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CORROSION & MATERIALS

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OIL & GAS FEATURE

Inside this Issue:

Australasian Corrosion Association Inc. — Semper Tuens

CORROSION & PREVENTION 2017

PROUDLY PRESENTED BY: CORROSION ASSOCIATION AUSTRALASIAN INC.

MAJOR SPONSOR: JOTUN

FIRST ANNOUNCEMENT & CALL FOR PAPERS

CALL FOR PAPERS

Submissions are now open and welcomed on all aspects of corrosion and its control for Corrosion & Prevention 2017. Papers are subject to peer review and if accepted will be published in the Conference Proceedings.

Critical dates for acceptance of abstracts and papers are:

CLOSE OF ABSTRACTS: 20 MARCH

ACCEPTANCE OF ABSTRACTS: 10 APRIL

RECEIPT OF PAPERS: 9 JUNE

SUBMIT AN ABSTRACT

Please refer to www.acaconference.com.au for further information about the submission process.

GUIDE TO SUBMISSION

Papers submitted to the Corrosion & Prevention 2017 Conference must be an unpublished original work. It is the responsibility of the author to obtain necessary clearance/ permission from their organisation. Copyright of the paper is assigned to the ACA. Abstracts should include the names of all authors, an appropriate title and a brief summary. All authors who are accepted are required to present their paper at the conference.

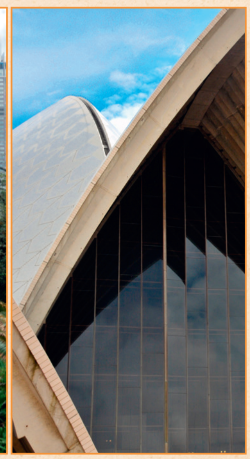
THE DESTINATION - SYDNEY

Known the world over as Australia's 'Harbour City', Sydney is blessed with stunning natural landscapes and a near-perfect climate. Living is serious business in Sydney which is fun loving and full of energy. Delegates will have the opportunity to choose from the many attractions that Sydney and the surrounds have to offer, with activities to suit all tastes ranging from fine restaurants, arts and culture, shopping, family attractions, visiting the Iconic Sydney Opera House or Sydney Harbour Bridge, pristine beaches or Taronga Zoo.

Sydney is also home to world-class meeting infrastructure and accommodation options. Just as importantly, it offers easy accessibility between the airport, conference facilities and the city centre, and is a safe and stable destination for international visitors and locals alike.

Sydney ticks all the boxes!

Check it out:
www.sydney.com



TECHNICAL TOPICS

Corrosion & Prevention 2017 invites technical papers on all subjects related to corrosion. The conference will bring together leading researchers and industry practitioners who combat corrosion on a daily basis. Diverse technical streams will showcase the latest developments in corrosion, ranging from fundamental corrosion science to hands-on application. Submissions may include research papers, review papers and case studies related to the technical streams and industry sectors below:

TECHNICAL STREAMS

Concrete
- Concrete deterioration
- Reinforcement corrosion
- Concrete coatings & repair
- Cathodic protection of reinforcement

Steel Corrosion
- Coating of steel structures
- Cathodic Protection of steel structures
- Microbiological induced corrosion of steel
- Steel in a marine environment

Water Infrastructure
- Pipe corrosion and Condition Assessment
- Water Treatment Plant & Waste Water Treatment Plant Corrosion

Oil & Gas
- CP of pipelines
- Refinery issues
- Marine structures

High temperature corrosion
- Non-ferrous metal corrosion
- Other Corrosion issues

INDUSTRY SECTORS

This conference will have material of value to those working with the following industries:

- Building and construction
- Cultural and historical materials preservation
- Defence, aviation, maritime
- Education and research
- Food processing
- Government
- Marine, transportation and infrastructure
- Mining and resources
- Oil & Gas
- Power Generation and energy systems
- Water and wastewater

CONFERENCE ORGANISING COMMITTEE

- Simon Krismer (Conference Convenor)
- Matthew Dafter
- Brad Dockrill
- Callan Herron

CONFERENCE TECHNICAL COMMITTEE

- Bruce Hinton (Technical Chair)
- Rob Melchers
- David Nicholas
- Mike Tan
- Geoff White

SPONSORSHIP AND EXHIBITION

Sponsorship will enable your organisation to make a significant contribution towards the success of Corrosion & Prevention 2017. In return, the conference offers strong branding and exposure in a focused and professional environment. As with every Conference the exhibition will form an integral part of the activities. It provides companies with an opportunity to come face to face with the delegates, providing a marketplace to increase your organisation's visibility and to showcase and demonstrate your products and services.

For further information, please contact Lucy Krelle, Event Manager at the Australasian Corrosion Association +61 3 9890 4833 or email lkrelle@corrosion.com.au who will assist you with your enquiry.

YOUR HOSTS

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

AUSTRALASIAN CORROSION ASSOCIATION INC. SEMPER TUENS

The mission of the ACA is to be leaders throughout Australasia in disseminating knowledge to enable best practice in corrosion management, thereby ensuring the environment is protected, public safety is enhanced and that economies are improved.

www.acaconference.com.au




Corrosion & Materials

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

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

The Australasian Corrosion Association Inc

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

Front Cover Photo: Low pressure water washing a natural gas main line valve, after an algaecide application.
Photo courtesy Craig Ross at NSB Infrastructure.

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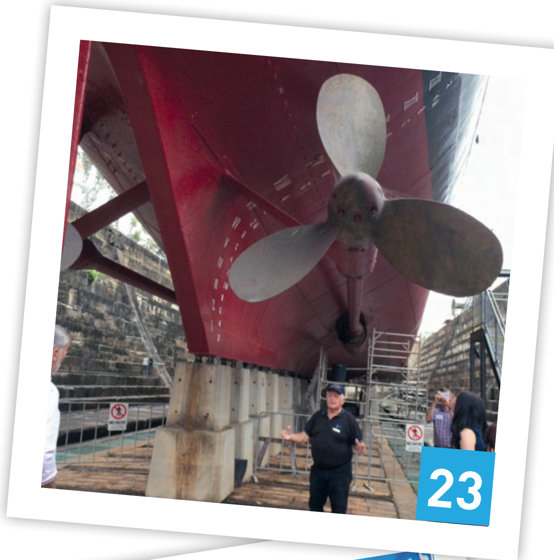

Dr Matthew Dafter
President

I am honoured to serve as the President of the Australasian Corrosion Association Inc. in 2017, until the conference this November in Sydney.

As possibly one of the younger Presidents in recent memory, I am honoured to have been entrusted to this role, and I acknowledge the experience of my learned colleagues who have shown such generosity in sharing their time and expertise in mentoring myself and other younger professionals in the industry.

It is this sharing of knowledge by our more experienced members that is vital to the longevity of the Association and the maintenance of high professional standards. The ACA supports a range of initiatives to foster professional development, including scholarships for travel and study and having been a recipient myself of an ACA travel scholarship, I can attest to the value of such an opportunity and the professional enrichment that it provides.

The Association continues to thrive and serve its members and the broader profession through a range of technical seminars, publications, training and professional development opportunities, and the annual conference.

I would encourage all members to take advantage of the professional development opportunities offered by the Association.

The ACA hopes to continue to deliver on our mission statement of 'assisting society to manage the impact of corrosion on asset durability' by focusing on four strategic areas of: membership, training, advocacy & communications as well as governance. In these challenging economic times, our Association continues to diversify our training programs, and continually strives to offer a range of relevant services to our members.

On behalf of all ACA members I would like to extend my sincere thanks to the many individuals who contribute to the successful functioning of the Association, whether it be by contributing to a local Branch, a Technical Group committee, Council, representing on Standards, etc.

Thanks must also go to the outgoing President, John Duncan, and the Board, for their hard work and dedication to the Association. I trust that 2017 will bring continued opportunities for our members, and I look forward to seeing many of you at the 2017 conference.

Dr Matthew Dafter
President

ACA 2017 Events

Part of the role of the ACA is to organise events that bring together industry experts to present on new technologies, updates to standards, and share knowledge and experiences via case studies on a variety of projects. Here are the events planned for 2017.

February

Oil & Gas (part of the AOG conference)
22-24 February | Perth

May

Introduction to Corrosion
Thursday 4 May | Adelaide

Protecting New Zealand Infrastructure
Thursday 11 May | Auckland

Introduction to Corrosion
Thursday 18 May | Perth

Corrosion in the Oil & Gas Industries
Tuesday 23 May | Brisbane

June

Australian Electrolysis Committee
Friday 26 May | Melbourne

Pipeline Corrosion Management
Thursday 29 June | Melbourne

July

Brian Cherry Symposium - Concrete
26-27 July | Melbourne

August

Corrosion in the Oil & Gas Industries
Tuesday 22 August | New Plymouth

Corrosion & Asset Management
Thursday 31 August | Sydney

September

Coatings
Thursday 21 September | Tasmania

Branch Events

Each of the 8 ACA Branches will conduct regular technical events throughout 2017. 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

THE AUSTRALASIAN CORROSION ASSOCIATION INC
YOUNG CORROSION GROUP

Wesley Fawaz
Executive Officer

Happy New Year! I hope you thought of the ACA to help motivate you to progress your career and professional development while making your 2017 New Year resolutions.

Whether you're a job seeker, a career climber or an 'old dog' learning new tricks, this year, resolve to advance your education and learn some new skills with a course, conference or technical event from the ACA. By attending any of these ACA activities you will have a chance to network, more opportunities may come your way and you will leave with a refreshed perspective on your career.

Or perhaps you need to put more energy into training and developing your staff. If you're looking to fulfill a specific need for your organisation, consider an ACA 'in-house' course that can be brought to your location when it's convenient for you.

A great opportunity to build your profile in the industry is by making a presentation at the conference. To be held at the brand new International Convention Centre in Sydney, it's one of the finest convention centres in the world located in the busy precinct of Darling Harbour. It's a big convention centre and we will need a big attendance which all starts with an attractive technical program. The Call for Papers is now open and I encourage you all to consider submitting an abstract.

The ACA has recently started progress on its 2017-2019 strategic plan:

- The Board agreed to proceed with conducting two workshops facilitated by GHD to scope out a potential Cost of Corrosion Study. The first workshop was held in December with the second this month and I am also currently seeking government funding opportunities to undertake the study.
- If you are interested in joining a new working group for a 12 month project (linked to the ACA strategic plan) to review the current membership structure, develop strategies to enhance the member value proposition and to ensure existing members see the clear benefits of maintaining their ACA membership, you can email me at wesley.fawaz@corrosion.com.au
- New committees for contractors and asset owners have been established with the aim to enhance these groups involvement in ACA activities. The committees are currently developing their terms of reference and objectives and members will benefit from their work this year.

Applications for the newly created Sales & Business Development Manager role with the ACA closed at the end of January and I hope to make an announcement soon of the successful candidate. The purpose of the role is to research markets and promote the ACA membership, training courses and technical events as well as coordinating future course development in order to meet the strategic objectives of the organisation (specifically training and membership).

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

THE AUSTRALASIAN CORROSION ASSOCIATION INC.

TRAINING

ACA Training Calendar 2017

ACA/ACRA Corrosion & Protection of Concrete Structures

Member $1115   Non-member $1395

Melbourne   March 7-8
Sydney   June 5-6
Brisbane   September 11-12

ACA Coating Selection & Specification

Member $1560   Non-member $1900

Adelaide   March 27-29
Brisbane   June 14-16
New Zealand   August 28-30
Melbourne   October 16-18

Corrosion Technology Certificate
(Also offered as Home Study)

Member $2330   Non-member $2730

Perth   May 1-5
New Zealand   October 2-6
Melbourne   November 27 - December 1

Hot Dip Galvanizing Inspector Program

Member $1560 Non-member $1900

Tasmania   February 27-28
Melbourne   March 30-31
Adelaide   June 1-2
Perth   June 26-27
Sydney   September 14-15
New Zealand   November 28-29

NACE Cathodic Protection Program CP 1 –

Australia Member $3335 Non-member $3670
Thailand Member $2600 Non-member $2850

Thailand   March 6-10
Brisbane   May 8-12
Perth   October 9-13
Thailand   October 30 - November 3

NACE Cathodic Protection Program CP 2 –

Australia Member $3335 Non-member $3670
Thailand Member $2600 Non-member $2850

Thailand   March 13-17
Brisbane   May 15-19
Perth   October 16-20
Thailand   November 6-10

NACE Coating Inspection Program CIP 1

Australia Member $3740 Non-member $4275
Thailand Member $2950 Non-member $3180

Cairns   February 20-25
Thailand   March 6-11
Brisbane   April 3-8
Perth   May 8-13
Adelaide   May 15-20
Sydney   June 19-24
Melbourne   July 3-8
Vietnam   July 10-15
Brisbane   July 31 - August 5
Perth   September 11-16
New Zealand   October 9-14
Sydney   November 6-11
Thailand   November 27-December 2

NACE Coating Inspection Program CIP 2

Australia Member $3740 Non-member $4275
Thailand Member $2950 Non-member $3180

Thailand   March 13-18
Adelaide   May 22-27
Vietnam   July 17-22
Brisbane   August 7-12
Perth   September 18-23
Thailand   December 4-9

Prerequisites now apply to this course.

NACE Pipeline Corrosion Integrity Management

Member $2950 Non-member $3250

Perth   June 19-23
Melbourne   June 26-30

SSPC Concrete Coating Inspection Program

Level 1 $3000 Level 1 and 2 $3500

Melbourne   May 1-5

IN-HOUSE TRAINING

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

The ACA can present any of its courses exclusively for an organisation; we can also tailor any course to your organisation's specific needs. Please contact the ACA's training department on +61 03 9890 4833 or aca@corrosion.com.au

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

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

Surface Coatings Protecting Townsville Assets

The economic impact of corrosion is often exacerbated in humid, tropical conditions found in areas such as northern Queensland. The moisture and heat accelerate the deterioration of machinery, vehicles and assets. Applying a protective surface coating is one way of minimising or reducing the effect.

"Our company started out as domestic and commercial painters, so our journey has been different to many other applicators," said Haydon Mann, Director of Rhino Linings Townsville. "However, the Rhino Linings dealership has allowed us to move into all sorts of other asset protection work."

When the opportunity of taking up a full dealership came up, Mann didn't have to deliberate long before accepting. "Lots of the techniques you learn as a painter are the same for using Rhino Lining's spray polymers," said Mann. "Most important is that preparation is key to getting a great finish."

During his company's first year as an applicator/dealer, Mann's staff worked a diverse range of projects which included coating a whole boat, cane harvester spirals and other farm equipment, in addition to vehicles and floors.

Mann stated that a compelling reason for taking on the dealership was the support that his company had been given. "The support staff would do anything to help us when we phoned and give us advice based on their breadth of knowledge and depth of experience."

"Up here in the North, we can sometimes be forgotten or dismissed by suppliers and companies in the big cities," Mann added. "Rhino Linings would always be willing to develop a plan or share a case study for a similar situation."

Rhino Linings Australia manufactures locally so applicators and customers are not dependent on delivery schedules from an overseas supplier. The company also assists its dealers in developing best method procedures and practices for chemical handling and machinery used to apply the company's products.

New ACAF Project Manager

The ACA Foundation Board is pleased to welcome Linda Lawrie to the new role of Project Manager.

Linda has been engaged to manage a series of exciting projects designed to lift the profile of the Foundation's work within schools and the wider community, and to administer the Foundation's scholarship program.

Linda has experience in both Project Management and Executive Officer roles in government and the not-for-profit sector. In 2016 Linda was engaged as a freelance Executive Officer in the veterinary pathology and health services industries. Linda also has considerable experience within the education and training sector having worked as a TAFE lecturer in Business Management earlier in her career. This was followed by 15 years as a private training consultant to business and government.

Linda has a Bachelor of Arts, Diploma of Education and Certificate IV in Training and Assessment which enables her to deliver nationally accredited training.

Linda can be contacted at the email foundation@corrosion.com.au and welcomes input from ACA members, Foundation donors and the community, on the Foundation's initiatives.

300 Years of Combined CP Field Experience

CORROSION CONTROL ENGINEERING

At a recent meeting in Sydney, Corrosion Control Engineering's senior management team celebrated a combined 300 years' experience in the field of cathodic protection and asset integrity management.

Corrosion Control Engineering commenced operation in Sydney in 2001. In the last 15 years, additional offices have been established in Melbourne, Brisbane, Townsville, Perth, Auckland and New Plymouth.

CCE is Australasia's largest and most experienced Cathodic Protection specialist, with approximately 80 employees, the majority of whom are corrosion engineers and field technicians.

Pictured from left to right are Daryl McCormick, Jim Galanos, John Grapiglia, Jim Steele, John Kalis, Peter Kalis, Jason Paterson, Grant Chamberlain and Grahame Strong.

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ACA Welcomes New Members

Corporate Bronze

Absolute Blast Ltd
www.absoluteblast.co.nz
Absolute Blast is a specialist Protective Coating, Grit blasting and Industrial coatings company supplying a fast, efficient coating and blasting service throughout New Zealand using processes such as; glass bead, garnet and steel grit blasting, paint spraying and thermal zinc coating using arc spray.

Absolute Blast Steel blasting and coatings work covers a wide range of Commercial and Industrial industries including the: Engineering, Transport, Waste removal, Construction, Restoration and Petrochemical industries.

Rema Tip Top
www.rema-tiptop.com.au
Since 1923 the STAHLGRUBER group has been delivering top quality for satisfied customers. Today subsidiaries and agents represent the brand REMA TIP TOP in over 170 countries around the globe. The continual expansion of national and international market activities and the expansion and optimization of the sales structure, service and product range guarantee customers the best possible performance.

Another secret of the REMA TIP TOP success is the global interaction between high-value products, professional services and experienced and highly qualified employees. The worldwide REMA TIP TOP network permits them to pass on their know-how and thus learn from each other on a daily basis. In this manner they can guarantee absolute reliability and dependability and contribute to the success of their customers.

Australian Inhibitor
www.australianinhibitor.com.au
Australian Inhibitor is dedicated to providing unsurpassed protection from corrosion to all ferrous and non-ferrous metals and alloys. Their VCI's form a physical hydrophobic layer that prevents water & moisture directly contacting the metal surface. Their VCI solutions will protect product on the shop floor, in storage & in the field.

Complete Steel Projects
www.completeprojects.com.au
Complete Steel Projects was established in 2005 as a steel fabrication company. Since then the company has expanded its range of services to include rigging, cladding, blasting, painting and equipment and HR solutions in response to the demands of the mining and resources sectors. Their commitment to guarantee client satisfaction in a safe, economical and ethical way has seen them become the preferred provider for many of the industry's best known companies. They believe our strength comes from the commitment and diverse experience of our employees, their efforts in maintaining our company ethos and our dedication to both their personal development and their safety.

Dalrymple Bay Coal Terminal Pty Ltd
www.dbct.com.au
Located at the Port of Hay Point, Dalrymple Bay Coal Terminal (DBCT) is part of one of the largest coal exporting ports in the world. The terminal operates around the clock exporting thermal and metallurgical coal from Central Queensland's Bowen Basin mines to ports around the world.

The terminal is a common user facility, owned by the Queensland State Government and leased to DBCT Management (DBCTM) on a 50 year lease, with a 49 year option, to operate, maintain and develop the terminal.

Dalrymple Bay Coal Terminal Pty Ltd (DBCT P/L), a company owned by a selection of mining companies using the terminal, is contracted by DBCTM under an Operations and Maintenance Contract (OMC) to operate and maintain the terminal on a daily basis.

With an uncompromising dedication to ensuring the safety of its people and the surrounding community, coupled with an unparalleled persistence to achieve operational excellence, DBCT P/L has been reliably exporting coal to the world for 30 years.

A.HAK Industrial Services
www.a-hak-is.com/en
A.Hak Industrial Services (better known as HIS) provide a complete range of services to the oil, gas and petrochemical industries around the world. Through their Pipeline, Inspection, Storage Tank and Industrial service lines, they can assist you in every step of your plant operation – from design to end-of-life – to assure the best possible operation throughout your installation's work cycle.

As operation costs continue to rise – certainly in a challenging economic cycle – it's important to keep pipelines, storage facilities and every related aspect of your installation in top working order. By offering integrated services, they can assure maximum plant integrity and sustainable operation.

HIS is based in The Netherlands and maintains offices in Brazil, France, Germany, Italy, Malaysia, Romania, South Africa, Spain, the United Arab Emirates, the United Kingdom and the United States.

AUSTRALASIAN CORROSION ASSOCIATION INC.
SEMPER TUENS

PACIFIC CORROSION CONSULTANTS LTD

BACKGROUND

Pacific Corrosion Consultants Ltd (PCC) is a new division of LTH Ltd, the umbrella company for a number of specialist consultancy teams with its foundations in the power engineering field. Linetech was formed in 2004 with a merger of Linelink Ltd and Power Line Solutions (NZ) Ltd. The original Linelink company was formed in 1994 as a result of the privatisation of the electricity industry in New Zealand.

In the early 1990's Wal Marshall and Mike Boardman, now both Directors of LTH were instrumental in developing the Transpower transmission tower painting refurbishment program. The work included developing the process methods, specifications, training and Contractor development. Now, some 25 years later, the tower structure maintenance program is Transpower's largest area of expenditure.

The PCC team has since grown to be the largest independent 3rd party coatings inspection group in New Zealand with around ten staff with ACA and NACE certification.

PCC – THE NEW BOY ON THE BLOCK?

Whilst the servicing of the transmission tower work has been our mainstay, through our reputation, we were developing a market outside these areas, predominantly infrastructure. With this ever-expanding client base, it was decided that we needed a platform that reflected the broader capability and experience of corrosion and coatings consultancy both within New Zealand and the wider Pacific area. At the same time, there is an increased public scrutiny of infrastructure asset management and the demands for reliability, durability and on-going safety expectations. By providing our clients with easily understood, comprehensive advice and assessment information we have been able to secure on-going business relationships with many of New Zealand's major asset owners.

CAPABILITIES

Our experienced and qualified inspection team are able to carry out that critical element in asset management - accurate condition assessment. Armed with a detailed picture of the subject, we can develop the optimal protective coating maintenance strategy. Supported by experienced specification designers, PCC can provide comprehensive, tailored specifications to fit into the Client's work package documentation. During the course of the project we can provide third party compliance inspection services and on-going advice to both Client and Contractor as required.

Where there are protective coating issues, we have team members capable of carrying out coating failure investigation, analysis and remediation services. Our transmission tower climbing capability together with rope access (IRATA) and confined space training and high resolution UAV (drone) operations allow us to get access to challenging structures throughout NZ, Australia and the Pacific.

PCC PACIFIC CORROSION CONSULTANTS

ACA Auckland Site Visit Report

October 2016.

A group of ACA members and guests were given a conducted tour around the Steel & Tube Stainless plant in East Tamaki, Auckland, on the evening of 19th October 2016. Our host for the tour of the **S&T Stainless** plant was Russell Thorburn, Business Development Manager – S&T Stainless.

The S&T Auckland site is the main distribution warehouse for stainless steel, engineering steels, Blucher plumbing-drainage solutions, and Rimex architectural metal finishes. The plant also encompasses sales of the ComFlor composite decking system.

The site visit enabled the attendees to view the S&T steel product range, processing facilities, and the scale of the S&T Auckland operation.

The tour started with a live viewing of a slitting machine, cutting 1.5mm grade 304 SS coils into various sizes of flat sheets. The SS sheets, with 2B mill finish, were then put through a dedicated polishing machine to produce a No.4 satin finish on the SS sheet – a finish that is much favoured by architects. The tour continued through the factory and warehouse where attendees viewed the carbon steel (CS) cutting facilities, storage facilities for CS and SS, and the Blucher 316 SS press-fit plumbing/drainage pipework and fittings held in stock.

The tour continued with Russell outlining the S&T operations throughout the country, a demonstration of the SS press-fit system, and SS products that are employed in architecture, building and construction. The meeting concluded with refreshments, kindly provided by S&T, and further discussion. Finally, ACA Auckland Chair Raed El Sarraf thanked Russell Thorburn for the excellent tour and a very informative explanation of the wide S&T Stainless product range available in NZ. **Les Boulton**

Vic Christmas Trivia Night

On the 7th of December the Victorian Branch of the ACA got together to share in some Christmas cheer. This year the Christmas party was a trivia night at the Waterside Hotel in Melbourne. Approximately 40 members and partners attended to join in the merriment. The victors were presented with certificates and chocolates while the team who came last received wooden spoons (still a practical prize in the end!). **Candice Blackney**

Newcastle Christmas Event

The Newcastle Christmas Event was held on Wednesday 14 December 2016 at The Beach Hotel. 31 people attended the event. Robert Jeffrey presented – 'Corrosion of Stainless Steel Pool Fittings'. **Simon Krismer**

QLD Branch Christmas Wrap Up

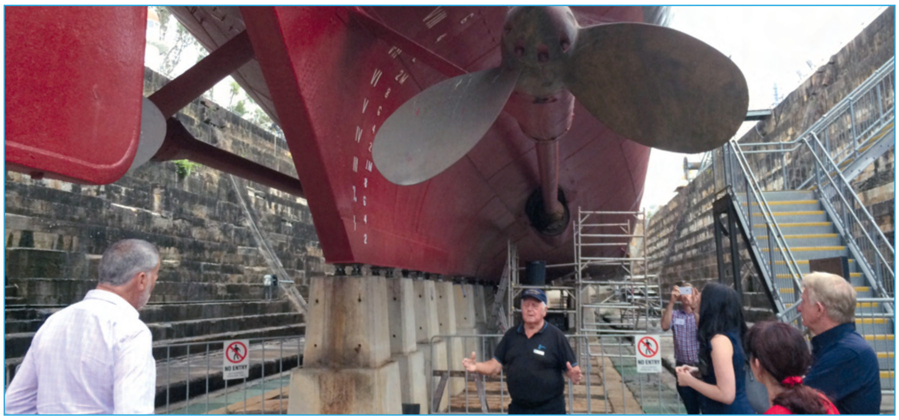
The Queensland Branch of the ACA were hosted by the Queensland Maritime Museum for the end of year Christmas function. The previous year's function had been a roaring success and this year the enthusiasm continued with a solid turnout. The aft deck of the frigate, the HMAS Diamantina, provided the quirky venue. The members and their guests were treated to a guided tour around the ship by some very knowledgeable volunteer members of the museum. These volunteers spend their time looking after, maintaining and displaying the exhibits. A very knowledgeable guide, Percy, recommended to anyone interested in volunteering to contact 07-3844 5361 or email volunteering@maritimemuseum.com.au. Percy described a gentleman who started volunteering at the age of 92 and retired recently at 96! His primary task was to polish the propellers of the exhibits.

Whilst some of the attendees were treated to a tour of the inside of the ship in 2015, a most unusual tour was conducted of the hull in the Dry Dock. Accompanied by several ladies in high heels, the tour party cut an unlikely picture in the rough, dank and working environment of what is an important part of Queensland maritime history, the Dry Dock itself. With stone blocks hewn by convicts, each stone bearing the convict's unique mark, the Dry Dock was completed in 1881. The HMAS Diamantina, an historic ship for the fact it was built locally and was the vessel on which the final Japanese surrender of WWII was signed.

The hull of the HMAS Diamantina has some unusual features, including twin screws with long shafts exiting midships, where the engine is located. The engines were recently "turned over" with an auxiliary engine to ensure the working parts are all serviceable. Percy hinted at the museum's ambition to refloat the frigate in the future. The hull has many openings, a most counter-intuitive phenomenon, however these serve as cooling water inlets, outlets, earthing points and not to mention - the unmentionable outlet. Percy was quick to advise the tour party not to stand under that particular outlet! There were hull perforations for bow-thrusters, not installed, and possibly the most important hull feature, the "thing that goes ping", the sonar.

The group got up close to the Dry Dock weir, incredibly holding back the mighty Brisbane River. It was rather unnerving standing at the base, several metres below water level, just a metre on the other side.

After an informative tour and appreciation of the work these volunteers do to maintain a piece of Queensland's maritime history, a sumptuous feast was enjoyed, washed down with a cold beer. Once again, the popular ACA Queensland Branch Christmas party and the wonderful museum hosts provided the attendees with a memorable time at "a night at the museum!". **Wayne Thomson**



CORROSION & PREVENTION 2016

PROUDLY PRESENTED BY: MAJOR SPONSOR:

CONFERENCE REVIEW

Overview

The ACA and New Zealand - Auckland Division welcomed over 400 delegates, exhibitors, partners, visitors and staff to the city of Auckland for Corrosion & Prevention 2016 (C&P2016). The annual conference is established as the Australasian corrosion industry's premier technical event and 2016 was no exception. Held over three days at SkyCity, C&P2016 covered a range of technical topics including a cutting-edge blend of the latest research and industry practice presentations including 6 Plenary lectures, 7 technical forums and 100 individual paper presentations.

As always, the social element of the conference was much enjoyed by delegates. The Sunday evening First Time Delegates Function sponsored by the Galvanizers Association of Australia held at SkyCity was well attended and gave first time delegates the opportunity to be briefed about the conference format and the benefits of networking with peers at the conference. The Welcome Function sponsored by Dulux Protective Coatings was held during the Exhibition Launch and featured Haka Legend performing a traditional Maori welcome. Monday's Young Corrosion Group Event at The Bluestone Room sponsored by the Galvanizers Association of Australia was also well received. On Tuesday evening the ACA Annual Awards Dinner sponsored by Denso Australia was held with live entertainment by Ben Hurley - the comedy act and Two Many Chiefs group, the musical act. Finally the Farewell Function sponsored by Les Boulton & Associates on Wednesday at Bar 21 at SkyCity closed the conference and friends old and new saying farewell to each other.

Plenary Speakers

The conference was officially opened on Monday morning by President John Duncan who welcomed all delegates, exhibitors and speakers to the conference. Other welcome messages came from Conference Convenor Raed El Sarraf and conference Technical Committee Chair, Raman Singh. The traditional Ed Potter Corrosion Clock, powered by a galvanic corrosion cell, was officially started by Professor Bruce Hinton. The clock is used to keep time at every ACA conference.

After the official opening, proceedings commenced with plenary lecturer Nick Laycock from Shell, Qatar, speaking on 'Corrosion Control in Wet Gas Pipelines'. This was followed by Howard Combs of Carboline, USA presenting 'Emerging technologies for Pipeline Coatings – for Directional Drilling'. On Tuesday morning delegates were treated to the annual PF Thompson Lecture delivered this year by Patricia Shaw, BRANZ, NZ. Patricia upheld the tradition of the PFT lecture, started by Dr Edmund Potter in 1970, by providing an interesting discussion of the 'Corrosion of Polymetric Materials'. The PFT is recognised as the highlight of the technical program each year. After completion of the PFT, Professor Digby Macdonald from the Departments of Nuclear Engineering, University of California spoke about 'Photo-Electrochemical Study of the Passive State'. Wednesday morning commenced with Sandy Williamson from NACE International, talking about the Results of the NACE IMPACT Study. The final Plenary was delivered candidly by Professor David Williams of Auckland University on the 'Advancement of Corrosion Science through New Experimental Methods'.






The conference technical committee thanks all of the plenary lecturers, both local and international, for their outstanding presentations.

Forums and Technical Program

A feature of Corrosion & Prevention 2016 was the technical forums organised by the ACA Technical Groups. This year there was a major focus on outcomes. The Forums held included; Coatings, Cathodic Protection, Concrete Structure & Buildings, Oil & Gas, Asset Management, Research and a new Contractors Forum. The discussions in these sessions were robust as usual and very worthwhile for the attendees. These forums are an ideal setting, for both formal and informal exchange of experiences, case studies, problems, ideas and solutions with experts in each field.

The technical paper program was substantial as always and sessions were arranged to bring theory and practice together. Corrosion & Prevention 2016 saw the delivery of just under 100 papers in total in Auckland. Major areas such as corrosion mechanisms, materials, coatings, cathodic protection, asset management, pipelines and concrete structures were spread over the three days of the conference.

Trade Exhibition

Corrosion & Prevention 2016 featured a large trade show with 62 exhibition booths. Exhibitors included; materials suppliers, equipment vendors, specialist contractors and consultants. Delegates were able to browse the stands throughout the conference and take the opportunity to discuss products and services with the exhibitors. Exhibitors benefited from broad exposure to corrosion industry practitioners from around Australia, New Zealand and the world.

Conclusion

On behalf of the ACA and the conference committee, thanks are extended to C&P2016's Major Sponsor - Carboline, Supporting Sponsors - 3C Corrosion Control Company; Freyssinet Australia, Jotun Australia and Russell Fraser Sales. Thanks as well go to our other sponsors; Denso New Zealand, Dulux Protective Coatings, Galvanizers Association of Australia, Les Boulton & Associates, Anode Engineering, Blastquip/BlastOne, G2 Solutions, Phoenix Australasia, Zinga and International Paint and all the exhibitors for their support of the conference. Thanks also go to the plenary lecturers, speakers, session chairs and all delegates without whom the conference would not exist. A special mention must be made of the ACA conference committee and ACA staff for their outstanding work in organising a well run conference.

In 2017 Corrosion & Prevention will be held from 12-15 November at the International Convention Centre, Darling Harbour, Sydney, NSW.

For more information refer go to the ACA conference website www.acaconference.com.au

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Opening Address: John Duncan

Ladies and gentlemen and colleagues in the fight against materials degradation,

It is a pleasure and a privilege to address you in this opening session of the 2016 ACA Corrosion Conference. For those of you who do not know me, my name is John Duncan, and I have been President of ACA since the conference in Adelaide last year. I'm now retired, but spent 34 years full-time with BRANZ – the Building Research Association of New Zealand – and inevitably a few of my comments in the next few minutes are drawn from that experience.

All of us, whether we are designing or maintaining structures and equipment, or devising new means of controlling materials degradation, have a vested interest in sharing and extending our knowledge through events like this. There is an inevitable cost-effectiveness balancing act that any designer or consultant or proprietor faces in determining the design of a facility, the appropriate selection of materials, the quality assurance routines that will be needed during construction, and the consequent maintenance regimes that the client would become committed to. It is important for all involved in the design/construction/materials supply/maintenance chain to stay abreast of new knowledge so that all are working to achieve the goal.

I'd like to share two reflections with you from working in the corrosion protection information industry in New Zealand, as I did for many years. The first is about the lessening of collegial discussion. When we formed the Wellington Division in the late 1970s, it was of course a different commercial market. But the extent to which professionals in the corrosion protection industry openly shared their knowledge at ACA meetings was outstanding in those days. That didn't mean that consultants were being undermined; but it did mean that generic information on problems was spread rapidly. The introduction of 'user pays' by the government into the science and technology sector in the 1990s made a huge negative difference to preparedness of organisations to share information, and to allow their staff to do so. The subsequently more litigious environment over the past two decades has in my view reinforced this stifling of information sharing. I believe this has taken us backwards in New Zealand in taking a NZ Inc approach to the best means of protecting our national assets.

Its also a reason why the ACA conference coming to New Zealand every eight years is welcomed – it brings a wealth of new knowledge, and new perspectives on issues, to the country. Ten percent of our attendees at this conference come from outside Australasia. I can only hope that enough New Zealanders have recognised the opportunity that this – the biggest ever corrosion conference in New Zealand – is bringing to them.

As I said last night at the Welcome function, taking advantage at conferences like this of discussions over a coffee break, or a beer or a wine, is as enlightening (and sometimes even more so) than listening to lectures and their subsequent discussions, and there is a wealth of knowledge on the stands of the exhibitors with people who know what best from their product ranges will deliver the cost-effective solution. And importantly we have opportunities to listen to, and meet, and discuss issues with, people who we wouldn't usually come across, from across Australasia and across the world. I hope that we can all leave the conference feeling we have got new strings to our bow in our everyday work.

The second reflection is about 'learning companies'. I remember visiting the Corrosion and Protection Centre at UMIST in the 1980s, and being told by the consultants there that they were finding that every seven years they were being commissioned to solve essentially the same problem for a company, because the people who had responsibility seven years earlier had moved to other positions in the company or elsewhere, and the company had not retained adequately the knowledge that had already been conveyed to them. And they named some big-name companies for which they had found this held true. I'm sure that the organisations represented here have already learnt that trick. But there are an awful lot of client companies that don't seem to.

In 1984, Standards New Zealand wrote into one of their documents caveats about the use of weathering steel in coastal environments. That was after several high-profile buildings had suffered cladding failures within a decade with this material. I am still reading in the media reports this year of this being specified on new construction. I hope that all concerned know what they are doing.

It is often a matter of telling a joke at the start of a speech like this. You'll have noticed that I didn't, nor do I intend to. We all know that corrosion is no joking matter, even if John Oliver does seem to have found some hilarious aspects in his monologues. If you have not seen on YouTube his message about the degradation of US infrastructure, it's well worth a look. Many of us feel that those messages apply equally in our own countries outside USA – but politicians around the world don't seem to feel it rewarding enough to be able to claim that they have built safe and efficient infrastructure and put in place the mechanisms for maintaining it. That is one of the reasons why the ACA Strategic Plan is putting emphasis on getting these messages more clearly in front of decision-makers at all levels of Australasian governments, and is why for instance there will be a stream aimed at informing asset managers on Wednesday afternoon.

And the fun that John Oliver pokes at these things has a very serious underpinning. I want to commend to you the talk on Wednesday morning by Sandy Williamson about the Impact study carried out in USA, which explicitly addresses the avoidable costs of corrosion and puts hard numbers behind the humour. This is the latest in a series carried out in economies all around the world since the Uhlig report in 1949 on the cost of corrosion to the US. We know every economy is different – which is the argument that the politicians use for why they don't need to believe the numbers will apply in their own country. But they can't deny that the findings are strikingly similar – there is a direct cost to the economy of let us say at least 2% of GDP per year due to materials degradation, and somewhere between 25 and 40% of the cost is avoidable using already-known technology. And there are indirect costs – perhaps as much again in GDP terms – on top of this. And that's been found in economies as diverse as USA, UK, Egypt, India and Japan.

We in the ACA are setting out to get this message across. We are revitalising our education and training programs to make sure they are relevant to the issues faced by our industries today. We are running in our Branches regular sessions to enhance our own understanding, and those of colleagues in other fields, about up-to-date knowledge, and our Technical Groups organise seminars around Australasia to focus on specific topic areas, as well as organising forums within the conference. And each year the whole organisation comes together for the Conference, to cross-fertilise the understanding between technical areas and between the geographies of Australasia. I again express my hope that we can all leave the conference feeling we have got new strings to our bow in our everyday work and I'm pleased to declare the conference open.

CORROSION & PREVENTION 2016 PHOTOS











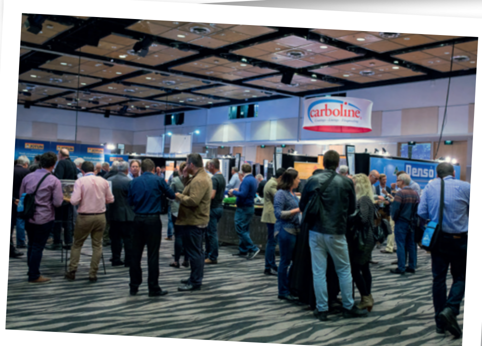


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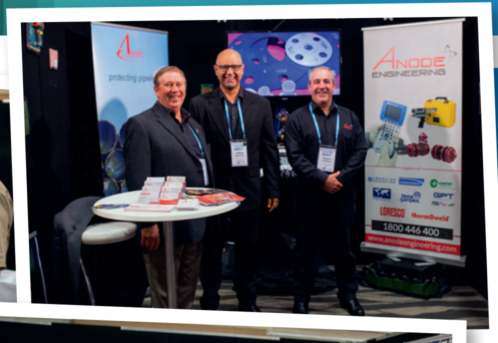
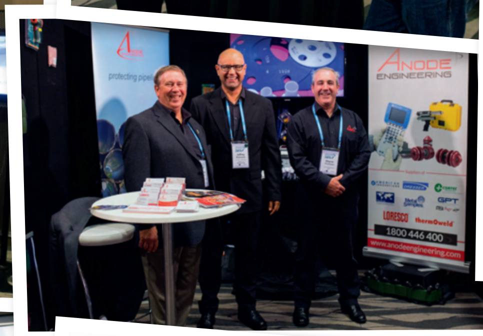
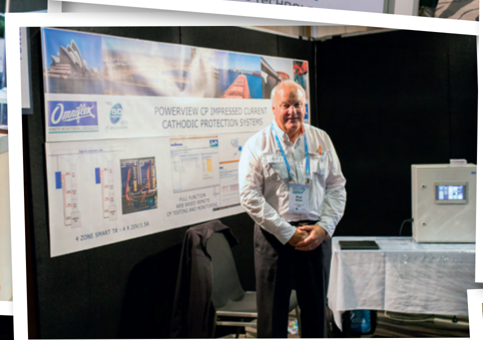
Jodie Ivory receiving the award from Conference Convenor Raed El Sarraf.

CORROSION & PREVENTION 2016 EXHIBITORS





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TESTIMONIAL

FIRST TIME CONFERENCE ATTENDEE TESTIMONIAL

I was very excited when I was offered the opportunity to attend the Corrosion & Prevention Conference for the first time in 2016. Introduced to the industry by my parent company Anode Engineering, I was excited by the prospect of learning more about what we do with regards to the design and manufacture of Cathodic Protection systems and how Lordco as a leading supplier of products and materials might better serve the various markets represented at the Conference.

I made sure to attend all the functions beginning with the First-Time Delegates Function. The organisers introduced themselves and from the outset introduced me to new people. It was enjoyable and interesting right from the start! From there we all went to the Welcome Reception and Exhibition Opening, which officially kicked off a great three days of events.

The Plenaries, Presentations, discussions and Technical Forums were not only fascinating but were given by people leading in their fields. I felt I was receiving the best the industry had to offer. With 4 Streams going at any one time it was easy to choose talks in one's own field or an area of interest or simply listen to something new. Also, you were free to just visit the exhibitions, talk with suppliers and become acquainted with new products and technologies.

Jeffrey Robinson

The Awards Dinner was special and characterised for me the spirit of the Conference. People passionate about the industry working with others to do the work and communicate the importance of mitigating corrosion.

The Conference exceeded my expectations. I became part of that larger community of people willing to help each other and as such strengthened and gained relationships that would help me help my customers.

Thank you to the ACA team for organising a great event. I look forward to seeing everyone next time!

Jeffrey Robinson BA, BCom (Hon)
Technical Sales Representative
www.lordco.co.nz Mob: 0212484423

AWARDS

Each year a series of ACA Awards are announced and presented to successful recipients during the Annual Awards Dinner at the annual ACA conference – Corrosion & Prevention.

The ACA awards papers of outstanding quality presented at a conference, seminar or symposium held under the auspices of the ACA, or published in the ACA's publication Corrosion & Materials. These papers are judged by the ACA Awards Committee comprised of **Les Boulton, Bruce Hinton** and **Erwin Gamboa**.

The ACA also recognises members for outstanding services to the Association through Life Membership and services to the industry through other prestigious awards.

AC Kennett Award

Patricia Shaw accepting the Award.

The AC Kennett Award is awarded each year to the best paper presented under the auspices of the Association that deals with non-metallic corrosion. The recipient also receives a cheque for $1,500. The recipient of the AC Kennett Award was Patricia Shaw and Nick Marston for the paper, 'Reliable Durability Prediction of Polymeric Materials'.

SUMMARY:
Most polymeric materials used outdoors undergo degradation due to environmental exposure, particularly solar UV radiation, affecting their durability. New Zealand's climatic variables significantly affect the durability of polymeric materials, and reliable durability assessments can be difficult.

The New Zealand Building Code is primarily performance-based. This requires the durability performance of materials to be demonstrated through laboratory testing, a documented history of use, or by analogy with the behaviour of similar building components. However, little practical guidance is provided concerning how these criteria might be satisfied.

This paper described the development of a durability verification test method for polymeric materials, using Fourier transform infrared (FTIR) spectroscopy. FTIR, with chemometric analysis, was used to correlate outdoor exposure with accelerated aging tests, looking at both degradation mechanism and exposure time.

Once completed, the FTIR method meant that accelerated aging tests can be used to reliably predict the durability performance of polymeric materials naturally exposed during service. This may include assessment of 'new' products, serving to alleviate the suspicion often associated with new building products. It may also provide a method for predicting the remaining serviceable life of outdoor exposed polymeric materials used in New Zealand.

Best Papers

In pursuit of attracting quality technical papers, the ACA annually awards two certificates of merit for papers either published in Corrosion & Materials or presented at the annual conference. The award will be made only where the standard of papers is of a level warranting recognition; one certificate is for the best review paper and the other is for the best research paper.

Marshall Fordham Best Research Paper Award

David Young accepting the Award.

The Marshall Fordham Best Research Paper Award was presented to was presented to David Young on behalf of J Zhang for the paper '**Corrosion Behaviour of Ferritic FE-CR Alloys in CO_2 – H_2O – SO_2 Gases at 800°**'presented at Corrosion & Prevention 2016 in Auckland.

SUMMARY:
In the present study, model alloys of Fe-9Cr, Fe-20Cr (all values in wt.%) and these alloys with the addition of 2%Mn or 0.5%Si were exposed to Ar-20%CO_2-20%H_2O-(0, 0.5%)SO_2 gas at 800°C for up to 500h. Fe-9Cr and Fe-9Cr-2Mn alloys experienced breakaway oxidation in all gases, although the growth of iron-rich oxide scale was retarded by the presence of SO_2. However, the oxidation of Fe-9Cr-0.5Si alloy was greatly accelerated by the presence of SO_2. A slow growing Cr_2O_3 scale formed on Fe-20Cr alloys when the gas contained SO_2, preventing breakaway oxidation. However, the presence of SO_2 provided no further improvement on the already high corrosion resistance of Mn and Si containing Fe-20Cr alloy in wet CO_2 gas. Effects of sulphur on carburisation and breakaway oxidation were discussed.

David Whitby Best Review Paper Award

Dean Ferguson accepting the Award.

The David Whitby Best Review Paper Award was presented to Dean Ferguson and C J Trewern for the paper '**Design Challenges Associated with the Use of Non-Metallic Materials in Marine Sheet Pile Walls**' that was presented at Corrosion & Prevention 2016 in Auckland.

SUMMARY:
With long term durability, low maintenance and long design life as the standard requirements for high-value marine infrastructure projects, designers are increasingly looking for innovative ways to meet these engineering and economic challenges. One particular example is sheet pile walls, for which replacement during a structure's life is often either impossible or impracticable.

Sheet pile walls are often subject to aggressive environments. Exposed to a combination of submerged, tidal, atmospheric and buried environments, they can also be subject to impact and abrasion during service. The traditional approach to steel sheet pile wall durability has been through the use of secondary corrosion protection measures such as protective coatings, cathodic protection systems or corrosion loss allowances. While generally effective in the submerged zone, neither of the first two options are very effective above water especially in the long term. Furthermore these systems can require extensive ongoing monitoring and maintenance.

This paper identified and reviewed a number of alternative non-metallic sheet pile materials and products which are available in the market. While the durability and structural design risks associated with traditional metallic sheet piles are well known and a standardised design approach exists, these unfamiliar materials come with their own risks and limitations. The authors identified and discussed design challenges including potential durability risks to be considered when designing with these specific material types, as well as the impact of different material properties (both long and short term) on structural design.

ACA Student Research Award

Amy Spark accepting the Award.

The ACA Student Research Award is presented to full time post graduate students in recognition for work on fundamental or applied research in any branch of corrosion during the course of a higher degree in Science, Engineering or related discipline. The award is judged upon significance of the work to the community, originality and soundness of the research.

ACA Student Research Award 2016 was presented to Amy Spark who also receieves $2,500.

Life Membership

Life Membership is awarded for outstanding service to the ACA over an extended period either to a Branch or the Council and is awarded only as agreed by Council. At Corrosion & Prevention 2016, two Life Memberships were awarded:

Rob Francis

- Rob joined his local Branch Committee in 1984, was Branch Treasurer in 1988, Branch President in 1999 and elected Honorary Member of his Branch in 2012
- Rob has his own company and over 35 years' experience in corrosion and its mitigation, especially in the area of protective coatings for steelwork and marine environments. His experience also covers ferrous metals, technical training and quality assurance
- Rob was Past Chair of the ACA Protective Coatings Technical Group and was involved with the establishment of the Victor Nightingall and Rust Awards
- Rob was Chairman, Australian Painting Contractor Certification Program (PCCP) (1990– 1997)
- Rob was also Chairman of Australian Standards Committees MT14/2 that revised AS/NZS 2312 (Guide to the protection of structural steel against atmospheric corrosion by the use of protective coatings)
- Rob was the editor of the first and only ACA book, 'Sixty years of Inorganic Zinc Coatings'.
- Rob was employed at the Corrosion Prevention Centre as Technical Officer (1988 to 1999) where he developed several of the ACA training courses
- Rob was ACA President in 2000

Rob Francis accepting the Award.

Corrosion Medal

Brian Kinsella

The Corrosion Medal is the Association's most prestigious award. It is bestowed for outstanding scientific or technological work in the field of corrosion in Australasia. Meritorious contributions in Australasia to the mitigation of corrosion shall also be a basis for the award.

- Brian's main interests are electrochemistry, corrosion and corrosion inhibitors. The focus has been CO_2 and H_2S corrosion in oil and gas production where he has authored or co-authored over 100 papers in this area
- Brian was the visiting Stocker Professor at Ohio University from September 2008 until March 2011 where he worked in the Institute for Corrosion and Multiphase Technology
- Brian was the Founder and Director of the Corrosion Research Group at Curtin University (1987 – 2007)
- In November 2013 Brian was invited to the position of Deputy Director, Applied Corrosion Research and Testing, Curtin Corrosion Engineering Industry Centre, Curtin University

Brian Kinsella accepting the Award.

PARTNER PROGRAM

Auckland, New Zealand was very delighted to host the ACA Conference 2016.

As Partner Programme Convenor I found the PP was so very enjoyable with such a fun loving group of 26 ladies from NZ, Australia, USA, Canada and the U.K. and one very lucky young gentleman from the USA.

On Monday, our first day, we headed north by coach to Puhoi (much chatter by the participants and equally as much on the homeward trip at the end of the day). At the Puhoi Village we were treated to traditional Devonshire teas at one of the oldest tearooms in NZ accompanied by a 15 minute presentation of the history of the Bohemian immigrants and how they came to settle in this area in 1863.

Then up the road to the Puhoi Valley Cheese factory, (which employs more than 80 people- some of whom are descendants of the original Bohemian settlers). Here we indulged in some cheese tasting along with a presentation. The factory has a history of European cheese makers. The most recent being a Frenchman, and it was he who gave us such an informative presentation. After 30 minutes travelling further north we arrived at Morris & James Pottery Cafe in Matakana for lunch. Here we could enjoy more local, fresh produce before walking across the courtyard to the Pottery Showroom and a presentation of their amazing range of individually hand-crafted pots, wall art and sculptural pieces all crafted from the local Matakana clay. A full, but exciting day for our first day.

Day 2 was a more relaxing one with a short ferry trip across the harbour to Devonport where we were met by two mini coaches and given an extremely interesting guided tour of historic Devonport including panoramic views from the summits of the two extinct volcanoes – just a shame about the weather. Then on to McHughs at Cheltenham for a buffet luncheon. Here we had panoramic views overlooking the gulf and Rangitoto Island, after which we had leisure time in historic Devonport Village which is renowned for its various boutiques.

Our final day started with a visit to the Auckland Museum for 2 hours in the morning where everyone was able to explore at their leisure the areas of interest to themselves. Then it was back to SkyCity for lunch with the Delegates. We then undertook a short walk to the Auckland Art Gallery which has the most extensive collection of national and international art in NZ. We were given a 2 hour private guided tour in 2 groups with our guides explaining key pieces and their history. Just so extremely interesting.

An excellent programme which we all so enjoyed.

Liz Boulton – PP Convenor 2016

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ACA Conference Scholarship Recipients

The ACA Foundation was delighted to award 4 First Timer Conference Scholarships to enable individuals to attend and participate in Corrosion & Prevention 2016. The Scholarships target those who have not previously attended an annual ACA Conference. Scholarships were awarded to Thomas Clayton, Andre Lerk, Dylan Pearce, and Jessie Shuttleworth. The Post Graduate Conference Attendance Scholarship, which supports a post graduate student to attend the ACA conference, was awarded to Ahmed Osman.

Post Graduate Conference Attendance Scholarship

- **Ahmed Osman**

First timers Conference Scholarships

- **Thomas Clayton**
- **Andre Lerk**
- **Dylan Pearce**
- **Jessie Shuttleworth**

All Scholarship recipients welcomed the significant opportunity provided by the ACA Foundation to participate in Corrosion & Prevention 2016. In their post-conference reports the recipients nominated the following conference highlights and benefits.

"Attending several conference streams helped me to acquire more knowledge in the field of corrosion engineering and research developments especially in the area of microbiologically influenced corrosion (MIC) which is my area of research."

"The social program (First time delegates function, Young corrosion group event, and ACA annual awards dinner…etc.) was delightful and interesting. I got the chance to chat with different people from both research and industry as it is a great benefit to interact with the corrosion community."

"The exhibition was fantastic and included a wide range of companies that significantly contribute in the corrosion industry globally, in Australia, and New Zealand."

"I benefitted a lot from the ample opportunities to network and gain insights into the diverse expertise of my more battle-hardened fellow anti-corrosion fighters."

"Plenary sessions also were beneficial as they showed what the real challenges that face pipeline integrity are, and how people from the industry can work to mitigate these challenges."

"The different seminars focusing on relatively new techniques or technologies available for corrosion remediation or prevention were of real practical interest."

"Ultimately, it was a great opportunity to get out and meet a lot of different professionals from the corrosion industry and learn from their experiences."

Ahmed Osman

Thomas Clayton

Andre Lerk

Scholarship Recipients at the ACA Annual Awards Dinner

Dylan Pearce

At the Awards Dinner, Warren Green, Chair of the ACA Foundation, announced the recipients of the ACA Foundation International Conference Scholarship, valued at $3,500, and the Brian Cherry International Travel Scholarship, valued at $8,500.

- **Mark Dragar**
  (International Conference Scholarship)

Mark Dragar received the International Conference Scholarship which provides support to attend and participate in an international conference. Mr Dragar is the Asset Manager Pipelines at Jemena Asset Management.

- **Igor Chaves**
  (Brian Cherry International Travel Scholarship)

Igor Chaves received the Brian Cherry International Travel Scholarship which enables the recipient to meet with, or participate in, site visits of research facilities, projects of significance, industries and educationalists and to attend an international corrosion conference. Dr Chaves is currently a research academic at the University of Newcastle, Australia, where he has been awarded a PhD for studies in corrosion analysis and prediction.

On behalf of its 2016 Scholarship recipients, the ACA Foundation would like to sincerely thank all of the Foundation Centurions and Donors for their generous and ongoing support.

Jessie Shuttleworth

Mark Dragar

Igor Chaves

ACA Standards Update

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

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

This Standards report focuses on Oil & Gas in relation to corrosion.

As previously reported this is in two stages, namely:

1. A global standards and publication focus at 16 January 2017, searching through SAIGLOBAL Publications at https://infostore.saiglobal.com/store, for all current publications and standards relating to corrosion and its prevention for the topic of 'Oil and Gas'.

These results are shown in Tables 1.

2. A SAI Global search, as previously reported 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 16 September 2016 - 16 January 2017, 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 Table 2.

Summary

1. Through SAIGLOBAL Publications at https://infostore.saiglobal.com/store they were for a search on:

   a) For Titles search on https://infostore.saiglobal.com/store on 16 January 2017 for 'oil and gas and corrosion' there were 47 citations, 0 from AS/ASNZS; see Table 1a for highlights.

   b) For Titles search on https://infostore.saiglobal.com/store on 16 January 2017 for 'oil and corrosion without gas' there were 53 citations, 0 from AS/ASNZS; see Table 2b for highlights.

   c) For Titles search on https://infostore.saiglobal.com/store on 16 January 2017 for 'gas and corrosion without oil' there were 130 citations, 1 from AS/ASNZS; see Table 3c for highlights.

   d) For Titles search on https://infostore.saiglobal.com/store on 16 January 2017 for 'petroleum and corrosion without gas' there were 53 citations, none from AS/ASNZS; see Table 4d for highlights.

A search for 'petroleum and corrosion without oil' produced no new NACE, ISO or ASTM standards not listed previously.

1. Across SAIGLOBAL online Standards Publications there was a total of 66 listings of new standards, Drafts and Amendments found that were issued from 16 September 2016 to 16 January 2017; 2 from AS AS/NZS relating to reinforcing corrosion in concrete;

   a. AS 1012.20.1:2016 Methods of testing concrete - Determination of chloride and sulfate in hardened concrete and aggregates - Nitric acid extraction method

   b. AS 1012.20.2:2016 Methods of testing concrete - Determination of water-soluble chloride in aggregates and hardened concrete.

These results are shown in **Table 1b** for 'oil and corrosion without gas' high-lights

ASTM	NACE	ISO
ASTM D4310-10(2015) Standard Test Method for Determination of Sludging and Corrosion Tendencies of Inhibited Mineral Oils	NACE 1D182:2005 Wheel Test Method used for Evaluation of Film-persistent Corrosion Inhibitors for Oilfield Applications	ISO/TS 12928:1999 Lubricants, Industrial Oils and Related Products (Class L) - Family R (Products for Temporary Protection Against Corrosion) - Guidelines for Establishing Specifications
ASTM F1137-11e1 Standard Specification for Phosphate/ Oil Corrosion Protective Coatings for Fasteners	NACE 1F192:2013 Use of Corrosion-Resistant Alloys in Oilfield Environments	ISO 6743-8:1987 Lubricants, Industrial Oils and Related Products (Class L) - Classification - Part 8: Family R (Temporary Protection Against Corrosion)
ASTM G170-06(2012) Standard Guide for Evaluating and Qualifying Oilfield and Refinery Corrosion Inhibitors in the Laboratory	NACE SP 07 75:1999 (R2013) Preparation, Installation, Analysis, and Interpretation of Corrosion Coupons in Oilfield Operations	
ASTM G184-06(2016) Standard Practice for Evaluating and Qualifying Oil Field and Refinery Corrosion Inhibitors Using the Rotating Cage	NACE TM 01 98:2011 Slow Strain Rate Test Method for Screening Corrosion-Resistant Alloys for Stress Corrosion Cracking in Sour Oilfield Service	
ASTM G185-06(2016) Standard Practice for Evaluating and Qualifying Oil Field and Refinery Corrosion Inhibitors Using the Rotating Cylinder Electrode		**API**
ASTM G205-16 Standard Guide for Determining Emulsion Properties, Wetting Behavior, and Corrosion-Inhibitory Properties of Crude Oils		API 939-C Ed. 1 (2009) Guidelines for Avoiding Sulfidation (sulfidic) Corrosion Failures in Oil Refineries
ASTM G208-12(2016) Standard Practice for Evaluating and Qualifying Oilfield and Refinery Corrosion Inhibitors Using Jet Impingement Apparatus		

Table 1c for 'gas and corrosion without oil' high-lights

AS		
AS 60068.2.60-2003 Environmental testing - Tests - Test Ke: Flowing mixed gas corrosion test		
ISO	**ASTM**	**NACE**
ISO 10062:2006 Corrosion Tests in Artificial Atmosphere at Very Low Concentrations of Polluting Gas(es)	ASTM D1838-16 Standard Test Method for Copper Strip Corrosion by Liquefied Petroleum (LP) Gases	NACE SP 01 10:2010 Wet Gas Internal Corrosion Direct Assessment Methodology for Pipelines
ISO 13680:2010 Petroleum and Natural Gas Industries - Corrosion-resistant Alloy Seamless Tubes for use as casing, tubing and coupling stock - Technical delivery conditions	ASTM F363-99(2011) Standard Test Method for Corrosion Testing of Gaskets	NACE SP 02 06:2016 Internal Corrosion Direct Assessment Methodology for Pipelines Carrying Normally Dry Natural Gas (Dg-Icda)
ISO 18797-1:2016 Petroleum, petrochemical and natural gas industries - External corrosion protection of risers by coatings and linings - Part 1: Elastomeric coating systems-polychloroprene or EPDM	ASTM G186-05(2016) Standard Test Method for Determining Whether Gas-Leak-Detector Fluid Solutions Can Cause Stress Corrosion Cracking of Brass Alloys	
ISO 21207:2015 Corrosion Tests in Artificial Atmospheres - Accelerated Corrosion Tests Involving Alternate Exposure to Corrosion-Promoting Gases, Neutral Salt-Spray and Drying		
ISO/DIS 13680 Petroleum and Natural Gas Industries - Corrosion-Resistant Alloy Seamless Tubes for use as Casing, Tubing and Coupling Stock - Technical Delivery Conditions		

Table 1d for 'petroleum and corrosion without gas' high-lights

NACE	ASTM	ISO
NACE 34103:2014 Overview of Sulfidation (Sulfidic) Corrosion in Petroleum Refining Hydroprocessing Units	ASTM D 130 ADJUNCT Adjunct to D130 Copper Strip Corrosion Standard for Petroleum	ISO 4404-1:2012 Petroleum and Related Products - Determination of the Corrosion Resistance of Fire-Resistant Hydraulic Fluids - Part 1: Water-Containing Fluids
NACE SP 01 76:2007 Corrosion Control of Submerged Areas of Permanently Installed Steel Offshore Structures Associated with Petroleum Production	ASTM D7548-16a Standard Test Method for Determination of Accelerated Iron Corrosion in Petroleum Products	ISO 4404-2:2010 Petroleum and Related Products - Determination of the Corrosion Resistance of Fire-Resistant Hydraulic Fluids - Part 2: Non-Aqueous Fluids
NACE SP 02 08:2008 Internal Corrosion Direct Assessment Methodology for Liquid Petroleum Pipelines		

Table 2 below.

Stage 1 Report on SAIGLOBAL Publications at https://infostore.saiglobal.com/store, for all current publications and standards relating to 'oil and gas and corrosion'.

Table 1a for 'oil and gas and corrosion' high-lights

NACE	ISO	EI (Energy Institute)
NACE 1C187:2005 Use of Galvanic Probe Corrosion Monitors in Oil and Gas Drilling and Production Operations	ISO 15156-3:2015 Petroleumand Natural Gas Industries - Materials for Use In H_2S-Containing Environments in Oil and Gas Production - Part 3: Cracking-Resistant Cras (Corrosion-Resistant Alloys) and Other Alloys	EI GUIDE CORROSION MGMT. Ed. 1 (2008) Guidance for Corrosion Management in Oil and Gas Production and Processing
NACE 31014:2014 Field Monitoring of Corrosion Rates in Oil and Gas Production Environments Using Electrochemical Techniques	ISO 21457:2010 Petroleum, Petrochemical and Natural Gas Industries - Materials Selection and Corrosion Control for Oil and Gas Production Systems	
NACE 31215:2015 Laboratory Evaluation of Corrosion Inhibitors Used in the Oil and Gas Industry		
NACE 61114:2014 Underdeposit Corrosion (Udc) Testing and Mitigation Methods in the Oil and Gas Industry		
NACE MR 0175 ISO 15156:2015 Petroleum, Petrochemical, and Natural Gas Industries - Materials for Use in H_2S-Containing Environments in Oil and Gas Production - Part 1: General Principles for Selection of Cracking-Resistant Materials - Part 2: Cracking-Resistant Carbon and Lowalloy Steels, and the Use of Cast Irons - Part 3: Cracking-Resistant CRAS (Corrosion-Resistant Alloys) and Other Alloys		
NACE SP 01 92:2012 Monitoring Corrosion in Oil and Gas Production with Iron Counts		

Table 1b for 'oil and corrosion without gas' high-lights

ASTM	NACE	ISO
ASTM D4310-10(2015) Standard Test Method for Determination of Sludging and Corrosion Tendencies of Inhibited Mineral Oils	NACE 1D182:2005 Wheel Test Method Used for Evaluation of Film-persistent Corrosion Inhibitors for Oilfield Applications	ISO/TS 12928:1999 Lubricants, Industrial Oils and Related Products (Class L) - Family R (Products for Temporary Protection Against Corrosion) - Guidelines for Establishing Specifications
ASTM F1137-11e1 Standard Specification for Phosphate/ Oil Corrosion Protective Coatings for Fasteners	NACE 1F192:2013 Use of Corrosion-Resistant Alloys in Oilfield Environments	ISO 6743-8:1987 Lubricants, Industrial Oils and Related Products (Class L) - Classification - Part 8: Family R (Temporary Protection Against Corrosion)
ASTM G170-06(2012) Standard Guide for Evaluating and Qualifying Oilfield and Refinery Corrosion Inhibitors in the Laboratory	NACE SP 07 75:1999 (R2013) Preparation, Installation, Analysis, and Interpretation of Corrosion Coupons in Oilfield Operations	
ASTM G184-06(2016) Standard Practice for Evaluating and Qualifying Oil Field and Refinery Corrosion Inhibitors Using the Rotating Cage	NACE TM 01 98:2011 Slow Strain Rate Test Method for Screening Corrosion-Resistant Alloys for Stress Corrosion Cracking in Sour Oilfield Service	
ASTM G185-06(2016) Standard Practice for Evaluating and Qualifying Oil Field and Refinery Corrosion Inhibitors Using the Rotating Cylinder Electrode		**API**
ASTM G205-16 Standard Guide for Determining Emulsion Properties, Wetting Behavior, and Corrosion-Inhibitory Properties of Crude Oils		API 939-C Ed. 1 (2009) Guidelines for Avoiding Sulfidation (Sulfidic) Corrosion Failures in Oil Refineries
ASTM G208-12(2016) Standard Practice for Evaluating and Qualifying Oilfield and Refinery Corrosion Inhibitors Using Jet Impingement Apparatus		

Table 1c for 'gas and corrosion without oil' high-lights

AS		
AS 60068.2.60-2003 Environmental testing - Tests - Test Ke: Flowing mixed gas corrosion test		
ISO	**ASTM**	**NACE**
ISO 10062:2006 Corrosion Tests in Artificial Atmosphere At Very Low Concentrations of Polluting Gas(es)	ASTM D1838-16 Standard Test Method for Copper Strip Corrosion by Liquefied Petroleum (LP) Gases	NACE SP 01 10:2010 Wet Gas Internal Corrosion Direct Assessment Methodology for Pipelines
ISO 13680:2010 Petroleum and Natural Gas Industries - Corrosion-Resistant Alloy Seamless Tubes for Use as Casing, Tubing and Coupling Stock - Technical Delivery Conditions	ASTM F363-99(2011) Standard Test Method for Corrosion Testing of Gaskets	NACE SP 02 06:2016 Internal Corrosion Direct Assessment Methodology for Pipelines Carrying Normally Dry Natural Gas (Dg-Icda)
ISO 18797-1:2016 Petroleum, Petrochemical and Natural Gas Industries - External Corrosion Protection of Risers by Coatings and Linings - Part 1: Elastomeric Coating Systems-Polychloroprene or EPDM	ASTM G186-05(2016) Standard Test Method for Determining Whether Gas-Leak-Detector Fluid Solutions can Cause Stress Corrosion Cracking of Brass Alloys	

ISO 21207:2015 Corrosion Tests in Artificial Atmospheres - Accelerated Corrosion Tests Involving Alternate Exposure to Corrosion-Promoting Gases, Neutral Salt-Spray and Drying		
ISO/DIS 13680 Petroleum and Natural Gas Industries - Corrosion-Resistant Alloy Seamless Tubes for use as Casing, Tubing and Coupling Stock - Technical Delivery Conditions		

Table 1d for 'petroleum and corrosion without gas' high-lights

NACE	ASTM	ISO
NACE 34103:2014 Overview of Sulfidation (Sulfidic) Corrosion in Petroleum Refining Hydroprocessing Units	ASTM D 130 ADJUNCT Adjunct To D130 Copper Strip Corrosion Standard for Petroleum	ISO 4404-1:2012 Petroleum and Related Products - Determination of the Corrosion Resistance of Fire-Resistant Hydraulic Fluids - Part 1: Water-Containing Fluids
NACE SP 01 76:2007 Corrosion Control of Submerged Areas of Permanently Installed Steel Offshore Structures Associated with Petroleum Production	ASTM D7548-16a Standard Test Method for Determination of Accelerated Iron Corrosion in Petroleum Products	ISO 4404-2:2010 Petroleum and Related Products - Determination of The Corrosion Resistance of Fire-Resistant Hydraulic Fluids - Part 2: Non-Aqueous Fluids
NACE SP 02 08:2008 Internal Corrosion Direct Assessment Methodology for Liquid Petroleum Pipelines		

Table 2 Standards for AS, AS/NZS, EN, ANSI, ASTM, BSI, DIN, ETSI, JSA, NSAI and Standards and Amendments for ISO & IEC PUBLISHED from 16 September 2015 - 13 January 2017 for:

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 21 October 2015 - 12 January 2016	
Key word search on 'durability'- 7 citations with 0 corrosion related citations found.	
Key word search on 'corrosion' or 'corrosivity' or 'corrosive'; but not 'anodizing' or 'anodize(d)'- 15 citations found; 0 from AS/NZS	
ISO 15741:2016	Paints And Varnishes - Friction-Reduction Coatings for The Interior of on- and Offshore Steel Pipelines for Non-Corrosive Gases
ISO/FDIS 10129	Plain Bearings - Testing of Bearing Metals - Resistance to Corrosion by Lubricants Under Static Conditions
ISO/FDIS 14713-3	Zinc Coatings - Guidelines and Recommendations for The Protection Against Corrosion of Iron and Steel in Structures - Part 3: Sherardizing
ISO/FDIS 6509-2	Corrosion of Metals and Alloys - Determination of Dezincification Resistance of Copper Alloys with Zinc - Part 2: Assessment Criteria
ISO/FDIS 9227	Corrosion Tests in Artificial Atmospheres - Salt Spray Tests
ISO/DIS 19280	Corrosion of Metals and Alloys - Measurement of Critical Crevice Temperature for Cylindrical Crevice Geometries in Ferric Chloride Solution
I.S. EN ISO 4623-2:2016	Paints And Varnishes - Determination of Resistance to Filiform Corrosion - Part 2: Aluminium Substrates (ISO 4623-2:2016)
JIS Z 1535:2014	Corrosion Inhibitor Treated Papers for Iron and Steel
DIN EN ISO 14713-1 (2016-12) (Draft	Zinc Coatings - Guidelines and Recommendations for the Protection Against Corrosion of Iron and Steel in Structures - Part 1: General Principles Of Design And Corrosion Resistance (ISO/FDIS 14713-1:2016); German and English Version FprEN ISO 14713-1:2016
DIN EN ISO 28706-3 (2016-11) (Draft)	Vitreous and Porcelain Enamels - Determination of Resistance to Chemical Corrosion - Part 3: Determination of Resistance to Chemical Corrosion by Alkaline Liquids Using a Hexagonal Vessel or a Tretragonal Glass Bottle (ISO/DIS 28706-3:2016); German and English Version prEN ISO 28706-3:2016
DIN 65480 (2016-12)	Aerospace Series - Hexagon Nuts with Flange and Mj Thread, Self-Locking, Corrosion-Resisting Steel - Class: 1100 MPa/315 øC; Text in German and English

MS 51606 Revision D Notice 1 Validation	Pin, Grooved, Headless (Half Length Reverse Taper Groove) Corrosion-Resistant Steel - Revision D Notice 1 Validation
MS 51957 Revision D Notice 1 Validation	Screw, Machine, Pan Head, Cross-Recessed, Corrosion Resistant Steel, Unc-2A - Revision D Notice 1 Validation
MS 51960 Revision D Notice 1 Validation	Screw, Machine - Flat Countersunk Head, 82 Degree, Cross-Recessed, Corrosion Resistant Steel, Unf-2A - Revision D Notice 1 Validation
QPL 23398 Revision Oct 2016	Qualified Product List of Products Qualified Under Performance Specification - Mil-L-23398 - Lubricant, Solid Film, Air-Cured, Corrosion Inhibiting, Nato Code Number S-749 - Revision Oct 2016
Key word search on 'paint' and or 'coating'; but not 'anodizing' or 'anodize(d)' or corrosion– 37 relevant (and Publications found; 0 for AS AS/NZS	
ISO 15741:2016	Paints and Varnishes - Friction-Reduction Coatings for the Interior of on- and Offshore Steel Pipelines for Non-Corrosive Gases
DIN EN ISO 16482-1 (2016-11)	Binders for Paints and Varnishes - Determination of the Non-Volatile-Matter Content of Aqueous Rosin-Resin Dispersions - Part 1: Oven Method (ISO 16482-1:2013)
DIN EN ISO 16482-2 (2016-11)	Binders for Paints and Varnishes - Determination of the Non-Volatile-Matter Content of Aqueous Rosin-Resin Dispersions - Part 2: Microwave Method (ISO 16482-2:2013)
DIN EN ISO 3248 (2016-12)	Paints and Varnishes - Determination of the Effect of Heat (ISO 3248:2016)
DIN EN 71-7/A1 (2017-01) (Draft)	Safety of Toys - Part 7: Finger Paints - Requirements and Test Methods; German and English Version EN 71-7:2014/prA1:2016
DIN EN ISO 7784-1 (2016-12)	Paints and Varnishes - Determination of Resistance to Abrasion - Part 1: Method with Abrasive-Paper Covered Wheels and Rotating Test Specimen (ISO 7784-1:2016)
DIN EN ISO 7784-2 (2016-12)	Paints and Varnishes - Determination of Resistance to Abrasion - Part 2: Method with Abrasive Rubber Wheels and Rotating Test Specimen (ISO 7784-2:2016)
DIN EN ISO 7784-3 (2016-12)	Paints and Varnishes - Determination of Resistance to Abrasion - Part 3: Method with Abrasive-Paper Covered Wheel and Linearly Reciprocating Test Specimen (ISO 7784-3:2016)
DIN EN 927-6 (2016-12) (Draft)	Paints and Varnishes - Coating Materials and Coating Systems for Exterior Wood - Part 6: Exposure of Wood Coatings to Artificial Weathering using Fluorescent UV Lamps and Water; German and English Version prEN 927-6:2016
ISO 1434:2016	Natural Rubber in Bales - Amount of Bale Coating - Determination
ISO 14577-4:2016	Metallic Materials - Instrumented Indentation Test for Hardness and Materials Parameters - Part 4: Test Method for Metallic and Non-Metallic Coatings
ISO 15741:2016	Paints and Varnishes - Friction-Reduction Coatings for the Interior of On- and Offshore Steel Pipelines for Non-Corrosive Gases
ISO 19487:2016	Metallic and Other Inorganic Coatings - Electrodeposited Nickel-Ceramics Composite Coatings
ISO 19598:2016	Metallic Coatings - Electroplated Coatings of Zinc and Zinc Alloys on Iron or Steel with Supplementary Cr(Vi)-Free Treatment
ISO 19603:2016	Fine Ceramics (Advanced Ceramics, Advanced Technical Ceramics) - Test Method for Determining Elastic Modulus and Bending Strength of Thick Ceramic Coatings
ISO 20343:2017	Fine Ceramics (Advanced Ceramics, Advanced Technical Ceramics) - Test Method for Determining Elastic Modulus of Thick Ceramic Coatings at Elevated Temperature
ISO/FDIS 14713-3	Zinc Coatings - Guidelines and Recommendations for the Protection Against Corrosion of Iron and Steel in Structures - Part 3: Sherardizing
ISO/DIS 18796-1	Petroleum, Petrochemicals and Natural Gas Industries - Internal Coating and Lining of Carbon Steel Process Vessels - Part 1: Technical Requirements
IEC 60664-3 Ed. 3.0 (Bilingual 2016)	Insulation Coordination for Equipment Within Low-Voltage Systems - Part 3: Use of Coating, Potting or Moulding for Protection Against Pollution
I.S. EN ISO 14577-4:2016	Metallic Materials - Instrumented Indentation Test for Hardness And Materials Parameters - Part 4: Test Method for Metallic and Non-Metallic Coatings (ISO 14577-4:2016)
I.S. EN ISO 19598:2016	Metallic Coatings - Electroplated Coatings of Zinc and Zinc Alloys on Iron or Steel With Supplementary Cr(6)-free Treatment (ISO 19598:2016)
I.S. EN ISO 2286-2:2016	Rubber- or Plastics-coated Fabrics - Determination of Roll Characteristics - Part 2: Methods for Determination of Total Mass per Unit Area, Mass per Unit Area of Coating and Mass per Unit Area of Substrate

DIN EN ISO 14647 (2016-11)	Metallic Coatings - Determination of Porosity in Gold Coatings on Metal Substrates - Nitric Acid Vapour Test (ISO 14647:2000)
DIN EN ISO 14713-1 (2016-12) (Draft)	Zinc Coatings - Guidelines and Recommendations for the Protection Against Corrosion of Iron and Steel in Structures - Part 1: General Principles of Design and Corrosion Resistance (ISO/Fdis 14713-1:2016); German and English Version FprEN ISO 14713-1:2016
ISO/FDIS 14713-3	Zinc Coatings - Guidelines and Recommendations for the Protection Against Corrosion of Iron and Steel in Structures - Part 3: Sherardizing
DIN EN ISO 20502 (2016-11)	Fine Ceramics (Advanced Ceramics, Advanced Technical Ceramics) - Determination of Adhesion of Ceramic Coatings By Scratch Testing (ISO 20502:2005 Including Cor 1:2009)
DIN EN ISO 2178 (2016-11)	Non-Magnetic Coatings on Magnetic Substrates - Measurement of Coating Thickness - Magnetic Method (ISO 2178:2016)
DIN EN ISO 26423 (2016-11)	Fine Ceramics (Advanced Ceramics, Advanced Technical Ceramics) - Determination of Coating Thickness by Crater-Grinding Method (ISO 26423:2009)
DIN EN ISO 26424 (2016-11)	Fine Ceramics (Advanced Ceramics, Advanced Technical Ceramics) - Determination of the Abrasion Resistance of Coatings by a Micro-Scale Abrasion Test (ISO 26424:2008)
DIN EN ISO 2931 (2017-01) (Draft)	Anodizing of Aluminium and its Alloys - Assessment of Quality of Sealed Anodic Oxidation Coatings by Measurement of Admittance (ISO/DIS 2931:2016); German and English version prEN ISO 2931:2016
DIN EN ISO 3210 (2016-12) (Draft)	Anodizing of Aluminium and its Alloys - Assessment of Quality of Sealed Anodic Oxidation Coatings by Measurement of the Loss of Mass After Immersion in Acid Solution(S) (ISO/DIS 3210.2:2016); German and English Version prEN ISO 3210:2016
DIN EN 4474 (2016-11)	Aerospace Series - Aluminium Pigmented Coatings - Coating Methods; German and English Version EN 4474:2016
DIN EN 927-6 (2016-12) (Draft)	Paints and Varnishes - Coating Materials and Coating Systems for Exterior Wood - Part 6: Exposure of Wood Coatings to Artificial Weathering Using Fluorescent UV Lamps and Water; German and English Version prEN 927-6:2016
ISO 19598:2016	Metallic Coatings - Electroplated Coatings of Zinc and Zinc Alloys on Iron or Steel with Supplementary Cr(Vi)-Free Treatment
ISO/DIS 18796-1	Petroleum, Petrochemicals and Natural Gas Industries - Internal Coating and Lining of Carbon Steel Process Vessels - Part 1: Technical Requirements
MIL DTL 53022 Revision E Notice 1 Validation	Primer, Epoxy Coating, Corrosion Inhibiting Lead and Chromate Free - Revision E Notice 1 Validation
MIL PRF 85285 Revision E Notice 1 Validation	Coating: Polyurethane, Aircraft and Support Equipment - Revision E Notice 1 Validation
Key word search on 'galvanize' or 'galvanized' or galvanizing' (and the galvanise variants) – 1 citations found, 0 from AS AS/NZS.	
ISO/DIS 19203	Hot-Dip Galvanized and Zinc-Aluminium Coated High Tensile Steel Wire for Bridge Cables - Specifications
Key word search on 'corrosion' and 'concrete' or 'concrete' and 'coatings' – 2 Standard Publications found reinforcing steel related.	
AS 1012.20.1:2016	Methods of Testing Concrete - Determination of Chloride and Sulfate in Hardened Concrete and Aggregates - Nitric Acid Extraction Method
AS 1012.20.2:2016	Methods of Testing Concrete - Determination of Water-Soluble Chloride in Aggregates and Hardened Concrete
Key word search on 'cathode' or 'cathodic' – 2 Standard Publications found; 0 from AS AS/NZS.	
ISO/FDIS 15257	Cathodic Protection - Competence Levels of Cathodic Protection Persons - Basis for a Certification Scheme
ISO 12696:2016	Cathodic Protection of Steel in Concrete
Key word search on 'anode' or 'anodes' or 'anodic' – 0 Standard Publications found.	
Keyword Search on 'electrochemical' or 'electrolysis' or 'electroplated' - 6 Standard Publications found, none from AA or AS/NZS.	
DIN EN ISO 16773-1 (2016-12)	Electrochemical Impedance Spectroscopy (EIS) on Coated and Uncoated Metallic Specimens - Part 1: Terms and Definitions (ISO 16773-1:2016)

DIN EN ISO 16773-2 (2016-12)	Electrochemical Impedance Spectroscopy (EIS) on Coated and Uncoated Metallic Specimens - Part 2: Collection of Data (ISO 16773-2:2016)
DIN EN ISO 16773-3 (2016-12)	Electrochemical Impedance Spectroscopy (EIS) on Coated and Uncoated Metallic Specimens - Part 3: Processing and Analysis of Data From Dummy Cells (ISO 16773-3:2016)
ISO 19598:2016	Metallic Coatings - Electroplated Coatings of Zinc and Zinc Alloys on Iron or Steel with Supplementary Cr(VI)-Free Treatment
I.S. EN ISO 19598:2016	Metallic Coatings - Electroplated Coatings of Zinc and Zinc Alloys on Iron or Steel with Supplementary Cr(6)-free Treatment (ISO 19598:2016)
DIN EN 14038-1 (2016-10)	Electrochemical Realkalization and Chloride Extraction Treatments for Reinforced Concrete - Part 1: Realkalization
Keyword Search on 'anodize' or 'anodized' - 5 Publications found	
ISO/DIS 3210.2	Anodizing of Aluminium and its Alloys - Assessment of Quality of Sealed Anodic Oxidation Coatings by Measurement of the Loss of Mass After Immersion in Acid Solution(S)
DIN EN 17059 (2016-12) (Draft)	Plating and Anodizing Lines - Safety Requirements; German and English Version PrEN 17059:2016
DIN EN ISO 2143 (2017-01) (Draft)	Anodizing of Aluminium and its Alloys - Estimation of Loss of Absorptive Power of Anodic Oxidation Coatings After Sealing - Dye-Spot Test with Prior Acid Treatment (ISO/DIS 2143:2016); German and English Version PrEN ISO 2143:2016
DIN EN ISO 2931 (2017-01) (Draft)	Anodizing of Aluminium and its Alloys - Assessment of Quality of Sealed Anodic Oxidation Coatings by Measurement of Admittance (ISO/DIS 2931:2016); German and English Version PrEN ISO 2931:2016
DIN EN ISO 3210 (2016-12) (Draft)	Anodizing of Aluminium and its Alloys - Assessment of Quality of Sealed Anodic Oxidation Coatings by Measurement of the Loss of Mass After Immersion in Acid Solution(S) (ISO/DIS 3210.2:2016); German and English Version PrEN ISO 3210:2016

NSB Infrastructure

Q: In what year was your company established?

A: NSB was originally formed in 1967, so has been operating for 50 years, and is a family owned business now operated by the third generation.

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

A: The company originally had just the founder working, but after a couple of years his sons started working with him.

Q: How many do you currently employ?

A: We have 25 on staff of which 20 are trained blasters and applicators.

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

A: No, just spread throughout New Zealand. However as we are looking to grow we are now starting to actively look at what other markets are available.

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

A: We are predominantly abrasive blasters and coatings applicators. We are the largest applicator of thermal sprayed metals in New Zealand.

However in the last few years we have worked considerably more in assessments, overall project design and implementation of maintenance plans.

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

A: We try to cover most markets in the corrosion protection field, however we do specialize to a degree in bridge coating and structural steel. We also work in the oil and gas fields. We have started working with infrastructure owners as well, assessing networks and designing maintenance packages.

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

A: Both workshop and site based, we have one of the largest facilities in New Zealand but do have multiple site crews operating.

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

A: Depends on types of steel and beam sizes, in bridging 10,000sqm plus and in commercial structural up to 8,000sqm.

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

A: We do a considerable amount of consulting, asset condition

assessment and programmed maintenance type work.

We have found that while asset owners use broad based consultants to do their network assessments their lack of knowledge around corrosion protection and rectification allows us to offer a more specialised service. We now work in conjunction with these engineers to help deliver a complete package.

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

A: The full refurbishment of a Wellington gas main, situated over a live electrified rail line and stream. It had an outer casing that was corroded through in multiple areas, with the gas main that was concealed and showing an unknown degree of corrosion under X-Ray.

Varying contractors had had four attempts to complete the refurbishment and had stopped as they were unable to satisfy the asset owner that it could be completed with acceptable risk exposure. It was considered the asset owners highest risk project, and had been for a number of years.

With 4 months of design and risk assessment we satisfied the client that the works could be done and completed the project with no issues. Furthermore the asset owner won an environmental award for the works undertaken and the protection of the surrounding stream and park.

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

A: With the right degree of planning and analysis things do happen as expected.

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

A: We are registered with the government based ITO training scheme which is mostly internal. This scheme has multiple unit standards that the staff work through and we have a qualified assessor on staff who ensures they meet the required standards.

Furthermore we are using an independent coatings inspector, who has vast experience on the tools, to run workshops for staff. Our staff know and respect his skills so we have found it to be very useful.

We have also started talking with the SSPC Train the Painter as a further independent supplier.

Craig Ross.
www.nsb.net.nz

NSB INFRASTRUCTURE

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 3 9890-4833 or via email to aca@corrosion.com.au.

Please note: this list is current as at 19 January 2017.

ACA Coating Inspectors

Name	Cert. No.	Expiry Date
Alan Lee	3539	31/12/18
Alistair MacKenzie	4191	31/12/17
Andrew Aidulis	1404	31/12/20
Andrew Martin	545	31/12/19
Anthony Heuthorst	2297	31/12/19
Basyl Jakimow	3230	31/12/20
Ben Biddle	1279	31/12/20
Bradley Marsh	3232	31/12/20
Brett Meredith	2218	31/12/21
Brian Harris	1054	31/12/18
Charles Wheeler	3943	31/12/20
Clayton Henry	1595	31/12/17
Clifford Parkes	3607	31/12/20
Clinton Iliffe	4034	31/12/20
Craig Williams	4176	31/12/20
Daniel Lillas	3597	30/11/19
Dave Elder	155	31/12/20
David Lepelaar	3356	31/12/18
Dennis O'Loughlin	7353	31/12/17
Dennis Tremain	1036	31/12/17
Derek Allen	3870	31/12/20
Don Herrigan	4033	31/12/20
Dragan Stevanovic	2960	31/12/18
Eric Norman	7340	31/12/17
Frank Hiron	2888	31/12/18
Garry Matthias	1481	31/12/21
Gary Abbott	4080	31/12/20
Gary Smith	2512	31/12/19
Geoffrey White	75	31/12/21
Graeme Kelly	721	31/12/17
Graham Porten	2257	31/12/19
Harold Burkett	361	28/2/17
Jason Bourke	2597	31/12/19
Jeffrey Hurst	1746	31/12/18
Jerry Forslind	1129	31/12/21
John Cooke	3235	31/12/18
John Mitchell	1042	31/12/17
Jonathan Mace	4035	31/12/21
Joseph Kowal	553	31/12/20
Kamran Armin	4232	31/12/21
Kerry Cooper	2483	31/12/20
Kevin Sellars	7352	31/12/17
Laurence Snook	1526	31/12/17
Leonard Kong	3538	31/12/18
Lorraine Pidgeon	1513	31/12/17
Luis Carro	2212	31/12/17

Mark Weston	883	31/12/17
Mervyn Perry	268	31/12/17
Micah Butt	2397	31/12/22
Michael Boardman	1051	31/12/17
Michael Crowley	4197	31/12/17
Michael Johnstone	2964	31/12/18
Michael Sillis	844	31/12/17
Narend Lal	3355	31/12/19
Neil Alan Lewis	2598	31/12/18
Neil Stewart	1358	31/12/17
Nick Edwards	1992	31/12/20
Paul Hunter	2988	31/12/17
Paul Vince	7355	31/12/17
Peter Hart	1	31/12/21
Peter Luke	3795	31/12/19
Peter McCormack	4353	31/12/17
Peter Nicholson	4086	31/12/20

Peter Sutton	3183	31/12/17
Phill Dravitski	1593	31/12/20
Phillip Foster	2254	31/12/19
Ray Grose	2956	31/12/22
Rob Francis	720	31/12/17
Robert de Graaf	719	31/12/17
Robert Freedman	76	31/12/21
Robert Glover	1362	31/12/17
Robert Johnson	2625	31/12/18
Rod Cockle	1410	31/12/20
Roger Kearney	1121	31/12/18
Rohan Healy	3184	31/12/17
Roman Dankiw	872	31/12/21
Russell Tierney	2000	31/12/20
Sean Anthony Burke	3428	31/12/18
Shane White	2869	31/12/21
Spencer Macsween	3170	31/12/17

Stephen Nixon	2256	31/12/17
Steve Dyer	3879	31/12/20
Stuart Bayliss	247	31/12/18
Todd Elkin	3402	31/12/20
Tony Evans	2086	31/12/17
Tony Mans	3233	31/12/17
Tony Ridgers	421	31/12/20
Tracey Sherman	1829	31/12/18
Trevor Baensch	2211	31/12/20
Trevor Smith	1035	31/12/17
Vic Monarca	2053	31/12/21
Wayne Ferguson	893	31/12/17
Wayne Gray	3606	31/12/19
Wessel Mulder	7351	31/12/17
William Dunn	3386	31/12/18
Willie Mandeno	1216	31/12/17

Discontinuation of the ACA Coating Inspection Certificate

The Australasian Corrosion Association (ACA) wishes to notify all relevant individuals of its decision to discontinue the ACA Coating Inspection Certificate.

This decision was made in light of a number of factors, one of which has been the growing popularity of the internationally recognised NACE Coating Inspection Program Certification.

The ACA Coating Refresher Course has commenced being phased out and will be discontinued officially as at **31st December 2017**. If your ACA Coating Inspector Certification has expired you no longer are able to renew your certification. If you are due to renew your certification this year you can do so by either:

- Attend the ACA Coating Inspection Refresher course in Australia or New Zealand in 2017

or

- If you have a current NACE CIP Certification simply complete a refresher form, you are not required to attend the one day refresher course.

This will be the last opportunity to renew your certification, if neither method of refreshing is completed your Certification will expire and will no longer be valid. If you require a refresher form please email Skye Russell on srussell@corrosion.com.au

NEW PRODUCT SHOWCASE

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

AMS Trex™ Device Communicator

Emerson Automation Solutions introduces Power the Loop technology for the AMS Trex™ Device Communicator, helping users work more effectively and perform faster device configuration – on the bench or in the field – by removing the need for an external power supply.

The Trex communicator supports Emerson's Project Certainty initiative, adding flexibility in project scheduling and helping project teams achieve faster startup times. When using the Trex communicator in the field for new projects, Power the Loop technology can help take device configuration off the critical path. The Trex communicator allows users to power devices directly from the handheld communicator. Users can perform device configuration tasks before power and I/O infrastructure are in place, and without the need for the installation of the host system, wiring, piping, and other elements. During everyday field maintenance, users will no longer waste time searching the shop for a compatible power supply or confirming adequate loop resistance before connecting to a device. Technicians can simply connect the communicator to a loose device to power it, speeding configuration on the bench.

"The ability to power a hard loop off of the Trex unit is huge," said Joel Holmes, principal engineer at Monsanto. "We no longer need to have an additional power supply or loop simulator on hand, whether it's out in the field or back in our shop. It's a huge advantage for the technician."

"The Trex communicator gives technicians the flexibility they need to work efficiently in the field without carrying extra equipment," said Mani J, marketing director for Emerson's reliability solutions. "By reducing the number of tools necessary for configuration and commissioning, technicians can easily increase productivity and speed project startups."

For more information, go to emerson.com/trex.

New MDE-2000 Marksman™ II

Spectronics Corporation has released the new MDE-2000 MarksmanTM II ultrasonic diagnostic tool for detecting leaks and component defects long before they lead to costly and time consuming equipment failure. The MDE-2000 Marksman II converts and amplifies inaudible ultrasonic signals into audible sound. The allows the NDT technician to 'hear' even the smallest compressed air, natural gas, propane tank, vacuum, steam and other pressurized leaks before they lead to equipment failure. The Marksman II also identifies electrical arcs, sparks and worn or noisy bearings.

The Marksman II uses a two-tiered approach to ensure accurate diagnosis. The receiver converts inaudible ultrasonic signals into audible sound using heterodyne circuitry. Then, its unique Sound Signature Technology fine tunes the audible sound into the natural sound emitted by the leak itself. A 5-LED signal intensity indicator and audible alarm pinpoint the exact source of the problem. An Internal Noise Control (INC) feature safeguards against ambient noise.

The Marksman II comes complete with an ultrasonic receiver, full-sized, heavy duty, noise-canceling headphones, a hollow air probe, a solid contact probe and an ultrasonic emitter that helps locate faulty seals, gaskets and weather-stripping in doors, windows, ductwork and other non-pressurized enclosures. All components are packed in a sturdy carrying case.

For more information contact Russell Fraser Sales:

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

Spectroline LTK-441 LeakTracker™ Kit

A leaking system can cost valuable time and money and the greater the leak, the greater the expense. The new Spectroline LTK-441 LeakTracker™ Kit is ideal for all oil-based fluid system applications as it can pinpoint the exact source of leaks in hydraulic equipment, compressors, engines, gearboxes and fuel systems. The LeakTracker kit is highly sensitive and can detect leaks that other systems cannot however it is not limited to small-scale leaks and in fact the LeakTracker kit can treat up to 240 litres of oil-based fluid.

The LeakTracker kit includes 1 x 200ml twin-neck bottle of patented OIL-GLO™ 44 concentrated oil dye, 1 x 200ml spray bottle of GLO-AWAY™ dye cleaner, 6 Dye treatment tags, UV-absorbing glasses, belt holster, lanyard, batteries and a rugged carrying case.

The star of the kit is the powerful LT-300 LeakTracker™ leak detection flashlight. Its high-output LED delivers pure UV light for superior fluorescent dye response. It features 'instant-on' operation; reaching full intensity immediately. Cordless and compact, the LeakTracker torch is able to reach into cramped areas inaccessible to larger lamps.
A rugged, corrosion-resistant, anodized aluminum lamp body stands up to years of heavy use. Powered by three 'AAA' batteries (included), it provides 4 hours of continuous service and a 100,000-hour LED service life.

For more information contact Russell Fraser Sales:

T: +612 9545 4433
F: +612 9545 4218
E: rfs@rfsales.com.au
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THE UNIVERSITY OF AUCKLAND
Te Whare Wānanga o Tāmaki Makaurau
NEW ZEALAND

Surface Engineering Research at the University of Auckland, New Zealand

Corrosion and wear are two of the most important failure forms in mechanical and manufacturing industries. Coating and surface modification are the main tools to protect machinery and equipment from these types of failure. The '**Coating and Electrochemistry Group**' led by Professor Wei Gao in the Department of Chemical and Materials Engineering, Faculty of Engineering, the University of Auckland are actively working on the area of surface engineering.

This group currently has 10 PhD students, several Postdoctoral Fellows (Yuxin Wang, Fengyan Hou and Seeleng Tai) and academic visitors. Supported by the Department and Research Centre for Surface and Materials Science, this group works on various coating processing technologies, surface mechanical, chemical and functional property optimization, and micro/nano-structure characterization. The group focuses on both theoretical understanding and industrial applications, evidenced by a large amount of high-level journal publications and patents. They are also supported by the University's Commercial Arm – The Auckland UniServices, working with a wide range of the New Zealand and international coating companies. Their research has received great attention from many New Zealand and overseas users. Their coating products are tested and used by several of the world's leading manufacturing companies.

Here are some research examples from this group:

1. Corrosion and wear resistant coatings

This group has been making great efforts to develop innovative coating technologies on different substrates, especially on the steels, magnesium (Mg), aluminium (Al) and copper (Cu) alloys. Recently, they applied multi-layer technology to optimize the surface properties of coatings. For example, electroless double-layered Ni-P/Ni-P-ZrO_2 coatings with different phosphorus contents have been prepared on AZ 31 Mg alloy. The high phosphorus inner layer provides superior corrosion resistance while the low phosphorus composite outer layer provides excellent mechanical properties. This controllable duplex electroless coating system possesses excellent anticorrosion properties and wear resistance, a detailed report has been published on *Surface and Coatings Technology*, 2015, 261: p161-166.

The hot dipping method was utilised to produce Zn-Al-Mg alloy coatings on mild steel. It was found that proper addition of active element Mg can form a blocking layer on the surface of coating during corrosion, resulting in a significant enhancement of corrosion resistance compared with the traditional Zn and Zn-Al coatings. This new type of sacrificial coating may find wide applications in the construction industry, automobile and the other structural material areas (*Journal of Alloys and Compounds*, 2016, 670: p239-248).

Coating and Electrochemistry Group Photo.

2. Novel nanostructured composite coatings

2.1 Synthesis of nano-composite coatings using a novel sol-enhanced deposition technique

Nano-composite coatings have wide applications for their superior mechanical and corrosion properties. The strengthening effects relies on the dispersion of nano-particles. However, when solid nano-particles are added into the electrolyte, particle agglomeration is difficult to avoid, which will largely decrease the strengthening effect.

This group has developed a novel method which combines sol-gel process and electrochemical deposition process to produce nano-composite coatings. In this method, a small amount of oxide containing sol is added into the traditional electrolyte, making the just-formed nano-particle deposit onto the substrate together with metal ions, therefore avoiding the particle agglomeration. This method can produce truly nano-structured composite coatings, which possess much improved mechanical properties than that of the traditional coatings without sacrificing any corrosion resistance, surface gloss and electrical conductivity.

The related dopant technology was developed to promote the real application of sol-enhanced coating methods. Multiple sol-enhanced coatings were also developed in order to further improve the the properties of the original coatings. Scaling up tests have been conducted with the help of UniServices in an effort to realise industrial applications. (Chapter 6: Nanocomposite coatings deposited by sol-enhanced electrochemical methods, *Electrodeposition of Composite Materials*, edited by Adel M. A. Mohamed and Teresa D. Golden, Intech, 2016)

2.2 Nano-composite coatings produced by ionic co-discharging

This innovative co-discharging process comes from the sol-enhanced plating research. This process is similar to the conventional co-deposition method. However, instead of mixing and depositing inert particles with metals onto a substrate, this method lets the precursor of nanoparticles exist as ions in the electrolyte, and allows them to discharge on the cathode at the same time. By using this method, coatings of two or more phases may be electroplated onto substrates. The second phase can be a metal (such as Bi), or solid solution alloys, or intermetallic compounds. This type of composite coatings also possess superior surface properties. (*Chemical Engineering Journal* 2012, 192(2): 242-245)

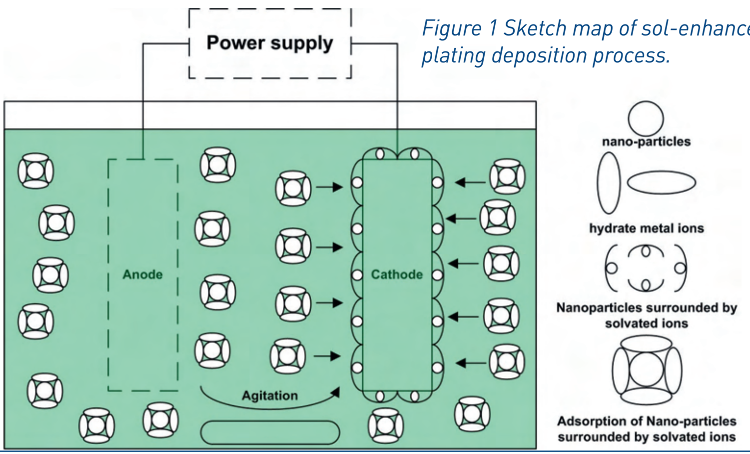

Figure 1 Sketch map of sol-enhanced plating deposition process.

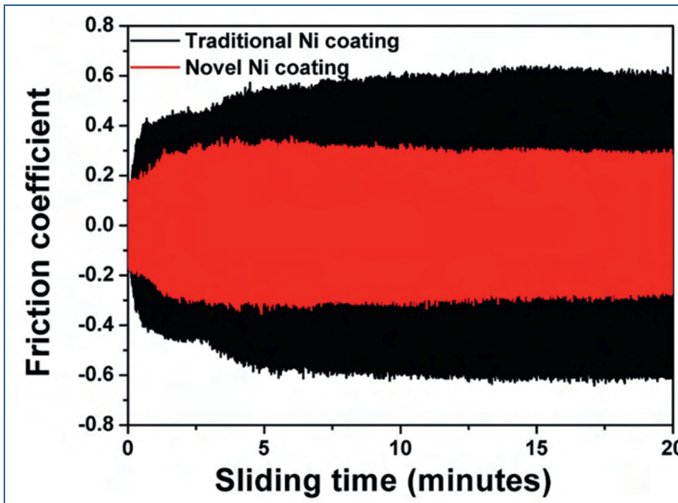

Figure 2 Frictional coefficient of novel Ni coating.

3. New functional coatings

This group uses simple and effective ways to fabricate a series micro/nano-structured coatings with desirable functions. This method combines anodizing with a nanostructured coating. A large number of metals including Al, Ti, Zn and Mg and their alloys can be used as substrates without size and shape restriction. Desirable surface properties such as super-hydrophobicity, super-icephobicity, antifouling property and antimicrobial property can be effectively achieved. For example, a semi-spherical smooth coating surface reduces the friction coefficient to ~50 % of the ordinary coating surface. The wettability of anodized Ti surface can be controlled from a water-contact angle from 2º (super-hydrophilic) to 172º (super-hydrophobic). Some of the anodization treatment can make the coatings very durable with high adhesion. Repair of a damaged surface is simple. The super-hydrophobicity and low friction with high durability on a large surface area is on top of the wish-list for worldwide materials scientists and engineers, and will open a door to a new frontier of surface science and engineering. (Provisional Patent "Method to create thin functional coatings on light alloys", Auckland, New Zealand, 2016).

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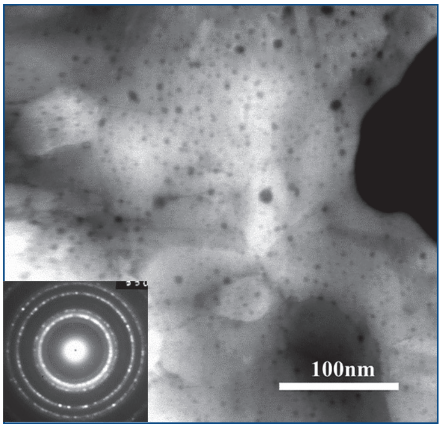


Figure 3 Sol-enhanced TiO_2 nanoparticle dispersed Ni coating.

The Importance of Asset Management Systems in Long Term Corrosion Control

Mark Dragar, Asset Manager Pipelines, Jemena Asset Management

Too often we as engineers and managers of critical infrastructure focus on the technical details in a bid to control corrosion. We focus on the design and the performance of the products we specify to ensure we eliminate corrosion from our assets. However, our experience tells us that over time, the elements of nature take their toll on the integrity of our assets; constantly challenging our best designs and taking advantage of our not so good designs.

Historically, our employees have become the ultimate source of asset knowledge; knowing when something is 'not right' and when to take action. For many organisations that manage large long term assets, it had become a given that the right person with the right knowledge would still be performing the same role as always, maintaining continuity in managing the issues that threaten the integrity of our assets.

So what happens when an organisation responsible for the operations and maintenance of long term critical infrastructure is subject to changes in management structure, organisational structure, loss of asset records and worst of all loss of employees with critical asset knowledge. With the sea-saw of building and losing knowledge over the years it becomes apparent that the ability to manage integrity over the long term becomes most critical to the asset manager.

As obvious as it might sound, developing a system and its associated processes to manage both field activity and the records that it generates is a good first step. Taking it further, a system that fuses the integrity management cycle with the business processes to ensure essential activities are budgeted, scheduled and actioned is even better. From personal experience, achieving even the former is a huge undertaking for any business let alone aiming to implement the latter. The resources and commitment required to achieve such a goal is not to be taken lightly, but is more than worth it if you get it right.

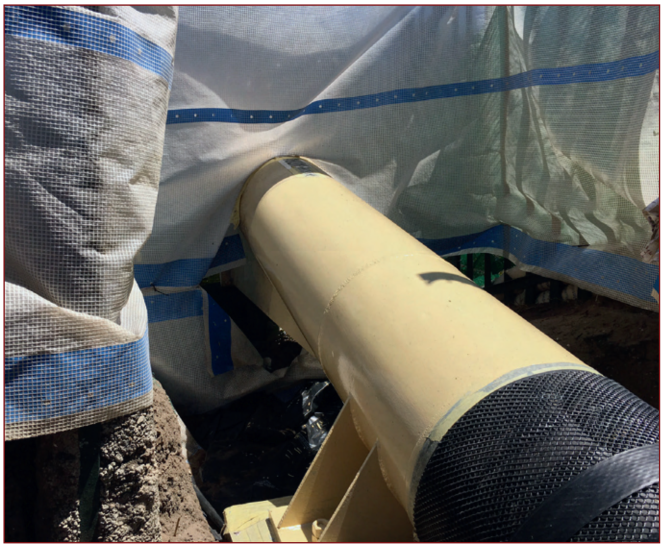
This is a journey that I have been a part of at Jemena over the last 2 years, responsible for implementing the Asset Management System and developing the processes for my asset class, all with the ultimate goal of contributing towards Jemena's accreditation to the ISO 55000

East End after Excavation.

East End Corrosion.

Pipe bridge crossing body of water.

Pipe cleaned and recoated.



The above ground pipe section recoated.

Asset Management Standard. It has been within this journey, that we have questioned everything we currently do and that which we no longer do. Looking at the records that we have and the ones we believe we need to maintain the asset in a sustainable manner.

It was at this point one of my engineers presented me with a discovery he had made with his field based colleague; corrosion at the soil-air transition point where our asset crosses a body of water. How had this happened? We have always regularly inspected these assets… right? Looking to find records of such inspections, all that was discovered were service orders that were shown as completed, but little information on the status of the condition of the asset at each inspection.

An investigation of the cause revealed that the corrosion was attributed to coating failure combined with an environment conducive to corrosion, whilst cathodic protection was ineffective because the design had isolated that section of the asset from the CP current.

However, upon further analysis, it was clear that the real issue was not the corrosion, nor that the records had not been kept; these were just the end result of the fact that the process for managing this threat had not been documented. I could not locate any documentation stating the requirements of the inspection, the records that needed to be captured as part of the inspection, where the records were to be kept or how the findings would be escalated if something unusual was identified.

Immediately, this presented an opportunity to document the process of inspection and review the existing documented process for repair of the discovered anomaly. Despite the additional work involved in documenting the process, which was on top of the work involved in repairing the corrosion, the value added from this activity is truly realised when the organisation can continue to change and grow without detriment to the asset, through having appropriately documented and understood processes that naturally drive our critical activities.

It is here, that the importance of a well-developed Asset Management System is understood, as the 'value' realised by pursuing the aforementioned opportunity is recognised as one of the four principles that the ISO 55001 international asset management standard reinforces ('leadership', 'alignment' and 'assurance' being the others). However, the real key to the success of any such system is how deeply it is integrated into one's organisation (i.e. 'alignment') and how committed that organisation is (i.e. 'leadership') to implementing it.

This Paper was originally presented at C&P2016.

Corrosion and Corrosion Inhibition in Wet Gas Pipelines

D. Ugur[1], J. Sonke[1] and N. Laycock[2]

[1]Shell Global Solutions, Grasweg 31, Amsterdam, 1031 HW, The Netherlands. [2]Qatar Shell Research and Technology Centre, QSTP, Education City, Qatar

1. Introduction

Wet gas pipelines present multiple challenges for corrosion and integrity engineers. In particular, the presence of CO_2 and H_2S can create the potential for very high internal corrosion rates and in some cases for Stress Corrosion Cracking. The approach taken to the internal corrosion control for such pipelines will usually begin with a detailed threat assessment, identifying all possible corrosion mechanisms and selecting the most appropriate controls (or barriers) to prevent these mechanisms from leading to pipeline failure. In most cases, the corrosion control is primarily achieved by continuous injection of a corrosion inhibitor (CI). Many different inhibitor formulations are available in the market and the selection for a particular application is typically based on a programme of qualification testing in the laboratory. Such programmes are intended to ensure that the chosen inhibitor will provide adequate protection to the equipment in all possible environmental conditions that are likely to be experienced during the project lifetime. Since it is not usually practical to test all possible combinations, a selection is often made based on the assumed 'worst case' conditions. This paper will briefly discuss some of the challenges in this approach.

2. Internal Corrosion Threat Assessment

This section presents a typical list of internal corrosion mechanisms that will be considered in a wet gas pipeline risk assessment. However, potential cracking mechanisms are generally avoided by materials selection and quality control according to well-known industry standards, and will not be covered any further in this paper, which is concerned with the non-cracking corrosion threats of general corrosion and pitting corrosion.

2.1 H_2S/CO_2 corrosion

For mixed acid gas regimes, there are three different corrosion domains to consider [1], based on the ratio of the partial pressures of CO_2 (pCO_2) and H_2S (pH_2S):

- $pCO_2/pH_2S > 500$: Sweet corrosion regime, CO_2 corrosion alone.
- pCO_2/pH_2S between 20 and 500: Mixed corrosion regime, slightly sour environment.
- $pCO_2/pH_2S < 20$: Sour corrosion regime, H_2S corrosion dominates.

The sweet CO_2 corrosion of carbon steel is one of the most prevalent and most studied internal damage mechanisms for oil and gas production facilities [2], and the formation of protective surface scales is known to be critically important in many cases [3]. There are a number of empirical and mechanistic models used within the industry to predict the un-inhibited (worst case) corrosion rates for the expected service conditions, but there remain some challenges in this area, particularly concerning the impact of surface scales on the predicted corrosion rate and morphology [4].

In sour corrosion, protective scales of iron sulphide corrosion products are generally formed, and these reduce the general corrosion rate to very low levels [5-12]. Unfortunately, where these surface scales suffer localized breakdown, pitting corrosion can occur at very high penetration rates. Again, in this area there is as yet no universally accepted model that can be used for advance prediction of the uninhibited corrosion rate.

2.2 Top-Of-Line Effects

At relatively high flow rates, pipelines will have an annular dispersed flow regime, which allows continuously injected corrosion inhibitor to reach the entire pipeline surface. However, at relatively low flow rates, a stratified flow regime can arise. In this case, the main aqueous phase in the bottom of the pipeline will contain any continuously injected corrosion inhibitor, but any condensing water in the Top Of the Line (TOL) will not contain the continuously injected corrosion inhibitor, and so there is a risk of TOL corrosion. In sweet gas, the uninhibited corrosion rate in the TOL is thought to depend on the water condensation rate and the chances of protective scale formation within the thin condensed film [13]. Nonetheless, in many cases it is considered prudent to use additional batch dosed corrosion inhibitors, which do protect the TOL, as a supplement to the continuous injection program. On the other hand, for sour corrosion, protection by sulphide scales means that TOL corrosion is considered a much lower risk and hence supplemental batch dosing is rarely required. The one potential exception to this arises when methanol (MeOH) is being injected for hydrate control. It is believed that condensation of a MeOH rich phase in the TOL can prevent the formation of protective sulphide scales and so lead to much higher corrosion rates. This threat is also potentially further aggravated by the presence of oxygen in the MeOH.

2.3 Oxygen Ingress

The produced fluids do not contain oxygen, but there is a need to consider the possibility of oxygen ingress during operation; for example, during chemical injection or maintenance work. In sweet systems, this could reduce the effectiveness of the corrosion inhibitor and lead to pitting corrosion, but the potential impact is much higher in sour systems, where the oxygen can both destabilize protective sulphide scales and react with H_2S to form elemental sulphur, which is highly corrosive when allowed to deposit on the surface of carbon steel. Although this potential for oxygen related corrosion problems in sour gas pipelines is very widely recognized [14], operators in general do not take any specific measures to limit the amount of oxygen introduced with injected chemicals (corrosion inhibitors, kinetic hydrate inhibitors, scale inhibitors). This is because the risk is deemed low due to the combination of the relatively small amounts of oxygen that are introduced (chemicals are typically introduced in only ppm levels) and, the fact that any oxygen content in the liquid phase would be further reduced by partitioning into the hydrocarbon phases.

2.4 Under Deposit Corrosion

In both sweet and sour pipelines, the formation of solid deposits (e.g. sand, corrosion products, other debris) in the bottom of the line creates a threat of Under Deposit Corrosion (UDC). This threat arises largely from the apparent ability of such deposits to prevent any injected corrosion inhibitor from accessing the metal surface beneath the deposit, while at the same time allowing the corrosive species to access the same surface and cause rapid pitting corrosion. It could as well be the case that the CI is absorbed by the suspended solids in the produced fluids, or the electrolyte composition beneath the deposit is completely different from the bulk of the fluid causing the CI to be ineffective. For high flow systems, deposits can also trigger erosion corrosion [15].

For sour pipelines in particular, UDC is often considered the most significant corrosion threat. The presence of deposits in sour pipelines has frequently been associated with maximum penetration rates of several tens of mm/y. It is very difficult to find continuous-injection corrosion inhibitors that are effective against UDC, especially when high chloride levels are present. Consequently, both routine operational pigging to sweep any deposits from the line and supplemental batch corrosion inhibitor application are often required to protect against UDC.

3. Corrosion Inhibitor Qualification

This paper focuses on a few key lessons learned from a number of qualification programs for continuous-dose corrosion inhibitors. Typical key acceptance criteria for such an inhibitor are shown in Table 1. The most important is that the corrosion rate for general corrosion should be less than 0.1 mm/y under various operating conditions. Similarly for pitting corrosion, the "pass" criterion is less than 0.18 mm/y, which corresponds to a 10 µm pit formed in 500 hr of qualification testing. Secondary properties such as emulsification and foaming tendency, long term storage stability, condensate stabilizer stability, and compatibility

Batch inhibitor qualification testing in progress at Shell Technology Center Amsterdam using the state of the art test equipment.

Criteria	Requirements
Primary	- CI must be effective in: □ Both high and low TDS brine; □ Both inlet and outlet (e.g., seabed) temperatures; □ Uncovered steel and preferably underneath deposits (FeS); □ the presence of other chemicals, e.g., MeOH (startup), hydrate inhibitors and batch inhibitors; - Must maintain protectiveness in: □ Spent acid flow back conditions (i.e., compatibility against low pH and in the presence of other produced chemicals); □ Shut in conditions (i.e., production stopped, temperature dropped, inhibitor present). Persistency should be as high as possible. □ Brief loss of injection (i.e., Flowing persistency: injection interrupted, production continuing). Persistency should be as high as possible. - Must be effective against galvanic corrosion, in particular the Alloy 625 – C steel couple. <u>- Effectiveness criteria:</u> □ General corrosion rate < 0.1 mm/y □ Pitting corrosion rate < 0.18 mm/y (i.e., max 1 pit with a max depth of 10 µm after a 500 hr test)
Secondary	- Should suffer no degradation during long term storage at local ambient conditions; - Low emulsification and foaming tendency; - Should produce no gunking/foaming in combination with downstream processing chemicals (e.g., sweetening agents such as Methyldiethanolamine - **MDEA**); - Should produce no gunking in condensate stabilizer; - High partitioning to water phase; - Established reliable and accurate residuals procedure in water phase (with & without the presence of field chemicals affecting the partitioning behavior, e.g., HI) - Compatibile with elastomers (e.g. valve seals) and GREs (Glass Reinforced Epoxy); - Compatible with metallic materials in the injection system; - Viscosity of the neat CI < 100 cP at 15 °C.

Table 1: CI qualification acceptance criteria and test requirements.

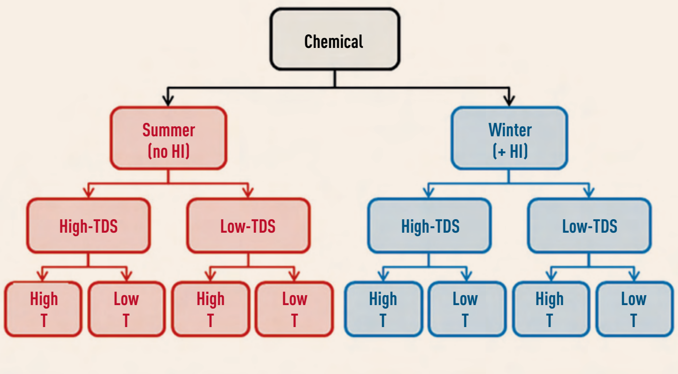


Figure 1: Schematic diagram showing typical range of possible conditions for inhibitor qualification testing.

with other chemicals used downstream are also tested, but are not the subject of this paper.

The first task is to determine what conditions should be used for the testing. Figure 1 shows a fairly typical set of variables that might be considered for a wet gas pipeline. For example in winter, the Corrosion Inhibitor (CI) will be used in conjunction with a Hydrate Inhibitor - e.g., a Kinetic Hydrate Inhibitor (KHI), Monoethylene Glycol (MEG), or an Anti Agglomerant (AA) - and it is known that this can cause mutual compatibility problems for both chemicals. Furthermore the wells will initially only produce condensed water, with a low Total Dissolved Solids (TDS) content, but at some stage they will produce formation water with a very much higher TDS. For all those conditions, the inlet end of the pipeline will generally be quite a bit hotter than the outlet. On top of these, there will usually be several candidate inhibitors that must be tested. Consequently, it is too expensive and time consuming to test every candidate chemical in every possible condition, and some decisions must be made about what constitutes the worst case (or cases).

3.1 Test Method

Corrosion inhibitor qualification tests are performed following the test procedures given elsewhere [15, 16]. The results are gathered from 5 fields in total; 2 producing oil and 3 producing gas. General corrosion rates are determined from electrochemical and weight loss measurements. For localized, i.e., pitting corrosion, samples are analysed with digital microscopy or profilometry as described in Ref. [15].

Electrodes used to assess the corrosion rates were made from ASTM A36 steel following the surface preparation procedures given in Ref. [15]. Brine compositions used in the tests are as per field analysis results; different brines are prepared for condensed water production and formation water production cases [15]. A brief overview of the test conditions used in this study is shown in Table 2. All corrosion inhibitors used are imidazoline based formulations, (i.e., quaternary ammonium compounds & proprietary ingredients). Corrosion inhibitors named as A, B, C and D correspond to candidates from different vendors nominated for qualification for a specific field.

3.2 Acid Gas Concentrations

The general approach here is to use predictive corrosion models, such as Hydrocor [1], to determine the conditions that would cause the highest uninhibited corrosion rates. As discussed above, for definitely sweet or definitely sour conditions, the only significant problem with this approach is that arising from difficulties in modelling the effect of protective scales at higher temperatures and higher pH values in sweet conditions. However, for the mixed regime, or where there is a significant difference in gas composition from different wells supplying the same pipeline, then there can be a significant impact on the inhibitor selection. For example, some inhibitors work well in both sweet and sour conditions, but others do not perform well under sour conditions where pitting is the dominant mode of corrosion. And while inhibitor performance is generally independent of CO_2 concentration over a wide range, there may be different performance with different levels of H_2S. In most cases, however, testing is simply carried out at the maximum CO_2 and H_2S concentrations.

Table 2: Summary of the test conditions used in the CI qualification work.

Autoclave conditions*	Pipeline inlet	Pipeline outlet
Temperature range (°C)	75 - 90	14 - 30
p(CO_2) range (bar)	2.3 - 4.2	0.75 - 3.2
p(H_2S) range (bar)	2 - 2.8	1.7 - 2.2
	Low TDS	High TDS
Salinity range (g/L)	4 - 6	30 - 220

* Ranges quoted in this table are a summary of 5 operating fields (2 oil and 3 gas fields); an individual field has been tested only for the conditions relevant to that specific field.

3.3 Test Temperatures

Pipeline fluid temperatures might typically vary between about 0 and 100 °C, which generally makes little difference to the predicted uninhibited corrosion rates, except in the cases where protective scaling is important and difficult to model. On the other hand, it is well known that temperature can have a potentially significant impact on corrosion inhibitor performance. Usually, it would be expected that the higher temperature conditions would be most challenging for the inhibitors, and in many cases only the high temperature conditions would be included in the qualification program. However, in several recent examples for similar sour gas conditions, we found that testing at the lower test temperatures produced the highest pitting corrosion rates for some of the inhibitors in some of the conditions (see Figure 2). Consequently, it is recommended that a low temperature test condition should always be included in sour service inhibitor qualifications.

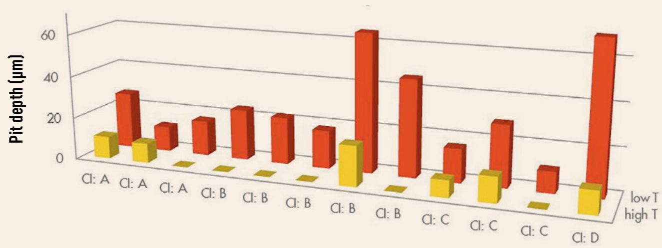


Figure 2: 500 hr corrosion testing results for multiple different corrosion inhibitors (A, B, C, D) in wet sour gas conditions, at a range of different test temperatures. In all cases, modelling suggested the highest uninhibited corrosion rates would be seen at the higher temperatures.

3.4 Salinity

For sour gas systems, where the formation of protective sulphide scales is expected, the general assumption is that higher chloride levels will lead to an increased risk of pitting corrosion. Various explanations have been proposed for this effect, mostly around destabilising effects of chloride on the protective scale and chloride concentration effects once they start to grow [17-19]. Whether or not these mechanistic explanations are correct, experience does suggest a detrimental effect of high chloride concentrations and 10,000 ppm chloride is sometimes considered a threshold value above which there is a much higher risk. However, in practical terms, it is important to recognise that increased chloride levels do not generally arise without other changes in the environment at the same time. For example, for the results shown in Figure 3, the High TDS case has five times more chloride than does the Low TDS case, but also includes additional bicarbonate and acetate ions, and thus has a slightly higher pH (e.g. pH 4.1 vs pH 3.5 at 14 °C). As shown in Figure 3, for these conditions, tests with inhibitors A-C all showed higher pitting corrosion rates in the Low TDS environment.

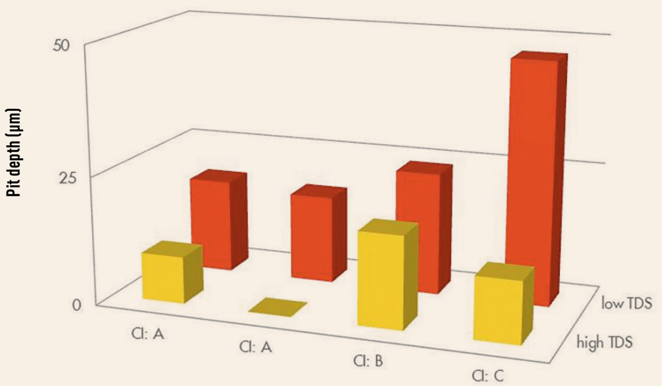
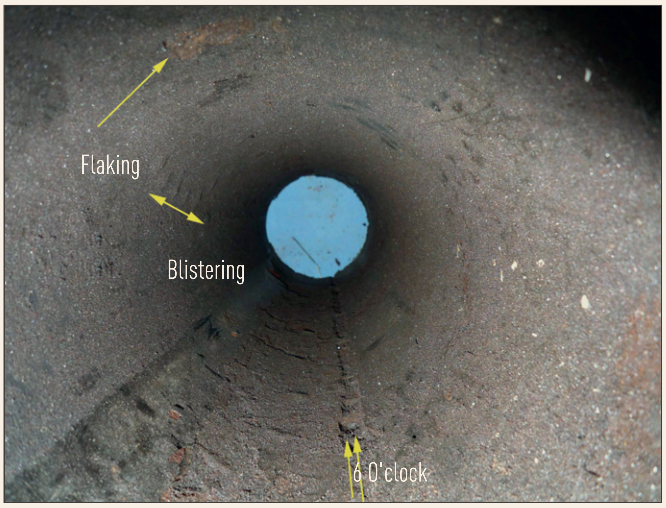


Figure 3: 500 hr corrosion testing results for multiple different corrosion inhibitors (A, B, C) in wet sour gas conditions, in both Low TDS (~ 6 g/L) and High TDS (~ 30 g/L) conditions.

Extreme corrosion and associated wall thinning can lead to dramatic loss of primary containment (LOPC) failures in the field.



Examples from typical corrosion patterns; 6 o'clock corrosion due to water drop out, flaking and blistering due to formation of porous & instable scales.

Table 3: Control results for un-inhibited tests with bare steel, FeS-covered steel and sand-covered steel coupons. Note that two very slightly different sour gas compositions were used ('A' and 'B'). All the results are from single tests and have been converted to units of mm/y for ease of comparison. For Weight Loss, this conversion assumes uniform corrosion.

	Corrosion Rates (mm/y)						
	BARE STEEL			FeS COVERED		SAND COVERED	
Test	Corrosion rate from LPR tests	Weight Loss	Pitting	Weight Loss	Pitting	Weight Loss	Pitting
Gas Comp A, Low TDS 14 °C	<0.05 - <0.01	0.033	3.6	8.9	15.9	N/A	N/A
Gas Comp A, Low TDS 90 °C	1.4 – 0.16	0.77	2.7	1.3	2.7	N/A	N/A
Gas Comp B High TDS 14 °C	<0.05 - <0.01	0.032	4.3	7.8	9.4	0	0
Gas Comp B High TDS 90 °C	3.4 - <0.05	0.12	11	18.2	21	0.33	2.2

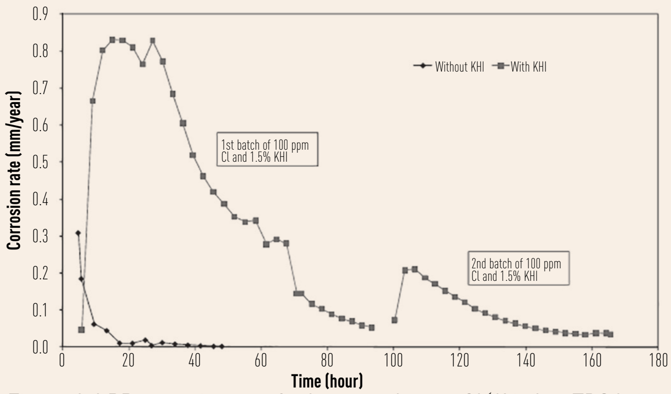


Figure 4: LPR corrosion rate for bare steel using CI 'A' in low TDS brine with and without KHI.

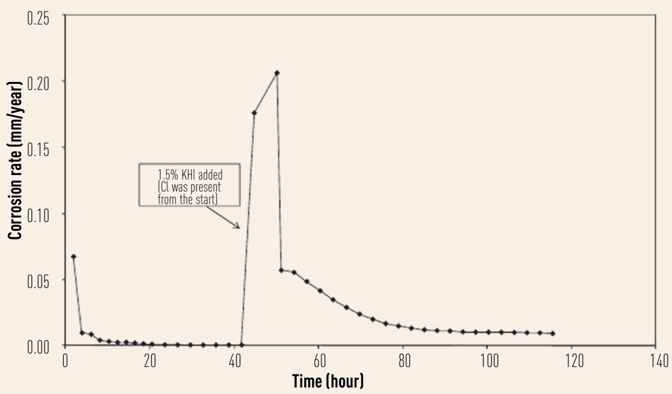


Figure 5: LPR corrosion rate for bare steel using CI 'A' in low TDS brine with HI added during the test.

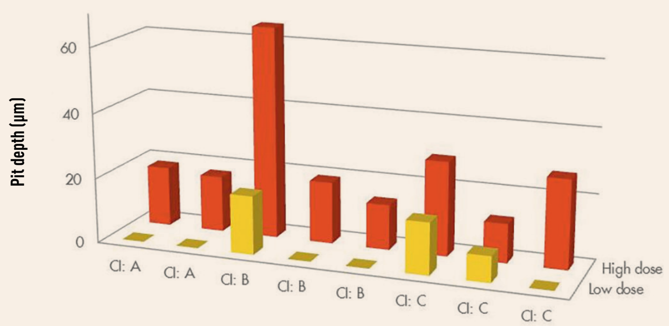


Figure 6: 500 hr corrosion testing results for CO_2/H_2S corrosion for three different inhibitors (A, B, C) at different dose rates, showing significantly worse performance at increased dose rates (CI:A, 20% increase; CI:B, 140% increase; CI:C, 140% increase with respect to the initial dose rate).

3.5 CI/HI Compatibility

When both a CI and HI are to be selected, it is possible to take different strategies; e.g. select a HI first, and then select a CI that will work with the already selected HI; or vice versa. In a recent project, it was first found that very few of the submitted HI products performed adequately in the presence of any of the submitted CIs, and then, having selected a HI, it was subsequently found that the HI could also negatively impact the performance of the CIs. For example, Figure 4 shows the (LPR) corrosion rate versus time for a candidate CI in low TDS brine, with and without KHI. Although the level of interference (i.e. the negative impact of the KHI on performance of the CI) seemed to decrease over time, a complete liquids refresh, including fresh CI and KHI, reinitiated the interference. As shown in Figure 5, adding the KHI in the middle of a CI test also showed a significant negative effect. It was eventually possible to qualify a compatible CI/KHI combination, but the point to be made here is that these effects are important, and the selection strategy (HI first or CI first) can make a considerable difference to the difficulty of the qualification process.

3.6 Including Organic Acids

In recent qualification tests for a sour gas system, we have found that the presence of 200 – 400 ppm acetic or formic acid can have a significant detrimental effect on the performance of the inhibitors. Overall, there appears to be a clear difference in the action of inhibitors in sweet and sour systems. In sweet systems, the inhibitors are able to function effectively in the absence of any surface scale of iron carbonate corrosion products. In sour systems, however, it seems that the inhibitors work together with the formation of protective iron sulphide scales. The presence of organic acids reduces the quality (protectiveness) of the scale (e.g. by complexation of ferrous ions), and this has a direct negative impact on the performance of the corrosion inhibitor. Hence, for inhibitor qualification for sour gas systems, it is critical to include organic acids if they are possibly present within the service environment [20, 21].

For testing purposes, it is also important to recognise that organic acids in a well stream are transported via the gas phase in the undissociated acid form or molecular form, which is in equilibrium with the liquid phases. If the aqueous phase is of a formation water type, the organic acids react with bicarbonate to form the organic acid anion. Consequently, artificial formation water should be made up with organic acid salt (not the acid). On the other hand, artificial condensed water should be made up with the parent acid (not the salt).

3.7 Under Deposit Corrosion Testing

As noted above, Under Deposit Corrosion is often considered to be the most significant corrosion threat for wet sour gas pipelines. In a recent qualification programme, an attempt was made to make test coupons with representative sand and FeS deposits. The 10mm deep sand deposits were made from acid washed sea sand with a 100-300 μm particle size range, which was applied dry in some cases and wetted with hydrocarbon condensate in other cases. The 4 mm deep FeS deposits were made using 100 mesh 99.9% FeS (Sigma-Aldrich 343161), and some elemental sulphur was present within this product. Table 3 shows some results for control tests (i.e., without inhibition), showing that the FeS deposits were considerably more aggressive. In this particular programme it was not possible to qualify a continuously dosed corrosion inhibitor to protect beneath the FeS deposits, and the design of qualification tests for UDC is not yet standardised [15, 22].

3.8 Qualified Inhibitor Dose Rate

The normal practice in qualification programmes is to test each product at only one CI concentration, which has been agreed based on discussions with the chemical vendors and takes into account project requirements for things like required storage volumes and injection pump sizing. The end result is an inhibitor qualified for a particular concentration, referred to as the Minimum Effective Inhibitor Concentration (MEIC), on top of which most operators will (at least initially) add a 10-30% safety factor. In practice, it will often be the case that actual injection rates and inhibitor concentrations are considerably higher than these qualified minimum levels. This is generally considered to be a problem only for downstream processing, where the secondary properties such as emulsification and foaming tendencies become critical. However, we have recently found that several inhibitors showed significantly worse performance at higher dose rates in sour conditions, as shown in Figure 6. Consequently, we believe that inhibitor qualification should include definition of both minimum and maximum allowable concentrations.

4. Conclusions

- Wet gas pipelines require high performance corrosion inhibitors, and the qualification process for such inhibitors can be quite complicated.
- When both chemical types are required, the mutual compatibility of HI and CI is a major hurdle to be cleared.
- When including organic acids in the test conditions, artificial formation water should be made up with organic acid salt (not the acid) while artificial condensed water should be made up with the parent acid (not the salt).
- In sour conditions, the presence of organic acids has a detrimental effect on CI performance.
- A robust test method does not yet exist to qualify inhibitors for control of Under Deposit Corrosion.
- In sour conditions, the most severe test for CI performance is not always at the highest temperature.
- In sour conditions, the most severe test for CI performance is not always at the highest salinity.
- In some cases, increased CI concentrations can result in less effective inhibitor performance.
- Overall, testing CIs only in the worst case condition identified from corrosion modelling of the un-inhibited conditions is a flawed concept; CIs need to be qualified over the full range of operating conditions.

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New Electrochemical Methods for Visualizing Dynamic Corrosion and Coating Disbondment Processes on Simulated Pipeline Conditions

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1. Introduction

Protective coatings and cathodic protection (CP) are widely applied as the principal means of protecting buried steel pipeline from soil corrosion. Unfortunately under some complex environmental conditions the effectiveness of these methods could not be ensured, and therefore techniques are needed to monitor and evaluate their performance [1,2]. For instance, the potential of a buried steel pipeline could be diverted from the standard 'safe' CP level (i.e. -850 mV vs copper/copper sulphate reference electrode) due to various reasons such as stray currents, flawed CP design or faulty CP control, leading to insufficient CP (in cases of anodic potential excursions) and over-protection (in cases of excessive negative potential excursions). Some forms of potential excursions are known to be harmful to buried steel pipelines; however currently the exact effects of potential excursions on CP efficiency and corrosion have not been sufficiently understood primarily due to difficulties in measuring these effects [3,4]. Over-protection is known to cause cathodic disbondment of pipeline coatings [5,6]. However traditional methods of evaluating cathodic disbondment based on visual inspection of pipeline conditions and laboratory testing of cathodic disbondment resistance have many limitations in quantitatively and instantaneously measuring and monitoring disbondment of thick pipeline coatings [6]. There is a need for the development of new methods that are able to perform in-situ and quantitative measurements of stray current corrosion and cathodic disbondment of pipeline coatings.

On the other hand, structural health monitoring and life prediction tools are needed to provide long-term remnant pipeline life prediction and in-situ pipeline condition monitoring. A critical step in pipeline structural health monitoring is the enhancement of technological capabilities that are required for quantifying the effects of key factors influencing buried pipeline corrosion and environmentally assisted materials degradation, and the development of condition monitoring technologies that are able to provide in-situ monitoring and site-specific warning of pipeline damage [1,2]. The concept of in-situ monitoring and site-specific warning of pipeline corrosion is illustrated by a case of monitoring localised corrosion under disbonded coatings using a new corrosion monitoring probe [7-10]. A basic principle that underpins the use of sensors or probes to monitor localised corrosion has been presented: Localised corrosion and coating failure are not an accidental occurrence, it occurs as the result of fundamental thermodynamic instability of a metal exposed to a specific environment. Therefore corrosion and coating disbondment occurring on a pipeline will also occur on a sensor or a probe made of the same material and exposed to the same environment as a pipeline [2]. Although the exact location of localised corrosion or coating disbondment could be difficult to pinpoint along the length of a buried pipeline, the 'worst-case scenario' and high risk pipeline sections and sites are predictable. Sensors can be embedded at these strategic sites to collect data that contain 'predictor features' signifying the occurrence of localised corrosion, CP failure, coating disbondment and degradation. Information from these sensors would enable pipeline owners to prioritise site survey and inspection operations, and to develop a maintenance strategy to manage aged pipelines, rather than replace them.

In this work, advantage was taken of the high temporal and spatial resolution of an electrochemically integrated multi-electrode array, often referred to as the Wire Beam Electrode (WBE) method, for probing localised electrode processes evolving dynamically and propagating freely on a steel electrode surface under the effect of cathodic protection and anodic transients. This paper provides an overview of our new approaches aimed at developing new probes for monitoring, categorising and quantifying the level and nature of external pipeline and coating damages under the combined effects of various inter-related variables and processes such as cathodic shielding, stray current corrosion, coating disbondment and localised corrosion [11-13].

2. Experimental Details

Figure 1 illustrates a typical experimental configuration using an electrochemically integrated multi-electrode array based sensor to facilitate the in-situ monitoring and visualisation of electrochemical processes occurring on buried steel surfaces under CP and anodic transient conditions [12]. The WBE sensor used in this work consists of 100 closely packed but isolated square shaped carbon steel electrodes (e.g. 2.44 mm x 2.44 mm) embedded in epoxy resin. The gaps between neighbouring electrodes were kept small (e.g. 0.10 ± 0.05 mm). After grinding using SiC 600 grit paper, the sensor was installed in a specifically designed sandy soil box cell [4,12] that facilitates the effective simulation and control of CP testing conditions. Washed fine sand with a typical resistivity of 1000 Ohm.cm was used in the sand box cell, and the resistivity was adjusted using a 3% NaCl solution. The sand box cell was sealed to prevent evaporation. A potentiostat (Bio-Logic Science Instrument) was used to apply CP and anodic transient signals on the sensor surface under potentiostatic control. Similar electrochemical cells and experimental setup were used in experiments for studying various inter-related processes such as cathodic shielding and localised corrosion [11], coating damage and disbondment [13]. More details on the experimental and data analysis methods can be found elsewhere [11-13].

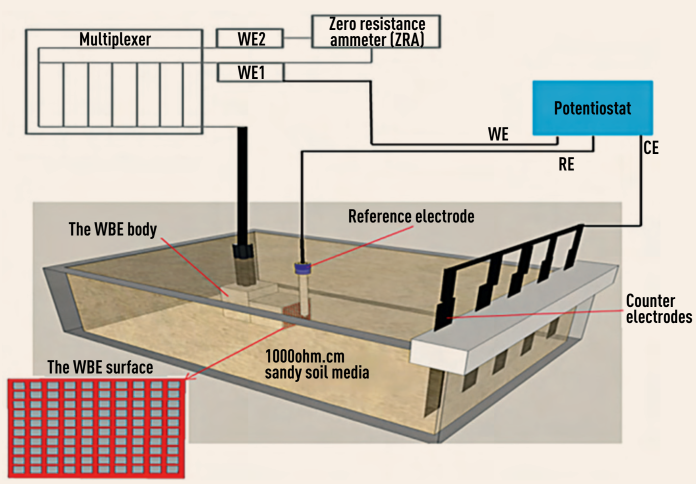

Figure 1. A typical experimental configuration for performing in-situ monitoring of electrochemical processes occurring on a WBE sensor surface buried in a soil cell under CP and anodic transient conditions [11].

3. Results and Discussion

3.1 Case 1: The monitoring of localised corrosion processes under simulated disbonded coatings

The monitoring of localised corrosion processes under a dynamically changing electrochemical environment under disbonded coatings is a technical challenge. Cathodic disbondment is a major form of electrochemically induced coating failure that frequently takes place at the metal/coating interface on cathodically protected steel infrastructure such as pipelines. Disbonded coatings are believed to shield CP current, and therefore localised corrosion frequently occurs under disbonded coatings. Currently there is no technique that can be used to perform in-situ monitoring of its occurrence in the field. Electrochemical techniques such as conventional electrochemical impedance spectroscopy (EIS), localised electrochemical impedance spectroscopy (LEIS), scanning Kelvin probe and scanning vibrating electrode techniques (SVET) have been employed to measure coating disbondment in the laboratory; however, there are significant obstacles for these techniques being practically used to monitor in-situ cathodic disbondment of thick pipeline coatings (e.g. 1000 μm in thickness) [7-9]. Currently detecting corrosion under disbonded coatings, especially at pipeline joints, relies heavily on periodic time based routine inspections using pipeline condition assessment methods including in-line inspection tools (intelligent pigs) and historical excavations. These methods are useful for detecting and locating big defects on the pipeline and for assessing the operation of CP systems, however they are often expensive and therefore are performed only on a periodic basis (usually every 5-15 years for intelligent pigs).

Another approach that should be useful for pipeline corrosion management is the use of corrosion monitoring and warning sensors. Currently the most widely adopted corrosion monitoring sensors in the pipeline industry are steel coupons and electrical resistance probes (ER probes). Steel coupons buried next to the pipe and electrically connected to it are used to assess the operation of CP systems; however conventional weight-loss measurement can be difficult for buried structures because of practical difficulties in coupon installation and excavation. ER probes, often referred to as 'intelligent' weight-loss coupons, are used to detect corrosion by monitoring the electrical resistance between the ends of an elongated coupon of constant cross-section subjected to the corrosive environment. The ER coupon can be electrically connected to the pipeline to simulate the bare metal exposed in a coating defect for detecting corrosion data under CP. A major limitation of ER probes is in the detection of localised corrosion such as corrosion under disbonded coatings, because an ER probe may not be able to simulate corrosion under disbonded coatings, and also because localised damages may not lead to any significant change in electrical resistance detectable by an ER probe. Although corrosion monitoring has been widely applied to many industrial structures such as chemical plants, practical application of existing corrosion monitoring techniques to buried structures such as a steel pipeline has been limited probably due to unavailability of suitable sensors [2].

A new sensor [9-11] has been designed to measure the distribution of electrochemical currents over an electrode array surface partially covered by a crevice that simulates a disbonded coating. The sensor has been evaluated using immersion tests at open circuit potential (OCP) and under CP conditions. A typical series of results are shown in Figure 2. Under both OCP and CP conditions, anodic as well as cathodic current densities were detected within the crevice. Corrosion patterns were estimated based on the current density distributions from two different methods [9-11]. The acceptable level of correlation with the corrosion damage observed at the array surface at the end of the tests suggests that the sensor surface has the potential to monitor localised corrosion under disbonded coatings. Using sensors to simulate and detect early stages of corrosion or to measure corrosion susceptibility under disbonded coatings could provide a valuable and inexpensive means of obtaining in situ monitoring information on the health of a structure.

3.2 Case 2: The monitoring of the effects of various forms of stray currents

Significant efforts have been made to systematically categorise and quantify the level and nature of damage to a pipeline as a result of CP excursions, however there are still major difficulties in drawing decisive conclusions because of the complexity of the electrochemical corrosion processes occurring at the complicated soil/buried steel interface. Technological difficulties in measuring buried steel corrosion under CP are believed to be the prime reason responsible for the lack of conclusions on the exact effects of CP excursions on pipeline corrosion. Currently potential recording is the most commonly used method for inspecting stray current activities in the pipeline industry; however potential recording does not provide sufficient information about corrosion rates and patterns. Weight-loss coupons have been used to determine corrosion rates of steel buried in soil, however weight-loss coupons are unable to provide in situ corrosion rate data required for quantifying the effects of relatively short duration CP potential excursions.

A major difficulty in stray current corrosion research is the lack of reliable and reproducible experimental methodologies that are able to systematically categorise and quantify the level and nature of damage as a result of various modes of CP excursions. In this work, the WBE method has been applied for the first time as a new sensor for detecting localised corrosion initiation under various dynamic anodic transient influences. Experiments have been carried out for measuring the effect of an anodic transient on the corrosion of a steel WBE sensor in a soil corrosion cell [12]. A typical series of results are shown in Figure 3. A common phenomenon that was observed from these tests is that shortly after an anodic transient was applied to a CP protected steel surface, anodic current and corrosion activity dropped dramatically from an initial anodic current peak value. This has been explained by the passivity of steel under CP induced high pH condition. Another phenomenon observed by inspecting the occurrence of local anodic currents in WBE maps was that localised corrosion initiation occurred after a critical duration. This critical duration could be explained by the breakdown of passivity under the effects of anodic transient induced pH and surface chemistry changes. This work suggests that the WBE sensor could be used as an effective tool for studying localised corrosion initiation under the effect of complex factors, as well as for the in-situ monitoring of stray current corrosion of buried steel structures.

3.3 Case 3: The monitoring of cathodic disbondment of coatings

Cathodic disbondment is a major form of electrochemically induced coating failure that frequently takes place at the metal/coating interface on cathodically protected steel infrastructure such as pipelines. Extensive research over the past decades has developed a good understanding of the phenomenon, however currently there is no technique that can be used to perform in-situ monitoring of its occurrence in the field. Traditional methods of evaluating cathodic disbondment of pipeline coatings are based on ex-situ visual

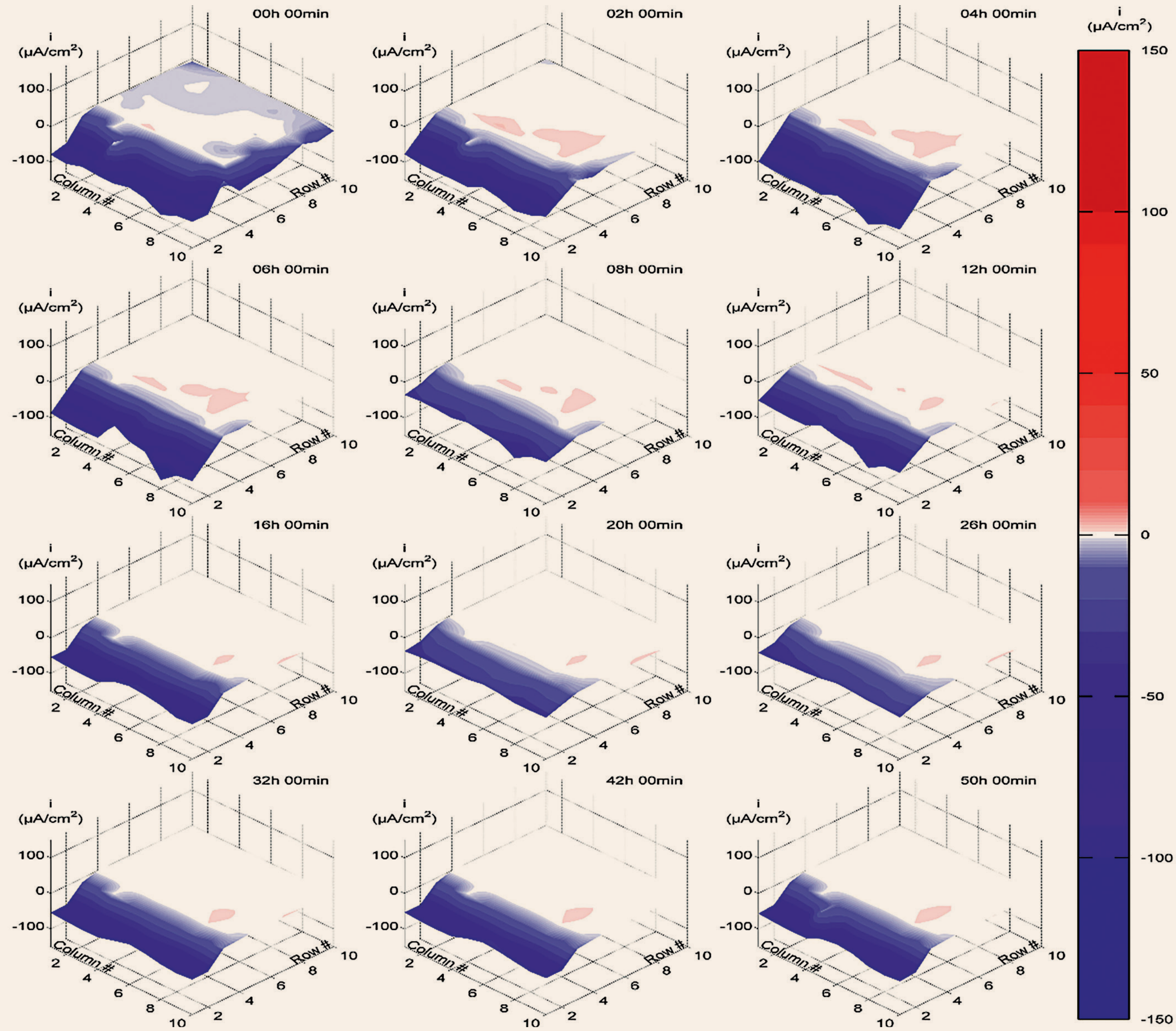

Figure 2. Current density maps taken from a steel WBE immersed in 0.1M NaCl solution with CP. CP potential: -730mV against Ag/AgCl/Sat. KCl reference electrode [11].

inspection of excavated pipes. Electrochemical techniques such as conventional electrochemical impedance spectroscopy, localised electrochemical impedance spectroscopy, scanning Kelvin probe and scanning vibrating electrode techniques (SVET) have been employed to measure coating disbondment in the laboratory; however, there are significant obstacles for these techniques being practically used to monitor in-situ cathodic disbondment of thick pipeline coatings (e.g. 1000µm in thickness). A thick coating would 'shield' the current from reaching the disbonded area, especially far away from the original defect, and therefore the measurements are more likely to be dominated by the lower impedance present at the coating defect areas. Under these conditions, little information can be obtained from higher impedance regions deep in the disbonded area. Indeed, in a previous study the authors have found that conventional EIS loses sensitivity in detecting cathodic disbondment propagation due to such limitations [6]. The electrode array [14] is a method that has been applied to measure local direct currents for evaluating the cathodic disbondment of defective thin coatings (< 100 micron) by Le Thu et al. [15] and Wang et al. [16]. However, there is little evidence to show that direct current mapping is sensitive enough to detect coating disbondment, especially at its propagation stage. This is a concern because a resistive coating film could 'shield' the direct current from flowing into the disbonded coating area. Here we describe a new approach to measuring coating disbondment based on local AC impedance measurement using the electrode array and assess the viability of different approaches. Previously Kong *et al.* [17] measured the EIS of individually selected steel electrodes in an electrode array; however the purpose of their measurement was for assessing the degradation of intact coatings (100 micron), not for monitoring coating disbondment.

Figure 4 shows typical maps of local impedance amplitude ($|Z|_{at\ 300\ MHz}$) and a direct current map measured after different periods of exposure of the sensor to the test solution under CP potential of -1.40 $V_{Ag/AgCl}$ or -0.95 $V_{Ag/AgCl.}$ It is clearly shown in maps (a) - (f) that, under a CP potential of -1.40 $V_{Ag/AgCl,}$ the impedance of electrodes surrounding the defect area continuously decreased (to less than 10^5 ohm) over the 624 hours (26 days) exposure period. These low impedance

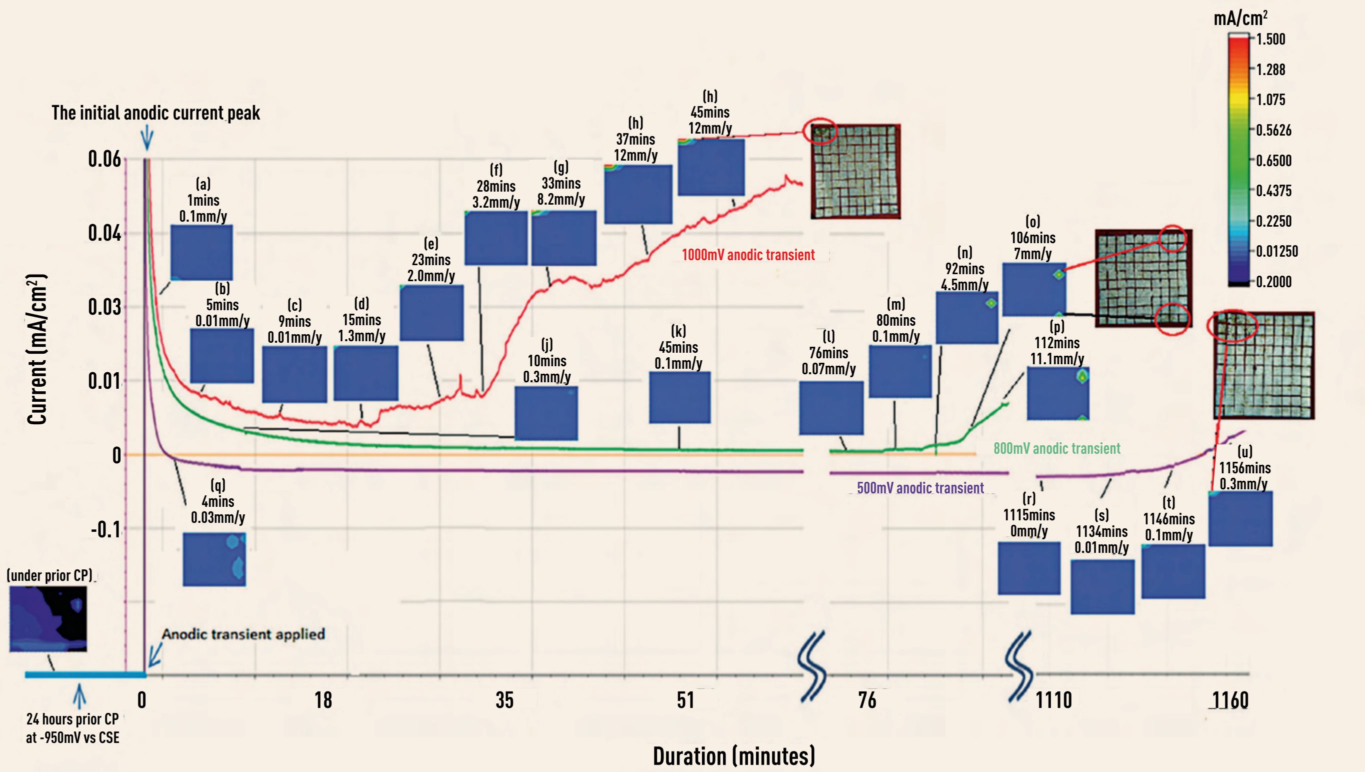

Figure 3. Monitoring of currents and WBE maps over a steel WBE buried in a soil cell under three different CP and anodic transient conditions [12].

areas expanded with the increasing exposure time, while electrodes located far away the defect area maintained a high impedance of larger than 10^7 ohm after 624 hours. These maps clearly indicate coating disbondment due to permeation of the test solution along the disbonded coating/metal interface gap rather than absorption of the solution by the coating. After 624 hours, as shown in Figure 4(f), the majority of electrodes on the sensor were disbonded. Direct current maps measured at -1.40 $V_{Ag/AgCl}$ (not shown here) also show similar coating disbondment processes and behaviour. However, when the CP potential was reduced from -1.40 $V_{Ag/AgCl}$ to -0.95 $V_{Ag/AgCl}$, as shown in Figure 4 (g) and Figure 4 (h), the impedance map still clearly shows the disbonded area, while the direct current map, on the other hand, lost sensitivity and this coating disbonded area was not visible, as seen in Figure 4 (h). This may explain a result reported by Le Thu et al. [15] that, in a previous attempt to measure coating disbondment using array electrodes (coating thickness 60 µm) under a CP potential of -1.5 $V_{vs.SCE}$, no significant coating disbondment was observed on direct current maps over a 336 hour exposure period [15]. This is clearly a major limitation of the direct current measurement technique given that a CP potential of -0.95 $V_{Ag/AgCl}$ is close to industry standard CP criteria for practical, coated pipeline.

These results illustrate that local electrochemical impedance measurements using an electrode array sensor have significantly improved sensitivity for monitoring the propagation of cathodic disbondment of defective coatings compared with the conventional overall electrochemical impedance and local current measurements approaches. This new approach also provides the opportunity of eliminating the effects of the low impedance coating defect regions on the visibility of higher impedance regions deep in the disbond coating, facilitating the probing of electrode processes and mechanisms in selected regions of heterogeneous electrode surfaces.

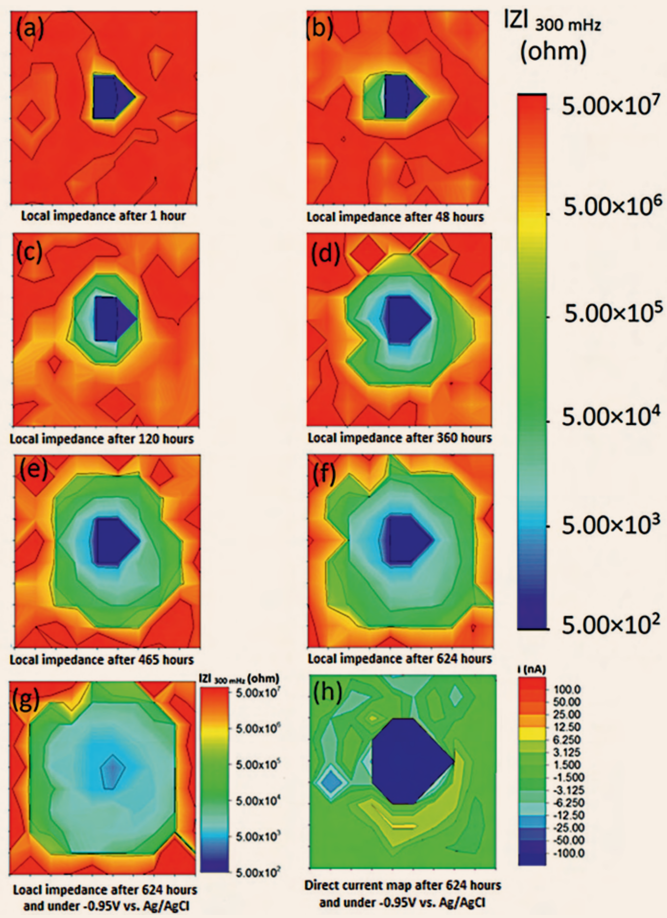

Figure 4. Typical maps of impedance amplitude (|Z| at 300 $_{MHz}$) and direct currents measured over a coated sensor after various periods of exposure and under different CP potential.

4. Conclusions

Sensors designed using an electrochemically integrated multi-electrode array have been successfully employed for (i) monitoring localised corrosion under the dynamically changing electrochemical environment under a simulated coating disbondment; (ii) visualising passivity and its breakdown and localised corrosion under the effect of dynamic anodic transients; and (iv) detecting coating disbondment under excessive cathodic protection conditions by measuring local electrochemical impedance.

5. Acknowledgments

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Corrosion Management Planning and its Role in PIM Strategy

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1. Introduction

Corrosion is one of the leading causes of failures in transmission pipelines. Figure 1 shows that in the United States corrosion accounts for over 17% of the all significant incidents (in onshore transmission lines) for the 10 year period from 2005 to 2014 [1]. Steel pipelines used for transporting produced oil and natural gas are subjected to corrosive environments both internally and externally. Corrosive constituents naturally occurring in the crude emulsion include oxygen (O_2), carbon dioxide (CO_2), hydrogen sulphide (H_2S) and water (H_2O). These are the main causes of internal corrosion. An example of the damage due to CO_2 corrosion is shown in Figure 2. External corrosion is driven by contaminants from the atmosphere (for above ground pipelines), soil (for underground pipelines) and seawater (for subsea pipelines). These can directly affect the electrochemical reaction of the metal and may cause accelerated corrosion leading to premature failure. The corrosion risks can be complicated and specific, not just to a single pipeline but to sections of a pipeline. Externally, changes in soil type and conductivity, or proximity to the sea could vary the inspection and maintenance requirements. Internally the requirements may vary with the pipeline usage or the field chemistry varying with time.

The consequences of failures are great. In 2015 NACE International stated that "The total annual cost of corrosion in the oil and gas production industry is estimated to be $1.372 billion, broken down into $589 million in surface pipeline and facility costs, $463 million annually in downhole tubing expenses, and another $320 million in capital expenditures related to corrosion... [2]". Apart from the large economic impact, the risks to the public from the potential release of hazardous liquid and gas from transmission pipelines can result in severe environmental consequences and even injuries or fatalities.

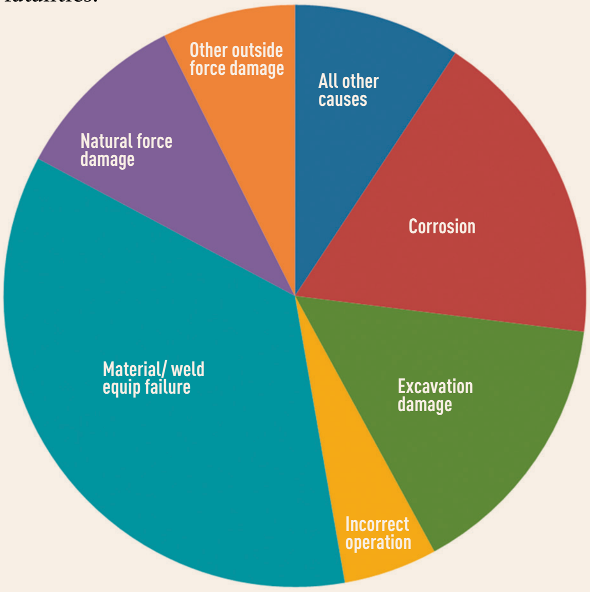

Figure 1. Significant incident cause breakdown for gas transmission lines [1].

Figure 2. Carbon steel piping of sweet gas (CO_2) system. Approximately 30 years in service.

Failure of a natural gas compressor station in 1965 prompted the formation of the United States Office of Pipeline Safety (OPS). This office's successor, the Pipeline and Hazardous Materials Safety Administration (PHMSA), has overseen the development of the current set of regulations that state the pipeline integrity management (PIM) and corrosion control requirements. Local guidelines such as Australian Standard AS 2885.3 Pipelines – Gas and liquid petroleum Part 3: Operation and Maintenance, also call for a corrosion management strategy (section 6.4.2) as part of the pipeline integrity management plan (PIMP) [3].

This paper addresses:

- Pipeline integrity management strategies and how a corrosion management plan fits into this system.
- How a corrosion management plan is developed.
- Examples of the implementation and review of the PIM document.

2. Pipeline Integrity Management Strategy

Pipeline Integrity Management (PIM) is a system of activities and controls to minimise the risk of failure. The system covers pipeline operation, inspection and maintenance practices. The approach to pipeline integrity management is graphically represented in the Figure 3. The use of PIM is recognised as best industry practice and has been embodied in code guidance such as AS 2885.3, DNV RP-F116, API 1160 and ASME B31.8S. Other relevant reference codes related to asset integrity management processes are given in API RP 1173, API 580, API 571, API 570, *etc.*

Figure 3. Pipeline Integrity Management Process (DNV RP F116 [4]).

For pipelines, the process must ensure all potential threats to a pipeline are identified. The threats are controlled and monitored using a plan that is continually reviewed and updated. The basic critical elements of the strategy are:

- Integrity Assessment and Integrity Management Planning: this addresses and assesses all threats to integrity. It begins at the design phase and continues throughout the life of the asset. The review covers structural integrity threats including mechanical loading cases (e.g. ground movement, denting and buckling), crack management, corrosion management and inhibition regimes. The plan must also address integrity management processes. These include stakeholder roles and responsibilities and how the operator is to manage change and its impact.

- Inspection and Verification: this addresses the methodologies and techniques employed to gather condition assessment data. This data will subsequently be used to verify the integrity status of the pipeline. This can include: inline inspection (ILI), direct inspection (e.g. ROV, CP, excavation, field NDT, right of way survey), corrosion monitoring probes and produced fluid sampling.

- Integrity Assessment (Fitness-for-service or FFS): this activity takes the condition assessment data gathered to determine the integrity status and remaining life of the pipeline. The use of established procedures and models (e.g. API 579) is required. For example, ILI data is used to underwrite the current fitness-for-service. Then, together with predictive corrosion models and production data, the rate of corrosion degradation is calculated to determine the remaining life.

- Mitigation, Intervention and Repair: on the basis of the integrity assessment, the integrity status of the line is reviewed. Adjustments are then made to the integrity management strategy or, where necessary, repairs identified.

This cyclic process is designed to ensure the pipeline's status, changes and the resulting effects are continuously monitored. This ensures the current integrity can be quantitatively defined and assured.

3. Role of the Corrosion Management Planning (CMP)
A corrosion management plan (CMP) is a standalone reference document that covers both internal and external corrosion issues. It details what actions are required to protect a new or existing pipeline against corrosion and related damage. It also forms an integral part of the overall integrity management framework, see Figure 4.

The specific objectives of the CMP document are as follows:

- To detail the corrosion and degradation mechanisms expected to affect that specific pipeline.

- To provide guidelines for the required mitigation practices, monitoring, inspection tools and maintenance against the corrosion related threats to the pipeline.

- To identify key performance indicators, set integrity performance criteria and provide a framework for review and audit of system performance for improvement.

- To define organisational competencies and provide a framework for related activities and detailed roles and responsibilities.

As shown in Figure 5, an effective corrosion management plan requires engagement with various stakeholders, i.e. operations, maintenance and inspection groups. The CMP should be incorporated within the practical implementation of the maintenance reference plan and integrity verification activities for the pipeline. Effective implementation of a corrosion management plan will allow potential challenges to be properly mitigated. These may include the asset aging, changes in feed/product specification or operating conditions. A corrosion management plan also provides a basic framework for review and audit of system performance and in the formulation of integrity operating windows (IOWs).

Best Industry Practice includes the following methodology when preparing a corrosion management plan.

Step 1: Review all potential failure modes and mechanisms and assess risk of occurrence.

This involves reviewing the design case and operational records and identifying relevant corrosion threats (both internal and external). Other damage mechanisms including third party damage, stress corrosion cracking, fatigue and erosion issues would also be addressed.

Step 2: Quantification of damage/corrosion rates.

The corrosion threat is quantified to determine its effect on the pipeline's integrity. Known corrosion data or predictive corrosion models are used to quantify the rate of corrosion. For example, industry accepted models such as the de Waard-Milliams and NORSOK M506 [5] may be used for CO_2 corrosion.

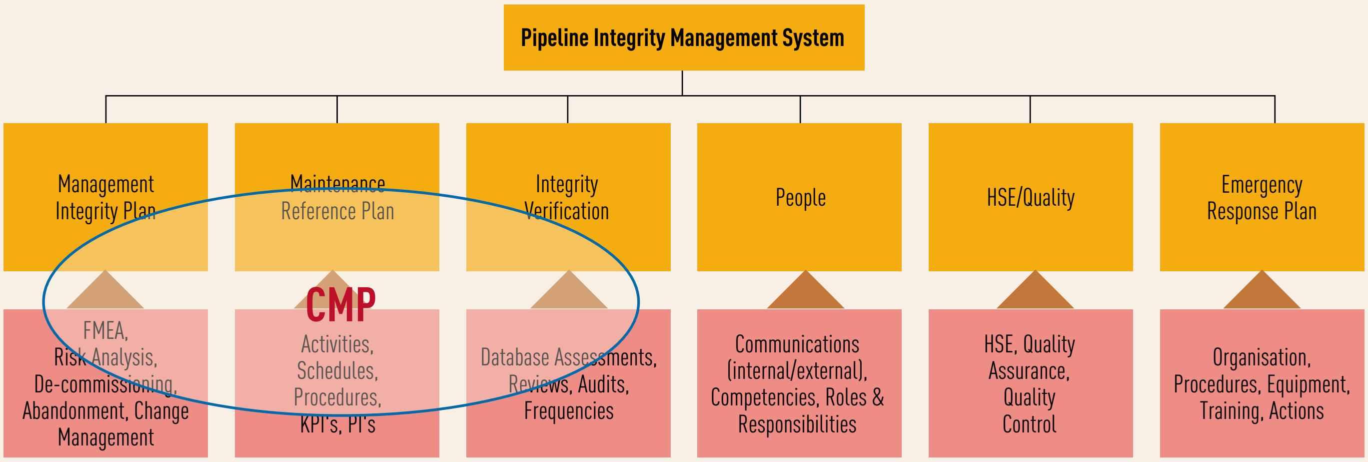

Figure 4. Pipeline Integrity Management System showing fit of CMP.

Step 3: Define mitigation actions, maintenance reference plan, performance metrics and monitoring.

The results of corrosion assessment and corrosion rate modelling are used to define the appropriate mitigation actions and to identify the key performance parameters for the pipeline. This may include determining or reviewing inhibitor strategy and the required uptime of the inhibitor system. The activities required to mitigate the risk of failures are described in maintenance reference plan. The assessment will also determine the operational parameters that are required to be monitored as well as the appropriate tools. In this task, the roles and responsibility of personnel are defined to ensure clear delineation of duties and prevent overlap of functions.

Step 4: Review and update maintenance reference plan, operational strategy and inspection strategy.

The CMP is a live document and should be periodically reviewed. Any changes in operation may introduce new corrosion and/or damage mechanisms, or may make existing ones irrelevant. During the review process, suitability of the mitigation strategies, maintenance activities and implementation are evaluated and updated. A formal review of the CMP should be a part of the pipeline integrity management plan (PIMP) review cycle. This is one of the key factors for a successful CMP. Regulatory guidelines such as AS 2885.3 Section 5.3 [3] specifies that the PIMP of each pipeline shall be reviewed at intervals not exceeding 5 years and, if necessary, amended whenever:

- Any significant changes occur (including corrosion, damage or process).
- New failure mechanism identified that could adversely affect safety of public, personnel or pipeline integrity.

While implementation of an effective corrosion management plan can provide pipeline integrity assurance, there are a number of limitations that may need to be considered, for example:

- Availability of reliable input data. Monitoring and inspection data may not be available due to poor pipeline management or due to design constraint, for example older pipelines might be designed as 'unpiggable' pipeline.
- Quality of data. The quality of monitoring/inspection data is highly dependent on the appropriateness of the tools and its resolution. For example an ultrasonic (UT) in-line inspection tool generally gives higher data resolution in comparison to a magnetic leakage flux (MFL) tool and can provide additional information for corrosion assessment, see Figure 6 for comparison between MFL and UT tools.
- Practicality of mitigation and inspection strategy, e.g. location of inhibitor injection unit, location of pig launcher and receiver stations, access for corrosion monitoring tools, access for excavation, etc.
- Lack of resources to conduct the planned mitigation and inspection actions.

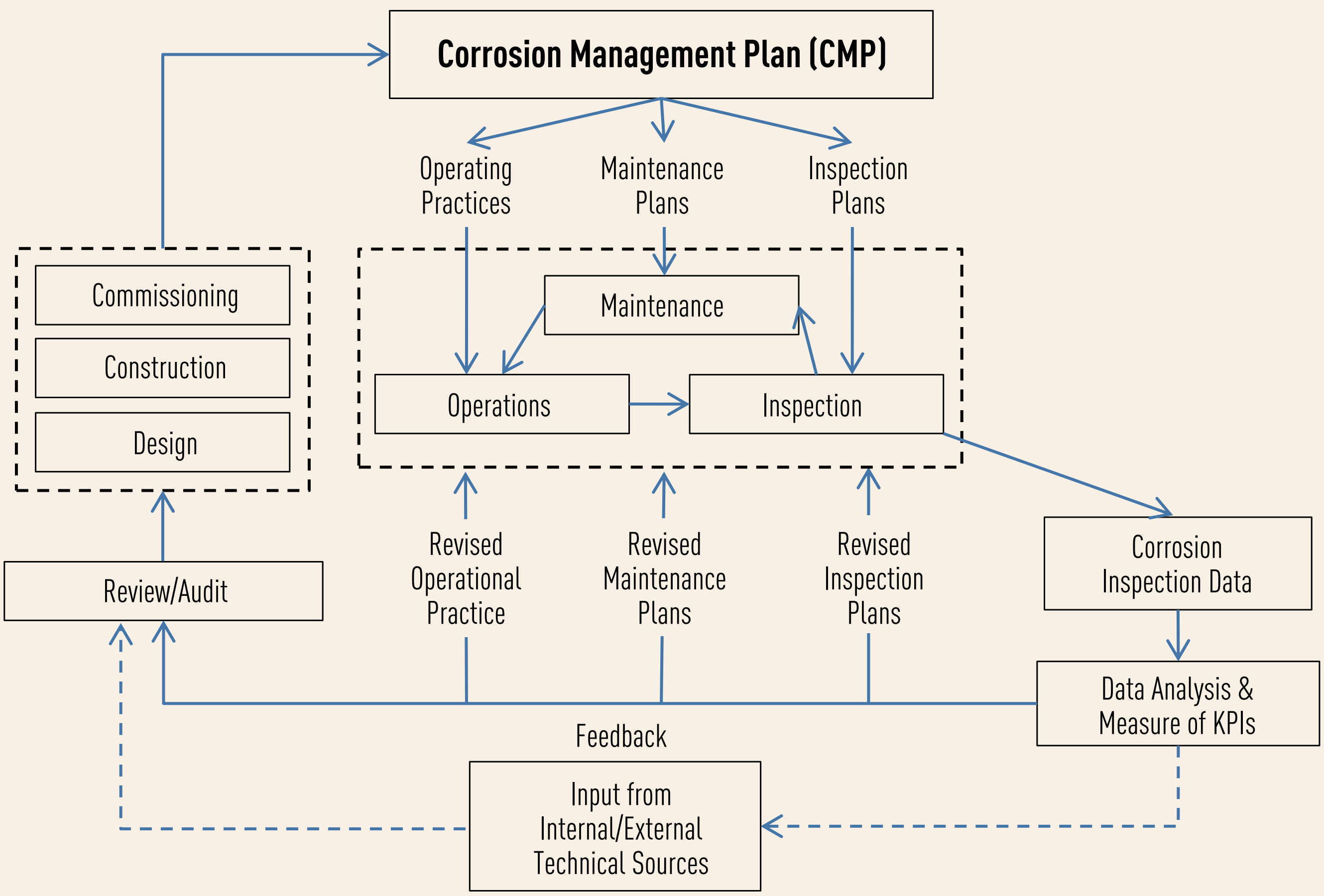

Figure 5. Role of CMP in Operations, Maintenance and Inspection.

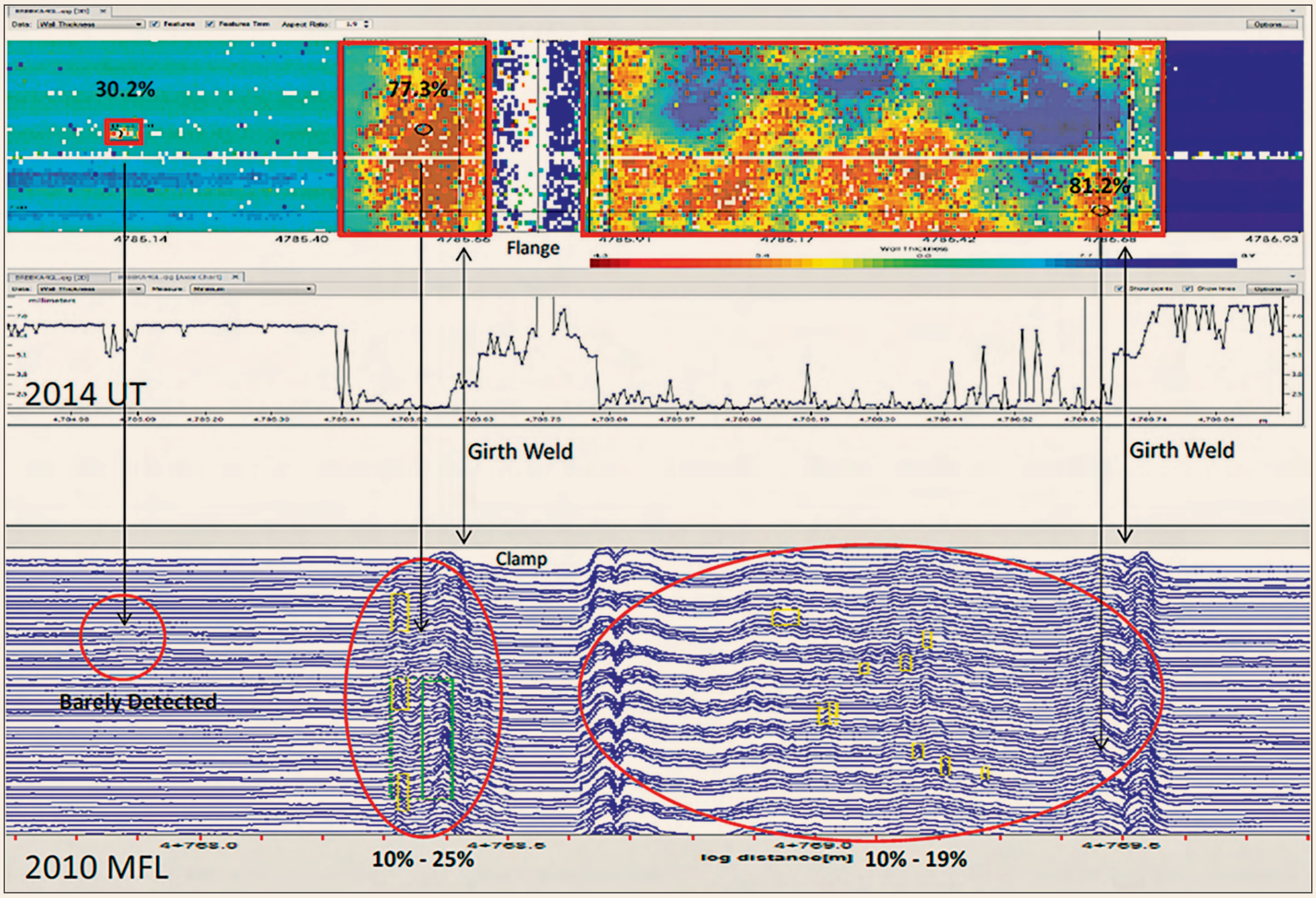

Figure 6. MFL vs. UT ILI data comparison.

4. Case Studies

4.1 Case Study 1: Development of a Corrosion Management Plan - Underground wet gas pipeline

A corrosion management plan was developed for an underground DN250 (10") X42 gas transmission pipeline. The newly installed pipeline spanned over 27 km transporting wet coal seam gas from the compression station to the end user facility. The pipeline had a basic integrity management plan; however no rigorous corrosion management plan (CMP) was implemented. The developed CMP was consistent with the requirements of Australian Standard AS 2885.3 Pipelines – Gas and liquid petroleum Part 3: Operation and Maintenance.

Specific corrosion related issues that were identified in the initial review included:

- Gas chemistry: the produced gas was expected to contain CO_2 and a very low level of H_2S. The risk of MIC was considered to be low.
- Flow modelling indicated significant water dropout along the length of the pipeline. Some liquid hold-up was expected as the low point drains (LPD) were not commissioned.
- A stratified flow regime was predicted over most sections with some slug flow on the uphill/inclined sections.
- Batch inhibition, proposed to be the primary corrosion mitigation strategy, could not be implemented due to operational constraints.

Corrosion assessment for the pipeline was completed in a systematic approach:

Step 1: Review all potential failure modes and mechanisms and assess risk of occurrence.

- Internal corrosion risks: primarily due to CO_2 corrosion, risk of inhibitor unavailability and under deposit corrosion.
- External corrosion risk: primary risk due to third party interference, cathodic protection (CP) interference and coating failure.

Step 2: Quantification of damage/corrosion rates.

- CO_2 corrosion is dependent on factors such as temperature, pH, partial pressure of CO_2 and flow rate. The worst case corrosion rate was predicted using the de Waard-Milliams model, see Figure 7. Note that some understanding on CO_2 corrosion processes and reliable information on fluid chemistry are required to produce an accurate corrosion model.

Step 3: Define mitigation actions, maintenance reference plan, performance metrics and monitoring.

- Specific CMP for CO_2 corrosion mitigation actions includes:
  - Inhibition – In collaboration with the chemical vendor, a suitable corrosion inhibitor (CI) was chosen. Controls were put in place to ensure transport of

inhibitor throughout the pipeline. Target dosing rate, CI availability and CI residuals were set based on operational conditions.

- Operational – Monthly pigging to remove liquid hold up and manual opening of low point drains (LPDs) at prescribed intervals to remove solid deposit.
- Inspection and monitoring – Water chemistry monitoring (monthly intervals), corrosion monitoring using electrical resistance (ER) probe and wall thickness measurement using manual and permanent UT sensors are to be installed in high risk areas (where practical). ILI verification at 5 years.

Step 4: Update Maintenance Reference Plan, operational strategy and inspection strategy.

- This pipeline was a newly installed pipeline; the CMP will be reviewed following a further 12 months of operation to evaluate the suitability of the recommended mitigation strategies, system performance and implementation. For example, monitoring frequencies may be relaxed following satisfactory results.

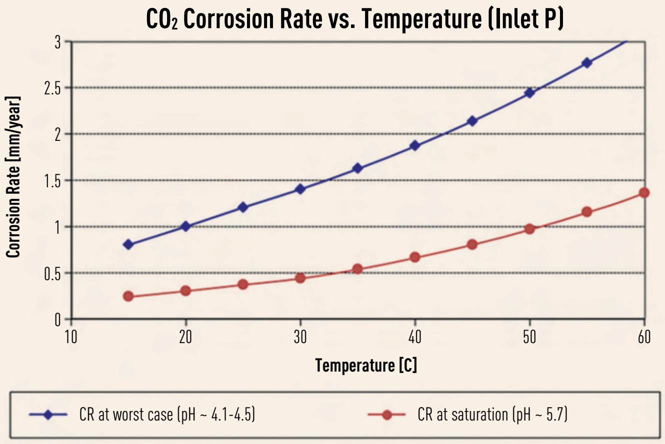

Figure 7. CO_2 corrosion modelling using de Waard-Milliams method.

The corrosion management plan (CMP) was developed to allow any corrosion risks to be mitigated and ensure the integrity of the pipeline for its design life. The benefits of a rigorous CMP include:

- Provides technical basis for integrity related activity.
- Quantifies pipeline integrity status.
- Allows operational and maintenance activities to be effectively planned and scheduled.
- **Demonstrates to stakeholders and regulator (with evidence) that pipeline integrity is effectively managed.**

4.2 Case Study 2: Root cause assessment and review of a Corrosion Management Plan: Subsea multiphase pipeline

A corrosion assessment was completed for a subsea pipeline following a reported leak. The assessment was part of a Fitness-For-Service (FFS) assessment. The 10" production pipeline transports multiphase product (oil, water and gas) from an offshore production platform. It had been in service for approximately 13 years prior to failure. A basic corrosion management plan was implemented 2 years prior to the corrosion assessment but was not regularly reviewed. A review of the pipeline monitoring data (e.g. ILI data, subsea verification data, performance history, subsea inspection surveys, riser inspection data) and existing corrosion management plan showed:

- The produced fluid contained high CO_2 content (~30 mol %) with a high operating pressure and temperature (90°C). CO_2 corrosion was identified as the primary internal corrosion risk for the pipeline.
- The production data showed increasing water cut in the produced fluid. Note that the inhibitor target concentration had not been modified to accommodate the increasing water cut.
- No corrosion features were observed in an MFL in-line inspection from 6 years previous to the corrosion assessment. UT in-line inspection results obtained more recently showed internal corrosion metal loss concentrated at the inlet of the pipeline at the 12 o'clock location.
- Compliance to corrosion management activities as prescribed in the CMP was variable; however the in-line inspection results and corrosion monitoring data suggested that the current mitigation strategy was effective in mitigating bottom of line CO_2 corrosion.
- The observed corrosion damage was consistent with top of line (TOL) corrosion caused by a combination of the following factors:
    - Multiphase product with stratified flow regime.
    - High gas temperature.
    - Condensation issue due to absence of thermal insulation in some pipeline sections.
- Further investigation into the root cause of the failure indicated that top of line corrosion was likely to have initiated 4 years before the corrosion assessment due to declining production fluid volumes. This change in operation occurred within the interval of the inline inspections and is consistent with the findings of each ILI run. Flow assurance assessment based on historical production data showed a shift in the flow regime from annular (mist) flow to stratified flow, see Figure 8. Pipeline operating under stratified flow regime increased the risk of top of line corrosion (TOL) where water condensation can occur on the top part of the pipeline. The risk of corrosion was highest at the inlet of the pipeline, particularly at areas where the pipeline was not thermally insulated.

In this case, while the initial pipeline CMP did not identify the risk of top of line corrosion, a review and audit of the CMP was not conducted on a regular basis. As a result, the effectiveness of the corrosion strategies was not measured and poor compliance was neither captured nor rectified. A full review of the CMP was prompted by the occurrence of a failure/leak. The review process revealed a declining production profile which gives rise to new corrosion threats, namely top of line corrosion. If a review process had been conducted on a regular basis, the new corrosion threats may have been captured at an earlier stage and an expensive failure could have been avoided. Additional benefits in conducting a review of CMP include:

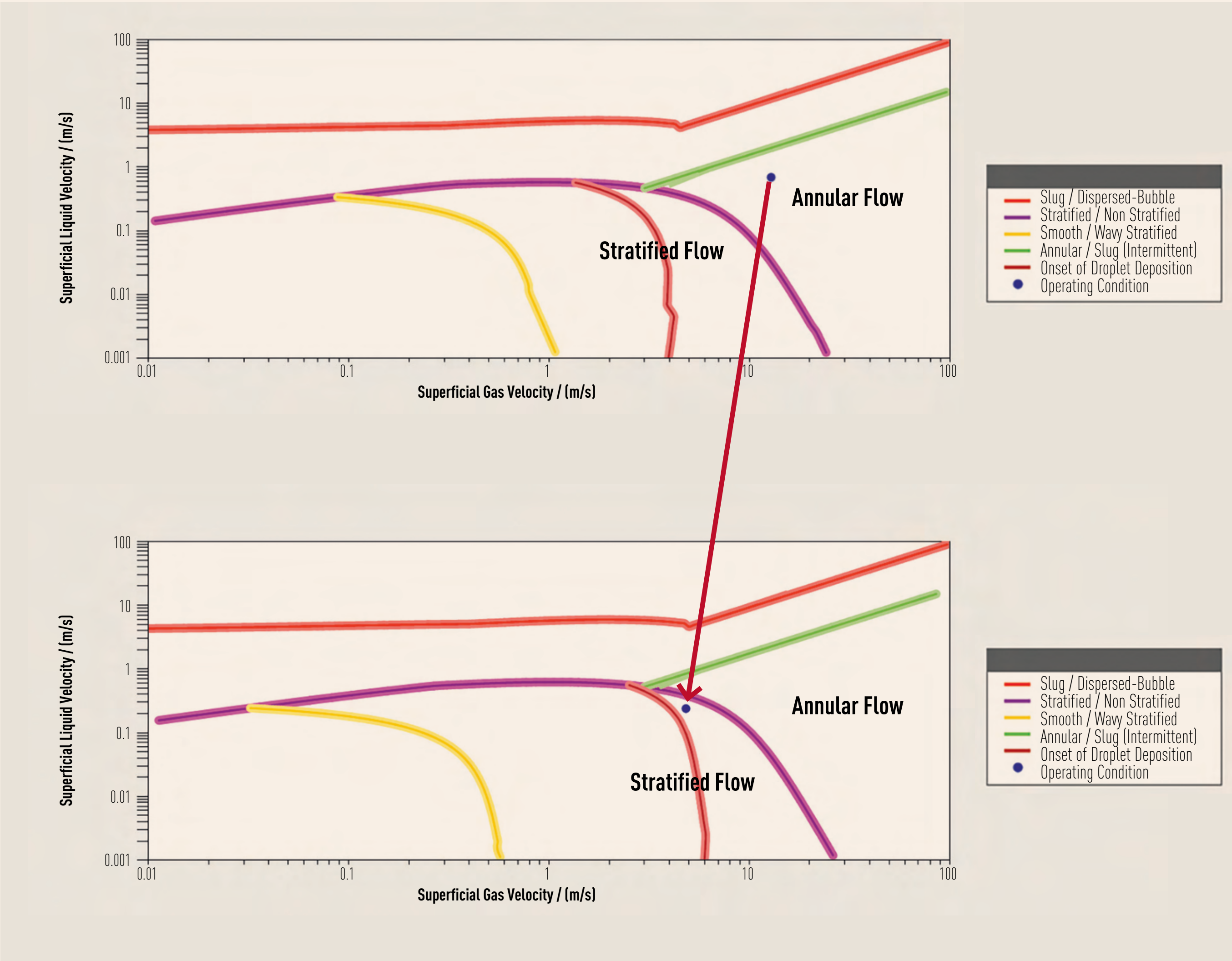

Figure 8. Flow assessment based on production data.

- Opportunity to reduce costs – i.e. optimisation of corrosion inhibitor dosage, pigging operation intervals.
- Provide basis for remaining life assessment.
- Defining the optimum interval for re-inspection with high resolution in-line inspection to verify the condition and integrity of the pipeline.

5. Conclusions
The following conclusions have been reached about the use of corrosion managements plans:

- Corrosion management plans are an important part of a Pipeline Integrity Management Plan (PIMP).
- The document provides technical basis for integrity related activity.
- Quantifies pipeline integrity status.
- Demonstrates to stakeholders and regulator (with evidence) that pipeline integrity is effectively managed.
- Allows operational and maintenance activities to be effectively planned and scheduled.
- However; care must be taken to:
  - Ensure stakeholders are aware of the limitations of the assessment input data and;
  - Periodically review the document to ensure it still effective for the current pipeline conditions.

6. Acknowledgments
The authors express their thanks to Quest Integrity Group for permission to publish this paper.

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