Sydney Division, 8 Thomas St
Chatswood NSW

Presenters:

Melbourne: Robert Francis, David Reilly & Wayne Burns

Sydney: Fred Salome, Alex Spillett & Allan Sterling

Overview of Program:

The ACA is holding this one day seminar to investigate the basic concepts of both protective coatings and cathodic protection. This seminar is aimed at people starting off in the corrosion industry or those wanting a refresher.

9:00am – 12:30pm

Protective Coatings (includes 30 min morning tea)

This session provides an introduction to basic concepts of protective coatings; including the various types of coatings, the inspection requirements and considerations when selecting such products.

This session is designed for those working outside the corrosion or protective coatings industry, such as engineers and architects, but would be suitable for anyone requiring a brief introduction to the subject. Attendees will have the opportunity to raise questions and discuss issues and experiences.

Highlights:

- Types of Coatings
- Coating Inspection
- Coating Maintenance
- Coating Selection

12:30pm – 1:30pm

LUNCH

1:30pm – 2:00pm

Introduction to Galvanizing

See how hot dip galvanizing is applied and learn about the benefits of this trusted, proven performer. Illustrated with everyday examples, this session will provide attendees with an overview of the galvanizing process as well as an awareness of situations where galvanizing can be used.

2:00pm – 5:30pm

Cathodic Protection (includes 30 min afternoon tea)

This session will cover the basic corrosion theory and the principles and monitoring methods used in cathodic protection followed by a demonstration of cathodic protection.

The session will enable participants to develop an awareness of the importance of cathodic protection to the maintenance and management of assets and an understanding of the basic principles of corrosion and cathodic protection.

Highlights:

- Cathodic Protection
- Measurement Equipment
- Field Measurement Techniques
- Cathodic Protection Demonstration

Registration: $150 (Including GST).
Please register online via the website at www.corrosion.com.au
Registration includes, arrival tea & coffee, morning/afternoon tea and lunch.
Handouts from the Seminar will be available in a hard copy booklet.

For further information about this seminar please contact Brendan Pejkovic on +61 3 9890 4833 or via email at bpejkovic@corrosion.com.au

ACA Auckland Division

February 2015 Meeting Report

The first meeting of the Auckland Division for 2015 was held on 12th February at The Landing hotel, Onehunga. The speaker was Aaron Davey, Manager of Marine and Civil Solutions, who gave a presentation on his recent diving adventure at the Chuuk Lagoon in Micronesia. In September 2014 Aaron was in a party that dived on 17 World War II Japanese ship wrecks lying in 60 metres of tropical water in the lagoon. About 60 ships laden with war materials including planes, artillery, ammunition, tanks, trucks and medical supplies for the Japanese war effort in the South Pacific, were bombed and sunk by US aircraft during Operation Hailstorm in February 1944. The ghost fleet of Chuuk Lagoon is considered to be the World's biggest ship graveyard and the remote lagoon is one of the best diving destinations in the world.

Aaron's presentation showed underwater images of many fascinating objects on the wrecks after 70 years immersion in tropical water (30 °C) with sunlight penetrating the lagoon waters to a considerable depth. He described the condition of steel and iron structures many of which were badly corroded and covered with thick organic growth. However, other materials like ceramics including hand basins, toilets, bricks, glass bottles, and rubber truck tyres were still in good condition. Even paper books had survived years of seawater exposure, but wooden objects had been ruined by sea worms. Aluminium components of aircraft had survived quite well, whereas brass shell cases and ammunition cartridges had undergone severe corrosion. The paint present on some metal structures was still in fair condition.

Aaron noted that marine corrosion of materials is a dynamic process with many variables at work, including organic growth on metal structures, warm tropical sea water, and oxygen levels in the water. After a Q&A session, Chairman Raed El Sarraf thanked Aaron for his interesting and well- illustrated presentation.

The ACA Auckland Division AGM was then held and the following members were elected to the Auckland Committee for 2015: Raed El Sarraf (Chair), John Duncan, Les Boulton, Aaron Davey, Grant Chamberlain, Bruce Fordyce, Sean Ryder, and two new members Ash Arya and Jeffrey Robinson.

Aaron Davey presenting on Chuuk Lagoon.

Testimonial from Muhammad Wasim

I am a PhD research student at RMIT University Melbourne Australia. I am working on corrosion studies of buried ferrous metal pipes for my PhD. Previously, I have worked overseas as a research engineer in a research centre and on various projects related to corrosion of reinforced concrete structures. I have some publications related to corrosion of reinforced concrete in reputable journals, including a US patent (US8745957 B2) and WO patent (WO2013154604A1) on Macro-Cell Corrosion Prevention Technique in Repaired Concrete. In addition to these publications, I have received several awards including a silver medal in 2012 with Dr. Raja Rizwan from Malaysia, and a gold medal in Geneva, Switzerland International Invention Exhibition in 2013.

In Feb 2015, I received a very competitive Graduate Student Award from NACE International. NACE International gave me a scholarship and travel grant to attend the award ceremony in Dallas, Texas on March 17 this year. As a PhD student getting an Award from a top corrosion organization is a huge achievement. My goal is to develop and establish myself in the field of corrosion science and engineering.

I am very thankful to ACA for their recognition of my NACE Graduate Student Award achievement. Such timely appreciation is a source of motivation for students like me and only encourages me to work harder for a better understanding of corrosion related problems.

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.

The ACA has completed in-house training for the likes of the following companies:

Anode Engineering — Positive–Product–Solutions
Comdain Infrastructure
Freyssinet

In-house Courses offered:

- Introduction to Corrosion
- Corrosion Technology
- Introduction to Protective Coatings
- Protective Coatings Quality Control
- Coatings Selection and Specification
- NACE CIP Levels 1, 2 & 3
- Introduction to Cathodic Protection
- Cathodic Protection Monitoring
- Cathodic Protection Advanced
- ACA/ACRA Corrosion & Protection of Reinforced Concrete
- Corrosion and CP of Concrete Structures

Requirements:

- Hosts to provide a room large enough to accommodate seating and tables for students and instructors. Certain courses may require an additional room for examinations on the last day of training
- Audio Visual equipment
- Meet a required minimum of 8 students or 12 students for NACE courses
- Courses must be paid for in full prior to the training.

Questions and for more information:

Please contact: Skye Russell on +61 3 9890 7866 or srussell@corrosion.com.au

ACA Christchurch Division

February 2015
Technical Event Report

The first ACA technical event in Christchurch for 2015 was held on 12th February Canterbury University. The speaker was Professor Milo Kral, Head of Mechanical Engineering at the university and he presented on fundamentals in corrosion, covering the reasons for corrosion, reactivity of metals in different environments, rate of corrosion, different forms of corrosion and ways to suppress corrosion.

Milo shared a number of very interesting case studies, which stimulated interesting discussions, especially the failure analysis of corrosion in stainless steel reinforcement in the Hunter Building at Victoria University in Wellington. The introductory slide to the case showed images of severe corrosion marks on the exterior surfaces of Oamaru stone where the stainless steel rods were present. What could possibly be causing the corrosion of stainless steel rods, embedded in Oamaru stone?

Through a process of elimination, physical inspection of core samples, interpretation of the Galvanic Series and a series of laboratory tests, Milo and his team were able to identify the galvanic reaction between the stainless steel and graphite, in which the stainless steel was the sacrificial anode and graphite the cathode, as the root cause of the failure. The presence of the graphite as a backing to the stone was only detected by viewing a core sample removed from a failure area. The capillary action of the stone introduced rain water as the electrolyte to the galvanic reaction. This case history emphasized the importance of design considerations in protecting assets from corrosion.

Milo in his case reviews also discussed corrosion failure of a meat freezer, tea stains on stainless steel, dezincification of shower fittings, crevice and pitting corrosion of 316 stainless steel in seawater, erosion corrosion in aluminium alloys, intergranular corrosion in aluminium alloys and different forms of stress corrosion cracking. The presentation concluded with a discussion on the prevention of each of the corrosion types as introduced during the presentation.

The event was sponsored by Concreteconnect, who treated the attendees to an array of afternoon tea treats and refreshments. Carl Wright (Industrial Coatings Manager) and Lionel Mason (Operations Manager) provided a brief introduction to their organisation, their focus on Quality Assurance in coating applications and specialist surface preparation abilities in Ultra High Pressure Water blasting. Carl invited the attendees to visit their website at www.concreteconnect.co.nz to view their range of services and different business units.

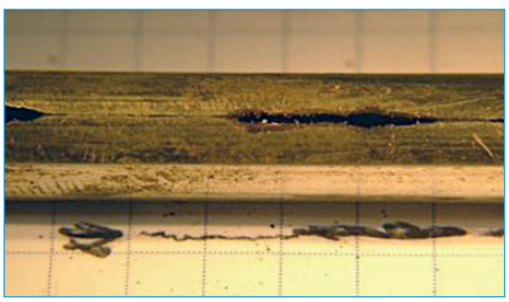
The event was concluded at 18:00 at which point René Hill thanked Professor Milo Kral for his interesting and thought provoking presentation, Canterbury University for providing a lecture room for the event and Carl and Lionel from Concreteconnect for the sponsorship.

Graeme Wells introduced the next technical event, Corrosion Protection in Fishing Vessels, held at Stark Bros in Lyttleton on 12 March 2015. Cameron Stark shared practical experiences and the event also included a site visit.

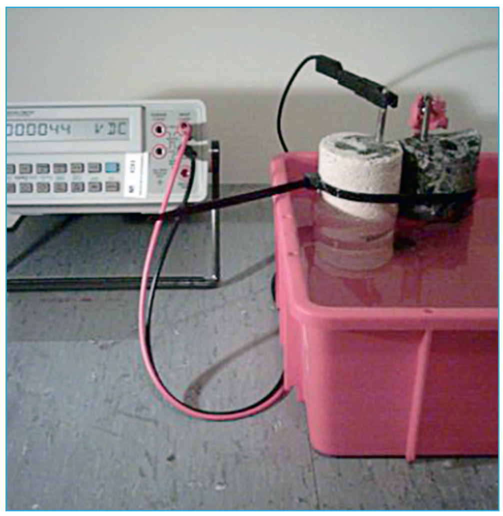
Hunter's Building Case study photographs *(Photographs from Milo's presentation)*

Corrosion stains of Oamaru Stone at the Hunters Building, Victoria University.

Core sample, showing presence of Graphite.



Stainless Steel rod, removed from core sample.



Laboratory simulation test (Graphite, masonry and steel rod) – Water level below stainless steel rod in stone sample. Capillary action was enough to keep masonry wet. After 8 hrs the current stabilized at 40 – 50 mA.

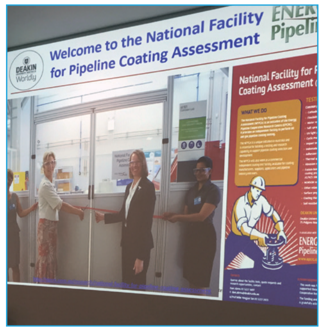
Victorian Branch Site Visit

National Facility for Pipeline Coating Assessment Energy Pipeline CRC at Deakin University, 18 February

Speaker 1 Mike Tan - Deakin Uni introducing the Pipeline Coating Facility capabilities.

Speaker 2 Davi Abreu.

Audience Front Row: John Rea - Inductabend, Peter Wade City - West Water, Dylan O'Keefe – City West Water, Nick Le – APA.



The lady on the Powerpoint is Valerie Linton, CEO, Energy Pipelines, Co-Operative Research Centre.

Group photos on site.

SA Branch AGM

26 February

Group photo showing the dinner cruise.

Neville Phillis receiving longevity certificate from President, Alex Shepherd.

Erwin Gamboa and Thomas Bettison (Reg Casling Award recipient).

Flinders Ports staff.

YCG-ers.

Adflex staff.

Queensland Branch Site Visit

Pipeline Cathodic Protection Demonstration, 15 February

Allan Sterling showing Josh Logan how to measure earthing potentials.

Nick Doblo explaining to the attendees how APA Group manages their pipeline integrity whilst Allan Sterling prepares for measuring earthing potentials.

Nick Doblo explaining what potentials are used to protect a pipeline through a Transformer Rectifier.

Nick Doblo taking the attentive crowd through the functions of a Transformer Rectifier unit.

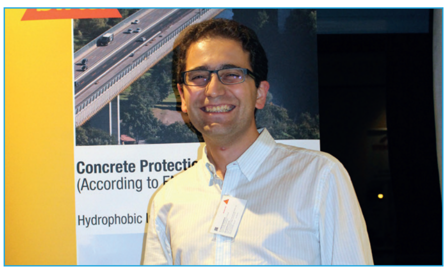
NSW Branch AGM, Mini Trade Show & Dinner

15 March

AGM dinner.

CCE - Pablo Juarez & Boris Krizman.

Jianqiang Zhang - outgoing President.



Mini Trade Show - Sika - Pedram Mojarrad.

Mini Trade Show networking.

Owen Harvey, Mohammad Ali, Jianqiang Zhang, Jim Galanos & Peter Kalis.

NEW PRODUCT SHOWCASE

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

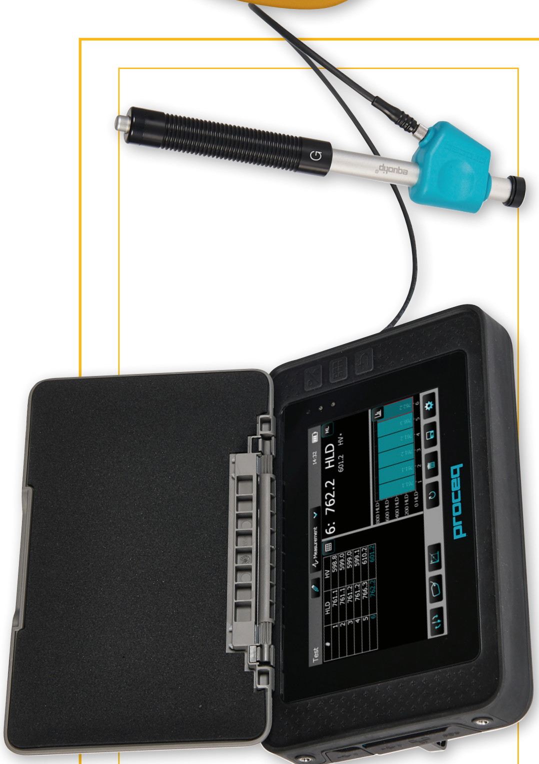
New RFG-1000 Ultrasonic Thickness Gauge

Russell Fraser Sales, Sydney has released the new RFG-1000 Ultrasonic Thickness Gauge at the rock-bottom price of $295 + GST. This inexpensive entry-level thickness gauge is packed with features including a large backlit LCD display, auto linear compensation and sound velocity measurement. The full kit includes an aluminium carry case with foam insert, stainless steel calibration block and 10mm 5MHZ transducer with couplant, all for $295 + GST.

This is a one-off stock item which will serve basic thickness gauging applications very well, so hurry, call Russell Fraser Sales on Tel: (02) 9545 4433 and get yours today.

Contact:
Russell Fraser Sales Pty Ltd

T: +612 9545 4433
F: +612 9545 4218
E: rfs@rfsales.com.au
Web: www.rfsales.com.au



Equotip 550 Portable Hardness Tester

Proceq has released their most versatile portable hardness tester in 60 years. Proceq's Equotip became the industry standard in portable hardness testing when it was introduced in 1975. Still proudly SWISS-MADE, Proceq's new Equotip 550 is a complete all-in-one hardness testing solution which combines Leeb with portable Rockwell methods.

The Equotip 550 excels with its latest generation full color, dual processor Touchscreen Unit packed with features. The instrument also features enhanced software with interactive wizards, automatic verification processes, personalized options, custom report functions and much more.

With a combination of Leeb and portable Rockwell methods, the Equotip 550 is ideal for a broad range of applications including but not limited to Oil & Gas, Automotive, Aerospace and Steel Working. The Equotip 550 is designed for rugged environments and is rated IP54 with special protection for hardware connections (probe connector, USB Host, USB Device and Ethernet).

The popular Equotip 3 portable hardness tester has been superseded by the new feature-packed Equotip 550. The Equotip 550 offers superior performance, increased efficiency and enhanced quality assurance. The new Equotip 550 is available from Proceq's Australian distributor Russell Fraser Sales. Contact:
Russell Fraser Sales Pty Ltd

T: +612 9545 4433
F: +612 9545 4218
E: rfs@rfsales.com.au
Web: www.rfsales.com.au

NEW PRODUCT SHOWCASE

JIREH Manual Pit Inspection Tool

Russell Fraser Sales, Sydney is now stocking the JIREH Pit Gage for measuring surface variations. The JIREH Pit Gauge is well-known for its accuracy, ease of use and modular design, making it the go-to tool for manual pit inspections. Russell Fraser Sales has stock of the JIREH Pit Gauge with 4 extension arms for maximum flexibility.

The JIREH Pit Gauge kit is of high build quality and includes 0″ – 0.5″ digital indicator; 3″ base; Blind side base (indicator can be transferred from 3″ base); 4 x 6″ extension arms; Extra contact point and a rugged plastic carrying case.

Contact:
Russell Fraser Sales Pty Ltd

T: +612 9545 4433
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E: rfs@rfsales.com.au
Web: www.rfsales.com.au

The hand-held RollerFORM probe.

The iPLEX RX videoscope.

The Nortec 600.

Olympus industrial instrumentation at AOG 2015

One of several devices demonstrated by Olympus at the 2015 Australasian Oil and Gas Exhibition and Conference (AOG) in Perth last month was the new Nortec 600 high-performance eddy current flaw detector. Part of the extensive range of Inspection and Measurement Systems from Olympus, the Nortec 600 is a compact, durable unit, that is ideal for markets such as industrial quality assurance in construction, oil and gas production and exploration. The rugged housing of the device makes it ideal for use in a wide range of harsh operating environments.

At AOG, maintenance and quality assurance professionals were able to learn more about the industry and applications of Non Destructive Testing (NDT), Remote Visual Inspection (RVI) and Handheld XRF from the experienced Olympus staff attending. NDT is any analysis technique used to evaluate the properties of materials or components without causing damage nor permanently alter the article being inspected. NDT can save both money and time in product evaluation, troubleshooting and research.

Colm Kinsella, Industrial Sales Specialist with Olympus, stated "The range of analysis, testing and imaging instrumentation featured this year illustrates our commitment to the development of new technologies, products and services."

In addition to the eddy current flaw detectors, Olympus also showed how phased array analysis simplifies the inspection of composites in addition to corrosion in pipes and vessels and that the latest portable, compact videoscope designs provide rugged durability for operation in harsh environments.

Olympus is a leading international company specialising in optics, electronics and precision engineering and continues its commitment to actively pursue the development of new technologies, products, and services that meet customer needs.

For further information, please contact:

www.olympus-ims.com

Victoria
Dorthe Svarrer, Sales & Marketing Coordinator
Industrial Business Division
Telephone: (03) 9265 5467
E-Mail:IBDinfo@olympus.com.au

Coatings Inspection Certificate

Up until 2005 The Australasian Corrosion Association Inc conducted a 5 day Coatings Inspection Certificate Course. It was designed to provide the requisite skills and knowledge to inspect protective coatings following the requirements of Australian/New Zealand Standards.

The list below contains the names of qualified ACA Coatings Inspectors who have satisfied the requirements to be issued with an ACA Coatings Inspection Certificate and who have 'refreshed' their certificate within the 5 year time frame required by the ACA Council. Some inspectors have cross – accredited to the internationally recognised NACE Coatings Inspection Program. In those cases, the validity of their ACA certification has been reconfirmed.

Every care has been take to ensure that at the time of publishing the information is correct. The Australasian Corrosion Association Inc does not accept any responsibility for any consequences which may arise from the use of this information. Those wanting to engage a Coatings Inspector should rely on their own judgement and if necessary seek other advice as to whether the person has suitable work experience and references for the type of work proposed.

No legal liability for negligence or otherwise can be accepted by The Australasian Corrosion Association Inc for the information or the use of the information contained in this listing.

If you have any queries please contact The Australasian Corrosion Association Incorporated directly on +61(0)3 9890-4833 or via email to aca@corrosion.com.au.

Please note: this list is current as at 13 March 2015.

ACA Coating Inspectors

Name	Cert. No.	Expiry Date
Richard Adams	1230	19/04/2015
Derek Allen	3870	31/12/2020
Kamran Armin	4232	28/02/2016
Peter Atkinson	3234	31/07/2015
Trevor Baensch	2211	12/08/2015
Travis Baensch	4209	12/08/2015
Stuart Bayliss	247	31/12/2018
Ben Biddle	1279	28/02/2015
Mark Blacklock	3501	2/07/2015
Michael Boardman	1051	31/12/2017
Jason Bourke	2597	31/12/2019
Matthew Boyle	1429	30/04/2016
Kingsley Brown	2603	31/10/2015
Sean Anthony Burke	3428	31/12/2018
Harold Burkett	361	28/02/2017
Elliot Burns	972	19/04/2015
Micah Butt	2397	31/10/2016
Luis Carro	2212	31/12/2017
Rod Cockle	1410	31/12/2020
John Cooke	3235	31/12/2018
Cameron Cooper	466	6/07/2016
Dean Crase	4137	6/07/2016
Michael Crowley	4197	31/12/2017
David Daly	7343	31/12/2016
Cheryl Dalzell	3940	19/04/2015
Robert de Graaf	719	31/12/2017
Phill Dravitski	1593	31/03/2015
William Dunn	3386	31/12/2018
Ken Dunn	1296	6/07/2016
Steve Dyer	3879	31/12/2020
Dave Elder	155	30/11/2015
Todd Elkin	3402	19/04/2015
John Elomar	4204	19/04/2015
Tony Emery	4130	2/07/2015
Tony Evans	2086	6/07/2016
Wayne Ferguson	893	31/12/2017
Phillip Foster	2254	31/12/2019
Rob Francis	720	31/12/2017
Robert Freedman	76	31/12/2017
Brett Gale	3774	12/08/2015
David Gates	2599	19/04/2015
Collin Gear	2623	31/12/2017
Robert Glover	1362	31/12/2017
Ian Glover	393	28/02/2015
Wayne Gray	3606	31/12/2019
Ray Grose	2956	31/12/2017
Jim Haig	394	12/08/2015
Brian Harris	1054	31/12/2018
Peter Hart	1	31/10/2015
Shane Hawker	7342	31/12/2016
Rohan Healy	3184	31/12/2017
Clayton Henry	1595	31/12/2017

Chris Heron	1619	31/05/2016
Don Herrigan	4033	12/08/2015
Anthony Heuthorst	2297	31/12/2019
Frank Hiron	2888	31/12/2018
Paul Hunter	2988	31/12/2017
Jeffrey Hurst	1746	31/12/2018
Gary Hussey	3984	2/07/2015
Clinton Iliffe	4034	12/08/2015
Robert Johnson	2625	31/12/2018
Matthew Johnson	2359	12/08/2015
Robert Johnson	3354	12/08/2015
Michael Johnstone	2964	31/12/2018
Roger Kearney	1121	31/12/2018
Graeme Kelly	721	31/12/2017
Leonard Kong	3538	31/12/2018
Narend Lal	3355	31/12/2019
Alan Lee	3539	31/12/2018
David Lepelaar	3356	31/12/2018
Neil Alan Lewis	2598	31/12/2018
Daniel Lillas	3597	30/11/2019
Peter Luke	3795	31/12/2019
Jonathan Mace	4035	6/07/2016
Alistair MacKenzie	4191	31/12/2017
Spencer Macsween	3170	31/12/2017
Willie Mandeno	1216	31/12/2017
Tony Mans	3233	31/12/2017
Bradley Marsh	3232	30/11/2015

Andrew Martin	545	31/12/2019
George Martin	669	2/07/2015
Garry Matthias	1481	30/04/2016
Peter McCormack	4353	31/12/2017
David McCormack	4352	6/07/2016
Brett Meredith	2218	30/11/2015
John Mitchell	1042	31/12/2017
Wayne Mitchell	3357	2/07/2015
Vic Monarca	2053	6/07/2016
Wessel Mulder	7351	31/12/2017
Peter Nicholson	4086	31/12/2020
Stephen Nixon	2256	31/12/2017
Eric Norman	7430	31/12/2016
Dennis O'Loughlin	7353	31/12/2017
Gerald Owen	7341	31/12/2016
Clifford Parkes	3607	31/12/2020
Mervyn Perry	268	31/12/2017
Lorraine Pidgeon	1513	31/12/2017
Graham Porten	2257	31/12/2019
David Power	2487	19/04/2015
Daniel Price	4129	30/06/2016
John Puljak	3780	12/08/2015
Barry Punter	1843	31/10/2015
Greg Reece	3508	19/04/2015
Tony Ridgers	421	31/12/2020
Rick Roberts	1316	28/02/2016
Dean Rowe	4200	2/07/2015

Valentine Scriha	1896	12/08/2015
Kevin Sellars	7352	31/12/2017
Kevin Sharman	627	30/11/2015
Tracey Sherman	1829	31/12/2018
Douglas Shipley	2221	2/07/2015
Michael Sillis	844	31/12/2017
Gary Smith	2512	31/12/2019
Trevor Smith	1035	31/12/2017
Laurence Snook	1526	31/12/2017
Dragan Stevanovic	2960	31/12/2018
Neil Stewart	1358	31/12/2017
Steven Stock	3923	6/07/2016
Steve Storey	3176	29/02/2016
Raymond Street	3173	31/05/2016
Peter Sutton	3183	31/12/2017
Dennis Tremain	1036	31/12/2017
Andy Vesco	3783	19/04/2015
Paul Vince	7355	31/12/2017
Charles Vincent	1827	31/03/2016
Mark Weston	883	31/12/2017
Charles Wheeler	3943	19/04/2015
Shane White	2869	31/08/2016
Craig Williams	4176	12/08/2015

The next Coatings Inspection Refresher Courses are In Adelaide November 14 & In New Zealand December 4.

See www.corrosion.com.au for more details

ACA Standards Update

Welcome to the 2nd 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	Issue 2015	Standards search for TG interests
Feb	Concrete Structures & Buildings	**August**	Cathodic Protection
April	Coatings	**October**	Mining Industry
June	Petroleum & Chemical Process Industries	**December**	Water & Waste Water

This Standards report focuses on.

Focus 1

As previously, the focus will be on global standards, searching through SAIGLOBAL Publications at https://infostore.saiglobal.com/store for all current publications and standards relating to the ACA technical Groups, with this editions group focus being the "Coatings" Technical Group.

These results are shown in Focus 1 listing below.

There were a total of 684 Publications on the key words "paint and corrosion", 3 from AS and AS/NZS, 1 from ASTM, 0 from NACE, 0 from SSPC, and 766 on the keywords "coating and corrosion" with 18 from AS AS/NZS, 13 from ASTM, 6 from NACE, 1 from SSPC.

Focus 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 **17 January 2015 to 16 March 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'.

These results are shown in the Focus 2 listing below.

There were 29 Documents with 1 AS Standard Update published (AS 2832.1:2015 Cathodic protection of metals - Pipes and cables) since 17 January 2015.

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

Focus 1 - Report on SAIGLOBAL Publications at https://infostore.saiglobal.com/store, for all current publications and standards relating to;

A. "paint and corrosion" gave 684 publications with 3 from AS and AS/NZS, 1 from ASTM, 0 from NACE, 0 from SSPC;

B. "Coating and corrosion" gave 766 publications with 18 from AS AS/NZS, 13 from ASTM, 6 from NACE, 1 from SSPC.

There will be duplication in each category when paint and coatings occur together. I was unable to get the search engine to differentiate these overlaps.

Focus 1A - Results for "paint and corrosion" with AS AS/NZS & ASTM publications

- AS 1580.452.2-2002 (R2013) - Paints and related materials - Methods of test - - Resistance to corrosion - Salt droplet test
- AS 1580.481.3-2002 (R2013) - Paints and related materials - Methods of test - Coatings - Exposed to weathering - Degree of corrosion of coated metal substrates
- AS/NZS 2312.1:2014 - Guide to the protection of structural steel against atmospheric corrosion by the use of protective coatings - Paint coatings
- ASTM A1004/A1004M-99(2014) - Standard Practice for Establishing Conformance to the Minimum Expected Corrosion Characteristics of Metallic, Painted-Metallic, and Nonmetallic-Coated Steel Sheet Intended for Use as Cold Formed Framing Members

Focus 1B - Results for "coating and corrosion" with AS AS/NZS, ASTM, NACE & SSPC publications

- AS 1247-2004 - Metallic coatings - Rating of test specimens and manufactured articles subject to corrosion tests
- AS 1247-2004/Amdt 1-2004 - Metallic coatings - Rating of test specimens and manufactured articles subject to corrosion tests
- AS 2331.3.1-2001 - Methods of test for metallic and related coatings - Corrosion and related property tests - Neutral salt spray (NSS) test

- AS 2331.3.10-2001 - Methods of test for metallic and related coatings - Corrosion and related property tests - Cracks and pores in chromium
- AS 2331.3.11-2004 - Methods of test for metallic and related coatings - Corrosion and related property tests - Chemical residue tests
- AS 2331.3.12-2006 - Methods of test for metallic and related coatings - Corrosion and related property tests - Cyclic salt fog/UV exposure of organically coated metal
- AS 2331.3.13-2006 - Methods of test for metallic and related coatings - Corrosion and related property tests - Wet (salt fog) /dry/humidity
- AS 2331.3.2-2001 - Methods of test for metallic and related coatings - Corrosion and related property tests - Acetic acid salt spray test (ASS test)
- AS 2331.3.3-2001 - Methods of test for metallic and related coatings - Corrosion and related property tests - Copper accelerated acetic acid salt spray test (CASS test)
- AS 2331.3.4-2001 - Methods of test for metallic and related coatings - Corrosion and related property tests - Thioacetamide anti-tarnish and porosity tests
- AS 2331.3.5-2001 - Methods of test for metallic and related coatings - Corrosion and related property tests - Sulfur dioxide/ hydrogen sulfide porosity tests
- AS 2331.3.6-2001 - Methods of test for metallic and related coatings - Corrosion and related property tests - Electrographic porosity test
- AS 2331.3.7-2004 - Methods of test for metallic and related coatings - Corrosion and related property tests - Corrodkote (Corr) test (ISO 4541:1978, MOD)
- AS 2331.3.8-2001 - Methods of test for metallic and related coatings - Corrosion and related property tests - Humidity test - 24 h cycle, damp heat
- AS 2331.3.9-2001 - Methods of test for metallic and related coatings - Corrosion and related property tests - Metallic coatings - Porosity tests - Ferroxyl test
- AS 1580.481.3-2002 (R2013) - Paints and related materials - Methods of test - Coatings - Exposed to weathering - Degree of corrosion of coated metal substrates
- AS/NZS 2312.1:2014 - Guide to the protection of structural steel against atmospheric corrosion by the use of protective coatings - Paint coatings
- AS/NZS 2312.2:2014 - Guide to the protection of structural steel against atmospheric corrosion by the use of protective coatings - Hot dip galvanizing
- ASTM D2803-09 - Standard Guide for Testing Filiform Corrosion Resistance of Organic Coatings on Metal
- ASTM D7893-13 - Standard Guide for Corrosion Test Panel Preparation, Testing, and Rating of Coil-Coated Building Products
- ASTM D6675-01(2011) - Standard Practice for Salt-Accelerated Outdoor Cosmetic Corrosion Testing of Organic Coatings on Automotive Sheet Steel
- ASTM F1136/F1136M-11 - Standard Specification for Zinc/Aluminum Corrosion Protective Coatings for Fasteners
- ASTM F1137-11e1 - Standard Specification for Phosphate/Oil Corrosion Protective Coatings for Fasteners
- ASTM F2833-11 - Standard Specification for Corrosion Protective Fastener Coatings with Zinc Rich Base Coat and Aluminum Organic/Inorganic Type
- ASTM G33-99(2010) - Standard Practice for Recording Data from Atmospheric Corrosion Tests of Metallic-Coated Steel Specimens
- AASTM STP290-61 - Twenty-year Atmospheric Corrosion Investigation Of Zinc-coated And Uncoated Wire And Wire Products
- ASTM STP585A-84 - Atmospheric Corrosion Investigation Of Aluminum-coated, Zinc-coated, And Copper-bearing Steel Wire And Wire Products: A Twenty-year Report

- ASTM B380-97(2013) - Standard Test Method for Corrosion Testing of Decorative Electrodeposited Coatings by the Corrodkote Procedure
- ASTM F3019/F3019M-14 - Standard Specification for Chromium Free Zinc-Flake Composite, with or without Integral Lubricant, Corrosion
- ASTM A1004/A1004M-99(2014) - Standard Practice for Establishing Conformance to the Minimum Expected Corrosion Characteristics of Metallic, Painted-Metallic, and Nonmetallic-Coated Steel Sheet Intended for Use as Cold Formed Framing Members
- ASTM F1428-92(2011) - Standard Specification for Aluminum Particle-Filled Basecoat/Organic or Inorganic Topcoat, Corrosion Protective
- 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 SP 01 08:2008 - Corrosion Control Of Offshore Structures By Protective Coatings
- NACE TM 01 83:1983 (R2006) - Evaluation Of Internal Plastic Coatings For Corrosion Control Of Tubular Goods In An Aqueous Flowing Environment
- NACE TM 01 85:1985 (R2006) - Evaluation Of Internal Plastic Coatings For Corrosion Control Of Tubular Goods By Autoclave Testing
- NACE 12:2003 - Specification For The Application Of Thermal Spray Coatings (metallizing) Of Aluminum, Zinc, And Their Alloys And Composites For The Corrosion Protection Of Steel
- NACE 14C296:1996 - A State-of-the-art Report On Protective Coatings For Mitigating Corrosion Under Insulation On Rail Tank Car
- SSPC-CS 23.00:2003 - Specification For The Application Of Thermal Spray Coatings (metallizing) Of Aluminum, Zinc, And Their Alloys And Composites For The Corrosion Protection Of Steels

Focus 2 - SAI Global, search 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, ALL published from 17 January 2015 to 16 March 2015.

This produced 29 Documents as listed below. There was 1 AS on AS/NZS Standard Update, namely;

AS 2832.1:2015	**Cathodic protection of metals - Pipes and cables**

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 17 January 2015 to 16 March 2015	
Key word search on 'durability'.- 4 non-corrosion related citations found	
ISO/FDIS 19095-4	Plastics - Evaluation of the adhesion interface performance in plastic-metal assemblies - Part 4: Environmental condition for durability
DR AS/NZS 3813:2015	Plastic monobloc chairs - Determination of strength and durability, stability, UV and weathering, and ignitability
15/30315053 DC BS EN 16818	Durability Of Wood And Wood-Based Products - Moisture Dynamics Of Wood And Wood-Based Products
15/30315056 DC BS EN 599-2	Durability Of Wood And Wood-Based Products - Efficacy Of Preventive Wood Preservatives As Determined By Biological Tests - Part 2: Labelling
Key word search on 'corrosion' or 'corrosivity' or 'corrosive'; but not 'anodizing' or 'anodize(d)'- 10 citations found (3 FORD Spec. ignored); 0 from AS or AS/ASNZ	
I.S. EN ISO 7539-10:2014	Corrosion of Metals and Alloys - Stress Corrosion Testing - Part 10: Reverse U-bend Method
I.S. EN ISO 7539-11:2014	Corrosion of Metals and Alloys - Stress Corrosion Cracking - Part 11: Guidelines for Testing the Resistance of Metals and Alloys to Hydrogen Embrittlement and Hydrogen-assisted
DIN EN 16602-70-20 (2015-02	Space product assurance - Determination of the susceptibility of silver-plated copper wire and cable to "red-plague" corrosion; English version
DIN 65242 (2015-02)	Aerospace - Anchor nuts with MJ-thread, deep counterbore, self-locking, floating, two lug, corrosion-resisting steel, classification: 1 100 MPa/315 øC/425 øC
DIN 65244 (2015-02)	Aerospace - Anchor nuts with MJ thread, deep counterbore, self-locking, floating, single lug, corrosion-resisting steel, classification: 1 100 MPa/315 øC/425 øC

DIN EN ISO 8044 (2015-02) (Draft)	Corrosion of metals and alloys - Basic terms and definitions (ISO/FDIS 8044:2014); Trilingual version
15/30320884 DC BS EN 2899	Aerospace Series - Vulcanized Rubbers - Test On The Susceptibility To Corrosion In A Damp Atmosphere Of Metals In Contact With Vulcanized Rubbers
BS EN ISO 7441:2015	Corrosion Of Metals And Alloys - Determination Of Bimetallic Corrosion In Atmospheric Exposure Corrosion Tests
BS EN ISO 7539-10:2014	Corrosion Of Metals And Alloys - Stress Corrosion Testing - Part 10: Reverse U-Bend Method
BS EN ISO 7539-11:2014	Corrosion Of Metals And Alloys - Stress Corrosion Cracking - Part 11: Guidelines For Testing The Resistance Of Metals And Alloys To Hydrogen Embrittlement And Hydrogen-Assisted Cracking
Key word search on 'paint' and or 'coating'; but not 'anodizing' or 'anodize(d)' or corrosion– 17 (4 from Ford & 1 not corrosion related, all ignored) publications found; 0 from AS AS/NZS.	
ISO/DIS 8502-9	Preparation of steel substrates before application of paints and related products - Tests for the assessment of surface cleanliness - Part 9: Field method for the conductometric determination of water-soluble salts
ISO/FDIS 8623	Tall-oil fatty acids for paints and varnishes - Test methods and characteristic values
DIN EN ISO 13803 (2015-02)	Paints and varnishes - Determination of haze on paint films at 20ø (ISO 13803:2014)
DIN EN ISO 2813 (2015-02)	Paints and varnishes - Determination of gloss value at 20ø, 60ø and 85ø (ISO 2813:2014)
15/30250137 DC BS EN ISO 8502-9	- Preparation Of Steel Substrates Before Application Of Paints And Related Products - Tests For The Assessment Of Surface Cleanliness - Part 9: Field Method For The Conductometric Determination Of Water-Soluble Salts
ISO/DIS 11950.2	Cold-reduced tinmill products - Electrolytic chromium/chromium oxide-coated steel
ISO/FDIS 16961	Petroleum, petrochemical and natural gas industries - Internal coating and lining of steel storage tanks
I.S. EN ISO 12736:2014	Petroleum and Natural gas Industries - wet Thermal Insulation Coatings for Pipelines, Flow Lines, Equipment and Subsea Structures (iso 12736:2014)
DIN EN ISO 21809-2 (2015-03)	Petroleum and natural gas industries - External coatings for buried or submerged pipelines used in pipeline transportation systems - Part 2: Single layer fusion-bonded epoxy coatings (ISO 21809-2:2014); English version EN ISO 21809-2:2014
BS EN ISO 12736:2014	Petroleum And Natural Gas Industries - Wet Thermal Insulation Coatings For Pipelines, Flow Lines, Equipment And Subsea Structures
BS EN 15814:2011+A2:2014	Polymer Modified Bituminous Thick Coatings For Waterproofing - Definitions And Requirements
BS EN 16602-70-13:2015	Space Product Assurance - Measurements Of The Peel And Pull-Off Strength Of Coatings And Finishes Using Pressure-Sensitive Tapes
Key word search on 'galvanize' or 'galvanized' or galvanizing'; 'galvanise' or 'galvanised' or galvanising' – 0 Standard Publications found.	
Key word search on 'corrosion' and 'concrete' or 'concrete' and 'coatings' – 1 surface protection Standard Publications found	
15/30316975 DC BS EN 1504-2	Products And Systems For The Protection And Repair Of Concrete Structures - Definitions, Requirements, Quality Control And Evaluation Of Conformity - Part 2: Surface Protection Systems For Concrete
Key word search on 'cathode' or 'cathodic' – 2corrosion related publication found; 1 from AS, AS/NZS	
AS 2832.1:2015	Cathodic protection of metals - Pipes and cables
ISO 15589-1:2015	Petroleum, petrochemical and natural gas industries - Cathodic protection of pipeline systems - Part 1: On-land pipelines
Key word search on 'anode' or 'anodes' or 'anodic' – 0 Standard Publications found	
Keyword Search on 'electrochemical' or 'electrolysis' or 'electroplated' - 3 corrosion related Standard Publications found; 0 from AS, AS/NZS	
ISO/DIS 11949.2	Cold-reduced tinmill products - Electrolytic tinplate
ISO/DIS 11950.2	Cold-reduced tinmill products - Electrolytic chromium/chromium oxide-coated steel
15/30248084 DC BS ISO 11949	Cold-Reduced Tinmill Products - Electrolytic Tinplate
Keyword Search on 'anodize' or 'anodized' - 0 Publications found	

Arthur Austin
ACA Standards Officer

ACAF International Travel Scholarship Report

by Mike Rutherford
Part 1

It is not often in life that one is afforded such an opportunity as that made possible in being a recipient of the ACA Foundation International Travel Scholarship and I sincerely thank the ACA Foundation for affording me such an opportunity.

The purpose of ACA Foundation International Travel Scholarship was to enable travel to attend and participate in an international corrosion conference, to undertake site visits to projects and project offices of significance in focussing on corrosion prevention and protection and to meet with key personnel to discuss projects and market trends, contact with whom is likely to benefit the Australasian corrosion community.

With such a broad charter available the planning of such a “once in a lifetime” trip was difficult with so many options. My industry experience has provided a varied background from construction and remediation chemical product manufacture and specification, through consultancy work in corrosion engineering to business development in remedial contracting.

Following review of international conferences that were available to attend within the time period, the inaugural NACE European Corrosion Conference-Expo 2014 in Spain was selected as my preferred conference.

Deciding the topics to cover, where best to visit and who to meet was an extremely difficult process. My final decision was to catch topics related to challenging concrete cathodic protection projects and the design and provision of a corrosion prevention system to a unique project where the system is to remain effective for a period of 100 years.

Following attendance at the Inaugural NACE European Corrosion Conference-Expo 2014 in Spain I travelled to France where site visits and meetings were held to discuss and overview challenging concrete cathodic protection project works and market trends in cathodic protection in France. The selected projects include the Issy les Moulineaux Swimming Pool in Paris, the Ajaccio Harbour Deck on Corsica Island, the Viaduc de Sylans on Lake Sylans, the Larivot Bridge in French Guiana, the Sea and Sun Centre in Valras and the Municipal Water Sports Center in La Grande-Motte.

Further time in France was spent with delegates from NOVARKA, a Joint Venture between VINCI Construction Grands Projets and Bouygues Travaux Publics, to discuss and overview the corrosion prevention system adopted for the Chernobyl Sarcophagus Confinement Shelter Project.

On completion of my time in France I travelled to the United Kingdom to continue further site visits and meetings in England, Wales, Scotland and Ireland.

So fulfilling were the experiences of the ACA Foundation International Travel Scholarship that reporting on my trip is unable to be confined to a single report for publication. Therefore, my report will be presented in two sections. The first report will cover the Inaugural NACE European Corrosion Conference-Expo 2014 and Corrosion Prevention and Protection for the Chernobyl Sarcophagus Confinement Shelter and the second report will cover site visits and meeting discussion in relation to challenging concrete cathodic protection projects in France and the United Kingdom.

Inaugural NACE European Corrosion Conference – Expo 2014

The Inaugural NACE European Corrosion Conference - Expo 2014 was held in the small town of San Lorenzo de El Escorial in the mountains to the north west of Madrid in Spain. The town houses a huge monastery and palace, built by King Felipe II between 1563 and 1584 was the venue for the event. . Besides being a monastery and a palace, it is also a mausoleum and holds the remains of most of the Spanish royals that ruled Spain during the last five centuries.

The Monastery of San Lorenzo de El Escorial was declared a Historic-Artistic Monument in 1931 and in 1984 was recognized by UNESCO as a World Heritage Site.

The Monastery of San Lorenzo de El Escorial.

The Inaugural NACE European Corrosion Conference-Expo 2014 was held between the 14th to the 16th May 2014. The Welcoming Function was held at the Monastery of San Lorenzo de El Escorial and consisted of a Welcoming Presentation and Cocktails and culminated with a traditional organ recital in the Basílica of the Monastery. Very different to our welcoming functions.

The Conference saw many experienced corrosion speakers give conference presentations relating to a wide array of fields of corrosion engineering.

The Conference was divided in three topic categories - general corrosion, cathodic protection and coatings.

In addition to the lectures there were master lectures presented by renowned corrosion industry professionals. Speakers for the Plenary Lectures were Amir Eliezer, Dr. Carmen Andrade, Delmar Doyle, Harvey Hack, Matthew Koch, Ricardo Eastella and Thomas Lewis.

Welcoming Function Address.

The attending delegates represented a wide range of backgrounds including manufacturing, consulting, contracting and suppliers from many

European countries with Spain, Italy and France all being well represented.

Participation was available in the topics that included Internal Corrosion for Oil and Gas Fields, AC/DC Interference and Corrosion Control for a Municipal Pipeline Network, Cathodic Protection and AC/DC Interference for Long-distance Pipeline and Stations, Protective Coatings for Pipelines and Tanks, Corrosion Control for Refineries, Corrosion Control for Petrochemical and Chemical Plant, Corrosion of Maritime and Offshore Structures, Electrochemical Measurement and Application, Pipeline Corrosion, Integrity Management, Anticorrosion Coatings, Hydrogen Embrittlement, Stress Corrosion Cracking and Corrosion Fatigue, Cathodic Protection for PCCP Pipe, Corrosion Resistant Alloy Pipe and CRA Clad Pipe, Corrosion Monitoring Technologies, Top of Line Corrosion, Corrosion Under Deposits, Novel Corrosion Control Technologies and Multiphase Flow Erosion.

The presenters and their associated organisations have provided a solid track record of performance throughout Europe by viewing the European market as being strategically important for growth plans in cathodic protection and corrosion engineering worldwide.

The lectures attended were very interesting and covered a very broad range of corrosion issues from the metabolic degradation, metabolic deposition, corroding and coating delamination from the surfaces of medical implants through to the worldwide standardising and certification of marine ballast tank water to prevent issues of corrosion within marine ballast tanks.

For their first conference in Europe, the NACE Madrid Iberia Section did very well in presenting the event. The registration process proved to be very difficult, however, the program was well organized with relevant topics presented by a broad range of experienced corrosion specialists.

The venue for the Conference was unique - constructed 400 years ago with no signs of corrosion.

Although the exhibits did not appear to add to the overall value to the Conference it was the first NACE Conference in Europe and I am sure that the volume and quality of exhibits will only improve.

Corrosion Prevention and Protection for the Chernobyl Sarcophagus Confinement Shelter

Project Background

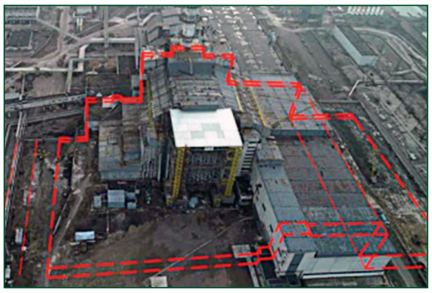
The Chernobyl disaster was a catastrophic nuclear accident that occurred on 26 April 1986 at the Chernobyl Nuclear Power Plant in Ukraine. An explosion and fire released large quantities of radioactive particles into the atmosphere, which spread over much of the western USSR and Europe.

The Chernobyl disaster was the worst nuclear power plant accident in history in terms of cost and casualties and is one of only two classified as a level 7 event (the maximum classification) on the International Nuclear Event Scale (the other being the Fukushima Daiichi nuclear disaster in 2011).

The battle to contain the contamination and avert a greater catastrophe ultimately involved over 500,000 workers and cost an estimated 18 billion $USD.

The design and construction of a new shelter for Chernobyl's infamous power station has raised some huge engineering challenges – noteably the corrosion prevention of the structure being one of the greater challenges.

Known as the Shelter Implementation Plan, the project is funded through the European Bank for Reconstruction and Development by 46 countries and organisations. Since 1998, the engineers have worked their way through a long list of onerous challenges from stabilising the crumbling sarcophagus that was hastily erected following the 1986 disaster, to building the office blocks and associated infrastructure essential for such a long-running initiative. The crowning glory being the construction of the New Safe Confinement (NSC) comprising of an immense steel arch, designed to last for 100 years, that will protect the sarcophagus from the elements, and enable engineers to safely and methodically tidy up a nuclear legacy that has troubled the world for the past 27 years.

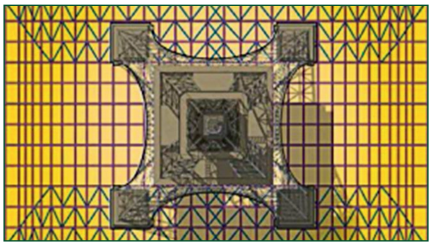


Area Covered by the New Safe Confinement.

Construction

Standing 110m high, 257m wide, 162m long and weighing 30,000 tonnes, the arch is large enough to enclose the Statue of Liberty or a 30 storey building and the footprint of the Eiffel Tower.

Structure size to enclose the Statue of Liberty.



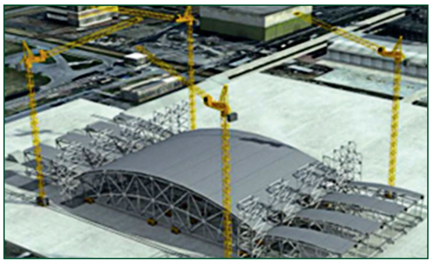
Eiffel Tower footprint enclosed in Structure.

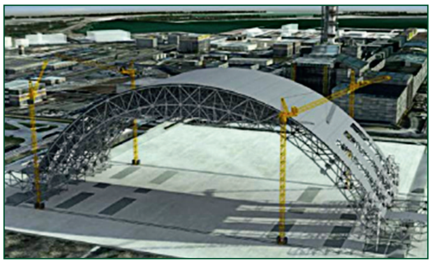
The NSC is currently being assembled 600m away from the damaged reactor where, thanks to the remediation work of the past two decades, the relatively low ground-level radiation dose levels enable engineers to work for up to 40 hours a week.

Ukrainian authorities have deemed that the 30km exclusion zone surrounding Chernobyl will not be completely safe for another 20,000 years. It is therefore surprising that it is deemed safe to work at the site. Nevertheless, Chernobyl remains an exceptionally hazardous place with many areas within the facility completely sealed off with dose rates close to the reactor extremely high. A remote assembly technique was viewed as attractive but did not completely solve the problem as the dose rate increases at higher elevations. To address this problem the engineering team developed an innovative erection process which ensures workers never stray above the 30m mark.

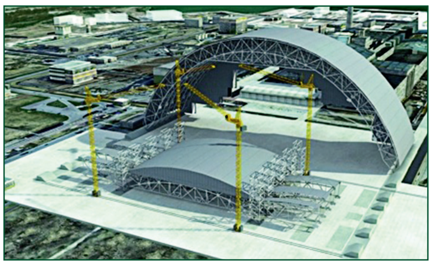
The highest part of the arch was constructed first with legs attached prior to being jacked 30m from the ground. The jacks were removed , another pair of legs were added and the structure was jacked a further 30m with the process repeated until the arch structure stood 110m from the ground. The jacks used to lift the arch were mounted on specially built towers with each jack controlled to move at the same time in order to lift the arch correctly.

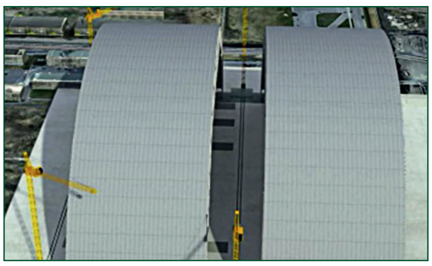
Although most of the systems and equipment used in assembly are bespoke, the jacks were previously used to raise sunken Russian nuclear submarine the Kursk in 2001.





Jacks Raising the NSC Structure.





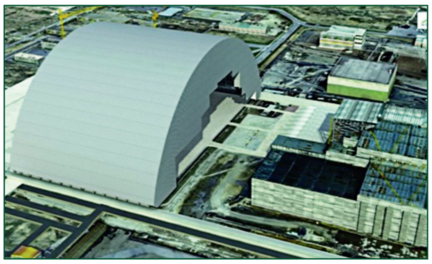
Structure Constructed in Two Halves.

Work is well under way on the structure and when the main structure is assembled the attention will be on the inside of the shelter and the systems and tools that will keep the structure safe to enable engineers to begin the deconstruction of the reactor.

The giant tracks along which the shelter will be moved are a huge engineering achievement as at each end of the tracks, in the erection zone and in the final resting position, approximately 400 huge piles have been driven 26m into the ground. In the area in between the two zones there are no piles but instead a spread foundation that rests on top of the ground. Whilst the erection and service zones will experience prolonged horizontal reaction forces, the shelter will pass relatively quickly over the area in between. On top of these foundations sit the rails along which the NSC will slide on specially developed Teflon bearing links.

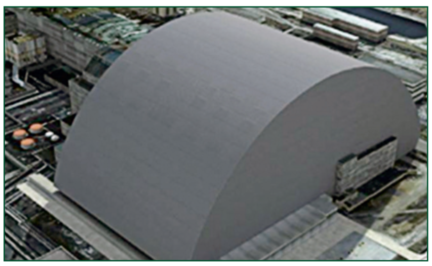
400 x 1m Piles Driven 26m into the Ground.

Over 17m in width and the height of a two-story building the vast concrete structures are topped with a stainless steel plate that is mounted at a specific angle to ensure that the shelter can be accurately positioned.



NSC Structure Prior to Place Over the Reactor.

If all goes to plan, at some point in 2015 the NSC will briefly become one of the largest moving structures on land as engineers begin carefully sliding it along vast tracks to its final resting place.



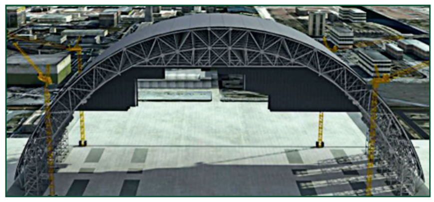
NSC Structure in Final Position.

Corrosion Prevention and Protection

With the shelter designed to remain in place for a minimum period of 100 years a host of monitoring and control systems were required to assist and to keep the structure safe and to reduce the need for regular maintenance. The engineering team devised a particularly simple solution to the threat and problem of corrosion.

Throughout the world there are several steel structures that have lasted in excess of 100 years such as the Eiffel Tower. To prevent corrosion issues the Eiffel tower is continually repainted as it is the more economical option, however this could not be undertaken at Chernobyl due to the hazard of the radiation dose rates close to the reactor.

The shelter external tubular steel structure is protected from corrosion through an air-conditioning system that circulates through the 12m space between the shelter's tubular steel structure and the stainless steel cladding.



Air-conditioning the 12m between the Steel Structure and Stainless Steel Cladding.

This air is circulated into the gap by means of large desiccant dryers which remove moisture to maintain the air at less than 40% relative humidity, a condition under which carbon steel will not corrode. The system recirculates 45,000 m^3 of air per hour at a pressure of 50 pascals higher than the outside air to prevent areas of stagnation developing internally. The system also heats the air in the annular space to 3°C warmer than the air within the shelter. The structure is one of a handful of buildings in the world that will enclose a volume of air large enough to create its own weather. By maintaining a temperature difference between the upper surfaces of the structure and the air within condensation and the prospect of "rain" falling on the shelter's radioactive contents is avoided.

As the shelter's contents is hazardous the engineering designers have equipped the shelter with technology for monitoring both seismic activity and radiation levels that are designed to withstand and survive earthquakes measuring 6 on the MSK scale (which is still widely used in Russia and former Soviet states).

Chernobyl's giant new shelter is an undeniably phenomenal engineering achievement becoming the result of international collaboration and the application of innovative technology on a monumental scale. For many engineers this project has been likened to working on the pyramids as you can't imagine working on anything much bigger than this project.

Mike Rutherford received the ACAF international travel scholarship.

ACA Foundation Centurion

Thank You

The ACA Foundation would like to thank ACA Foundation Centurions for their generous support of the work and mission of the ACA Foundation - *Advancing Corrosion Mitigation through Education*

A Word from a Centurion

"It's a pleasure to be an ACA Foundation Centurion as I have received so much assistance and encouragement from the ACA community throughout my career. It's a privilege to be able to support the association that has supported me and to contribute to the education of future generations of corrosionists."

Dr. David Nicholas,
Nicholas Corrosion & ACA Foundation Centurion.

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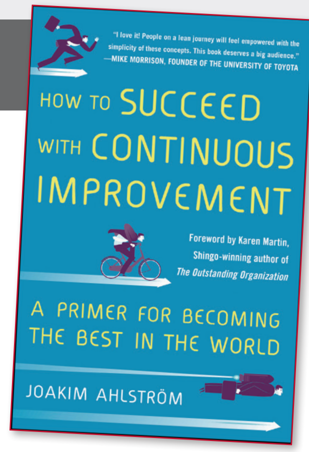
The Five Continuous Improvement Paradoxes

by Joakim Ahlström



Continuous improvement is key for many organizations in order to develop high performance, but they often feel intimidated by the very concept. Joakim Ahlström, one of the world's leading experts on the subject, maintains that the process is surprisingly simple. His article below illustrates the clear-cut -- albeit sometimes counter-intuitive -- steps to incorporating continuous improvement on a path to success.

Ahlström has successfully helped dozens of organizations around the world such as Coca Cola, Volvo, Ericsson and IKEA. His new book is *How to Succeed with Continuous Improvement: A Primer for Becoming the Best in the World*.

Succeeding with Continuous Improvement has proven harder than expected for many organizations. One big reason is that there are a few challenges most organizations sooner or later encounter and where your intuitive responses actually prevent you from succeeding.

Continuous Improvement Paradox #1 – Simplicity

A common reaction to failed improvement initiatives is going for a more advanced solution. Go the other way! Simplicity will stand the test of time.

For your organization to succeed with Continuous Improvement you have to make it a natural part of the everyday work of every employee. For that to become reality your approach can't be complicated. If it is, new employees will need special training to understand your improvement method, you will need additional support resources to keep progressing and backing it up will demand a great deal of your managers' time.

Time is probably your most limited resource, and in the long run you won't afford not to use everyone's creativity. Kill two birds with one stone, keep it simple to both save time and to give everyone a chance to contribute.

Continuous Improvement Paradox #2 – Focus

A common reaction to recurring problems is bombarding them with solutions. Go the other way! Focus and dig deeper to find the real cause of the problem.

Imagine what would happen if I took you and ten of your colleagues to a junkyard and asked you to build whatever you wanted.

The most common reaction would probably be to just stand there looking around, not sure what to do. Imagine instead that I asked you to build a vehicle that could transport all of you at least ten yards without any of you touching the ground. Now your heads would probably fill with images of wheels, axles, planks to stand on, and steering wheels to guide you along the way. Instantly you would become more creative and could start to organize and divide the work among you. Some people think that creativity grows best when all boundaries are removed. The opposite is true. When we limit and clarify the task it becomes easier for everyone to contribute.

The same principle applies to problem solving. When you zoom in, dig deeper, divide into smaller pieces and discard the unessential the aha moment will come, and that's when you find easy-to-implement solutions with great impact.

Continuous Improvement Paradox #3 – Visualization

A common reaction to lack of initiative is pointing out problems that need to be fixed. Go the other way! Visualize good examples and positive results first to inspire action.

In an environment where managers constantly tell or show people in what way they are inadequate nobody wants to be the center of attention. To draw focus away from themselves people will start pointing out faults they see around them instead, and before you know it you have developed a culture of blame.

If you start by visualizing good examples and positive results instead you will create a positive atmosphere and give people a chance to adopt a behavior worthy of praise. But even more importantly, when you continually highlight progress made and focus on the strengths people have you also create a safe environment where improvement potential can be expressed without people becoming defensive.

Continuous Improvement Paradox #4 – Ownership

A common reaction in crucial situations is adopting a command and control approach. Go the other way! Ownership is a prerequisite for using one's full potential.

If you are told exactly what to do when it really matters you will start to question your own ability to handle difficult situations. What's worse, when you are confronted with challenges in the future it is likely that your insecurity prevents you from taking good decisions or even acting at all.

For a manager it's a good idea to monitor how many questions he or she asks compared with the number of statements he or she makes. What is your question-statement ratio? Do you try to be more interested or more interesting? If you double your question-statement ratio, you will both learn more and get more out of your colleagues.

Continuous Improvement Paradox #5 – System

A common reaction to shortage of improvement ideas is launching an idea campaign. Go the other way! Only a systematic approach builds organizational improvement competence.

Running an idea campaign is a popular method for tapping into the creativity of an organization. There is only one problem with them. They kill creativity! If there is an unmet need to be listened to in an organization, an idea campaign might create a surge of ideas, a surge so big that only a fraction of all ideas can be implemented. This means the majority of people will get yet another confirmation that no one listens to their ideas, and next time they are less likely to contribute.

A systematic approach should not only make sure that improvements are made and problems are solved daily but also increase the improvement competence of your organization every day. When you have a SYSTEM like that you will Save Yourself Stress, Time, Energy and Money!

Joakim Ahlstöm is the author of How to Succeed with Continuous Improvement: A Primer for Becoming the Best in the World, available at Amazon; for more info, visit http://www.SucceedwithCI.com

Strini Industries Pty Ltd

Q: In what year was your company established?

A: Our company succeeds a second generation family business that expanded in 1990.

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

A: A single employee.

Q: How many do you currently employ?

A: We currently employ 8 staff directly with the addition of subcontractors and consultants for project specific requirements

Q: What is your core business?

A: Our core mainstream business is traditionally commercial-industrial painting, protective coatings, safety and environmental coatings, but it is the success of our newly developed innovative 'Moon Deck' glow in the dark coating systems that have elevated our company to a completely different level.

Q: What markets do you cover with your products or services?

A: Being a regional company we have always had to be diverse and cater for a vast range of products and services within oil and gas, marine, fabrication-structural but also local and state government departments of all sectors.

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

A: We are predominantly a site based company, but now may explore opportunities into manufacturing with continued development into new and innovative coating solutions alongside our 'Moon Deck' systems.

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

A: Due to the diversity of our company and as this question is typically aimed at mainstream blasting and coating companies generally profiled, it is difficult for us to respond. Our highly productive team can meet most challenges!

Q: Do you offer any special services outside your core business?

A: We are passionate about keeping up-to-date with new technology and products that are available globally. This has given us the technical field experience to specialise in safety coatings and environmentally sensitive coating solutions and also importantly methods that ultimately helped us with the development of our new innovative systems.

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

A: Pioneering Australia's first environmental glow in dark coating system that emits a passive form of lighting throughout the night facilitating pedestrian safety in darkness without any additional power source other than natural daylight.

To be directly invited to assist one of Australia's major infrastructure companies via instruction from the NSW department of Transport (to initially deliver a novel product trialed in the UK that similarly would never comply with Australian Standards and regulatory requirements), was a humble honour in its own right.

To eventually deliver a product application that had completely elevated the concept to an environmentally industrialised-commercially graded system that has proudly put our company in the forefront, not only in Australia but also abroad, was a satisfying achievement.

Q: What positive advice can you pass on to the coatings group from that satisfying project?

A: Take time to listen; to understand and continually grow your business.

Network with people that have strengths that can be shared and built upon to ultimately become the 'price setter' not the 'price getter'.

Q: Do you have an internal training scheme?

We conduct both internal training and outsource professional development courses, as our company evolves. Our training base has had to follow without compromise in all ways from; personal development, environmental sustainability, health and safety.

We have only just begun discussions with a Registered Training Organisation (RTO's) to develop the nationally trained accreditation scheme of our own 'Moon Deck' system to formalise licensing accredited contractors.

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Corrosion Research at James Cook University

JAMES COOK UNIVERSITY AUSTRALIA

Assoc Prof Bobby Mathan is the group leader of the "*Biomaterials and Engineering Materials (BEM) Lab*" at James Cook University (JCU), which he established to study corrosion in biomaterials and engineering materials. His research group mainly focuses on biomaterials corrosion, environment-assisted cracking, corrosion inhibitors, protective coatings and surface engineering. JCU's unique geographical location provides the research group with opportunities to understand and mitigate corrosion in the tropics. The BEM Lab has received a number of contracts from local minerals processing industries to solve corrosion-related problems in processing plants. His research group works closely with national and international universities and institutes including National Institute for Materials Science (NIMS) in Japan, Chosun University in South Korea and the Helmholtz Research Centre in Germany.

The BEM Lab's recent research projects are listed below:

(i) Biomaterials Corrosion

Over the past decade, there has been a growing interest in the development of biodegradable implants for bone fracture repair, and metallic magnesium is a potential candidate for such bioimplant applications. It is well documented in the literature that magnesium has many benefits as an implant material, being both biodegradable and biocompatible, as well as having mechanical properties well matched to natural bone. Unfortunately, magnesium corrodes too quickly under physiological conditions. Bobby and his team have been developing novel coatings to tailor the corrosion rate of magnesium and its alloys in body fluid. One of his recent studies was on improving the packing density of calcium phosphate coating on a magnesium alloy using electrochemical deposition method. He demonstrated that by modifying the coating solution, i.e., adding an organic solvent, calcium phosphate coating with high packing density can be achieved. The coating significantly improved the in vitro corrosion resistance of the alloy in simulated body fluid (SBF) (*Materials Letters, 76 (2012), 109-122*).

Generally, secondary phase particles in magnesium alloys are cathodic and more corrosion resistant than the magnesium matrix. The electrochemical potential difference between the matrix and secondary phase particles can lead to micro-galvanic corrosion in body fluid. The BEM Lab recently studied the effect of micro-galvanic corrosion on secondary phase particles in a magnesium alloy under in vitro conditions. Pure magnesium and $Mg_{17}Al_{12}$ (β-phase) were galvanically coupled in SBF and the corrosion behaviour of both the samples was studied. Interestingly, the galvanic coupling produced a phosphate/carbonate layer on the β-phase, which initially increased the corrosion resistance. However, the deposited phosphate/carbonate layer rapidly disintegrated once the galvanic coupling was removed and the β-phase started to corrode. This study suggests that although β-phase particles exhibit higher corrosion resistance than the matrix, they will eventually dissolve in body fluid (*Journal of Biomedical Materials Research A, 103(2014), 990-1000*).

A significant amount of research has been done on different chemical factors affecting the corrosion of magnesium and its alloys in physiological conditions, however literature on the effect of living cells on their corrosion behaviour is scarce. Recently, the BEM Lab in collaboration with NIMS (Japan) investigated the influence of living cells (L929) on the in vitro corrosion behaviour of a magnesium alloy. The study showed that the corrosion of the alloy increased significantly in the medium containing the cells as compared to that without cells. Microscopy analysis revealed localized corrosion in the vicinity of the cells. It was suggested that the cell metabolic activity has induced local pH drop and as a result increased the alloy corrosion (*Colloids and Surfaces B: Biointerfaces, 126(2015) 603-606*).

Ti-6Al-4V alloy is one of the most widely used metallic materials in orthopaedics and dentistry due to its high strength and biocompatibility. But the high elastic modulus of this alloy can have a negative impact on the bone healing process through a phenomenon known as stress shielding. The BEM Lab in collaboration with Chosun University (South Korea) has been working towards developing novel titanium-based alloys with lower elastic modulus as compared to the traditional Ti-6Al-4V alloy. Recently, they have surface engineered Ti-Ta alloys for improved biocompatibility and corrosion resistance. Nanotechnological approach was used to incorporate bone-like apatite particles on those alloys (*Materials Science and Engineering C, 46 (2015), 226-31*).

(ii) Environment-assisted Cracking

Aluminium and magnesium alloys are widely used in the automobile industry due to their high strength-to-weight ratio. However, these high strength light alloys are prone to a localized form of corrosion known as environment-assisted cracking (EAC), especially in chloride-containing environments. Over the past 15 years, Bobby has carried out extensive research on the EAC behaviour of high strength aluminium and magnesium alloys. He has published several research papers in this area. Notably, he reported that scandium addition to a high strength aluminium alloy (7010) inhibits recrystallization and hence enhance EAC resistance (*Engineering Fracture Mechanics, 77(2010), 249-56*). Currently, the BEM Lab in collaboration with Deakin University is focussing on hydrogen embrittlement susceptibility of high strength steels such as nanostructured bainitic steels and TWIP steels. Recently, they reported selective dissolution of retained austenite in nanostructure bainitic steels (*Advanced Engineering Materials, 16(2014), 442-444*). They aim to correlate the microstructure and hydrogen diffusivity in these high strength steels.

(iii) Polymer Coatings

Surface coating has always been a popular method for the protection of metals and alloys against corrosion. In recent years, researchers have paid attention on conducting polymer coatings for corrosion protection for their high environmental stability and particularly electrical conductivity which is claimed to be useful in corrosion inhibition. However, conducting polymer coatings on active metals have been a challenge due to metal dissolution and vigorous oxygen evolution during the coating process. The BEM Lab has recently investigated the effect of electrolyte stirring during the electropolymerisation of aniline on steel. The study showed that electrolyte stirring minimized oxygen bubbles growth and thereby reduced the defects in the coating. In chloride-containing solution, the polyaniline coated steel exhibited significantly high corrosion resistance (*Synthetic Metals, 180(2013), 54-58*).

(iv) Corrosion in Oil and Gas Industry

Corrosion is a common problem encountered in the oil and gas industry. Oil and gas pipelines, refineries and petrochemical plants have serious corrosion problems. Internal corrosion in oil and gas industry is generally caused by water, carbon dioxide (CO_2) and hydrogen sulphide (H_2S), and also can be aggravated by microbiological activity. Combating corrosion in these industries is paramount since the economic loss due to corrosion is extremely high. Among the various methods available to combat corrosion in these industries, the use of corrosion inhibitors is one of the best and economical methods. The BEM Lab is currently working on heterocyclic inhibitors containing cationic surfactants for corrosion protection of steel in the oil and gas industry.

Associate Professor Bobby Mathan

Bobby Mathan completed his PhD in 2005 at the Indian Institute of Technology (IIT) Bombay in India. He received a DAAD scholarship to carry out part of his PhD research at the University of Erlangen in Germany. He won the Best PhD Thesis Award from the National Association of Corrosion Engineers (NACE), India Section. After completing his PhD, he worked as a post-doctoral fellow for one year at the Helmholtz Research Centre in Germany. He also spent two years at Monash University as a post-doctoral fellow before joining James Cook University (JCU) as a Lecturer of Chemical Engineering in 2009. He is currently an Associate Professor and the Deputy Head of Matter and Materials in the College of Science, Technology and Engineering at JCU. His research interests include biomaterials corrosion, surface engineering, environment-assisted cracking, hydrogen permeation, corrosion inhibitors, polymer coatings and failure analysis. He has over 75 peer-reviewed publications, including 7 book chapters and 55+ journal articles. He is a serving member of the editorial boards of 3 international journals and a reviewer for many journals in the field of corrosion and materials engineering. He has received numerous awards and fellowships, including the prestigious JSPS Invitation Fellowship.

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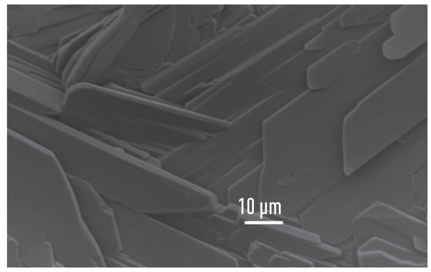
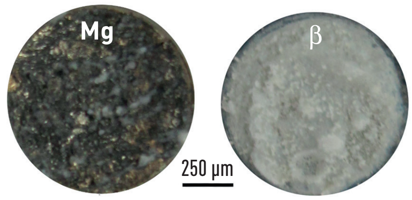
BEM Lab members (L to R): Mr Asif Baloch (MPhil student), Mr. Rhys Walter (PhD student), Ms. Hadis Khakbaz (Researcher), Mr. Oluwole Kazum (PhD student), Ms. Alyaa Alabbasi (MPhil student), Prof. Mohamed Rahuma (Visitor).



(a)



(b)

Figure 1. (a) High density packing of calcium phosphate on a magnesium alloy (Materials Letters, 76 (2012), 109-122); (b) In vitro galvanic effect in a magnesium alloy (Journal of Biomedical Materials Research A, 103(2014), 990-1000*).*

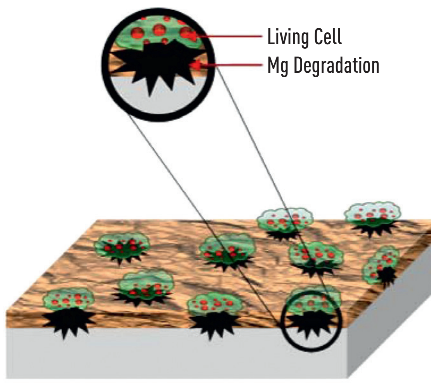


Figure 2. Schematic representation of biodegradation in magnesium in the presence of living cells (Colloids and Surfaces B: Biointerfaces, 126(2015) 603-606*).*

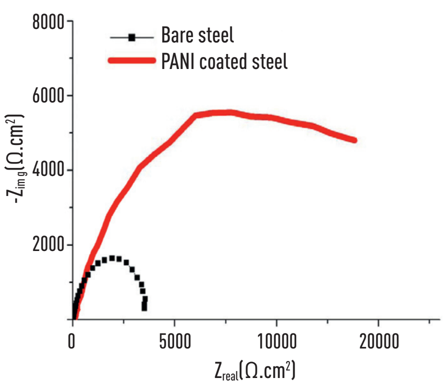


Figure 3. EIS results for polyaniline (PANI) coated steel in chloride-containing solution (Synthetic Metals, 180(2013), 54-58).

An introduction to AS/NZS 2312.2, Guide to the protection of structural steel against atmospheric corrosion by the use of protective coatings – Part 2: Hot dip galvanizing

Background

AS/NZS 2312, *Guide to the protection of structural steel against atmospheric corrosion by the use of protective coatings*, originated in 1967 as a guide for steel designers who needed advice on methods for the corrosion protection of structural steel. The last revision (2002) incorporated much information on the common methods of corrosion protection, including paint, hot dip galvanizing, thermal spray, powder coating and wrapping systems. Unfortunately the complexity of designing and specifying protective paint systems meant that much of the useful information on hot dip galvanizing was lost in the detail of the other systems.

During the review process, it was recognised that steel designers would benefit by separating it into product specific sections to avoid confusion. The revised Standard was released in December 2014; with Part 1 covering paint systems and Part 2 covering hot dip galvanizing (HDG). Both new parts use the same definitions from AS 4312 for corrosivity categories in Australia and Table 14 of NZS 3404.1:2009, but now clearly recognise that the design process and durability of the two products are very different.

Designers wishing to specify HDG need only use two Standards; one covering the design and durability of HDG steel (AS/NZS 2312.2), and the other dealing with the manufacturing process and tolerances (AS/NZS 4680).

Improved durability selection

AS/NZS 2312.2 references the latest international corrosivity (ISO 9223/ISO 9224) and design Standards for HDG (ISO 14713). This means that the design durability ("life to first maintenance") of HDG is now aligned with long term performance results from Australia and world recognised Standards. As a result, the estimated life for HDG coatings on structural steel has increased as shown in Table 1.

Figure. With a specified minimum HDG coating thickness of 85µm, AS/NZS 2312.2 can be used to estimate this bridge rail will be protected from rust for over 50 years in a C3 (medium) environment.

Table 1: Life to first maintenance of hot dip galvanized steel complying to AS/NZS 4680.

AS/NZS 4680				2014 versus 2002	AS/NZS 2312.2 Corrosivity category & Life to first maintenance (years)				
Steel thickness	Coating mass & thickness		Designation						
mm	g/m²	µm			C2	C3	C4	C5	CX*
>1.5 to ≤3.0	390	55	HDG390	2014	78->100	26-78	13-26	6-13	2-6
				2002	*25+*	*15-25*	*5-15*	*2-5*	--
>3.0 to ≤6.0	500	70	HDG500	2014	>100	33-100	16-33	8-16	2-8
				2002	*25+*	*25+*	*10-25*	*5-10*	--
>6.0	600	85	HDG600	2014	>100	40->100	20-40	10-20	3-10
				2002	*25+*	*25+*	*15-25*	*5-15*	--
>>6.0	900	125†	HDG900	2014	>100	60->100	30-60	15-30	5-15
				2002	*25+*	*25+*	*25+*	*10-25*	--

NOTES:

* "CX" is a new corrosivity category, not previously referenced in local or international Standards.

† Hot dip galvanized coatings thicker than 85µm are not specified in AS/NZS 4680, however in conjunction with the galvanizer, a specification can be written for thicker coatings.

A single table is provided for designers to compare the expected durability of different galvanized products, including in-line galvanized steel, allowing for a faster product selection process.

The durability of a HDG coating is now calculated from the minimum average coating thickness in AS/NZS 4680, which also means non-standard HDG thicknesses can be easily assessed for estimated life to first maintenance. This can be done by using Figure 2, where the macro-environment corrosivity zone can be determined from Table 2.

Australian and New Zealand Hot Dip Galvanizing Standards

Design & Durability

AS/NZS 2312.2

Guide to the protection of structural steel against atmospheric corrosion by the use of protective coatings – Part 2: Hot dip galvanizing

Manufacturing

AS/NZS 4680

Hot-dip galvanized (zinc) coatings on fabricated ferrous articles

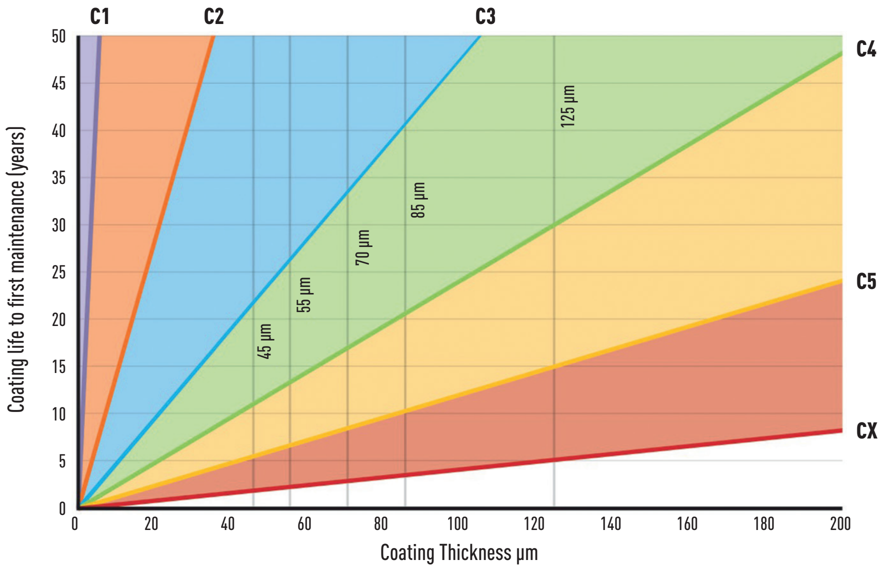


Figure 2: Calculated corrosivity rates for hot dip galvanizing from AS/NZS 2312.2 can be restated in a graphical format for quick estimates. For example, a coating thickness of 85µm can be estimated to last a minimum of 20 years to a maximum of 40 years in a C4 environment.

Table 2: Corrosivity in Australia as described in AS 4312.

Category		Generic examples	Specific examples
CX	Severe surf shore-line	Surf beach shoreline regions with very high salt deposition.	Some Newcastle beaches
C5	Surf Sea-shore	Within 200 m of rough seas & surf beaches. May be extended inland by prevailing winds & local conditions.	More than 500 m from the coast in some areas of Newcastle
C4	Calm Sea-shore	From 200 m to 1 km inland in areas with rough seas & surf. May be extended inland by prevailing winds & local conditions.	All coasts
		From the shoreline to 50 m inland around sheltered bays. In the immediate vicinity of calm salt water such as harbour foreshores.	
C3	Coastal	From 1 km to 10 km inland along ocean front areas with breaking surf & significant salt spray. May be extended inland to 50 km by prevailing winds & local conditions.	Metro areas of Perth, Wollongong, Sydney, Brisbane, Newcastle, & the Gold Coast
		From 100 m to 3 – 6 km inland for a less sheltered bay or gulf.	Adelaide & environs
		From 50 m to 1 km inland around sheltered bays.	Port Philip Bay & in urban & industrial areas with low pollution levels
C2	Arid/Urban Inland	Most areas of Australia at least 50 kilometres from the coast.	Canberra, Ballarat, Toowoomba & Alice Springs
		Inland 3 – 6 km for a less sheltered bay or gulf.	Adelaide & environs
		Can extend to within 1 km from quiet, sheltered seas.	Suburbs of Brisbane, Melbourne, Hobart
C1	Dry indoors	Inside heated or air conditioned buildings with clean atmospheres.	Commercial buildings

NOTE:
In New Zealand the generic examples of corrosivity categories are similar. For specific examples see Section 6.2 of AS/NZS 2312.2 and also Table 14 of NZS 3404.1:2009

New design advice

AS/NZS 2312.2 includes design advice on how the chemistry of some steels can be used to develop thicker coatings or when more durability is required than standard. In addition, when initial aesthetic appearance is important, the advice can be used to provide information on the typical coating characteristics, as described in Table 3.

continued over…

Table 3: The effect of silicon and phosphorus on hot dip galvanized coating characteristics.

Category	Si and P relationship		Initial appearance	Resistance to mechanical damage	Mass of coating	Typical use
A	Hot rolled	Si ≤ 0.04% Si+2.5P ≤ 0.09%	Excellent, typically shiny	Excellent	Standard; generally superior to the normal requirement	For compliance with Standard and excellent corrosion protection
	Cold rolled	Si + 2.5P ≤ 0.04%				
B	0.14% < Si ≤ 0.25%		Good, can tend to mottled or dull with increasing steel thickness	Good	Always heavier than normal; best specification for corrosive environments	Optimum long-term corrosion protection
C	0.04% < Si ≤ 0.14%		Can be dark and coarse	Reduced	Excessively thick coatings may occur	In non-abrasive environments can provide extreme corrosion protection
D	Si > 0.25%				Increases with %Si	

Figure 3: The Moment by Damian Vick, showing the four key stages of fabrication, galvanizing, painting and the final structure in place. This aesthetic sculpture is an example of a complex shape with sharp edges and is therefore suited to a duplex coating.

Painting over hot dip galvanizing (duplex coating)

An all new and detailed section on the **design** of duplex coatings (paint over HDG) is included, with two performance options for **durability** (aesthetic and corrosion). A duplex system will increase the service life of the HDG article beyond that of the unpainted article. Further, the total life of a properly specified, applied and maintained duplex coating system is significantly greater than the sum of the lives of the HDG coating and the paint coating alone (by 1.5 – 2.3 times, depending on the environment).

AS/NZS 2312.2 includes seven standard decorative and industrial paint systems suitable for most corrosivity environments and applications.

Engineering and fabrication design details

For engineers and fabricators, the design details are extensive and pictorial advice on good design practice provides clear instruction, such as the examples shown in Figure 4. The effect the fabricated article's condition has on the HDG process, for example the size of the article, laser cutting and other thermal processes, and required tolerances, are clearly described.

Appendices to the Standard also cover corrosion in different environments, including bimetallic corrosion and the interaction of HDG steel with soil, concrete, water, chemicals, and wood.

Summary

The new AS/NZS 2312.2 allows designers to more accurately estimate the durability of HDG coatings. In addition, the new Standard provides detailed design advice for duplex coatings, the effect of the steel chemistry and illustrates good design practice. It will serve as an essential aid for engineers, architects, specifiers and consultants for many years to come.

More information and free training on the use of AS/NZS 2312.2 and hot dip galvanizing in general is available from the Galvanizers Association of Australia (www.gaa.com.au) or Galvanizing Association of New Zealand (www.galvanizing.org.nz).

AS/NZS 2312.2 can be purchased from SAI Global (http://infostore.saiglobal.com/store/) or Standards New Zealand (www.standards.co.nz).

Peter Golding,
CEO, Galvanizers Association of Australia

Figure 4: Illustrations in Appendix A of AS/NZS 2312.2 allow the designer to improve zinc flow in the process, which will improve the aesthetics of the finished product, reduce the cost & eliminate danger to the galvanizing plant operators.

New Technology from Hempel improves zinc-rich epoxy primers

Hempel have developed a new technology that they claim improves the corrosion protection of traditional zinc-rich epoxy (ZRE) primers,which can still be applied using the same application techniques. This technology is called *AvantGuard*® and is said to make the metallic zinc pigment more active by combining it with hollow glass spheres and proprietary activators.

Introduction

Zinc coatings have a range of uses, including protecting industrial structures and equipment in tough C4 and C5 environments where saltwater and high humidity rapidly corrode unprotected steel. Zinc is more reactive than iron and so it acts as a sacrificial anode when in a protective coating, i.e. the zinc pigment corrodes instead of the iron to leave the steel intact. This process is known as the galvanic effect which requires the presence of electrical contact between the zinc particles.

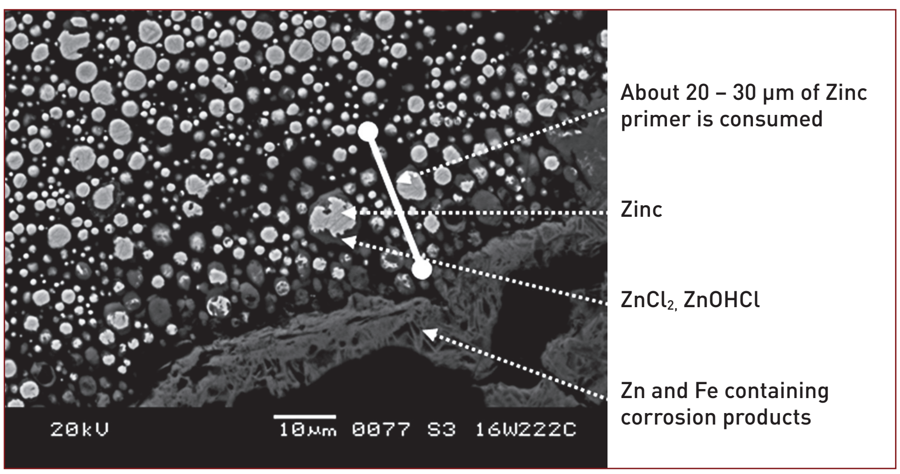
However, not much has changed within zinc coatings since they were first introduced in the 1960s. But,back in 2007, the R&D team at Hempel discovered that only around one-third of the zinc in a standard zinc epoxy provides galvanic protection.Hempel has now discovered a method of activating the zinc to improve the galvanic protection of zinc epoxy coatings.

Josep Palasi, Hempel's R&D Director, explained: "*Zinc is the single most important protective element in a zinc coating. However, our research showed that only the zinc in the first 20-30 microns of the coating is able to release electrons and become oxidised. As a normal zinc coating is around 60-80 microns, around two-thirds of the zinc is too far away from the point of corrosion and so is not able to protect the steel.*"

AvantGuard®

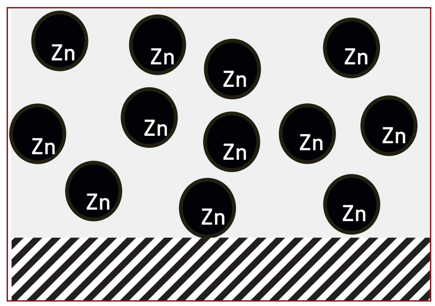
Hempel's solution was to combine the elements used in traditional zinc epoxies with two new substances: hollow glass spheres and proprietary activators. The new technology, known as *AvantGuard*®, can be used in all types of applications and leads to three main performance improvements over traditional zinc epoxies.

1. When the zinc particles and proprietary activators in the modified ZRE coatings come into contact with water and corrosive species, the proprietary activators increase the zinc particles' ability to release electrons. As a result, the zinc particles are activated throughout the whole film , which improves the galvanic effect without increasing zinc content. In addition, modified coatings are more water impermeable than unmodified ZRE and, once the zinc becomes oxidised, it forms a layer of insoluble salts on the surface and within the film that further increases the coating's resistance to water.

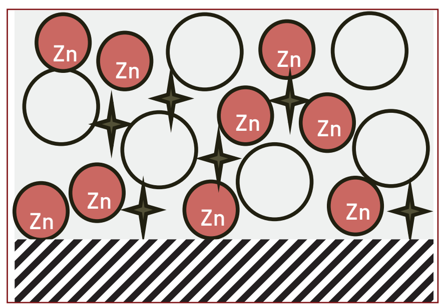


Claus Weinell, NACE 2007

Several experiments performed by Hempel between 2005 and 2007 explored the galvanic effect in zinc-rich primers. The experiments showed that in zinc epoxies with 80% zinc, only the zinc in the first 20-30 microns was consumed around the scribe area of a panel in a salt spray test.



Traditional zinc-rich epoxy



Zinc epoxy with AvantGuard® technology

2. Over time, chloride ions penetrate protective coatings and cause pitting corrosion, especially in aggressive saltwater environments. Hempel claim that their *AvantGuard*® modified coatings capture chloride ions by forming chloride-containing salts around the glass spheres. This significantly delays the corrosive process as some chloride ions are trapped in the coating so cannot reach the steel substrate.

Traditional zinc-rich epoxy 80%w zinc, 74 µm

Zinc epoxy with AvantGuard®, 79 µm

3. Zinc epoxies are often used for application where the steel is exposed to severe mechanical stress, such as during extreme temperature fluctuations found in some industries and environments. In a typical zinc protective system, the zinc primer is the weakest mechanical point and as a result, cracks can form in the coating as the steel expands and contracts. *AvantGuard®* coatings are different due to a phenomenon that Josep Palasi at Hempel calls "self-healing".

"When we put the *AvantGuard®* activated zinc epoxies through thermal cycling resistance tests, cracking tests and welding tests, we saw that they outperformed traditional zinc-rich epoxies with no activated zinc technology. The performance difference was extraordinary, and we were determined to find out why."

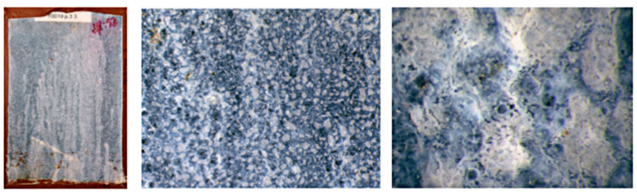
Hempel believes this improved performance is the result of two processes: the properties from the hollow glass spheres and the achieved positive effect from the unique zinc activation process.

Josep Palasi explains: "When a crack forms, the first penetrating step requires the most energy. After that, it takes very little energy for the crack to widen and affect the integrity of the coating. We discovered that the glass spheres could absorb most of the impact from the initial crack and stop it from developing. In addition, we observed that the sub-products formed during the zinc activation process actually occupy the space left by the micro-crack, preventing it from developing into a more serious crack. So we can say that *AvantGuard®* has a self-healing effect on micro-cracks, which is something that we have never seen before."

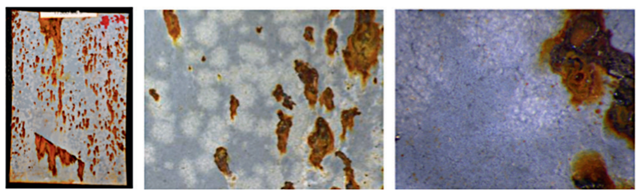
Hempel has recently launched HEMPADUR *AvantGuard®*, the first activated zinc primers to take advantage of their new technology. These coatings have been shown to outperform traditional zinc epoxies in tests performed by Hempel following international standards, including salt spray tests (ISO 12944 part 6), cyclic corrosion tests (ISO 20340 - NORSOK M-501 revision 6), water permeability tests (SSPC Paint 20 Type II) and thermal cycling resistance tests (NACE cracking test).

In addition, internal Hempel tests show that their modified coatings can be applied in both higher humidity and higher temperatures without blistering, and that there is reduced cracking risk at high dry film thicknesses.

(Ed: This article is based on information supplied to the ACA by Hempel)



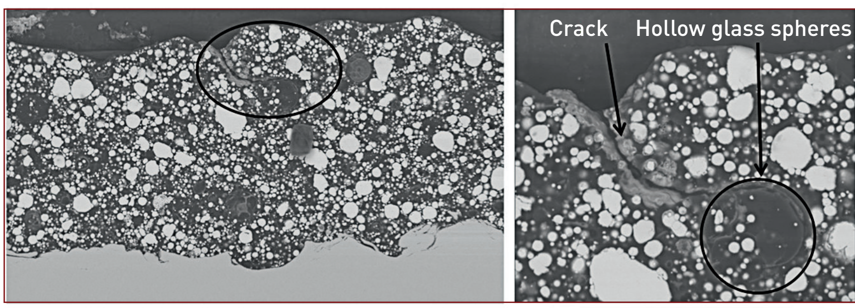
Zinc epoxy with AvantGuard® technology



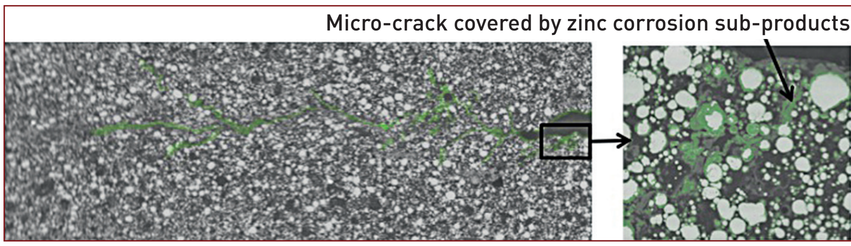
Traditional zinc-rich epoxy

When comparing traditional zinc-rich epoxies to AvantGuard® modified ZRE primers during salt spray tests, we see an abundant and uniform formation of a thin layer of zinc salts in the surface of the panel. This thin layer becomes an extra barrier against water and other corrosive species and helps improve the overall anti-corrosion mechanism. The tests were performed according to ISO 12944 (35°C, saturated atmosphere of an aqueous solution of NaCl (50 g/L)).

The pictures on the left shows the full panels, moving right the pictures show enlargements of the same panel.



The glass spheres in the coating absorb the impact of the initial crack and stop it from propagating. The picture on the right shows an enlargement of the crack seen on the left.



This SEM shows the hollow glass spheres forming at the base of a crack and stopping it from getting larger. The picture on the right shows an enlargement of the crack seen on the left.

Help is at hand for businesses looking to export

Many Australian businesses find that exporting can help to diversify their revenue, increase profits and provide opportunities for growth and expansion.

However, establishing a successful export operation is a large commitment for any business, which is why it's important to take time to fully understand what's needed before starting to look for opportunities.

Fortunately, there are a range of organisations and government agencies available to help businesses understand export markets and ensure they are well prepared before putting a foot out the door.

The foundations of export success

One of the first questions a potential exporter needs to ask is 'what do I want to achieve?'

Whether seeking an increase in scale or a diversification of revenue, clarifying what the business will achieve through exporting will help to confirm support internally. This internal support is important, as a successful export project requires involvement right across a business, particularly financially, but also in areas such as HR, logistics and sales.

Businesses will also find that integrating potential opportunities into day-to-day decision making ensures that when they win an export contract overseas, the people, procedures and financial support are already in place to execute it.

A useful starting point for businesses looking for more information on this aspect of exporting is state or city–based chambers of commerce. These organisations often provide useful information sessions and opportunities for businesses to network and connect with fellow exporters, or provide introductions to other exporters whose experience may offer useful insights.

Deciding on an export destination

It's crucial that businesses understand their export market, as not having enough market knowledge is a key reason why small and medium sized enterprises (SMEs) export plans can fail.

Australian businesses operating overseas often discover that local business practices, regulations, tax provisions and industrial relations policies differ significantly from comparable Australian norms. These differences could be minor, such as how often any local sales taxes need to be reported; to major differences which need to be built into any business case, such as legal

Case study

Industrial Protective Coatings Queensland

Industrial Protective Coatings Queensland (IPCQ) is a Queensland-based corrosion control specialist that operates in the petrochemical, gas and mining sectors.

Well-known within the industry and with a 25 year history, IPCQ's reputation for safety, reliability and customer service has helped it develop longstanding relationships with clients, suppliers, inspection authorities and local and state government agencies.

When IPCQ was awarded a contract from CBI Constructors Pty Ltd (CBIC, part of the CB&I group)to work on the INPEX Ichthys LNG project in Darwin, they needed to provide a performance and warranty bond to fulfil their contractual bonding obligations.

While their bank was very supportive of this contract and others in its pipeline, it required 100 per cent cash security before it could provide a bank guarantee. This would have tied up precious working capital which IPCQ needed available to secure new contracts as they arose, so their business consultant, recommended they speak to us.

Fortunately, as the contract meant IPCQ was operating as part of the export supply chain, Efic was able to provide a performance and warranty bond directly to CBIC, allowing IPCQ to secure this high-profile contract.

mechanisms which could allow the local government to repatriate a local operation and equipment.

The Australian Trade Commission, or Austrade, publishes a range of country profiles, which examine opportunities and provide insights into these local markets. Once a market has been chosen, an Austrade Export Adviser can often help with the finer details of getting export plans off the ground, such as planning trips to these markets.

Financing your export ambition

Another common problem encountered by potential Australian exporters is securing the much-needed finance to fund their export contracts.

Recent research we conducted found that over half of Australian SMEs expect access to finance will become more difficult over the next twelve months.

Much of this difficulty is related to the fact that SMEs' funding requirements often don't match the standard lending criteria of banks, making it difficult for them to attain the credit they need. Typically, banks will be looking for 'bricks and mortar' collateral, or significant assets to lend against; requirements that SMEs often aren't able to meet.

This finance is often the key to securing export contracts that may require substantial financial commitments up front in the form of performance and warranty bonds, or additional working capital to purchase new equipment and investment in growing the capabilities of the business.

SMEs who are having trouble accessing finance from their bank to fund an export contract may find that they're able to secure funding from other sources. This was the case when Industrial Protective Coatings Queensland faced difficulty securing funding for a major contract in an export supply chain and were able to secure finance from Efic, the Australian Government's export credit agency.

Taking the first step

Exporting can be a challenging undertaking, but is also extremely rewarding, with research by Austrade finding that companies who export are more profitable than those that only do business in Australia.

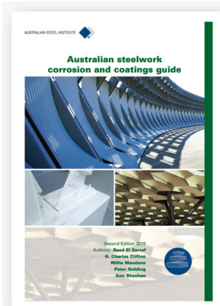
For any business interested in taking the first step towards exporting, or securing contracts in an export supply chain, it's worthwhile making use of the wide range of useful resources and specialist organisations available to assist with growing this aspect of their operation.

By Andrew Watson,
Efic Executive Director, SME

About the author

Andrew Watson is the Executive Director, SME, at Efic, a specialist financier that delivers simple and creative solutions for Australian companies to enable them to win business, grow internationally and achieve export success. (For more information see www.efic.gov.au).

Efic Finance for Australian Exporters



RESEARCH PAPER

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Trends In Long-Term Corrosion of Aluminium Alloys in Marine, Industrial and Urban Environments

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1. Introduction

Aluminium and its alloys are known to have excellent corrosion resistance, showing very little general and moderate pitting corrosion, including in seawater and marine conditions (Vargel 2004). This applies also to longer term corrosion behaviour (Schumacher 1979, Kreysa et al. 1992). For this reason aluminium and its alloys are the metals of choice for applications in the aerospace, defence and marine industries and increasingly they are being used in structural and other commercial infrastructure. For design of new infrastructure, prediction of likely future long-term behaviour is of interest and, consistent with modern methods for such prediction, this ideally requires the availability of models. Herein the firsts steps for such modelling are considered, respectively for corrosion loss and for pitting.

The favourable corrosion resistance of aluminium and its alloys is the result of the development of thin protective oxide films (Szklarska-Smialowska 1999). These can be achieved only in environments containing oxygen. Under these conditions the corrosion mass-loss usually is very small and tends to be non-uniform. Also, corrosion under these conditions usually is difficult to measure accurately and tends to show high variability. In some studies this has been circumvented by the use of average pit depth and average loss of tensile as alternate corrosion loss measures.

Corrosion observations for aluminium and its alloys that have been reported usually are for only short term exposures - such as for a few hours, days or weeks (see Ailor 1968 for a summary). There are some exceptions, particularly for atmospheric corrosion. For these 7, 10 and 20 years data sets have been reported, all in low to moderate temperature environments (Walton et al. 1953, Ailor 1968, Mattsson & Lindgren 1968, Sowinski & Sprowls 1982). The data from these studies invariably has been interpreted in terms of the well-known and widely applied power-law function for the corrosion of metals as a function of time:

$$c(t) = At^B$$

(1) with c is corrosion loss or pit depth, t is exposure time and A and B are constants obtained from fitting the function to data. Wide variation exist in the two constants between different sites, with, for example, B varying between 0.33 and 1.0 or more (e.g. Sowinski & Sprowls 1982). For example, for 10 years atmospheric exposure on the Spanish Mediterranean coast, a linear function was reported (Otero et al. 1978). This, of course, is the special case with $B = 1$. The theory has since been refined (Booth 1948, Evans 1960) and it has been shown that when applied to the marine immersion corrosion of steel Eqn. (1) is more consistent if considered not to apply immediately from first exposure and is limited to relatively short exposure periods (Melchers 2003a). This also results in much less variability in B. A recent review of many of the available data, including that for short exposure periods, concluded that Eqn. (1) is the most appropriate function for longer-term exposures (de la Fuenta et al. 2007). This was reported also for 10- and 20-year mass loss observations obtained in mainland China (Sun et al. 2009). In most cases support for the proposition that Eqn. (1) is a good fit to the data was obtained from plotting the data on a log-log plot. On such a plot Eqn. (1) is linear. However, on a log-log plot deviations from Eqn. (1) are much less obvious visually when compared to the same data represented on a natural axes plot.

The only long-term data for immersion and tidal corrosion is that from the Panama Canal Zone studies (Southwell et al. 1965) and these do not fit Eqn. (1) very well as will be described in the next section. It also will show that all of the data sets described in the open literature for the longer-term corrosion of aluminium and its alloys, including exposures in the atmosphere, in most cases do not show good agreement with Eqn. (1) when plotted on natural axes plots. Instead, most data sets have a trend much more consistent with the bi-modal form (Fig. 1) previously proposed for the corrosion of steel (Melchers 2003b, Melchers & Jeffrey 2008). The subsequent section considers why the bi-modal corrosion characteristic is appropriate also for aluminium. The proposed mechanisms governing the rate of corrosion are related to the build-up of corrosion products and the reduction in the rate of diffusion of oxygen to the corroding surface, including to any areas of localized corrosion (pitting). Eventually this creates conditions suitable for localized differential aeration, pitting and crevice corrosion under localized areas that are in an anoxic condition. The mechanisms are consistent with previously presented concepts for fast pit growth under autocatalytic hydrogen ion reduction and reducing pH within the pits. Since the main mechanism for aluminium corrosion involves pitting, some (limited) data for pitting corrosion also are considered and interpreted in view of earlier observations for the pitting of steels under long-term corrosion. Brief remarks are made about the possibility of microbiologically induced corrosion.

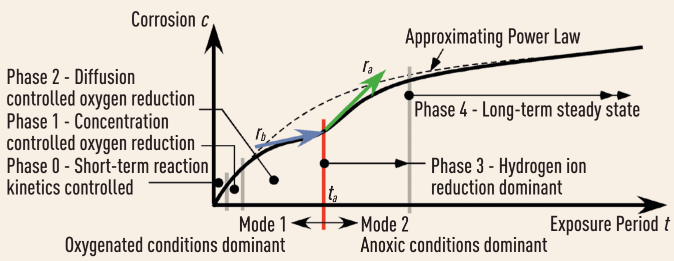


Figure 1. Schematic bi-modal model for long-term corrosion loss and pit depth in marine environments. In the idealized case the change from predominantly oxic to predominantly anoxic conditions occurs at t_a *with a change of instantaneous corrosion rate from* r_b *to* r_a*.*

2. Immersion Corrosion

Fig. 2 shows data sets for aluminium Al 1100 exposed for 16 years to seawater immersion and mid-tide conditions in the Panama Canal Zone (PCZ) Generally similar trends apply to Al 6061-T (Melchers 2014a). In both cases the data show a gradual decline in the rate of corrosion loss for the first few years. This is followed, after about 6 years of exposure, by a sudden and then declining increase. Obviously, this pattern is quite inconsistent with the power law Eqn. (1). Trend lines (light) have been drawn through the data using a standard smooth curve fitting routine employing the Stineman (1980) smoothing function. More generally, it can be seen that the light trends are broadly consistent with the bi-modal trend (Fig. 1). That trend is shown with the bold lines, termed 'interpreted' trends. They are anchored at the data points (i.e.

the reported observations) and then drawn subjectively using as a basis the expectation that the underlying data trends generally should be consistent with one another and with a bi-modal trend curve (Melchers 2014a). In these two cases little or no interpretation of the data is required to obtain a bi-modal trend curve.

For exposures in the (soft) fresh water Gutan Lake that is part of the Panama Canal Zone system, Fig. 3 shows the corrosion loss data and the trends as before, with the interpreted bi-modal trends in bold. Interestingly, the corrosion losses are very high compared with seawater immersion.

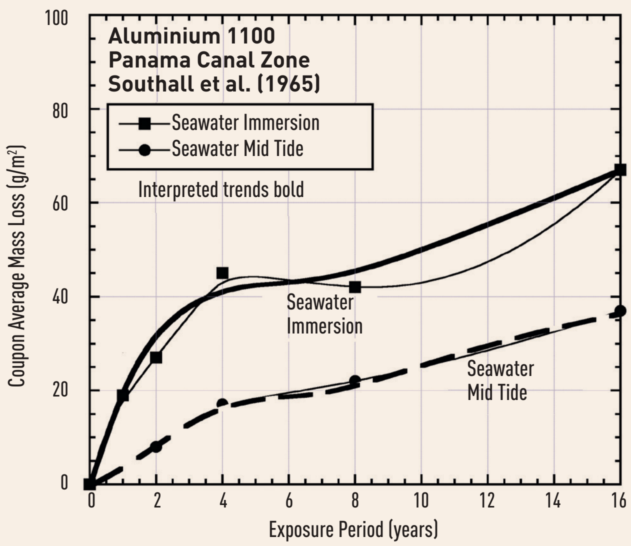


Figure 2. Data and interpreted trends for Al 1100 exposed to marine immersion and tidal immersion conditions. Data from Southwell, et al. (1965).

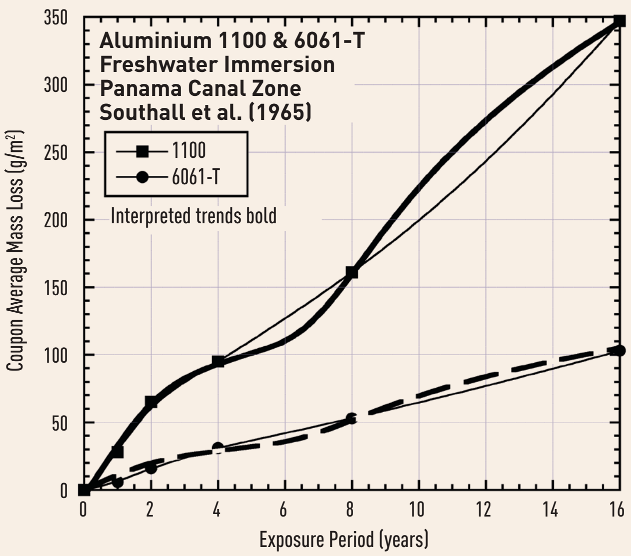


Figure 3. Data and interpreted trends for Al 1100 and Al 6061T exposed to freshwater immersion conditions (Gutan Lake, PCZ). Data from Southwell, et al. (1965).

3. Atmospheric Corrosion

For a number of different aluminium alloys Fig. 4 shows data for loss of tensile strength as a measure of coastal marine atmospheric corrosion over a 20-year period at La Jolla, CA (Walton & King 1955) together with interpreted trend lines. In two of the data sets inconsistency in data at year 6 is evident - both the corrosion losses before and after, at years 3 and 10, are much lower. This type of inconsistency is more likely for data sets with low overall levels of corrosion. However, consistency would be expected between all 4 sets of data and this leads to the interpreted curves shown. One point (marked) was adjusted to half its reported value - not inconsistent with failure to record one-sided corrosion losses rather than two-sided. Irrespective of this issue it is clear that none of the data sets in Fig. 4 could be interpreted as consistent with the power law (Eqn. 1), rather they tend to more consistent with the bi-modal characteristic.

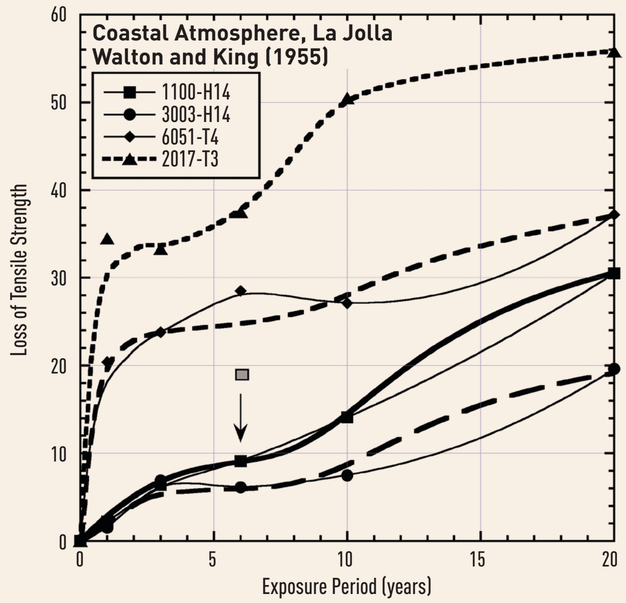


Figure 4. Loss of tensile strength data for several grades of aluminium under coastal marine atmospheric exposure conditions at La Jolla, California, together with interpreted data trends. Data from Walton and King (1955).

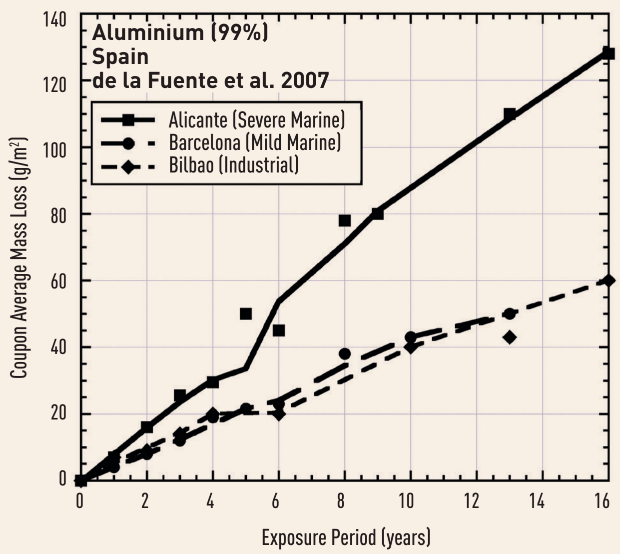


Figure 5. Data and trends, without interpretation, as obtained directly from the best-fit plotting routine, for 99% pure aluminium exposed to severe marine, mild marine and industrial atmospheres in Spain. Data from de la Fuente et al. (2007).

Fig. 5 shows average mass loss data for 99% pure aluminium exposed for up to 16 years to severe marine, mild marine, industrial and urban atmospheres in Spain (de la Fuente 2007). For these 3 data sets a weighted curve fit routine with a low level of smoothing (Chambers et al. 1983) produced the bi-modal trends shown. The same aluminium, exposed to rural and urban environments in Spain produced the data and trends shown in Fig. 6 (de la Fuente 2007). Previously, for the same test sites Morcillo et al. (1995) had noted that the mass loss data for the corrosion of steel, when plotted on log-log paper, showed two distinct non-overlapping trends. This is contrary to the single trend that would be observed if the data were consistent with the conventional power-law (Eqn. 1). To answer the question whether this is true also for aluminium, data in Fig. 6 was plotted on a log-log plot (Fig. 7). Although it is possible to represent all data iin each set by a single trend line (AB and CD, light broken lines) to be fitted through all the data but is it not a good fit. Better fits are obtained by the two distinct lines (shown in bold) one for each part of each data set. Such fits are mathematically equivalent to the bi-modal trends in Fig. 6.

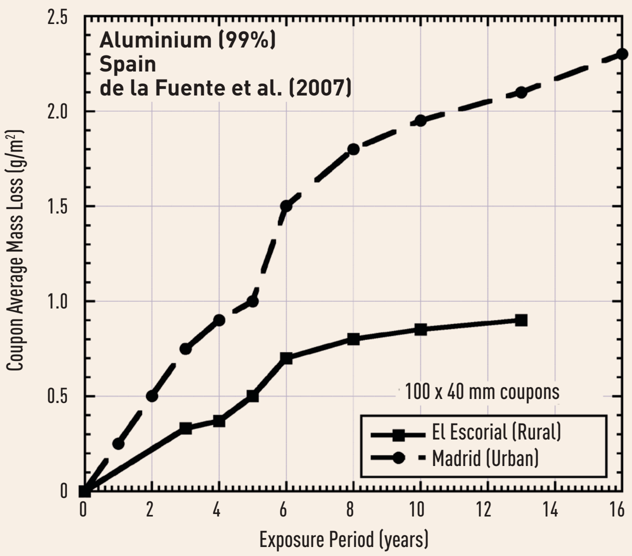


Figure 6. Data and trends, without interpretation, obtained directly from the best-fit plotting routine, for 99% pure aluminium in rural and urban atmospheres in Spain. Data from de la Fuente et al. (2007).

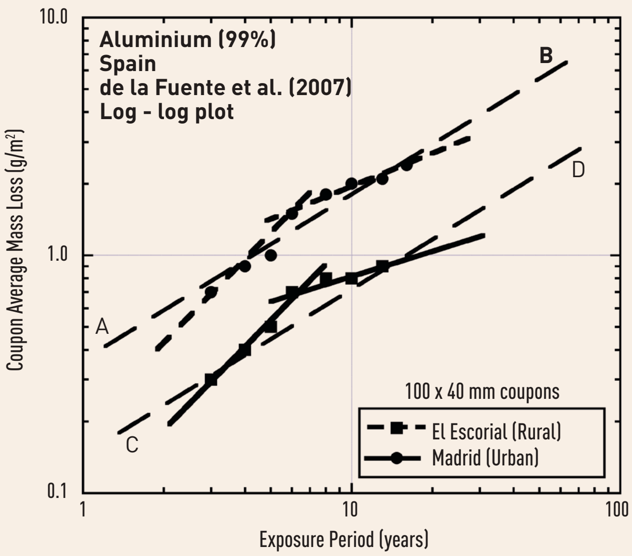


Figure 7. The same data as in Fig. 6 on a log-log plot showing two different linear trends for each data set, consistent with the bi-model model.

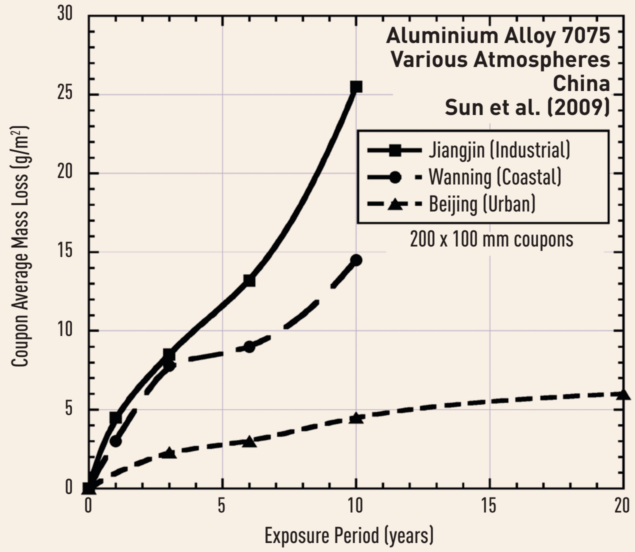


Figure 8. Data and trends, without interpretation for Al 7075 for industrial, marine coastal and urban exposures. Data from Sun et al. (2009).

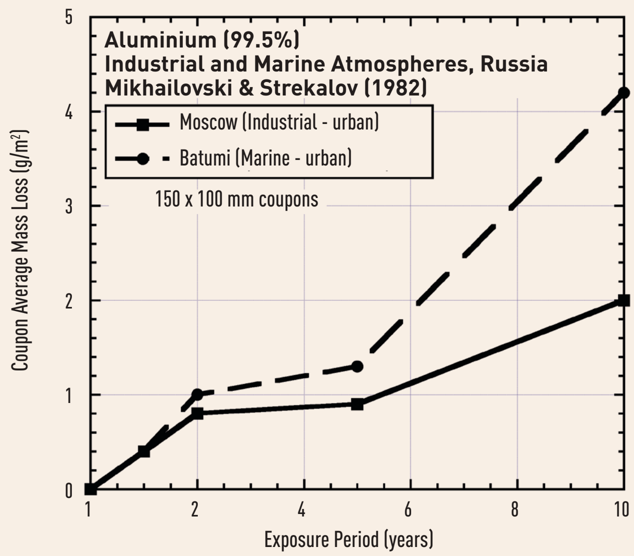


Figure 9. Data and piece-wise linear trends for 99.5% pure aluminium exposed to industrial-urban and marine-urban atmospheres. Data from Mikhailovski and Strekalov (1982).

Fig. 8 shows data obtained in China (Sun et al. 2009) for industrial, coastal and urban exposures. In each case the data sets are more consistent with bi-modal behaviour than with the power law. Finally, Fig. 9 shows data sets for marine-urban exposures and industrial-urban exposures in Russia over a 10-year period (Mikhailovski and Strekalov 1982). In both cases the data displays clear bi-modal characteristics. No interpretation is required. Similarly, for aluminium alloys 2024 and 7075 Mikhailovski & Strekalov 1982)

4. Pitting Corrosion

The data sets available in the open literature for pitting corrosion of aluminium are, perhaps surprisingly, small in number. Some data that can be considered for trending effects has been reported for atmospheric corrosion in Sweden (Mattson & Lindgren 1968). Fig. 10 gives two examples, for urban marine exposure and one for an industrial exposure site. No interpretation was required of these data - both show that the trend for pit depth is bi-modal. It is presumed that the data shown were the average values of the maximum pit depth measured on two or three replicate coupons. This has been the standard procedure for many years (e.g. Southwell, et al. 1958).

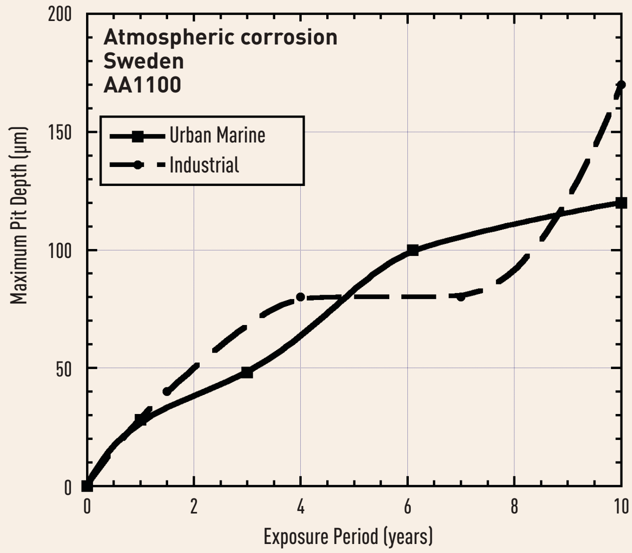
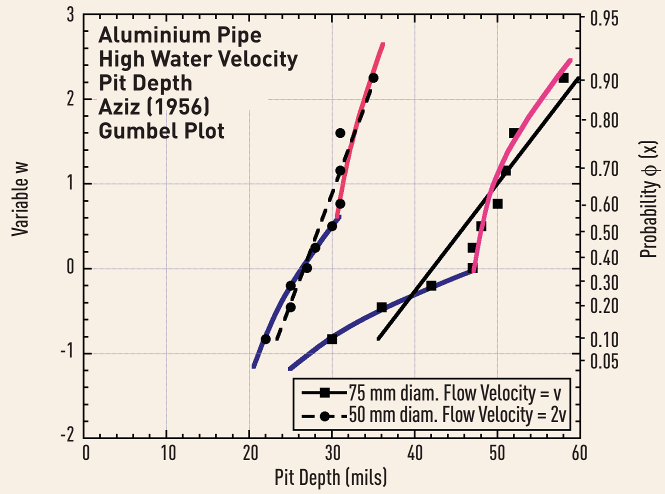


Figure 10. Data and best fit trends for AA1100 aluminium exposed in urban marine and in industrial environments showing that the trends are bi-modal also for pit depth. Data from Mattson & Lindgren (1968).

Usually there is considerable scatter in pit depth data. Of most interest in pitting corrosion is the probability of perforation, or, equivalently, the probability of a given maximum pit depth being reached. Analysis for this requires data for the scatter or variability in pit depths observed on a metal surface. The usual approach is to assume the that maximum pit depth is an independent random variable (or can be considered so asymptotically) and that all the sample pit depths are from one population. With this fundamental, although perhaps rather idealized, assumption statistical analysis can be applied. Since only the deepest of all pits are of interest the traditional approach has been to apply Extreme Value statistics to analyse the scatter in the deepest pit depth data (e.g. Galambos 1987). Such an analysis aims to relate the probability of a given pit depth being exceeded with the scatter in the data.

The Extreme Value distribution usually considered most appropriate for maximum pit depth data representation is the Gumbel EV distribution (Aziz 1956). Typically, the analysis proceeds by measuring a (considerable number) of the deepest pits, and then assigning each pit depth a cumulative probability. There are a number of such techniques. The simplest is the so-called 'rank-order' approach in which the pit depths are sorted in ascending order and then assigned a cumulative probability. Each pit depth value is then plotted on a so-called Gumbel plot against its assigned cumulative probability. A Gumbel plot is a special probability paper such that the data will plot as a straight line if the maximum pit depth y is Gumbel distributed (compare with Normal probability paper). The vertical (left) axis of a Gumbel plot is defined in terms of the standardized variable w that corresponds to the probability of exceedence $\phi(y)$ shown on the vertical axis at right. The theoretical details can be found in any standard text dealing with extreme value analysis (e.g. Galambos 1987).

The outcome of such an analysis can be illustrated with a set of maximum pit depth data reported by Aziz (1956) for a pipe of an unspecified aluminium alloy transporting water at unspecified high flow velocity. The reported data for deepest measured pit depths are shown on the Gumbel plot in Fig. 11(a). The straight lines shown are the best fit Gumbel lines for the complete set of data. They would be applicable if the whole data set was indeed Gumbel distributed. However, it is clear that each data set data can be interpreted also, and more accurately, in a different way, namely that each set consists instead of two sub-sets, marked with the two curves. In this interpretation the straight lines are not a particularly good fits. A better insight into the fitting issue can be obtained by plotting all the data on a Frechet plot, as in Fig. 11(b). It shows immediately that for each data set there are two distinct linear trends, indicating that for each data set one Frechet distribution is appropriate for smaller extreme depth pits and another for the deeper pits. When the straight lines in Fig. 11(b) are translated back onto the Gumbel extreme value plot of Fig. 11(a), they become non-linear. The resulting curves are much better fits to the data points than the straight lines in Fig. 11(a). Until recently this distinction in populations was not elucidated and analysts have simply lumped all data together and dismissed or ignored any variations about the line fitted through all the data. In so doing they implicitly ignored the mixing of distributions and assumed all the data as Gumbel distributed. Ultimately this was the result of the assumption that the pitting process is homogeneous and continuous in all respects.



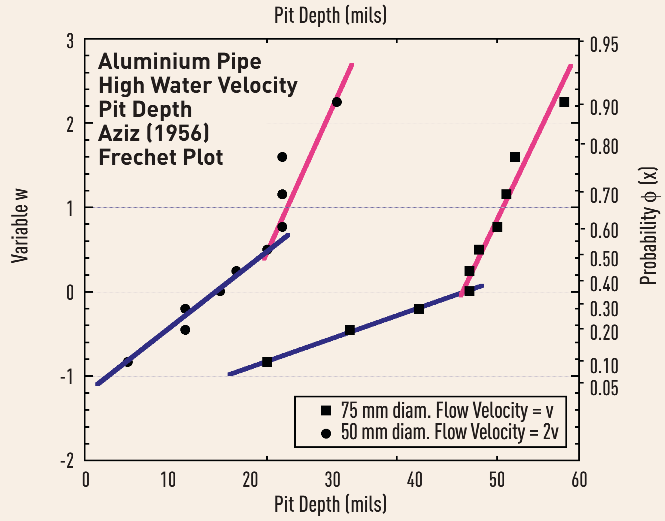


Figure 11. Examples of Gumbel plot with maximum pit depth data obtained at various exposure periods for aluminium pipe (a) showing with the straight line the conventional notion of one line through all data, and with the two curves discriminating between data sets, justified in (b) on the Frechet Extreme Value plot as Frechet distributed. Data from Aziz (1956).

5. Discussion

The pervasiveness of the bi-modal trend in Section 3 demands explanation. This is given below, but first it is noted that also the deviation from Gumbel for the deepest pits is of interest. As will become clear, the two phenomena are intimately related.

As is well-known, immediately after first exposure to air aluminium very quickly develops a thin, compact and highly corrosion resistant oxide (passive) film consisting, at ambient temperatures, of γ-alumina. This quickly hydrolyses, in the presence of water or moisture, first to a thin (2-3nm) layer of boehmite and other oxides in a complex mix of corrosion products. In the presence also of chlorides the corrosion products may include $AlCl_3$, $Al(OH)Cl_2$ and $Al(OH)_2Cl$, all in identified in practice, associated with highly acidic solutions and thus consistent with pitting as the principal form of corrosion for aluminium (Szklarska-Smialowska 1999, de la Fuente 2007). As corrosion progresses, the topography of the corroding surface becomes, at the micro-level, increasingly more non-uniform and more non-homogenous and, as a result, the built-up thickness and properties of corrosion product also become increasingly more non-uniform and non-homogenous. This is likely to produce local regions with very low oxygen concentration levels, with differential aeration cells likely to be established over the corroding surface. Superficially these will be randomly distributed. This establishes conditions sufficient for the initiation and progression of crevice and pitting corrosion under anoxic conditions (Shreir 1994). It can be considered the scenario applicable for $t < t_a$ In Fig. 1. For further corrosion under local anoxic conditions, the cathodic reaction must change to dissociation of water, with release of gaseous hydrogen initially being the rate controlling reaction (Melchers 2014a). This is supported, for example, by observations of hydrogen bubbling from corrosion pits (Bargeron & Benson 1980, McCafferty 2003). It is supported also by the step change in corrosion rate around time ta (Fig. 1) from the instantaneous rate of corrosion rb leading up to t_a and the rate r_a sometime after t_a (Fig. 1). This ratio will be 1:4 in the transition from inward oxygen effusion controlling the rate of corrosion to outward effusion of hydrogen controlling the instantaneous rate of corrosion after t_a. Effusion rather than diffusion is considered the appropriate mechanism since the barrier layer is likely to be very thin. The ratio 1:4 is the result of effusion being inversely proportional to the square root of the molecular masses of oxygen and hydrogen respectively. The trend lines for the plots in Figs. 2-9 can be made only subjectively and thus accurate assessment of r_b and r_a and hence the ratio r_a / r_b is not yet possible. However, visual inspection shows that in most cases the ratio is indeed around 4. This matter clearly requires more accurate investigation.

Of course, hydrogen evolution cannot remain the rate limiting step for very long since other corrosion products will effuse much less readily. While detailed investigation is still required, it can be proposed that the outward effusion, and perhaps eventually diffusion of a soluble aluminium corrosion product such as $AlCl_2^+$ may become rate limiting.

As noted in the introduction, the scenario of the development of aluminium corrosion having a bi-modal characteristic is parallel to the bi-modal characteristic for steel corrosion. For steel corrosion this has been argued to have implications also for the development of pitting corrosion and thus for the representation of pit depth uncertainty (Melchers 2008). Given the closeness in pitting progression mechanisms between steel (Wranglen 1974) and development of pitting corrosion for aluminium (Wranglen 1972, Shrier 1994), it is likely that there are similar issues involved in the reasons for the Frechet probability distribution. However, unlike marine corrosion of steel, it is generally considered unlikely that the marine corrosion of aluminium involves the influence of microbiological activity (Amonette et al. 2003, Little and Lee 2007). This scenario is not, however, inconsistent between the two metals, since it has been proposed that although pitting in steel could be influenced by microbiological activity, it need not be, even if very aggressive (Melchers 2014).

6. Conclusion

The empirical data drawn from a wide variety of sources shows that the trend for the long-term corrosion of aluminium is more consistent with the bi-modal function than with the classical power-law function. This is demonstrated here for examples of the corrosion of aluminium alloys exposed to seawater and fresh water immersion and also for exposures to marine, industrial, urban and combined environments.

As for the corrosion of steels, bi-modal function is considered to result from the build-up of corrosion products causing a change in the corrosion process from initially governed by oxygen reduction to one later being controlled later initially by hydrogen ion reduction. The eventual long term corrosion rate is considered to be rate-controlled by metal ion diffusion. Apart from initial corrosion, all the rate controlling steps are either diffusion or effusion rate-controlled processes. The precise mechanisms involved, particularly in the transition from oxygen control to hydrogen evolution control and for the longer term metal ion controlled behaviour remain matters for further research.

For pitting of aluminium an example is given that indicates that, like pitting of steels in marine environments, the statistics of maximum pit depths for aluminium is better modelled using the Frechet extreme value probability distribution rather than by an extension of the Gumbel distribution that is applicable to less deep pits in a cohort of maximum pit depth observations.

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