CORROSION

& Materials

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THE AUSTRALASIAN CORROSION ASSOCIATION INC.

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Dear ACA Members,

It was a great pleasure to see so many of you at the Cairns Conference in November. We had great feedback on the excitement and vibe of the conference in that tropical environment.

I was glad to hear that the number of delegates attending Cairns, was 19% higher than in Perth. Plus, we initiated new parts to the program in response to feedback from the 2023 conference. This year we offered a new Confidential Asset Owners session with the support of our strategic alliance partners AMPP, that helped to engage 30 asset owners (at least half of which haven't attended our conference in the past). We also reinvigorated the Defence Forum and Defence technical papers stream this year, which attracted a high level of senior defence-related personnel.

The ACA then held a private meeting between defence personnel, AMPP to investigate the potential alignment with the NAVSEA standards to work on Navy Shipyards in the USA.

The conference was also somewhat sad for me, as we farewelled long-time Board Director, Dean Ferguson, who stood down off the Board. Dean was chair of the ACA Board during the tumultuous COVID period, involving a near full staff turn-over and illness. This was coupled with the adoption of new systems and all the change that delivered to a restructured ACA. Most recently Dean has assisted with the By-Laws and assisted the ACA team with corporate history.

Thank you Dean for your major contribution and dedication over the past six years!

On the bright side, we did welcome back Dr Patricia Shaw back to the Board. Trish was previously on the ACA Board between 2020-2023. Trish will take an active role of the Finance, Audit & Risk Management Committee (FARMC) and the Membership and Advocacy Committee. Welcome back Trish!

Our President for the last two years, Isaac Isakovich, also stepped down. Isaac has been instrumental in bringing the ACA Board and the ACA Council closer together. Isaac brought such goodwill and positive intentions to the role – it was a pleasure working with him.

We are also happy to announce that Raed El Sarraf is now appointed as the new Council President. I am looking forward to working closely with Raed and the rest of the ACA Council to finalise the constitutional reform we have been working on for the past few months and we hope to have concluded by mid-year 2025. Ramon Salazar Romero has also been appointed as the Senior Vice President of the Council. Council will now work to fill the role of Junior Vice President within the next few months.

I would like to take this opportunity to thank all the ACA Board, ACA Council, ACA Branch Executives, Technical Group Chairs, and Standards Experts for their voluntary contributions in 2024. I look forward to working with your all and the ACA Team throughout 2025. Any ACA members that would like to share their views about the ACA please let me know, and travel safely and enjoy your holiday season!

Kingsley Brown

ACA Board Chair

Feature: Maritime & Coastal Environments

Reports

Profiles

Industry News

Training News

Feature: Maritime & Coastal Environments

Feature

Member Benefits

Conference Plenary Papers

Dear ACA Members,

As my time as President of The Australasian Corrosion Association (ACA) comes to an end, I want to take a moment to reflect on this incredible journey and to thank everyone who has been part of it. Serving as your President since November 2022 has been a true honor, and I'm so proud of everything we've achieved together.

Key Achievements During My Term

I'm thrilled to have been part of the relaunch of our specialised Corrosion & Materials journal and to share a message with our membership. This relaunch wasn't just about renewing our commitment to providing advanced insights in corrosion management but also about creating a unique space for learning, innovation, and community engagement. It has been amazing to see this initiative come to life.

This year, I was very pleased to welcome the new Council members for the 2024 term. Our discussions in 2024 affirmed our commitment to being a cornerstone for the ACA, providing robust support at all levels from the Board and Branches to our Technical Groups and Members. Together, we have worked hard to enhance ACA's education, training, and professional development programs. These programs are vital for elevating the expertise of our practitioners and inspiring the next generation of professionals.

The Council also developed and provided to the Board a document titled "The New Role of the Council," which will serve as an essential resource for drafting the new ACA constitution in 2025. This document highlights the evolving responsibilities and strategic contributions of the Council, ensuring our governance framework remains strong and adaptive to future challenges.

Global Engagement and Advocacy

Representing the ACA on the global stage has been a truly enriching experience. At the AMPP conferences in New Orleans and Denver, I had the privilege of learning from and sharing with experts in corrosion management and mitigation from around the world. These events offered incredible opportunities to exchange insights, catch up with old friends, and make new connections. I'm deeply grateful to AMPP for their excellent hospitality during these conferences.

Additionally, participating in the Sisters Society meeting was a highlight of my term. The discussions with global corrosion associations reinforced our shared dedication to sustainability and advanced corrosion mitigation techniques, which remain vital priorities for our industry.

Acknowledgments

To our Councillors, the Head Office team, the Board, Branches, technical groups, and every ACA member, thank you. Your support, hard work, and enthusiasm have been the backbone of everything we've accomplished. I'd also like to extend a special thank you to Scape Consulting, my employer, for their unwavering support over these past two years. Your understanding and encouragement have meant so much to me.

Most importantly, I want to thank my wife and kids for their incredible support throughout this journey. Your patience and encouragement have been invaluable, and I am so grateful for everything you've done to help me succeed in this role.

Looking Ahead

As I hand over the presidency to Raed El Sarraf, I want to congratulate him and wish him all the best in this very important role. I'm confident that the ACA will continue to thrive under his leadership.

Final Thoughts

Reflecting on these past two years, I'm filled with gratitude and pride. This journey has been about collaboration, learning, and a shared commitment to excellence. I'm leaving this role with so many great memories and a deep appreciation for the opportunities it has given me.

Thank you all for making this experience so memorable. I can't wait to see where the ACA goes next, and I look forward to seeing you all in Melbourne in November 2025. Let's continue working together to push the boundaries of what we can achieve.

Kind regards,

Isaac Isakovich Castillo
ACA Past-President

Greetings Fellow Corrosionists,

At the time of writing, we have enjoyed another successful Corrosion & Prevention Conference in Cairns. It was great to learn about the latest developments happening in our industry, catching up with old friends and making new ones. Furthermore, we have celebrated Christmas, and started a New Year, hoping that in 2025 we continue to grow and flourish.

I would like to thank Isaac Castillo again for his leadership and contributions as our President over the past 2 years, during which our Association was recovering from the Covid-19 disruptions and changes at the ACA Centre. However, it seems we may be turning the corner, as they say, and 2025 appears to be shaping up to be an exciting year with a number of technical events being planned throughout Australasia. From the Applicator and Coatings Roadshow, that will be held in Sydney, Perth, Auckland and Christchurch, a series of webinars, seminars, another comprehensive list of training courses, and of course our 2025 Corrosion & Prevention Conference that is to be held in Melbourne.

In addition to the above events that are being planned by the ACA Centre, I am also looking forward to seeing what our local Branches will be organising for us. One of my goals as President, is to revitalise our sense of community, by supporting the Branches in any way I can. Whether it is being their conduit, and yours of course, to the ACA Centre and the Board; to facilitating events or ideas to support our members and growing the Association. All of which, we can all contribute to, by offering to present at a local Branch event, or where possible sponsoring one; but more importantly by attending them.

We appear to have become used to staying at home, attending such technical events via Zoom. However, networking in person, catching up with fellow Corrosionist over a meal and/or a pint, is always the highlight of my calendar. Something that I still look forward to, is where we meet at our local club/pub for a yarn. As where else are you able to share experiences of a tricky corrosion "problem" you are dealing with, to hearing about a potential solution or product, or simply to catch up with friends.

So here's to 2025, the year that we reclaim our sense of community, growing our membership, making new friends and solving some rusty problems.

Raed El Sarraf

ACA President.

Dear ACA Members

Thank you to all the ACA members that contributed to a successful Corrosion & Prevention Conference in Cairns in November, 2024! It was an amazing experience for me. The level of interaction and engagement with such a broad distribution of our members was fantastic.

We received 80 responses to our post-conference survey and overall, the feedback was an improvement on the previous year. We received a 4.4 Star rating in Cairns compared to 4.0 Stars at the Perth Conference, 2023. Some of your standout sessions of the conference based on delegates responses were as follows:

- Water & Wastewater Forum
- Oil, Gas & Energy Forum
- Coatings Forum
- Navsea and Defence Forum and
- PF Thompson Plenary

Another new initiative was hosting the Cairns High School students on the Tuesday of conference. They had a great time interacting with our exhibitors and attending the PF Thompson Plenary by Nick Birbilis. A special thank you to the Conference Technical Committee, co-chaired by Scott Wade and Oscar Duyvestyn that organised this part of the program and all of the hard work that was required to make the conference program such a great line-up.

I also need to make mention of the ACA Team that worked tirelessly throughout the conference. They were rewarded by delegates for their hard work with a rating of 4.9 Stars!

There are some take-away messages that you as delegates, exhibitors and sponsors provided us that we will work on to continue to improve for the next conference in Melbourne. I would also like to extend our sincere thanks to all our sponsors and exhibitors of the conference. We wouldn't be holding this event without your support. A huge thank you to PPG who were the Platinum Sponsor in Cairns and were so impressed that they have already committed to being the Platinum Sponsorship of Melbourne! Thank you, PPG, for your trust and confidence!

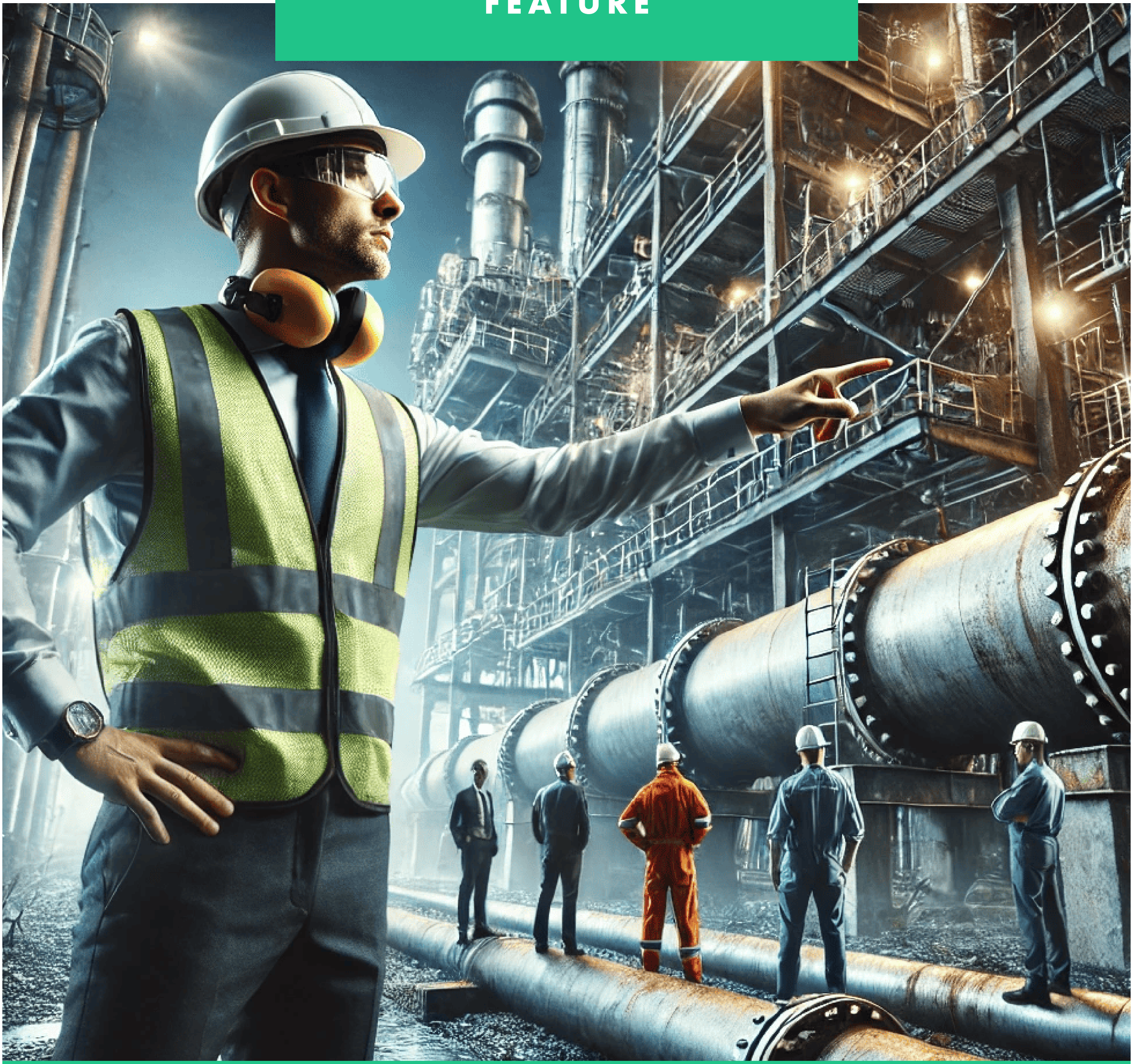
Finally, I am pleased to announce that we have a new senior team member at the ACA. Adrian Ruggiero joined us on 14 January 2025 as the new General Manager Operations. This role is all about offering some more support to our young ACA team and assisting me to improve our operations and servicing of our membership. Adrian will be the face of the ACA office in Preston, and this will allow me to spend more time on important advocacy issues for the corrosion sector and the ACA.

Adrian has had a broad work experience, including working for a Not for Profit most recently, and prior to that working in senior operations roles in construction and for BP America (In Australia and the USA). I am sure Adrian will guide the ACA to a new level of performance – so please welcome him to the corrosion community.

You can see details of the team on our website here: https://www.corrosion.com.au/about/board-management/ (Adrian coming soon).
Please feel free to contact me directly via maree.tetlow@corrosion.com.au or aca@corrosion.com.au

Maree Tetlow

ACA CEO



Corrosion: A Silent Threat to Energy Infrastructure - How to Fight Back

By Mike Dehghan

In the previous article (refer to ACA Materials and Corrosion Journal Vol. 44 – July 2024), I discussed the importance of corrosion management for infrastructure longevity and its elements). In this article, I will discuss the first two elements of corrosion management; proper planning, and policy and leadership.

Corrosion, the deterioration of materials due to chemical or electrochemical reactions, is a significant challenge in the energy industry. It can lead to equipment failures, safety hazards, and economic losses. Effective corrosion management is essential to ensure the reliability and longevity of energy infrastructure. A well-planned corrosion management program is a cornerstone of this effort.

Key elements of a proper corrosion management plan include:

- **Comprehensive Risk Assessment:** Conduct a thorough risk assessment to identify and evaluate potential corrosion risks throughout the energy system. Consider factors such as materials, environment, operating conditions, and maintenance practices.
- **Targeted Inspection and Monitoring:** Implement a targeted inspection and monitoring program to detect and assess corrosion damage effectively. Utilise appropriate non-destructive testing techniques and continuous monitoring systems.
- **Strategic Materials Selection:** Carefully select materials that are resistant to corrosion in specific environments. Consider factors such as temperature, pH, chemical exposure, and mechanical stresses.
- **Proactive Design and Construction:** Incorporate corrosion prevention measures into the design and construction of energy infrastructure from the outset. This may involve using protective coatings, cathodic or anodic protection, or designing structures to minimise corrosion-prone areas.
- **Optimised Maintenance and Repair:** Develop and implement an optimised maintenance and repair strategy to address corrosion damage and prevent further deterioration. Schedule regular inspections, repairs, and replacements as needed.
- **Comprehensive Training and Education:** Provide comprehensive training and education to employees on corrosion management principles and best practices. Ensure that personnel are equipped to recognise, prevent, and address corrosion issues effectively.

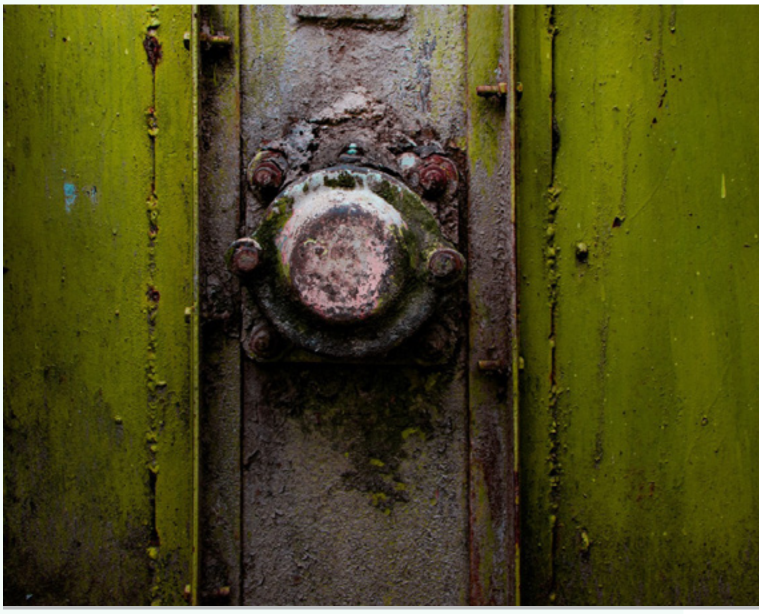
A well-planned corrosion management program can significantly reduce the impact of corrosion on energy infrastructure. By proactively addressing risks, monitoring for damage, and implementing appropriate prevention and mitigation measures, organisations can improve safety, reliability, and profitability.

The Role of Policy and Leadership in Corrosion Management

While a comprehensive plan is essential, its successful implementation depends on strong leadership and supportive policies. Policymakers and industry leaders play a critical role in creating the environment necessary for effective corrosion management.

Key policy considerations include:

- **Standards and Regulations:** Establishing and enforcing standards and regulations related to corrosion management in the energy industry. This ensures that organisations adhere to best practices and minimum requirements.
- **Research and Development:** Supporting research and development efforts to advance corrosion prevention technologies and improve



understanding of corrosion mechanisms. This can lead to innovative solutions and more effective corrosion management strategies.

- **Incentives and Subsidies:** Providing incentives and subsidies to encourage organisations to adopt corrosion management practices. This can help offset the initial costs of implementing preventive measures and promote long-term sustainability.
- **Collaboration and Partnerships:** Fostering collaboration and partnerships between industry, academia, and government agencies to share knowledge, resources, and best practices. This can help accelerate progress in corrosion management and address industry-wide challenges.

Leadership plays a crucial role in driving effective corrosion management by:

- **Setting Priorities:** Identifying corrosion management as a strategic priority and allocating resources accordingly.
- **Establishing a Culture of Safety:** Creating a culture that values safety and prioritises corrosion prevention.
- **Empowering Employees:** Empowering employees to take ownership of corrosion management responsibilities and report potential issues.
- **Promoting Innovation:** Encouraging innovation and the adoption of new technologies to improve corrosion prevention and mitigation.

Strong leadership is essential for driving the implementation of corrosion management policies. By providing clear direction, allocating adequate resources, and fostering a culture of safety and compliance, leaders can create an environment where corrosion management is a top priority. Effective leadership can also help to build consensus among stakeholders and ensure that corrosion management initiatives are aligned with broader business objectives.

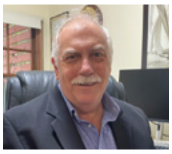
In conclusion, both planning and policy/leadership are critical components of effective corrosion management in the energy industry. A well-structured plan provides a roadmap for action, while strong leadership and supportive policies create the necessary environment for implementation. By working together, industry stakeholders can address the challenges of corrosion and ensure the safe, reliable, and efficient operation of energy infrastructure.

CORROSION & PREVENTION CAIRNS 2024

Corrosion & Prevention 2024 Conference *wrap-up!*

As we reflect on the remarkable experience at Corrosion and Prevention 2024, held in the breathtaking city of Cairns, Queensland, we are filled with a sense of pride and gratitude. The event brought together experts, innovators, and enthusiasts in the corrosion industry for an unforgettable few days of learning, networking, and celebration. From inspiring plenary sessions to engaging technical forums, this year's conference was a true testament to the power of collaboration and shared knowledge.

Thank you to our impressive lineup of seven distinguished plenary speakers who delivered presentations on our theme of: *Navigating Corrosion Challenges in Marine and Coastal Environments.*


David Harvey


Joyce Wright


Nick Birbilis


Blane McGuiness


Christine Crawshaw


Wayne Neil


Kathryn Dylejko

stats:

- 3 CONCURRENT STREAMS
- 387 ATTENDEES
- 8 TECHNICAL FORUMS
- 28 SPONSORS
- 80 PAPERS
- 70 EXHIBITORS

PLENARY SPOTLIGHT

David Harvey - Marine Manager ANZ, Fiji and PNG | PPG INDUSTRIES

EVOLUTION OF FOUL RELEASE COATINGS

David's paper presented the development of biocide free, foul release coatings, how they were imagined, their development, their impact on the use of conventional antifouling coatings and their newfound importance in the modern era of transport and our focus on the reduction of CO2 emissions.

Joyce Wright - Retired: ManagerNewport News Shipbuilding A Division of Huntington Ingalls Industries

BRIDGING THE GAP: INTEGRATING EXPERTISE AND TECHNOLOGY TO TACKLE WORKFORCE CHALLENGES IN THE MARITIME INDUSTRY

The maritime shipyard industry faces critical workforce challenges, including skilled labor shortages, an aging workforce, and resistance to technological change. Joyce's paper explores collaborative strategies for addressing these issues through a synergy of experienced technical expertise and emerging innovations.

Christine Crawshaw - Director | Infrastructure Advisory Group

PORTS - ANCHORS OF THE ENERGY TRANSITION

Australia's ambitious target to achieve net zero emissions by 2050 and integrate 82% renewable energy into its electricity grid by 2030 underscores the critical role of Offshore Wind in the nation's energy transition. Christine's paper explores the corrosion challenges inherent in offshore wind, including material selection, protective coatings, cathodic protection, and maintenance strategies to extend the life of wind structures.

Nick Birbilis - Executive Dean | Faculty of Science, Engineering and the Built Environment

SOME MICROSTRUCTURAL INFLUENCES UPON LOCALISED CORROSION

The degradation of metallic alloys is a process that is, over extended time periods, basically assured. The 'engineering alloys' that are critical to essentially all facets of modern life, are highly engineered to 'cheat nature'. Herein, some examples of microstructural effects on corrosion are touched upon, including how they may impact early / localised corrosion.

Wayne Neil & Kathryn Dylejko - DSTG

CATHODIC PROTECTION AND ITS IMPLICATIONS FOR VESSELS IN THE ROYAL AUSTRALIAN NAVY

Cathodic protection systems on Royal Australian Navy vessels have unique challenges which need to be managed by Defence. Australian ships operate in warmer waters, berth for longer periods, and have operational profiles that can differ significantly from commercial ships.

Blane McGuiness - Executive Manager | Marine & Civil Maintenance (MCM)

SUSTAINABLY LED ASSET MANAGEMENT: A PACIFIC CASE STUDY QUEENS WHARF, LAUTOKA FIJI

The presence and ingress of chlorides, particularly in marine environments, is one of the main factors responsible for the deterioration of steel reinforced concrete structures. Through this case study, the reemergence of Electrochemical Chloride Extraction and the retrofitting of water base anode Impressed Current Cathodic Protection Systems are two ways preventative intervention have been utilised to curb the progression of deterioration across Queens Wharf, Lautoka, Fiji.

HIGHLIGHTS

Social Event | **YCG POOL PARTY**

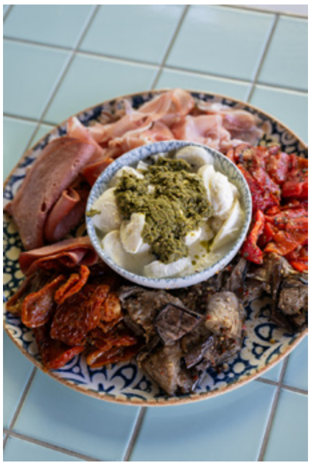
Our YCG Pool Party took place offsite at The Crystalbrook Bailey, where we had an impressive turnout of 35 attendees. Members of our young corrosion community from across Australia and New Zealand met to network, learn, and socialise and have a dip in the pool with like-minded individuals, while also gaining insights from our more experienced peers.











HIGHLIGHTS

Social Event | **Welcome Function**

The C&P24 Welcome Function was hosted at the Crystalbrook Bailey, and we had an incredible turnout! This event was a fantastic way to launch our conference in Cairns, enabling colleagues to reconnect after a year apart. With the theme of "wear your Hawaiian shirt," attendees enjoyed plenty of laughter, networking opportunities, and overall a wonderful time had by all.







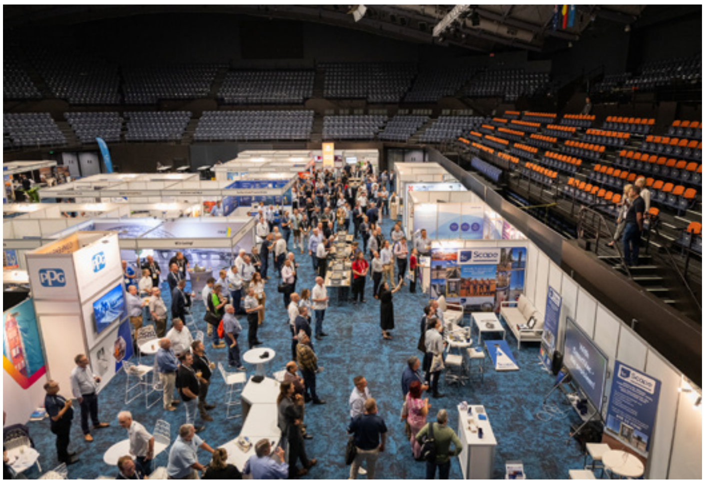


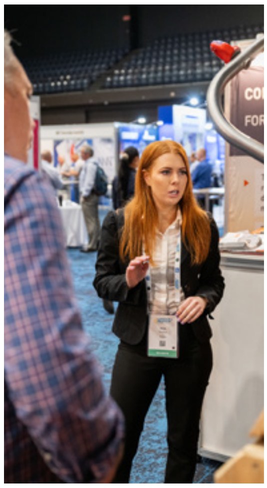


HIGHLIGHTS

EXHIBITION HALL

Our Exhibition Hall was overflowing this year, featuring an impressive 70 exhibitors presenting their corrosion products and services. Additionally, the exhibition space served as the venue for our Exhibition Opening/Asset Owner Reception, which turned out to be a fantastic success!





HIGHLIGHTS

Social Event | **Women in Corrosion Breakfast**

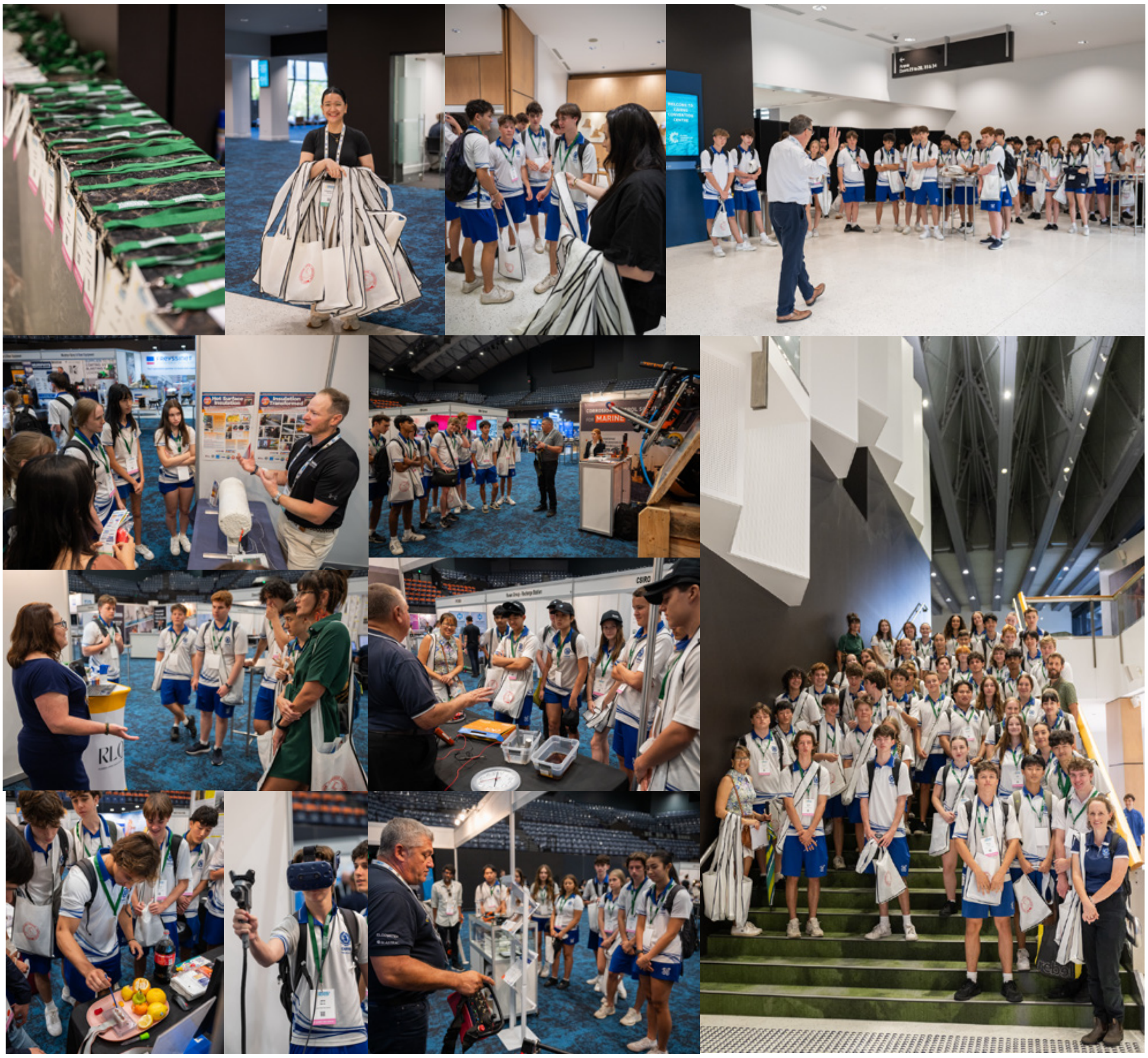
The ACA once again hosted its annual Women in Corrosion Breakfast this year at C&P24. This breakfast event featured a relaxed panel discussion with six remarkable women who excel in corrosion mitigation. Elaine Chiu from Dulux served as the host, engaging the panelists in conversations about their experiences within the corrosion industry. This year's esteemed panelists included:

- Joyce Wright | Ship Building Expert
- Christine Crawshaw (Director) | Infrastructure Advisory Group
- Kirstie Smith (Operations Manager) | Spillers Quality Corrosion Control
- Cara Sorenson (Business Manager at IPCQ Pty Ltd) | Industrial Protective Coatings QLD
- Mahsa Esfahani (Lead Engineer, Materials) | Aurecon
- Seii Chen (Consulting Engineer) | Duratec Australia

HIGHLIGHTS

School Educational Outreach Program

This year marks a significant milestone for the ACA, as we successfully integrated a School Education Outreach Program into our agenda for the first time. We welcomed 60 Year 11 students to the conference, and we believed that this enhanced their academic learning but also provided them with valuable insights into the interdisciplinary nature of corrosion science and its importance in today's world. The students attended the plenary speaker sessions of Nick Birbilis & Christine Crawshaw. Students then visited and spent time with the following exhibitors: UCC where they watched and participated in the wrapping of a pipe, AMPP Australia Chapter using a Virtual Reality Spray Gun, Anode Engineering learning about Anodes and how they work, Precision Laser Cleaning taking a look at laser cleaning equipment, BlastOne learning automation in surface preparation, NeoTech Coatings explaining sustainability options for heat energy conservation, Reevo Resources: Introduction to Rubber Lining, DH Tech: Learn the answer to what is dehumidification? & Deakin University: What is happening at Deakin University?



HIGHLIGHTS

Social Event | **Awards Dinner**

The Corrosion & Prevention 2024 Annual Awards Dinner, held on 12 November at the Trinity Ballroom in Cairns, was a night of celebration and recognition for the exceptional contributions within the corrosion industry. Bringing together leaders, innovators, and emerging talent, the event highlighted achievements across research, innovation, and professional development. The evening began with a moving Welcome to Gimuy/Cairns Homelands of the Yirrganydji people, performed by Minjil, a group of four beautifully costumed and painted dancers, and an additional two musicians. The ACA Chair Kingsley Brown, then reflected on the power of the corrosion community and collaboration in driving innovation and progress. Guests were treated to a gourmet dinner, alongside a ballot bidding auction, with proceeds benefiting the ACA Foundation.

Awards Dinner Cont...

Top Honors for Industry Papers

The evening commenced with the prestigious paper awards, recognising outstanding research and practical contributions:

- Arthur Kennett Award:

Ian MacLeod | Corrosion of Rock Art in Western Australia: Alteration of Pigments and Weathering of Engraved Rocks.

- Marshall Fordham Award:

Giles Harrison, Michael Gray and Mariela Calizaya | Effect of Flow Conditions on Submerged Metallic Substrates; Cathodic Current Density Required to Achieve Cathodic Protection Criteria

- David Whitby Award:

Seii Deng Chen | Taking Asset Inspection to New Heights: Exploring the Role of Drones

- Les Boulton Award:

Blane McGuiness and Oliver Gasior | Fremantle Rail Bridge ICCD System Design & Construction Remediation Challenges

The Mike Rutherford Golden Trowel Award

A highlight of the evening was the renaming of the **Golden Trowel Award** to the **Mike Rutherford Golden Trowel Award**. The Chair of the Applicator Technical Group, Tim Billing, invited Donna Rutherford, Mike's widow to be present at this announcement. This renaming of the award honoured Mike Rutherford's enduring legacy as a mentor, innovator, and advocate for excellence in concrete remediation and protection, and ensure Mike's influence continues to inspire the corrosion community. Donna Rutherford announced the award winner: **Jamie Horan** | Pensar Infrastructure

Awards Dinner Cont...

Honouring Industry Icons
The Life Membership Award, the highest honor for outstanding and continuous service to the ACA, was presented to two remarkable individuals:

Richard Brodribb

Richard Brodribb has provided outstanding continuous service to the ACA over an extended period. Richard's dedication to our association has been nothing short of remarkable. He has devoted decades of service, exemplifying a deep commitment to the values and mission of our organization. Throughout his tenure, he has not only supported the Victorian Branch with unwavering loyalty but has also played a pivotal role in various initiatives that have advanced our goals. Richard's involvement in the CP technical committee has been particularly noteworthy, as he volunteered countless hours to enhance our programs and foster innovation within the field. Richards's contributions extend beyond mere participation; he has been a source of inspiration and guidance for many, mentoring newer members and sharing his extensive knowledge and expertise. His passion for our association and its mission has helped to cultivate a strong sense of community and collaboration among members.

Geoff White

Geoff has made a profound impact on our association through both his volunteer efforts and professional service. Geoff has generously dedicated his time and expertise to serve as an expert on numerous technical groups, contributing invaluable insights and guidance that have greatly benefited our community. Geoff's commitment to advancing knowledge and best practices in the field of coatings has established him as a respected industry leader. Through Geoff's tireless efforts, he has not only enhanced the capabilities of our association but has also inspired countless others to engage and contribute. His leadership and dedication exemplify the spirit of service that we celebrate at our awards events. Ben Biddle was asked to come up to the stage to personally hand his mentor, Geoff White, with his life membership award. This was a moving tribute for everyone to witness.

YCG National Award, recognizing exceptional members under 35, was awarded to **Anthony Roccisano** for his innovation and leadership in corrosion prevention.
Dr Anthony Roccisano was the 2023 winner of the Marshall Fordham Best Research Paper Award, and was part of The University of South Australia Team that won the STEM Research Team of the Year Award for their work on "Coatings for Extreme Environments." Anthony is also an author of a number of published or presented technical papers. Anthony has also been Vice President of the South Australian Branch of the ACA for the past two years, and has been the YCG delegate on the SA Branch in prior years.

Awards Dinner Cont...

Awards for Industry Excellence

The Recognition of Service Awards recognise the significant contributions of our volunteers to assist the ACA's operational efforts. This year we honoured:


Scott Wade


Willie Mandeno


Dean Ferguson


Andrew Russell

The Rust Award, is awarded annually to a protective coatings contractor who has demonstrated a meritorious or innovative performance in the field of concrete remediation and protection. This was presented to:

Michael Ippoliti
Nigel Spiller

The Aude Sapere Award, acknowledges ACA Member organisation's ongoing commitment to the training and professional development of the staff through holding an ACA-delivered training courses each calendar year. This year the award was to:

Kaefer

KAEFER

Awards Dinner Cont...

Fostering Future Professionals

The ACA Foundation awarded several scholarships, recognizing rising talent and supporting professional growth:

- Denso Australia & ACA Foundation Training Scholarships: Aaron Davis and Sophia Odlin
- Denso Australia & ACA Foundation Professional Conference Attendance Scholarships: Dr. Farzaneh Farivar and Nate Berends
- Infracorr Consulting & ACA Foundation Final Year Student Conference Attendance Scholarship: Ngoc Bao Huynh.
- Mike Rutherford Memorial Award: Seb Schubert Arriaza
- UCC & ACA Foundation Conference Attendance or Training Scholarship: John Millett
- Phoenix Solutions & ACA Foundation Conference Attendance or Training Scholarship: Leikin Cottam.
- Marine and Civil Maintenance Professional Development and Conference Attendance Awards: Andres Gonzales







The awards were completed with a lively auction of donated items by Ian Godson and Rachelle Rigby. These auction of donated items along with the silent auction items delivered just under $7,000 to the ACA Foundation for their ongoing work to support younger generations to broaden their knowledge of corrosion.



FORUM SPOTLIGHT

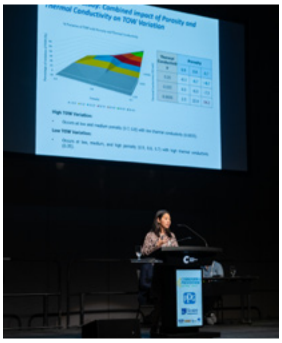
Conference Forum Spotlight: Collaborating for Progress at Corrosion & Prevention 2024

Set against the stunning backdrop of Cairns, the Corrosion & Prevention 2024 Conference wasn't just an industry event—it was a vibrant celebration of knowledge, innovation, and collaboration. Bringing together leaders, academics, and practitioners from around the world, the conference provided a platform to share groundbreaking insights, tackle critical challenges, and advance the field of corrosion management and asset protection.

At the heart of the event were its specialized forums, each carefully designed to explore sector-specific issues and emerging trends. These forums served as dynamic hubs for sharing ideas, discovering solutions, and fostering professional growth. Attendees left inspired and equipped to tackle the challenges ahead.

Oil, Gas & Energy Forum

CONNECTING INDUSTRY WITH INNOVATION

A standout session this year was the Oil, Gas & Energy Forum, which debuted under the newly branded Oil, Gas & Energy Technical Group. Chaired by Arthur Kokolekos, the forum explored the theme "Connecting Industry with Innovation & Best Practices" and attracted a strong mix of local and international experts. Reflecting on the session's success, Arthur said: "The turnout was fantastic, with an engaged audience and dynamic discussions. The diversity of expertise in the room made it a truly interactive experience. A special thank-you to our technical group secretary, Margarita Vargas, whose support was invaluable." The forum featured cutting-edge presentations addressing real-world challenges and innovative practices. Attendees walked away with practical insights, reaffirming the critical role of collaboration in driving progress across the industry.

Non-Ferrous Forum

CRITICAL INFRASTRUCTURE




Chaired by Igor Chaves, the *Non-Ferrous Materials Forum* provided a deep dive into materials essential for critical infrastructure. With presentations on magnesium alloys, nickel aluminum bronze, and aluminum alloys, the forum sparked lively debates among its 50 attendees. The impressive speaker lineup included: **Prof. Robert Melchers:** Trends in corrosion modeling for magnesium alloys, **Darren Cram:** Assisted cracking and cavitation performance of nickel aluminum bronze, **Dr. David Nicholas:** Pitting corrosion trends in copper alloys & **Dr. Amir Farzaneh:** Failure mechanisms of aluminum alloys in seawater. Igor praised the session's interactive nature: *"The presentations were delivered on time, and the audience engagement was exceptional. Prof. Melchers' insights, in particular, sparked meaningful debates that connected seamlessly with other speakers' topics."*

FORUM SPOTLIGHT

Concrete Forum

DIVERSE PERSPECTIVES, FRESH IDEAS

The Concrete Forum tackled a range of topics, from system performance to condition assessment and repair strategies. Key presentations included:

- Mohammad Ali: Comparing SACP vs. ICCP and the need for clear performance criteria.
- Phil Karajayli: Balancing data collection and costs in concrete condition assessments.
- Jessica Lyndon: Challenges in material selection for alpine concrete repairs.

The session fostered healthy discussions and emphasized the importance of tailored solutions for long-lasting, resilient infrastructure.

Water Forum

SAFEGUARDING VITAL ASSETS

In the Water Forum, attendees explored practical solutions and innovative approaches to water asset management. Highlights included:

- Scott Gaebler: Best practices for applying polyurea and polyurethane coatings.
- David Nicholas: The potential of partially corrugated stainless-steel tubes in water pipelines.
- Geraldine Pedersen: Case studies on pipeline inspection and corrosion prevention systems.

The strong audience engagement underscored the importance of precision and innovation in protecting these essential assets.

A Broader Perspective

Beyond these highlights, the conference hosted several other specialised forums, each contributing to a more comprehensive understanding of corrosion management:

- NAVSEA & Defence Forum: Addressing corrosion challenges in naval and defense infrastructure.
- Applicator Forum: Offering hands-on insights for those on the front lines of corrosion prevention.
- Coatings Forum: Exploring advancements in protective coatings across industries.

Each forum was thoughtfully curated to inspire dialogue, spark new ideas, and deliver actionable solutions attendees could implement in their work.

Looking Ahead

Corrosion & Prevention 2024 was a testament to the power of collaboration and knowledge-sharing. From the forward-thinking discussions in the Oil, Gas & Energy Forum to the technical deep dives in the Concrete and Water Forums, every session highlighted the expertise and innovation driving the industry forward.

The Australasian Corrosion Association extends our thanks to the chairs, speakers, and attendees for making this year's event a resounding success. As we look to 2025, the ACA remains dedicated to fostering platforms that inspire research, spark dialogue, and deliver solutions with lasting impact.

Some Microstructural Influences Upon Localised Corrosion

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Keywords:

localised corrosion, alloys, microstructure, aluminium alloys, electron microscopy

ABSTRACT

The degradation of metallic alloys is a process that is, over extended time periods, basically assured. The 'engineering alloys' that are critical to essentially all facets of modern life, are highly engineered to 'cheat nature'. That is, immense amounts of energy are utilised to liberate ores (and specifically, oxides) to create metals and alloys. There is a considerable thermodynamic driving force for the reversion of metals and alloys to the ore-like state in atmospheric conditions – which gives rise to corrosion. It therefore follows that the composition, and the 'structure' of alloys will play a critical – and deterministic – role in how such reversion (i.e. corrosion) occurs. A foundational understanding of the role of alloy structure (specifically what metallurgists refer to as microstructure) is critical to understanding corrosion and its genesis at the functional length scale. Herein, some examples of microstructural effects on corrosion are touched upon, including how they may impact early / localised corrosion.

INTRODUCTION

The impact of corrosion on all facets of our way of life is profound. Whilst occurring silently, corrosion costs the economy of most nations approximately 3-4% of GDP, annually1. Studies accounting for the cost of corrosion include the recent Impact Study (USA)2, the recent Cost of Corrosion in China study3, and a report released in June 2021 commissioned by the Australasian Corrosion Association ('Impact of Corrosion in Australasia report4). It was estimated up to $78 billion per annum is being spent on remediating assets affected by corrosion in Australia - along with the associated corrosion prevention measures. What is consistent across all studies regarding the impact of corrosion, is that the effects have a major influence on essentially every industry and most industrial processes.

There is a clear and ongoing (urgent) need for the development of more corrosion resistant alloys, with enhanced durability. But how? In order to begin to answer such a question, one must deterministically be able to rationalise the origins of corrosion –

before having the 'tool kit' to be able to develop materials that can be more corrosion resistant by design. In other words, fundamental science needs to be the enabler that allows 'applied' outcomes – in service of society (where metallic alloys are now indispensable in energy, healthcare, communications and transportation).

One of history's finest examples of being able to link fundamental science to applied outcomes was a unique individual called Percival Faraday Thompson (PFT), (1885-1951), who was a metallurgist and analytical chemist – that worked a long career in the field of corrosion5. Much has been said regarding PFT, including his ability to be a thought leader and pioneer, but also a great scientist and educator. I will not repeat all such facets here, but whole-heartedly direct readers to wonderful relevant works6,7. One important statement that is attributed to PFT that rings true (and has, for over a century) is the following quote, "Around no subject of technical interest have prejudice and wrong thinking in the past, so wrapped a web of obscurity as that of the corrosion of materials". Such a statement can be interpreted thousands of ways, however what is still true, and remains true, is that there is ongoing obscurity regarding the deterministic origins of corrosion.

There are however, admittedly, good reasons why there has been ongoing obscurity regarding the deterministic origins of corrosion. As one example, advanced analytical microscopy was not readily available when many (if not, most) of the common engineering alloys were developed. The technology required to assess corrosion – and the factors controlling it – have emerged in earnest in the present millennium. Momentarily neglecting the consideration of corrosion, one may consider the development of other properties in engineering alloys. Key properties that are relevant to material usage include the yield strength of a material, the ductility of a material, and (mechanical) damage tolerance often assessed by quantities defined as tensile strength or toughness. The role of microstructural features on the development of such mechanical properties has been an endeavour of science that developed at a pace much more rapidly than say, the understanding of microstructural features on the development of corrosion properties of a material. Why is that? Perhaps PFT had some thoughts on why, but as a discipline, corrosion has (for reasons that defy all logic) remained an 'after thought'. In spite of nearly a century of studies on the cost of corrosion, the long-term economic perils of the corrosion menace have not been an adequate warning to much of global industrial practice (where, perhaps for reasons non-scientific, but driven by financial immediacy) to better understand corrosion. The good news is that things are changing. At the macro scale, practices such as durability management planning have been emerging across the infrastructure sector, which is very welcome. However, I will confine this paper to the scientifically interesting 'microscale'. So, what has been happening at the 'microscale' to better inform our understanding of corrosion? There are many things one could respond with, but I like a statement that was made by a professor in the USA by the name of Rudolph Buchheit, who after a seminal study in 19978 proclaimed that our understanding of corrosion is about to change forever. What Buchheit was referring to, was that the resolution from images captured by electron microscopes employing a field emission gun (FEG) as the electron source, were exceptional. Images from a FEG scanning electron microscope (SEM), were able to see localised corrosion occurring at the nano-scale, with unprecedented clarity previously not possible. In quick succession since then, the advent of analytical FEG-TEM (transmission electron microscopy), STEM (scanning transmission electron microscopy) and a method termed EBSD (electron backscatter diffraction) have permitted significant advances in our understanding and rationalisation of the genesis of corrosion; specifically, the role of microstructure on corrosion of engineering alloys. Some examples the author has had the pleasure of being involved with are concisely elaborated below.

DISCUSSION

Examples herein are intended to provide a sample of experiments and studies that have contributed to deterministically explaining the role of microstructure on corrosion of engineering alloys. The author concedes the examples are a synopsis of their work, whilst noting there are exceptional studies by others that have been occurring over the past decade which merit exploration from interested readers (i.e. Kosari9, Kosari10, Gharbi11, Williams12, and Ryan13).

The Role of Grain Size on Corrosion

Engineering alloys undergo a range of processing conditions (thermo-mechanical processing) following their casting. These different processing conditions can result in a range of grain sizes in the material microstructure, as depicted for pure aluminium (Al) in Figure 1.

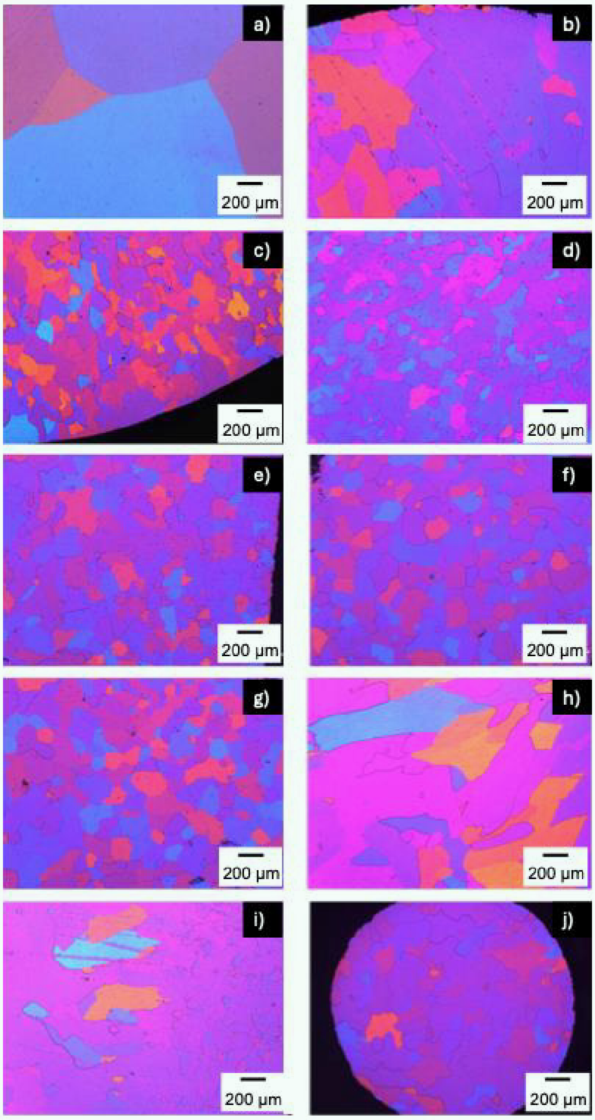

Figure 1: Sample optical micrographs of high purity aluminium after different processing routes and heat treatment times at 200°c: (a) as-cast 0 min, (b) ecap 1-pass 0 min, (c) ecap 4-pass 0 min, (d) ecap 8-pass 0 min, (e) smat 0 Min, (f) smat 10 min, (g) smat 60 min, (h) cold-rolled 0 min, (i) cryo-rolled 0 min, and (j) al wire 10 min. In all cases the scale bar is 200 micrometres[14].

The ability to study the grain size of engineering alloys was rapidly advanced with the advent of electron backscatter diffraction (EBSD), over the past two decades. An early EBSD image from a magnesium specimen is shown in Figure 2, taken by the author15. The advent of EBSD not only allows the ready assessment of grain sizes, but has the advantages including: (i) being able to quantify very fine grains, (ii) being able to also (simultaneously) quantify grain orientation, and (iii) accurate determination of grain size for grains that are irregularly shaped or over a wide size-range distribution.

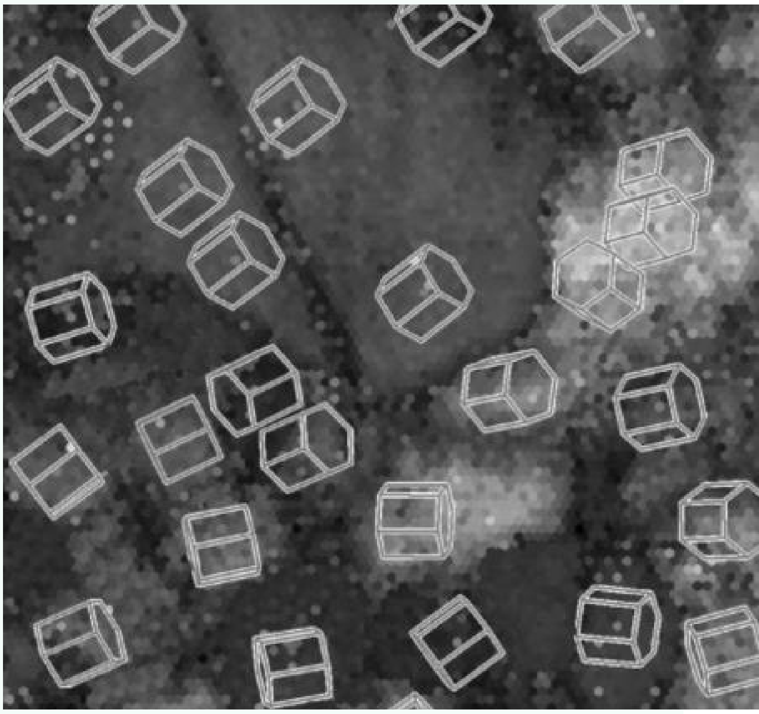

Figure 2: Unique grain ebsd map of magnesium (99.9%) after four ecap passes.

Through extensive review16 and original works17, a formalism relating the corrosion rate of engineering alloys (and pure metals) to grain size was developed. This is depicted by Eqn. 1, where A and B are constants that depend on the environment / test conditions, and gs is grain size.

icorr = (A) + (B)gs-0.5 Eqn (1)

The Role of Precipitate Size on Corrosion

Through many works in the 1990's using scanning electron microscopy, the localised nature of corrosion (in the origins of corrosion) was being exposed. Through the study of light alloys, the works of Buchheit, Scully, Nisancioglu, and several other groups across the world – showed that localised corrosion was being defined as a 'deterministic' process. Whilst the concise paper herein will not elaborate on the extensive works carried out on stainless steels and brasses (and, there is much exceptional work to speak of), the case study of aluminium alloys is an important example to elaborate on. This is because (i) it was noted that 'particles' of varying types (and sizes) in aluminium alloys influence the localised corrosion process, and (ii) aluminium alloys develop their mechanical properties through aging processes, that stimulate the growth of hardening precipitates. This latter point is one that was exploited by the author, in order to study the critical 'precipitate' (i.e. particle) size that may trigger particle / second phase localised corrosion. By looking at the rate of pitting (as electrochemically measured from the metastable pitting frequency using potentiostatic transient testing18), as a function of aging time, one may determine at what critical aging time the alloy undergoes a transition from 'no localised corrosion', to, 'localised corrosion' prone. This is demonstrated in Figure 3, for a model Al-Cu-Mg alloy.

Through correlative high-resolution scanning-TEM, it was possible to determine a critical precipitate thickness below which pitting did not occur, and above which pitting occurred19. This is depicted in Figure 4, where the images reveal the critical thickness for precipitate (i.e. particle) induced localised corrosion is at ~5 nm. This notion of a critical thickness below which localised corrosion did not occur, was subsequently demonstrated (again with advanced correlative microscopy) for other alloys, including Al-Zn-Mg (7xxx series) alloys20, and Al-Cu-Li (2xxx series) alloys21.

Corrosion Mechanisms at the Nano/Atomic Scale

Ongoing developments in transmission electron microscopy allowed the simultaneous imaging and x-ray mapping through scanning transmission electron microscopy. The use of field emission electron sources also allowed imaging and analytical x-ray mapping to occur at high resolution. The aforementioned early works of Buchheit had revealed that localised corrosion occurred on Al-Cu-Mg alloys, also indicating that the process of localised (particle induced) corrosion was associated with the so-called 'de-alloying' process. That is, corrosion of particles did not occur uniformly in the alloys they populate. The particle itself would undergo a process of incongruent dissolution, which is directly akin to 'de-alloying'. Through meticulous experiments, Kairy developed a quasi in-situ process for tracking localised corrosion at the nanoscale as a function of time (i.e. time

>3 order of magnitude increasein the metastable pit rate was observed after critical ageing.

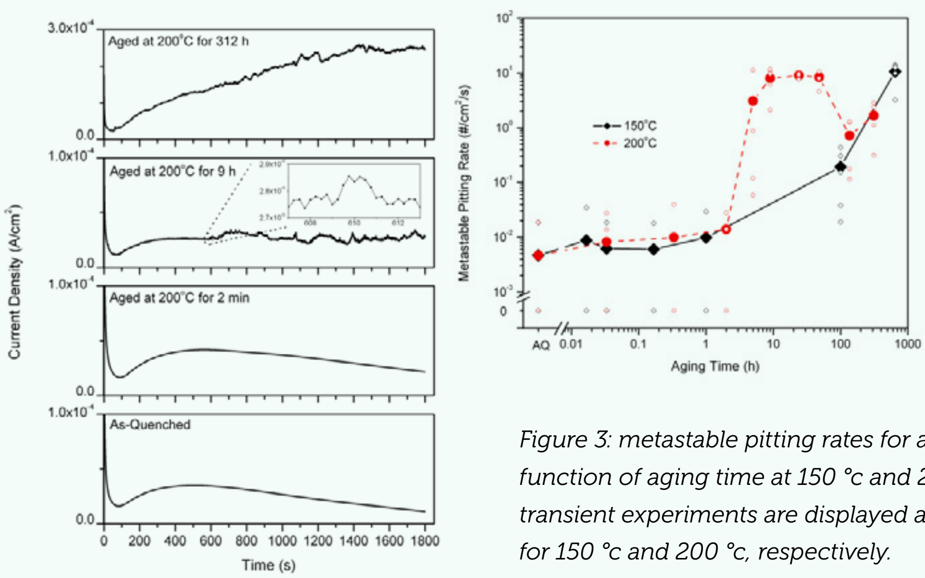

Figure 3: metastable pitting rates for al–1.1cu–1.7mg (at. %) As a function of aging time at 150 °c and 200 °c. Results from individual transient experiments are displayed as empty diamonds and circles for 150 °c and 200 °c, respectively.

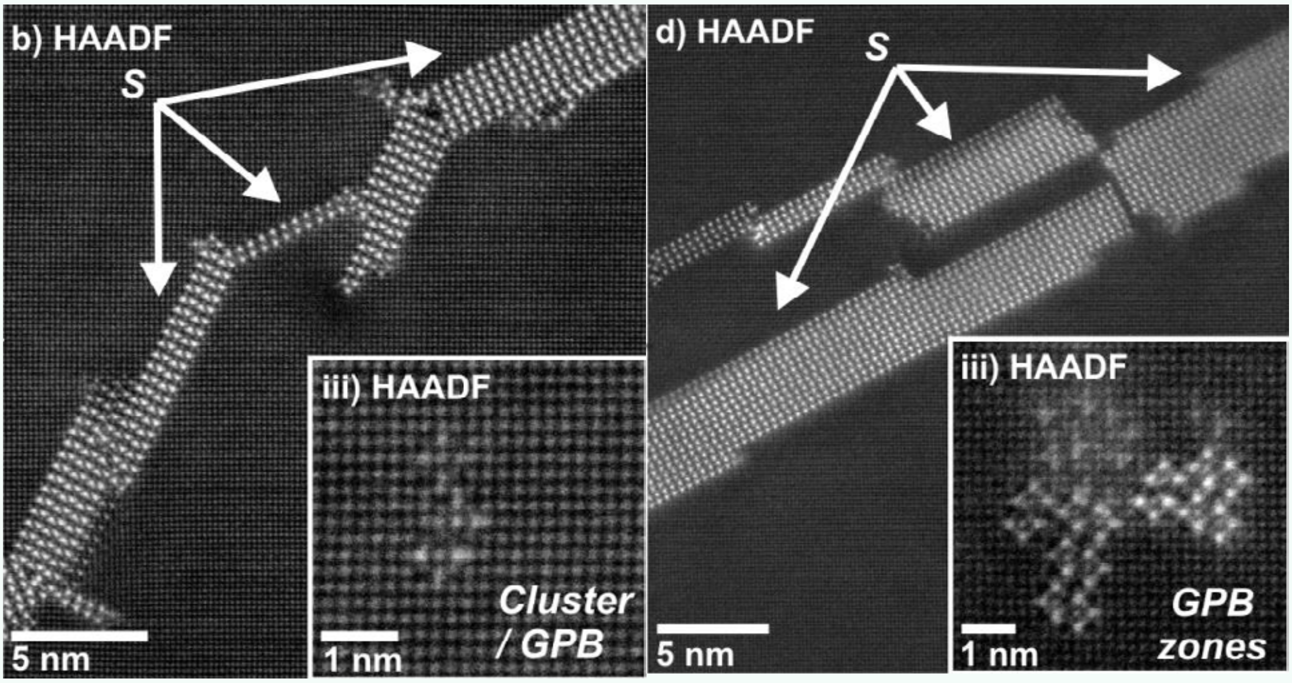

Figure 4: Bright field (bf) and high angular annular dark field (haadf) scanning transmission electron micrographs (stem) of representative microstructures in samples aged: (left) 2 h at 200 °c, (right) 9 h at 200 °c. Insets are higher magnifcation images of atomic scale clusters throughout the alloy matrix.

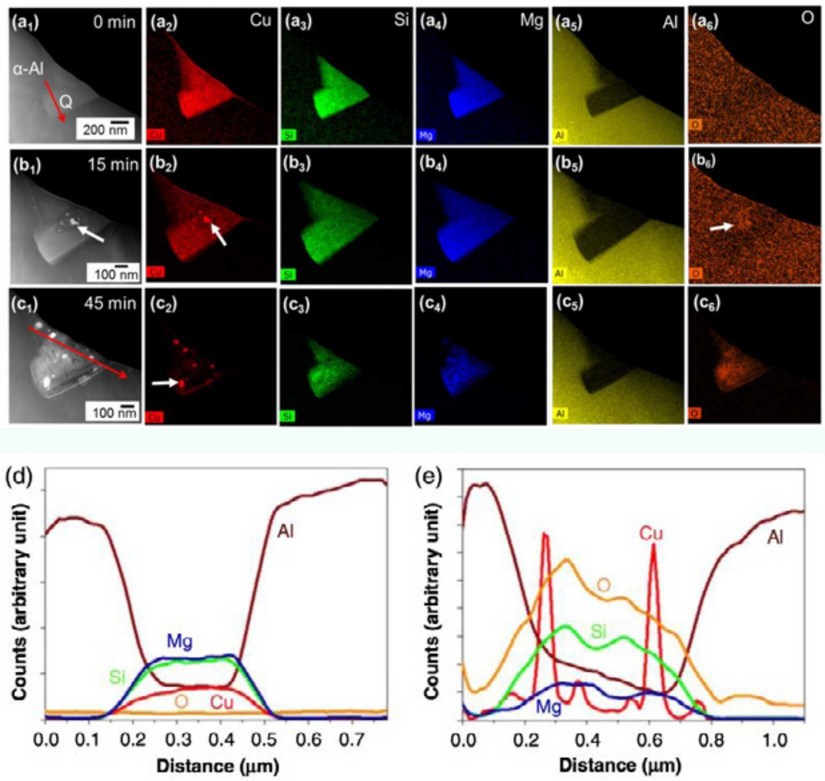

Figure 5: HAADF-stem images of q-phase (al4cu3mg7si6) in the matrix of al-0.9si-0.74mg-0.84cu-0.08fe-0.14mn (wt. %) Sheet aged at 400°c for 30 d, as a function of immersion time in 0.1 M nacl; (a1), (b1), and (c1) are the haadf images prior to immersion, and after 15 min and 45 min immersion, respectively, and (a2) through (a6), (b2) through (b6), and (c2) through (c6) are the eds maps corresponding to (a1), (b1), and (c1), respectively. (A1) the nano-q-phase precipitate in the α-al matrix. Arrow in (b1) points to the high atomic number contrast nanoparticles on q-phase, and the corresponding regions in (b2) and (b6) show cu and o enrichment, respectively. Arrow in (c2) points to the cu enrichment in q-phase. (D) and (e) eds line analysis along the arrows in (a1) and (c1), respectively.

of exposure to a corrosion environment). The results of such testing are depicted in Figure 5 22 for Al-alloys used in automotive applications.

What is seen from Figure 5, is that incongruent dissolution occurs for a precipitate, namely $Al_4Cu_3Mg_7Si_6$, at the nanoscale. Time dependent

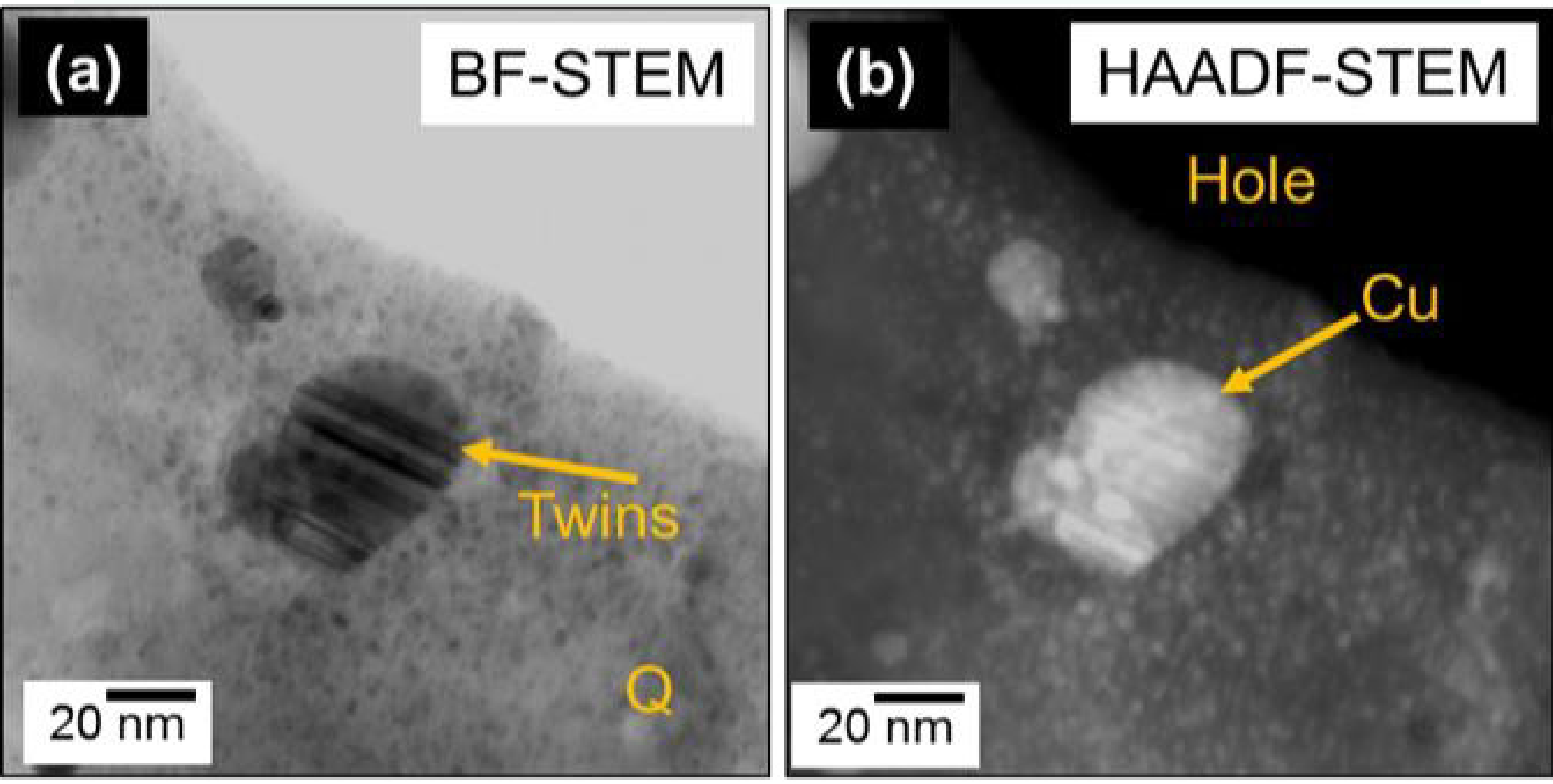

Figure 6: (a) and (b) high-magnification bf- and haadf-stem images of the q-phase (al4cu3mg7si6) precipitate, in the matrix of al-0.9si-0.74mg-0.84cu-0.08fe-0.14mn (wt. %) Sheet aged at 400°c for 30 d, after 45 min immersion in 0.1 M nacl. Arrow in (a) shows twins on the cu particle.

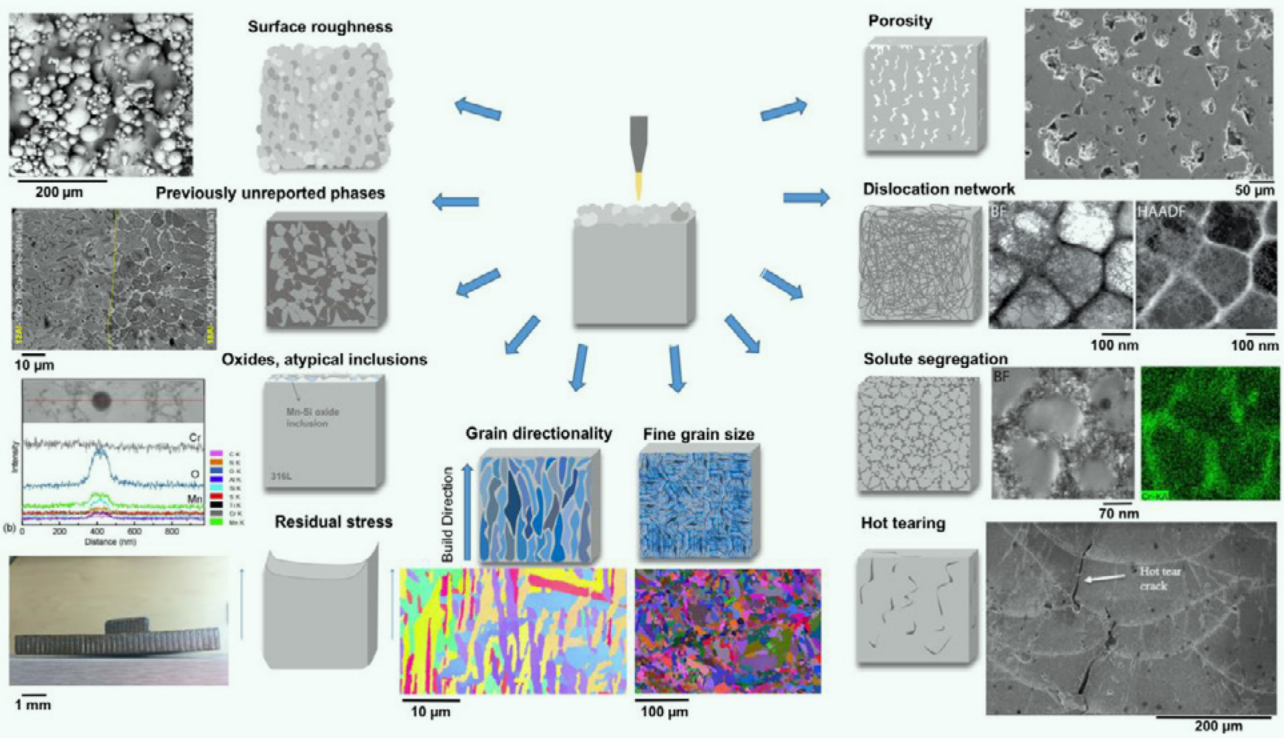

Figure 7: Schematic diagram summarizing the potential impact of am processing on the overall microstructure of the produced components. The potential influence of each processing variable is illustrated by data reported in the literature.

imaging reveals the preferential dissolution of aluminium; but also revealed the dissolution and redeposition of copper. A closer look at the redeposited copper is provided in Figure 6, revealing that essentially pure Cu is redeposited on the alloy surface following incongruent dissolution of Al4Cu3Mg7Si6. This is depicted in Figure 6, where it is also revealed that redeposited Cu forms with the inclusion of so-called 'nano-twins'. The broader works that relate to this system 23,24 (Al-Mg-Si-Cu) are also foundational in suggesting that all localised corrosion (in all alloys) occurs by a process of incongruent dissolution.

Corrosion of Complex Engineering Alloys

The corrosion of engineering alloys is a deterministic result of the alloy microstructure, as noted from the examples provided above. However, there is still much to learn. As one example, the emerging class of additively manufactured alloys (i.e. produced by 3D printing), pose some unique microstructures and morphologic traits 25, as shown in Figure 7.

Understanding (deterministically) the corrosion of additively manufactured alloys is an area of enquiry that requires much future work. The same is true for the emerging class of so-called multi-principal element alloys26.

CONCLUSIONS

Corrosion is a deterministic process, that occurs in a manner that is rational (based on the metal/ alloy microstructure, and its environment). The paper herein has shown examples of how microstructure will influence corrosion. The examples herein are not exhaustive, and are admittedly confined to a short review of only some works done by the author. The study of microstructural effects on corrosion is (in spite of the wide use of engineering alloys) still rather nascent. There however remains much work to do, to understand the many facets of microstructure, and how they deterministically influence corrosion.

A more quantitative and definitive understanding of microstructural effects on corrosion is a necessary platform for predictive modelling of alloy corrosion (and degradation more generally). Corrosion models that can predict corrosion, its propagation and rate, will serve to inform durability management tools – but more importantly be the platform from which corrosion resistant alloys may be rationally designed.

ACKNOWLEDGMENTS

This concise paper has utilised the exceptional work of many researchers (now professional engineers and academics) over the past two decades. These include Dr. Kevin Ralston, A/Prof. Rajeev Gupta, Dr. Shravan Kairy, Dr. Oumaïma Gharbi and Dr. Victor Cruz de Faria. A special thanks to Professor Rudy Buchheit for many sustained discussions over the years, regarding localised corrosion.

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AUTHOR DETAILS

Nick Birbilis is the Executive Dean of the Faculty of Science, Engineering and Built Environment at Deakin University, Australia. His research has sought to rationalise the behaviour of engineering alloys from a deterministic perspective. His interests also include computational studies of materials and machine learning tools to accelerate materials discovery. His awards include the H.H. Uhlig Award, U.R. Evans Award, ATSE Batterham Medal, ACA Corrosion Medal; along with recognition as a Fellow of ASM International, The Electrochemical Society, International Society of Electrochemistry, NACE/AMPP and Engineers Australia.

Ports: Anchors of the Energy Transition

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Keywords:

Offshore Wind, Port Infrastructure, Corrosion Protection, Energy Transition, Renewable Energy

Abstract:

Australia's ambitious target to achieve net zero emissions by 2050 and integrate 82% renewable energy into its electricity grid by 2030 underscores the critical role of Offshore Wind in the nation's energy transition. With extensive wind zones identified along our coastline, offshore wind will be pivotal to achieve our ambition. However, this renewable future hinges on the readiness of Australia's ports, which will serve as essential hubs for construction, logistics, and long-term maintenance of offshore wind farms. Port infrastructure upgrades are necessary to accommodate the scale and complexity of offshore wind development, especially in managing the increased size of turbine components, specialised vessels, and operational demands. Additionally, the expansion of offshore wind will drive significant demand for corrosion technologists, not only for port infrastructure but also across the entire Offshore Wind asset lifecycle—from manufacturing and storage to installation and ongoing management. This paper explores the corrosion challenges inherent in offshore wind, including material selection, protective coatings, cathodic protection, and maintenance strategies to extend the life of wind structures. It further discusses how the corrosion industry can proactively prepare for this transition, ensuring resilience in both Port infrastructure and offshore wind operations. With international examples guiding the way, the Australian corrosion sector must now take active steps to meet the demands of this emerging energy landscape. How prepared are we for this transformation?

Figure 1: Renewable energy offshore wind farm

INTRODUCTION

As Australia seeks to transition to a low-carbon economy, the nation's commitment to achieving net zero emissions by 2050 and increasing renewable energy generation to 82% of its electricity grid by 2030 has intensified the focus on offshore wind as a critical component of this energy transition. Offshore wind offers significant potential to harness vast marine wind resources and support decarbonisation efforts, making it a central pillar in the country's renewable energy strategy. With several offshore wind zones identified along Australia's extensive coastline, ports are set to become vital infrastructure hubs that will enable the construction, operation, and maintenance of this new energy frontier.

The readiness of ports is a crucial factor in enabling offshore wind development. Given the scale and complexity of offshore wind projects, including the transport and assembly of large turbine components, specialised vessels, and the need for long-term maintenance, Australian ports must undergo significant upgrades to meet the demands of this burgeoning industry. Furthermore, these developments will increase the need for corrosion management, both for new and existing port infrastructure and across the lifecycle of offshore wind assets. Corrosion technologists will play a vital role in ensuring the longevity and durability of these structures in challenging marine environments.

This paper will explore the intersection of port infrastructure and offshore wind, examining the upgrades necessary for ports to support the energy transition, with a particular focus on corrosion considerations. It will discuss the critical role of the corrosion industry in preparing for this transition and draw on lessons from international experiences in offshore wind development. The aim is to offer insights into how the Corrosion workforce in Australia can effectively prepare for the future of renewable energy.

DISCUSSION

Australia aims to achieve net zero emissions by 2050 and 82% renewable energy in its electricity grid by 2030

The federal and state governments are investing heavily in renewable projects, with a significant focus on infrastructure that can support large-scale renewable energy integration. Australia has seen rapid growth in solar and onshore wind energy. In 2024, renewables generated nearly 40% of Australia's electricity, a major increase from previous years [1]. However, the country still faces challenges in reaching its 82% renewable target by 2030.

The growth of renewables needs to accelerate significantly to phase out coal and natural gas, this is where offshore wind will play a vital role. Offshore wind is considered a crucial solution for Australia to meet its renewable energy targets. Our vast coastline provides ample opportunity for large-scale offshore wind farms, which have higher energy generation capacity than onshore wind or solar [2].

Offshore wind will play a key role in achieving our renewable energy target

Australia's first offshore wind projects, such as the Star of the South in Victoria [3], are now in the planning stages, with more expected to follow, including the Great Eastern Offshore Wind Project [4] and Spinifex Offshore Wind Farm in South West Victoria [5]. Offshore wind will support energy generation during periods of low solar output and provide consistent, scalable energy to meet growing demand. Offshore wind will play a role in balancing the grid as other fossil fuel power plants are retired.

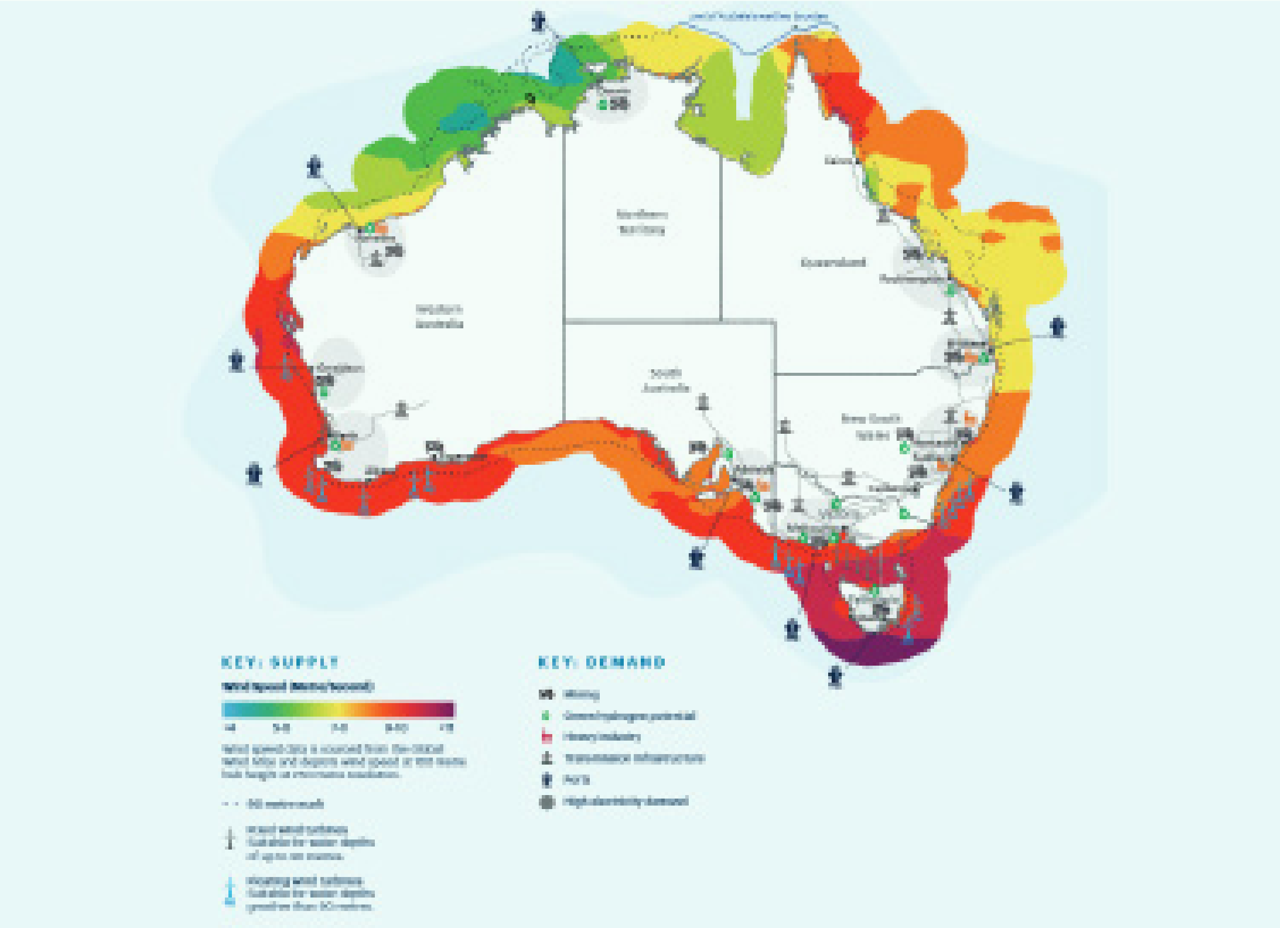

Figure 2: Areas deemed suitable by federal government for offshore wind with wind speed estimates

In Victoria, fossil fuel plants are earmarked to retire in 2028 for Yallourn Power Station, followed by Loy Yang B power station in 2032 and for Loy Yang A power station in 2035, although there are considerations to bring forward its retirement to meet Victoria's climate goals [6].

Offshore wind zones in Australia

Six offshore wind zones have been designated for development in Australia, in key regions including Gippsland (Vic), Hunter (NSW), Illawarra (NSW), Portland (Victoria), Southern Ocean, Bass Strait. The Gippsland zone in Victoria is currently the most advanced, with projects like the Star of the South leading development. Currently, several large-scale projects are moving through the various approval stages. The map shown in Figure 2 shows the areas deemed suitable by Federal Government for Offshore Wind based on average wind speed estimates and proximity to infrastructure that can support offshore wind farms.

Ports are the anchors to offshore wind development

Ports are essential for assembling, maintaining, and deploying offshore wind turbines. They will become hubs for offshore wind development, handling large-scale components and facilitating construction.

The Port of Hastings in Victoria has been identified as the most suitable site for the Victorian Renewable Energy Terminal, which will support offshore wind construction in the Gippsland zone. The proposed Victorian Renewable Energy Terminal (VRET) at the Port of Hastings will facilitate the construction of offshore wind farms by serving as a staging area for the assembly and transport of large wind turbine components. This development will be critical because Australia currently lacks ports equipped to handle large-scale offshore wind construction.

Figure 3: Artists impression of renewable energy port.

The site is strategically advantageous due to its deep-water channels and proximity to the offshore wind projects in Gippsland. The VRET is currently undergoing an Environment Effects Statement (EES) process, including the establishment of a Technical Reference Group (TRG) to oversee the process [7].

Given the volume of expected offshore wind projects in Australia, a number of Ports like Port of Hastings will play a key role and will require significant upgrades to support offshore wind infrastructure, including heavy-duty quay areas, expanded storage, and enhanced corrosion protection.

Figure 3 shows an artists impression of a renewable energy Port, showing the extent of space required for laydown area of offshore wind components.

Port upgrades will be essential to support the needs of offshore wind construction and ongoing maintenance

Significant port upgrades will be required to support the needs of Offshore wind construction and ongoing maintenance. These upgrades will include refurbishment and strengthening of existing port components, as well as the addition of capacity through new construction. Offshore wind turbines, especially their foundations and towers, can be up to 60-120 metres long and weigh 1,000-1,500 tonnes, depending on the size of the Turbine. Ports will require reinforced quays with heavy-duty pavements to withstand the weight of these components during assembly and staging.

The United Kingdom, Germany, China and Denmark made significant Port upgrades to support their globally leading offshore wind development.

1. United Kingdom

In the UK, the Port of Hull and Grimsby underwent significant upgrades to support offshore wind operations, particularly through the Green Port Hull project, completed in 2016. Siemens Gamesa, alongside Associated British Ports (ABP), invested £500 million to develop key infrastructure at Hull, transforming the port into a hub for wind turbine manufacturing and servicing. This included the construction of a 540,000 m² blade manufacturing facility, alongside new quayside infrastructure that supports roll-on-roll-off operations for easier and safer loading of turbine components.

Additionally, a new service and maintenance facility, spread across 12,300 m², was built to support turbine upkeep and pre-assembly phases. The project also involved in-filling wet docks to expand storage and operational space. These developments enabled Hull to serve as a major logistical centre for offshore wind farms like Race Bank and Dudgeon East, which Siemens was commissioned to supply with turbines [8].

2. China

China has made significant strides in upgrading its ports to support the offshore wind industry, enabling the offshore wind capacity to grow to 45% of global offshore wind capacity [13]. Ports such as those in Jiangsu, Guangdong, and Shandong provinces have undergone extensive development to accommodate large-scale offshore wind projects. Coastal provinces in China have been focused on developing new offshore wind capacity. Guangdong aims to install 18 GW of offshore capacity by 2025, while Fujian, Zhejiang, and Jiangsu aim to install 13.3 GW, 6 GW, and 9 GW of offshore wind power projects by 2025, respectively [9].

These upgrades included expanding port areas, enhancing logistics facilities, and building specialised infrastructure to handle massive wind turbine components. New port berths and heavy-lift cranes were installed to manage these logistics. The Port of Sheyang and Yancheng have been pivotal in supporting nearby offshore wind farms and facilitating the logistics for wind turbine components. China developed ports to support both construction and long-term maintenance of offshore wind farms. This rapid development has positioned China as the largest offshore wind market in the world, supporting both domestic and international growth of the industry [10].

3. Germany

Cuxhaven Port in Germany has undergone significant upgrades to bolster its capabilities for the offshore wind industry. The most notable enhancement was the construction of a new berthing space and a roll-on/roll-off (RoRo) ramp, which was completed in 2017. This expansion included 1,340 metres of berthing space and depths of up to 11.6 metres, to allow for the heavy loads to be loaded directly onto RoRo ships [11].

In addition, a new heavy-lift berth with a total capacity of 8.5 hectares was constructed to support the storage and transhipment of monopiles and transition pieces for Northland Power's Deutsche Bucht windfarm, in the North Sea [12].

4. Denmark

Denmark's Esbjerg Port was transformed into a major hub for offshore wind assembly and deployment. Esbjerg Port serves as a logistical hub for several major offshore wind projects, including the Horns Rev and the Walney Extension. The port expanded its facilities to accommodate large offshore wind components, including turbine towers and blades. This included the construction of new quays and deep-water berths. The total investment in the port's development was approximately DKK 2.5 billion (approximately AUD 550 million).

Esbjerg Port increased its berth capacity to handle larger vessels associated with offshore wind logistics. This included over 10 dedicated berths for offshore wind operations. The port area allocated for offshore wind expanded to around 600,000 square metres, providing the required space for assembly, storage, and transportation. The port has been a leader in the offshore wind industry since they participated in the construction of the first large scale offshore wind farm in Denmark in 2002. Approximately 80% of Europe's current offshore wind capacity has passed through the port, together exceeding 4 GW of offshore wind capacity [13].

Further expansion projects are planned with up to DKK 7 billion (approximately AUD 1.5 billion) construction of offshore wind turbine production facilities, new terminals and development of a multi modal hub, to integrate sea transport with road, rail and air freight – due for completion by 2032. This investment is part of the broader goal to establish 134 GW of offshore wind capacity by 2030 and 300 GW by 2050 in the North Sea region [14].

Port upgrades and construction will increase demand for Corrosion technologists, but so too will Offshore wind design, construction and maintenance

Australia is in its early stages of developing an offshore wind industry. The design, construction, ongoing maintenance, and the associated establishment of a new supply chain, will demand the skills of corrosion technologists in Australia. Many offshore wind projects will be part funded by Government grants. These Government grants aim to stimulate local employment, creating an incredible opportunity for the local Corrosion workforce in Australia to work closely with international offshore wind construction companies, local consultants and local manufacturers to bring marine corrosion capabilities to a new industry for Australia. We will explore the role the corrosion industry can play in offshore wind further, however before we do, let's understand the basics of offshore wind structures.

Overview of Offshore wind structures

The size and scale of offshore wind structures is hard to comprehend, without a reference point. Much larger than their onshore counterparts, offshore wind rotor diameters are reaching over 200m and are projected to reach 300m by 2050. The larger the diameter, the greater the power output of the turbine.

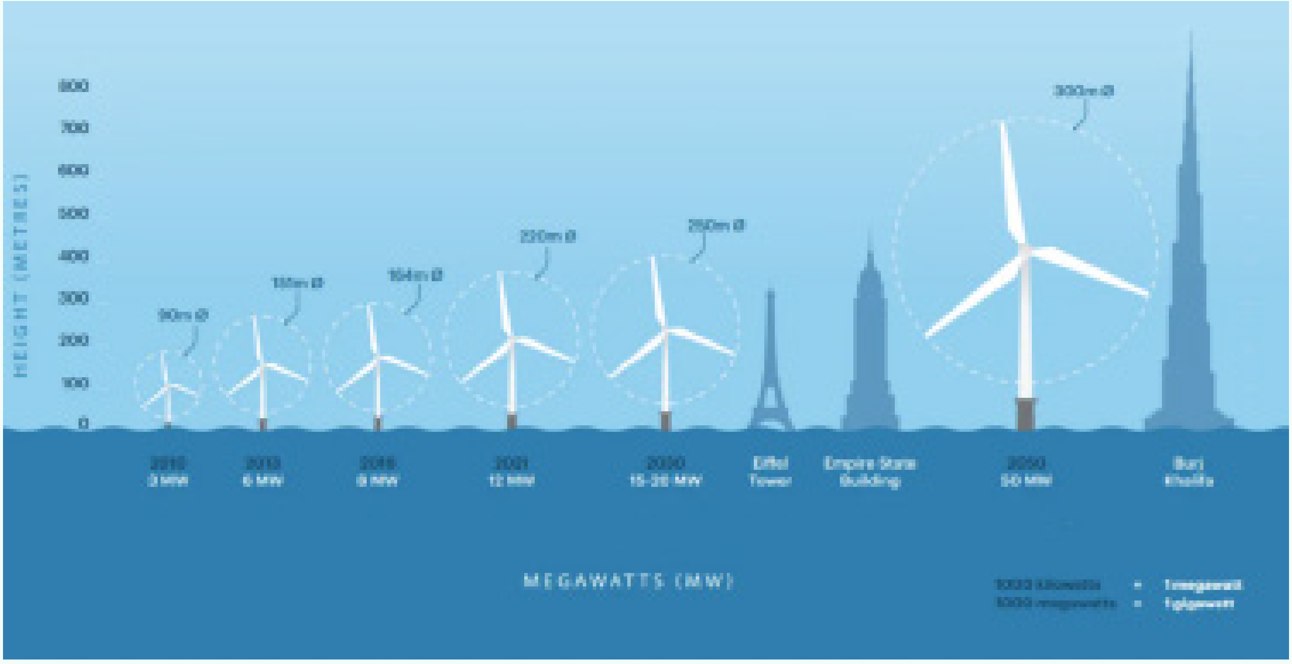

Figure 4: Relative size of offshore wind turbines

Key components include foundations (monopiles, jackets, and floating structures and their auxiliaries), towers, turbines (which can generate 7 to 20 MW depending on their rotor diameter), and electrical infrastructure including cables (dynamic cables for floating structures) and substations. The construction timeline for these structures can span 2 to 5 years, with installation taking 6 to 12 months post-foundation completion. As the offshore wind sector continues to expand, global advancements in technology and infrastructure will enhance efficiency and capacity [19].

The monopile construction approach is a prevalent method used for offshore wind turbine foundations, particularly in shallow waters. This technique involves driving large, cylindrical steel tubes, or monopiles, deep into the seabed to provide a stable base for wind turbines. Typically ranging from 2 to 6 meters in diameter, monopiles can extend up to 30 meters or more below the seabed, depending on soil conditions and water depth. The monopile foundation is favoured for its relatively low cost and installation efficiency, making it suitable for offshore wind projects here in Australia. See Figure 7 for the monopile foundation construction approach.

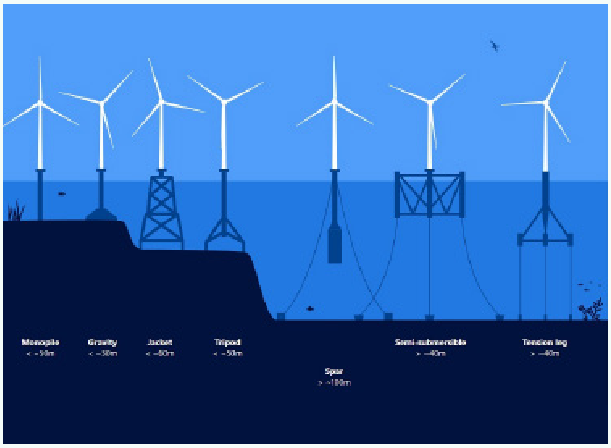

Figure 5: Different types of offshore wind turbines

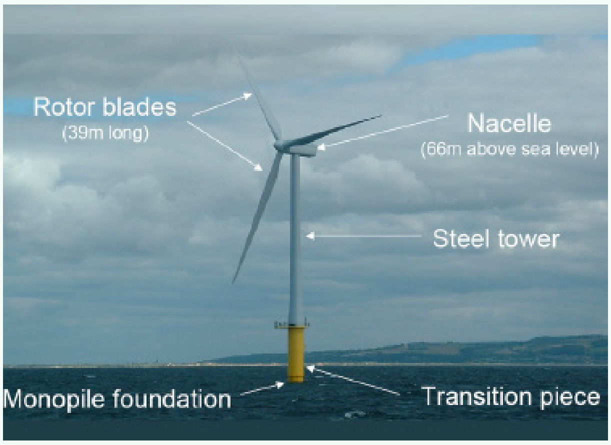

Figure 6: Components of a monopile offshore wind turbine

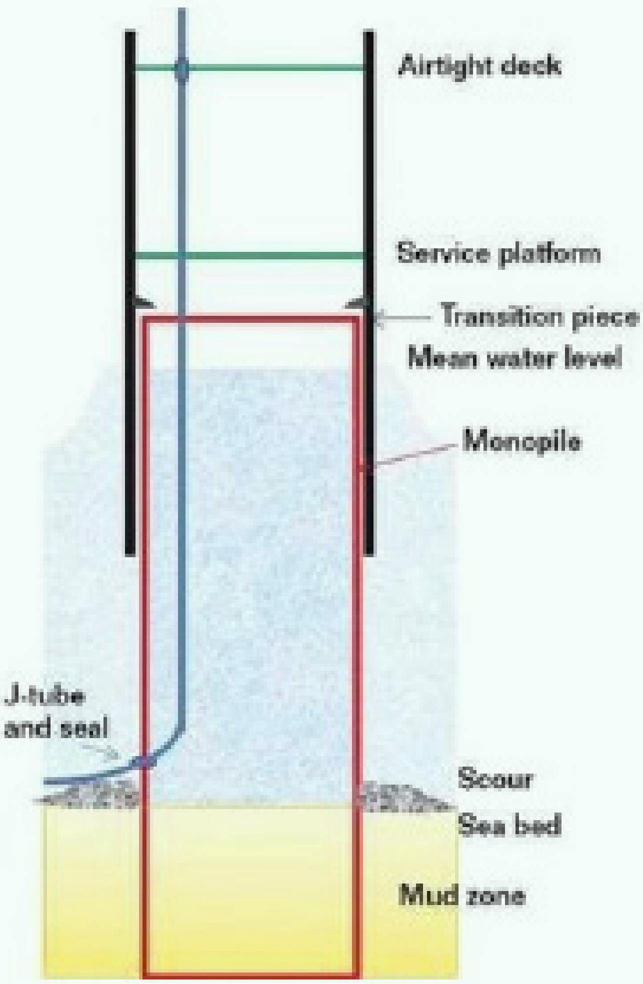

Figure 7: Monopile construction

Corrosion considerations over the offshore wind asset lifecycle

Corrosion is a major concern throughout the lifecycle of offshore wind turbines, given the harsh marine conditions and high wind zones. Consideration must be given to the durability of offshore wind turbines to secure Australia's energy future. Whilst Australia is lagging behind other countries in Offshore wind, it does come with the advantage of being able to take the learnings from the global offshore wind industry, with structures that have been in service for up to 10 years, to improve the design and construction methods. Let's explore the corrosion considerations throughout the lifecycle of an Offshore wind monopile structure and some of the learnings we can apply here in Australia.

1. Design and Manufacture

Selecting the right materials is critical to mitigate corrosion. Components such as the nacelle, blades, tower, and foundations are often made of steel, aluminium, composites, and have corrosion resistant coatings. The materials selection needs to take into account the exposure environment. The offshore wind structure corrosion zones are shown in Figure 8.

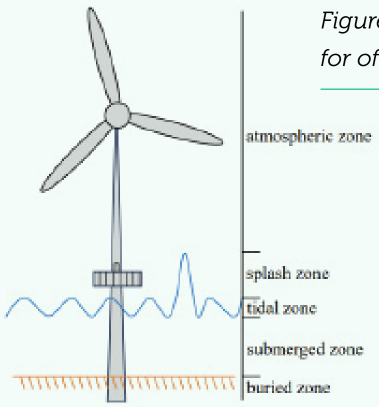

Figure 8: Corrosion zones for offshore wind turbines

External corrosion considerations for the foundation are similar to that observed in other offshore industries, and corrosion protection is prescribed in current industry guidelines based on experiences from the oil and gas industry. Cathodic protection (CP) of offshore structures with galvanic anodes is a well-established corrosion prevention technique, and DNV-RP-B401 provides requirements and guidelines for CP design, anode manufacturing, and installation of galvanic anodes. The design of an impressed current CP (ICCP) system is described in DNV-OS-J101, NACE SP0176, and BS EN 12495. Coating use is mandatory in the atmospheric and splash zones. External surfaces of the submerged zone have CP; and in the splash zone, CP may be assumed to be fully protective below the mean water level. In most projects, the CP system uses galvanic anodes placed on the transition piece, but ICCP systems are being applied in an increasing number of projects. A protective coating applied in the submerged zone is optional and primarily intended to reduce the level of CP required. General recommendations for coating systems to be used offshore are given in international standards such as

EN ISO 12944, ISO 20340, and NORSOK M-501 [15]. Given the presence of sulfate-reducing bacteria in Australian waters potentially contributing to Microbial Induced Corrosion (MIC) in the tidal zone [16], ICCP, combined with coating application will provide the greatest protection against MIC.

Internal corrosion considerations must also be taken into account. Internal corrosion of the transition piece for example should include coatings and/or CP as part of the internal corrosion protection. Several wind farm owners have retrofit existing monopile structures with internal galvanic CP systems as well as include internal CP as part of the design for new projects.

Industry experience has shown, that it is difficult in practice to completely seal compartments and render them airtight. If the closed-compartment structure is not properly sealed, direct ingress of air is possible. Seawater and oxygen ingress have been detected in foundations that are two to 10 years old, which increased the rate of corrosion and localised corrosion attacks. Furthermore, in some cases, the increasing water level led to the internal aluminum ladder acting as a sacrificial anode (Figure 9). Today, air tight platforms are now much better controlled, the offshore wind industry has come a long way with improving the design to significantly reduce internal corrosion.

Figure 9: The lower part of the internal aluminium ladder, which is located above the service platform, corroded away due to the water level rising above the service platform.

Design considerations must take these learnings into account, and design appropriate corrosion mitigation measures.

2. Storage and Pre-Assembly

As shown in the artists impression Figure 3, Turbine components are stored at or near coastal ports. During storage, temporary corrosion protection measures such as temporary epoxy protective coatings or wrapping of sensitive components are used to shield them from the marine environment. Careful protection of the components during lifting and transport are also used, to reduce the risk of coating damage.

3. Construction and Installation

During the assembly of offshore wind structures, welded joints are areas prone to corrosion. Reapplication of corrosion protection after welding is essential. Any coating damage that occurs during transportation or installation must be addressed to maintain corrosion resistance. Touch-up coatings and sealants are applied to restore the integrity of the protection layers. The installation of foundation piles, often driven into the seabed, can wear away corrosion protection layers. Protective sheathings or coatings that are impact-resistant are applied to piles prior to installation. Even with these measures in place, studies have shown that 30% of corrosion caused on Offshore Wind structures is from mechanical damage [23]. Offshore wind structures are typically constructed in phases (called campaigns), using 3-4 month windows of opportunity where the weather is most suitable for construction. The first campaign focuses on foundation installation and the transition piece, with the second campaign focused on turbine installation. The period between the first and second campaign can be 6-12 months. During this period, (called the Standalone phase), the foundations are subject to bird droppings, as birds use the top of the transition piece as a resting place. Prior to the second campaign, a costly exercise is undertaken to remove the bird droppings and perform touch ups to the protective coating.

4. Ongoing Management and Maintenance

In offshore wind turbine maintenance, structures are generally inspected at regular intervals to prevent corrosion and structural damage. For instance, coating systems should be inspected every 4,200 hours, which typically means about two inspections per year. This frequent inspection schedule is crucial due to the harsh marine environment, where high moisture and salt levels can rapidly accelerate corrosion.

Maintenance challenges in these environments include costly repairs, particularly for on-site coating applications, which can be up to 7,000% more costly when compared to factory coatings. Surface preparation for repairs can also be difficult, given the constant exposure to moisture and salt. New developments in repair coatings are better suited for these conditions, improving protective performance despite poor surface conditions [17].

Additionally, the use of drones and quadcopters equipped with camera and laser systems for inspections is increasing. These unmanned aerial systems allow for more efficient inspections, particularly in high-wind environments where manual inspections might be impractical or dangerous. This technology is being integrated with plant monitoring systems (such as SCADA), further reducing the need for manual on-site inspections [25].

Recent developments in digital, automated corrosion management include drones that film affected areas, providing automatic detection and filtering of damaged sections. The programme generates the documentation and transfers it into a 3D model. The Hamburg-based offshore wind farm operator, Global Tech I, won the award for the Product Innovation of the Year. The team includes experts in digitalisation and artificial intelligence and is backed by the University of Aarlborg and the Energy Cluster Denmark. [18]

Submerged parts of wind turbines also require ongoing inspection and monitoring. Monitoring the effectiveness of the ICCP systems and ensuring their potentials are balanced to prevent any surface area from being under-protected will be essential to ensure the design is providing the intended protection. The condition of antifouling coatings will also form part of the inspection regime, to prevent marine biofouling from accelerating corrosion on submerged components. Routine underwater inspections, which have traditionally been performed by divers, will shift to being performed by ROV's (Remote Operated Vehicles) (Figure 10), to detect signs of early corrosion. This will improve the safety of these inspections and allow for longer periods between dive inspections. In Europe, companies are moving away from contracting professional divers due to safety concerns and cost considerations, making ROV's more prevalent for inspections. ROV's capability goes beyond visual inspection, to now include NDT as well as underwater welding, though this is still in its infancy.

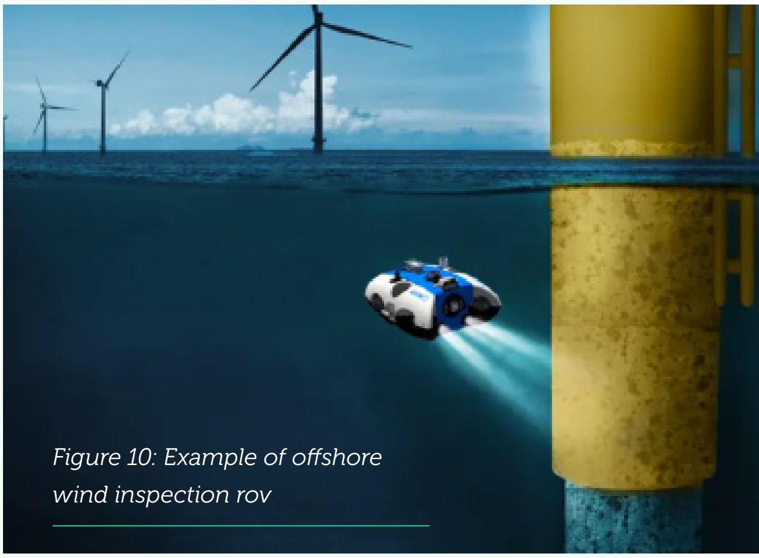

Figure 10: Example of offshore wind inspection rov

Inspections focus on high-risk areas such as welds, submerged structures, and areas with mechanical stress or coating damage. ROV's can also serve other purposes, such as monitoring marine life and checking critical infrastructure for security threats.

The Corrosion industry can prepare now for the transition

The time is now to prepare for the energy transition. As Corrosion technologists, consultants and asset managers, there are a number of steps we can take to prepare:

1. Enhance knowledge of offshore wind
2. Develop, identify, and test new inspection

and monitoring technologies suitable for offshore wind

3. Innovate and seek out sustainable corrosion prevention and management solutions suitable for offshore wind environments
4. Contribute to standards development and research

1. Enhance Knowledge of Offshore Wind

There are three ways Corrosion technologists interested in working in the Offshore Wind industry can build their knowledge; gain international experience directly on offshore wind projects, partner locally with offshore wind developers, such as Star of the South, or undertake further research and study in the field.

Gaining international experience on offshore wind projects will provide valuable and practical skills that can be applied to Australia's emerging offshore wind industry. Sean Barker (co-author) did this, as a Certification Manager for some of the first offshore wind projects in France. Sean led collaboration with certification bodies, regulatory agencies, engineering firms, and constructors to guarantee adherence to international standards, regulations, and industry best practices. The projects were governed by the internationally recognised IEC, IECRE and DNV standards with the site conditions, design (including load and limit-state analyses, offshore corrosion and underwater scour management), construction, transport & installation and commissioning of the turbine and its foundation and the offshore substation applicable for certification. By leveraging global best practices and lessons learned from international projects, Sean's background serves as a blueprint for overcoming the technical and logistical hurdles that Australia's fledgling industry will face. His global experience will play a pivotal role in ensuring that the local industry can develop efficiently, align with international standards, and rapidly scale to meet the country's renewable energy goals.

Supporting offshore wind companies locally, such as Star of the South, will provide exposure to the offshore wind industry, as they bring their in house global expertise to Australia.

Undertaking further research or study in the field will enhance knowledge in preparation to participate in the offshore wind industry in Australia. There are several ways this can be done, ranging from full tertiary degrees to short courses and professional certifications. International Universities like Strathclyde (UK) [19] and Cranfield (UK) [20] offer postgraduate programs in offshore renewable energy, while locally, UNSW provides undergraduate and masters courses in renewable energy engineering [21]. Short courses, such as those from DTU Wind Energy (Denmark) [22] and TU Delft (Netherlands) [], focus on specific aspects of offshore wind, including technology, economics, and structural design. For hands-on skills, Global Wind Organisation (GWO) provides essential safety and technical training [23]. Certifications from institutions like Renewables Academy (RENAC Academy) in Germany [24] are also an option (with international online learning options available). Lastly, attending offshore wind conferences like WindEurope [25], Global Offshore Wind Conference [26], and APAC Offshore Wind [27] often includes workshops, masterclasses, and panels on the latest technologies and project developments. Locally, the Australia Wind Energy Conference [28] will provide a great opportunity to learn about the latest developments in offshore wind in Australia. Soon, we will start to see more options for training available in Australia, including the establishment of the Victorian Governments Wind Worker Training Centre to build the necessary skills to support the local workforce to transition to the offshore wind industry [29].

2. Develop, identify, and test new inspection and monitoring technologies

Offshore wind operations are using predictive maintenance systems to detect early signs of corrosion. Developing, identifying and testing new and improved remote Corrosion monitoring technologies, as well as developing data analytics models that can forecast corrosion failure and optimise maintenance schedules that can be deployed in an offshore wind context will support the ongoing management of corrosion in future offshore wind structures.

Inspection techniques such as robotic systems like drones and ROV's are increasingly used to inspect and monitor offshore wind infrastructure. Practicing using these technologies now for inspections of Port infrastructure and offshore oil and gas infrastructure assets and testing their accuracy against data gathered from dive inspections will enable Corrosion specialists become proficient in using and analysing data from these inspection tools.

3. Identify sustainable Corrosion protection solutions

Exploring Eco-Friendly Corrosion Inhibitors, such as bio-based coatings and low-VOC systems, and researching their effectiveness in similar environmental conditions will help lead the way to be able to utilise these coating technologies for offshore wind, contributing to more sustainable corrosion maintenance practices.

4. Contributing to Standards Development and Research

Contributing to the development of standards and research is essential for advancing corrosion management in offshore wind applications. Corrosion technologists can play a critical role by participating in organisations like AMPP, DNV, or ISO, helping to create and refine standards that address the unique challenges of offshore wind. In addition, technologists can engage in research projects through universities or industry partnerships, focusing on corrosion issues specific to offshore environments. Cross-disciplinary collaboration—bringing together materials science, engineering, and environmental science—can drive the development of innovative solutions for corrosion protection in these extreme environments.

CONCLUSIONS

Australia's energy transition towards net zero by 2050 relies heavily on the successful integration of offshore wind into its renewable energy mix. Ports will be the key enablers of this transformation, serving as essential hubs for the assembly, transport, and maintenance of offshore wind farms. However, this comes with significant infrastructure challenges. Port upgrades, particularly in corrosion management, are critical to ensuring that Australia's ports can handle the scale and complexity of offshore wind development.

As we've seen from international examples, robust corrosion protection strategies—spanning material selection, coatings, and cathodic protection—are vital to extending the life of both port and wind infrastructure. The Australian corrosion industry has an important role to play, not only in upgrading port assets but also in safeguarding offshore wind assets throughout their lifecycle. By engaging in research, contributing to standards, and developing new solutions for corrosion protection in extreme marine environments, the corrosion sector can help ensure the resilience of this emerging industry.

The energy transition presents an exciting opportunity for both the port, offshore wind and corrosion industries. With proactive planning, investment in research, and the adoption of best practices, Australia's ports and corrosion professionals can be ready to support the offshore wind boom, ensuring the nation's renewable energy targets are met.

The question remains: how will you prepare for the transition?

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S. Barker is the Director at Infrastructure Advisory Group (IAG), a position he has held since 2024. Sean has 15 years of global experience in various roles within the Offshore Wind, Offshore Oil & Gas, Mining and Infrastructure industries. He has a diverse skillset in both design / engineering and construction including project management, regulatory compliance and certification management, interface management, resource management, technical document review and reporting, documentation for operation and associated coordination tasks.

Cathodic Protection and its Implications for Vessels in The Royal Australian Navy

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Keywords:
cathodic protection, corrosion, ships, Royal Australian Navy

ABSTRACT
Cathodic protection systems on Royal Australian Navy vessels have unique challenges which need to be managed by Defence. Australian ships operate in warmer waters, berth for longer periods, and have operational profiles that can differ significantly from commercial ships. This can lead to issues such as interactions between systems, excessive calcareous deposits, and complex multifactorial problems that can be difficult to diagnose. In this paper we present some examples and case studies of problems that can arise relating to Navy cathodic protection systems and methods to address and manage them.

INTRODUCTION
The first practical application of cathodic protection (CP) occurred 200 years ago, in experiments conducted by Sir Humphry Davy on Royal Navy's ships [1-3]. Prior to Davy's experiments, during the 1760's and 1770's, copper sheathing had been introduced to the timber hulls of Royal Navy ships as it was found to prevent timber worms and the adherence of weeds to the hull [4]. By the early 1820's, corrosion of copper sheathing was perceived to be an issue and Sir Humphrey Davy was approached by the Navy Board for advice. Then followed a series of experiments run by Davy on Royal Navy warships demonstrating the first practical application of CP [1-3].

Davy's initial experiments were conducted using thin strips of zinc, malleable or cast iron attached to Navy ships moored in Portsmouth harbour [1]. The results were such a success, that the Royal Navy issued an order for all their ships to be fitted with Davy's 'protectors'. Davy had noted a problem with the formation of carbonates of lime and magnesia to which weeds had attached, which he was able to mitigate through sizing of the protectors [4]. Davy further refined the sizing of the protectors in open-sea experiments when he sailed on His Majesty's Steam Boat Comet in July and August 1824 [3-5].

CONTENTS

Figure 1: HMS Samaran, one of the first ships to be cathodically protected [6].

Signs of problems started to arise with reports of increased fouling on the hulls of ships fitted with Davy's protectors. This included conflicting reports regarding the fouling on HMS Samarang (Figure 1) upon its return from a voyage to Bermuda [3]. Over the coming years, fouling was proven to be an issue on these protected ships, and the method was abandoned, despite its success in preventing hull corrosion.

An attempt to protect ships from corrosion with CP briefly emerged during the 1890s, when Thomas Edison experimented with towing impressed current anodes behind a ship [7]. This "trailing anode" technique was unsuccessful due to the cost of electricity and lack of appropriate materials and techniques. However, it demonstrated the ongoing desire for a system to reduce the labour and time required to maintain ship hulls.

Despite the initial discontinuation of the CP methods demonstrated by Davy, his scientific insights were ahead of his time and he pioneered a technique that we see on ships around the world today. CP of active (seagoing) ships began to re-emerge in the late 1940s and 1950s [7-9] and is now essential to preventing corrosion of Navy ships around the world. The contribution of his successor, Michael Faraday was also instrumental in laying the scientific foundations of CP, in particular his 1834 discovery of the quantitative connection between corrosion weight loss and electric current.

Here we have only provided the briefest of introductions to the history of CP on Navy vessels. There are numerous books and papers detailing the history of electrochemistry, CP and the contributions of Sir Humphrey Davy, many of which are well worth a read for the corrosion or CP enthusiast [4, 5, 10, 11].

Cathodic protection of Navy ships

CP is commonly applied today to prevent corrosion of a wide array of submerged or buried metallic structures including pipelines, offshore platforms, boilers, concrete reinforcement, wharves and ships. In all systems, there is a metallic structure to be protected, anodes to provide CP current, and an electrolyte (usually water or soil). Systems may also include additional components such as reference electrodes and transformer-rectifier units.

On ships, the metallic structures typically include painted steel or corrosion resistant alloys (e.g. aluminium, copper nickel, nickel aluminium bronze (NAB), etc.). As many of these tend to be electrically connected, for example the propeller and the hull, galvanic couples exist that require CP in addition to protection of the individual materials themselves.

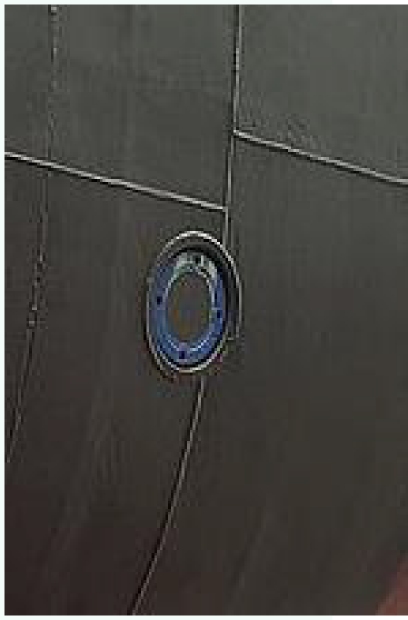
The electrolyte in a ship CP system is seawater, fresh water, or somewhere in between (brackish water). In the case of Navy ships, due to the nature of their operations, seawater is the most common electrolyte. Seawater is more conductive than soil or fresh water, which affects the protection current density requirements of the metals being protected. It also significantly reduces IR losses in the electrolyte, so potentials such as the "instant off" potential become irrelevant as the IR drop is negligible.

Whilst some smaller Navy vessels rely solely on sacrificial (galvanic) anode systems (Figure 2, left), larger Navy ships in the Royal Australian Navy (RAN) tend to use impressed current cathodic protection (ICCP) on their hulls (Figure B, right). This is due to their ability to provide higher currents and protect large surface areas with only a few anodes, thereby reducing the ongoing maintenance costs. However, large ships with ICCP systems tend to also be fitted with sacrificial anodes to provide additional protection to specific areas such as sea chests, ballast tanks, propellers or shafts. One reason ICCP tends not to be used in tanks as there is a risk of hydrogen evolution, which creates an explosion risk when hydrogen gas accumulates in a confined space. This can occur with ICCP systems when potentials drop below around-1.1 VCSE and hydrogen evolution becomes the dominant reduction reaction.

Ships tend to experience larger varations in CP current demand compared with other structures in seawater such as offshore platforms or wharves and piers. One of the main reasons for this is that when ships move through seawater, the protection current density is much higher than when they are stationary, due to the increased oxygen supply at the cathode. In addition, protection currents can change significantly over time due to the breakdown of paint coatings and the formation of calcareous deposits. Protection current density also changes slightly due to varying ocean conditions (temperature, salinity, dissolved oxygen). Because of the large variations in protection current required, ship ICCP systems tend to always be fitted with reference electrodes and a control system to ensure the appropriate current is being applied. Too little current can lead to corrosion, whilst too much can lead to overprotection, which is associated with problems such as hydrogen embrittlement, paint debonding, calcareous chalking of moving parts and excessive power usage.

CP of RAN ships comes with unique challenges not encountered in commercial shipping. One of the main challenges arises from the significant time spent in port compared to commercial ships. When alongside for weeks or months, the interactions with wharf CP systems become very important. Biofouling is also exacerbated, and without regular movement of parts such as bearings, calcareous chalk can accumulate and later cause excessive wear. This is

Figure 2: HMAS Arunta showing sacrifical anodes (left) [12], and an ICCP anode on a ship [13].



further worsened in Australian waters, where many of our Navy bases are in tropical locations which are known for their harsher biofouling environments compared with more temperate climates [14]. Furthermore, their operational profiles including speeds and locations can differ from commercial ships, and their designs do not always follow the same standards. Another unique challenge is the electromagnetic fields that arise from CP systems, which can be detected by adversaries and may need to be reduced for certain platforms and operating environments.

To summarise, RAN ships are complex systems that often operate under unique conditions. In identifying and addressing problems that occur in these systems, it is always important to consider the system as a whole, including not just the CP components but all other possible interactions. In the following sections of this paper, we discuss some examples of CP issues faced by the RAN and the approaches used to diagnose and address these issues.

Calcareous deposits: Friend or foe?

When CP is applied to structures in seawater (as is the case for Navy ships), the reactions occurring at the cathodic surface cause a local increase in pH, which in turn causes the precipitation of calcium carbonate (usually as aragonite) and magnesium hydroxide (as brucite). Even Davy noted such deposits during his 1824 experiments, when he described the copper sheathing as being "coated with carbonate of lime and magnesia" [1]. These deposits reduce the required CP current by acting as a barrier to oxygen and other cathodic depolarisers, as well as increasing the circuit resistance and interfacial pH.

Calcareous deposits on ships can have significant benefits. On ships using ICCP, calcareous deposits result in a lower load on the ship's power system and the ability to protect a larger hull area without causing excessively negative potentials near the anodes. The main benefit for sacrificial anode systems is that fewer anodes are required, and they will need to be replaced less frequently. Overall, Navy ships cost less to maintain and may have increased availability thanks to calcareous deposits.

Despite their benefits, calcareous deposits can be troublesome if they occur in unwanted locations, such as moving parts including shaft bearings. Calcareous deposits are an ongoing problem in water-lubricated propeller shaft applications causing accelerated bearing wear [15]. Figure 3 shows the appearance of a calcareous deposit on a propeller shaft bearing liner with CP at the macro scale and as seen using a scanning electron microscope (SEM). The deposit was also analysed using Fourier transform infrared spectroscopy and found to be primarily aragonite (calcium carbonate), with some brucite (magnesium hydroxide), and possibly calcite (calcium carbonate). The crystalline structure of the deposit has a "spikey" appearance which can be typical of aragonite. Because of this, and the fact that aragonite is harder than the bearing liner materials (which tend to be polymeric), its action on the bearing liners can lead to increased wear, and costly premature replacement.

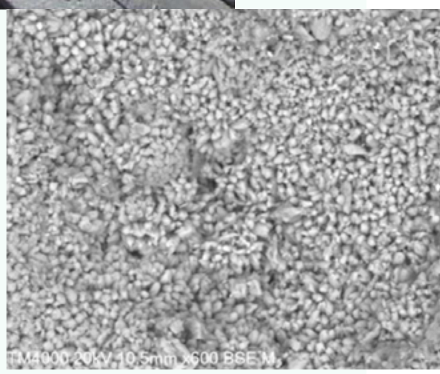


Figure 3: Propellor shaft bearing with a calcareous deposit (above) and at x600 magnification (right).

Figure 4: Hull valves – calcareous deposit from on valves which were seizing closed.

Other areas on ships that can be affected by calcareous deposits are any large, bare metallic components – such as hull valves that are exposed to seawater and CP. Figure C shows an example of this, where a hull valve on a Navy ship had seized closed due to the formation of calcareous deposits whilst under the protection of the wharf ICCP system. The inoperability of hull valves could have a catastrophic outcome if there was need for an emergency opening of these hull valves to allow seawater in (for firefighting purposes) or closing (if there was an uncontrolled flood on board).

There are several solutions to problematic calcareous deposits, and the most appropriate will depend on the cause. Problems associated with calcareous deposits in shaft bearings can be exacerbated for Navy ships which tend to spend more time alongside/berthed than commercial vessels. In this instance, a typical treatment is to turn the shaft regularly to remove any early deposits before they become too thick.

If the formation of problematic calcareous deposits is shown to be due to overprotection from an CP system, the problem may be solved by reducing the set point of an ICCP the system (and therefore the anode currents), or by removing sacrificial anodes near the shaft. However, this may not be possible as it may no longer prevent corrosion, and other solutions may be required. They may also be caused by overprotection when bonded to a wharf with its own CP system—this type of interaction will be discussed in the next section.

Another possible solution currently being investigated for shaft bearings is to introduce additional zinc anodes near the bearings. Zinc ions have been shown to inhibit the formation calcareous deposits on steel [16-18]. Furthermore, deposits found in Navy bearings with zinc anodes and where zinc was found in the crystal structure have tended to be associated with reduced wear. Experiments by the authors and their colleagues have confirmed that zinc ions reduce calcareous deposits on bearing liner materials. Figure D shows SEM images of deposits formed on gunmetal held

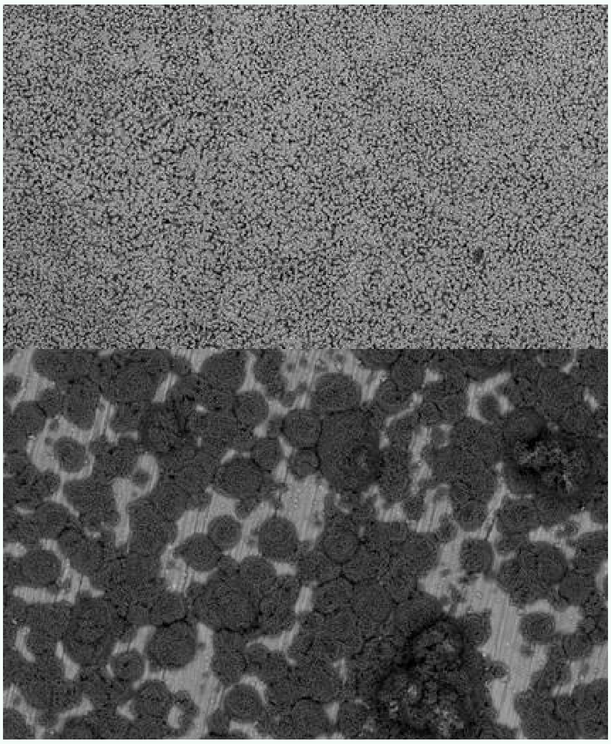


Figure 5: SEM images of calcareous deposits formed on gunmetal in artifical seawater (top) and artifical seawater with 10 mg/l zinc ions (bottom).

at –900 mV vs Ag/AgCl/KCl(sat.) for one week in artificial seawater. The left image shows the deposits without zinc ions, whilst the right image shows the deposit formed with 10 mg/L of zinc ions added. The deposit on the right is sparser, has a different structure, and was found to rub off more easily. These results have led to larger scale trials which are currently underway.

Interactions with wharf CP (over protection, under protection etc.)

The interaction between ship and shore CP systems can be complex in nature. Wharves and piers to which Navy ships are docked are often made from reinforced concrete or steel, which will usually have CP systems installed. When a ship is docked, it needs to be bonded to the shore to provide a current path to prevent stray current corrosion of the ship or the dock. Various issues can arise because of this arrangement, which can be exacerbated for Navy ships which tend to spend more time docked than commercial vessels. In this section we discuss some examples of such issues.

When a ship with ICCP bonds to a wharf, its ICCP system is turned off to prevent overload of the ship's ICCP system. The ship will instead be protected by the wharf CP. There are several problems that can arise.

The wharf CP system may cause over-protection near anodes or under-protection away from the anodes. This may not be a problem for short durations but for Navy vessels docked for long periods can cause problems. For example, it can lead to the development of excessive calcareous deposits as seen in the previous section.

If the wharf does not have CP or the system is not working, the ship and its sacrificial anodes will end up protecting the wharf. This can lead to accelerated corrosion of the ship's sacrificial anodes and under-protection or corrosion of the ship's hull. It can also lead to stray current corrosion of the wharf as shown in Figure E. If the ship ICCP were turned on, the high currents required to protect the wharf could cause overprotection near the ICCP anodes and under-protection in other areas. There

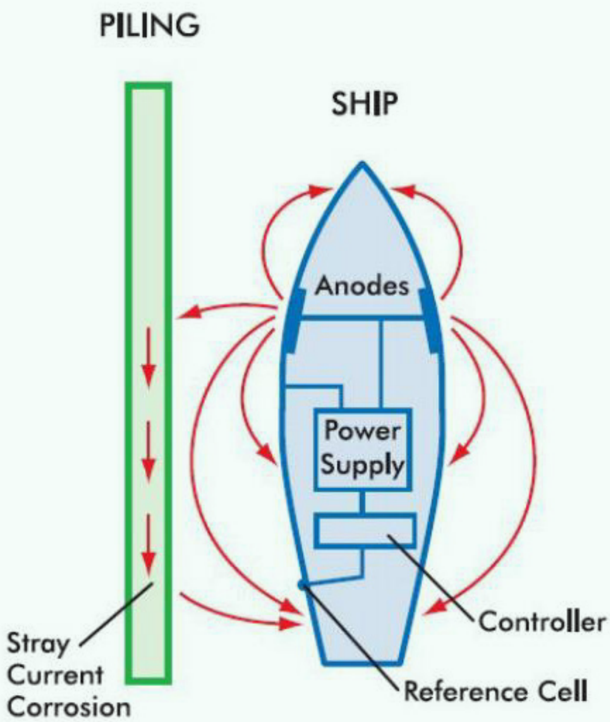


Figure 6: Stray current corrosion of the ICCP system of the ship to the dock [15].

are several ways in which we can minimise the occurrence of issues related to ship and wharf CP interactions. Firstly, proper maintenance of wharf CP and training of Navy personnel is essential. Wharf CP interactions should be investigated if issues such as excessive galvanic anode consumption or excessive calcareous deposits are encountered without an obvious cause. If problems are suspected, interactions can be identified by checking the direction of the current flowing through the bond cable – current flowing from the shore to the ship indicates that the ship is protecting the wharf, and vice versa. A diagram of the correct current flow direction is shown in Figure F. As we show in the following sections, a consideration for the ship system as a whole, rather than individual systems, is essential for diagnosing and solving CP problems.

Marine growth prevention system interactions

As we saw in Davy's experiments 200 years ago, the presence of copper ions in seawater inhibited marine growth (and in Davy's case, the lack thereof encouraged such growth!). This principle is still used

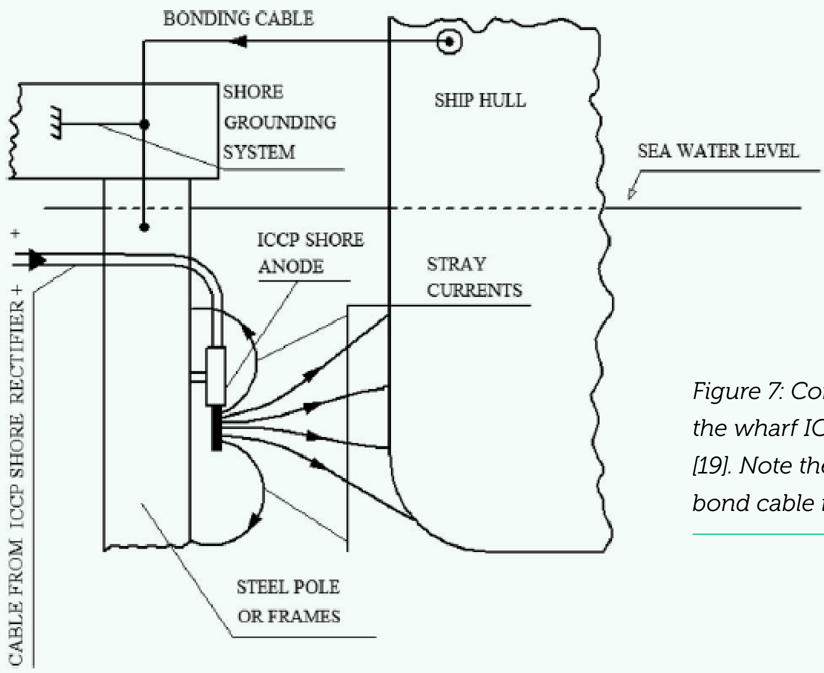
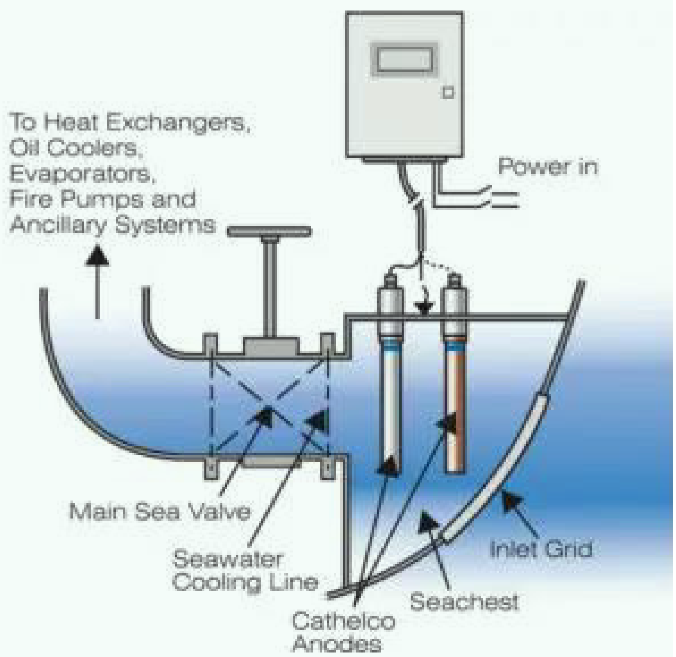


Figure 7: Correct direction of current flow where the wharf ICCP is protecting the bonded ship [19]. Note the direction of the current in the bond cable is going from ship-to-shore.

to our benefit today on many ships in their marine growth prevention systems (MGPS). These systems use copper anodes in areas such as sea chests or strainers to release copper ions into seawater piping systems, which prevents the adherence of marine growth. They also include a ferrous or aluminium anode to prevent corrosion within the piping. A typical setup is shown Figure G.

As with any corrosion cell, the MGPS system must also have a cathode, which is either a dedicated electrode alongside the copper and aluminium/ferrous anode, or the ship's hull (this is the case in Figure G). When the ship's hull is used, problems can arise when this internal system interacts with the external CP system designed to protect the hull from corrosion. For example, if the inlet grid (Figure G) is not earthed to the hull, current can flow to the external hull (or wharf, if things are particularly bad), quickly consuming the MGPS anodes. This requires untimely maintenance to replace depleted anodes, and excessive dissolution of copper from the MGPS

Figure 8: A typical MGPS system [19].



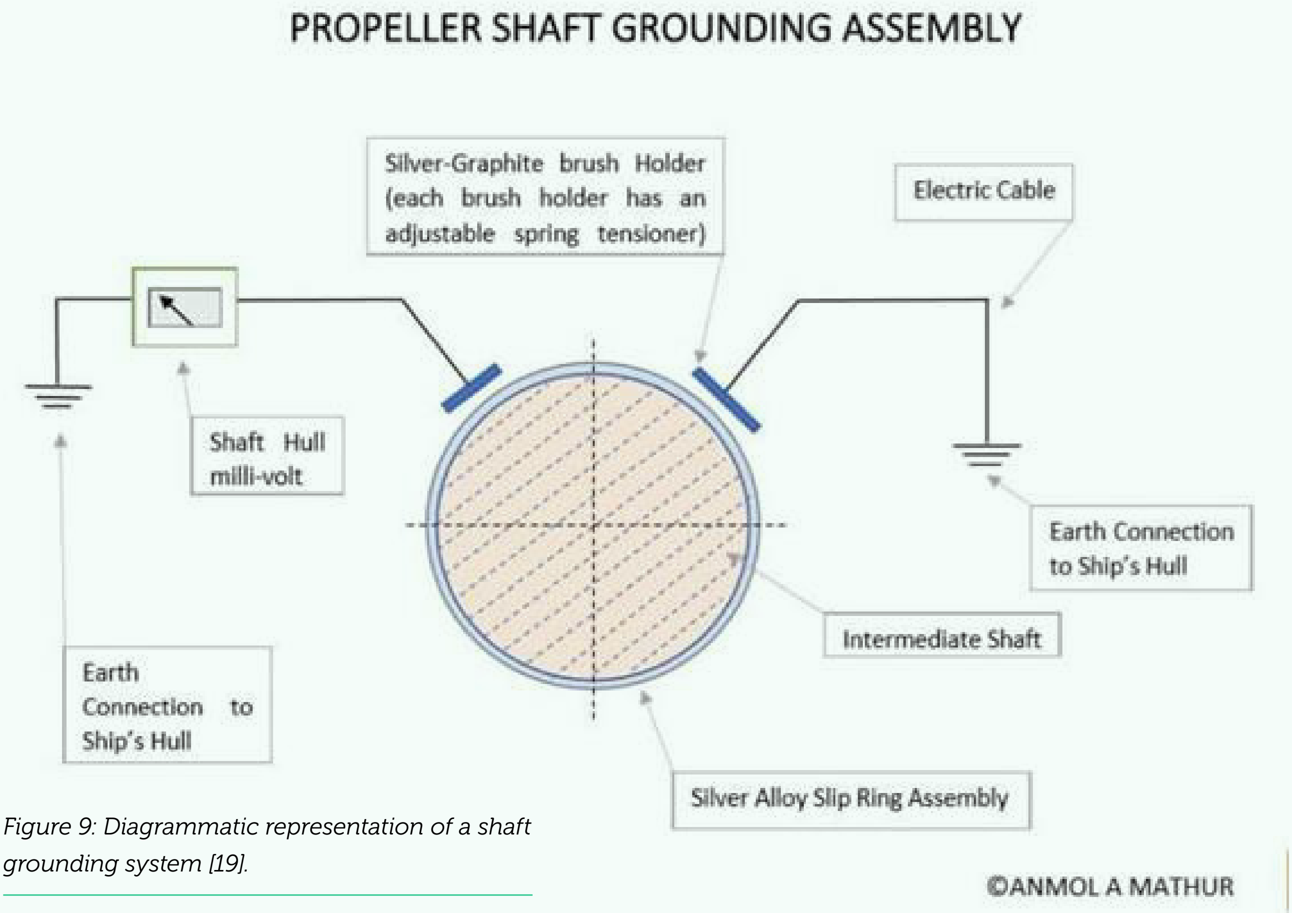


Figure 9: Diagrammatic representation of a shaft grounding system [19].

system may even cause downstream issues such as plating out of copper in heat exchangers. In addition, the potentials in this situation can be as negative as –1000 mV vs. Ag/AgCl/seawater which can cause issues such as cathodic disbondment of paint.

The scenario above can also cause a problem if the MGPS is close to the ICCP reference electrodes. The ICCP system will assume the hull is protected by the ICCP anodes and reduce the current output accordingly. However, this will not change the potential at the reference electrode significantly, as it is protected by the MGPS. The ICCP current will continue to reduce, possibly even to zero. As a result, metallic areas which aren't near the MGPS and reference electrodes, can become under-protected.

In this scenario interactions between systems can be assessed by monitoring outputs from the MGPS, ship CP and wharf CP with various combinations of systems switched on and off. Solutions may include adding a dedicated cathode to the MGPS or earthing the inlet grid to the hull, resolving any problems with ship or wharf CP systems, or crew education and training.

The example discussed here demonstrates a case of a component designer not considering the whole system approach of how one component (the MGPS system) can interfere with other systems (ship and wharf CP) and cause greater issues. In the next section, we will discuss an example where multiple systems failed due to a simple design issue with the root cause not discovered until the system was assessed as a whole.

What happens when shipboard ICCP goes bad?

Here we describe a case of a whole-system issue which lead to catastrophic failure of components, that was caused by a simple problem of inadequate shaft grounding. On a ship, the drive shaft which transfers power to the propellors is earthed with silver/carbon brushes, which allow the shaft and propellors to be earthed back to the ship's hull. If this earth is not satisfactory, there can be electrical discharge damage in the bearings, leading to micro-arc welding of the rolling components, quickly resulting in an unserviceable bearing. Furthermore, it is essential to the shipboard ICCP system as it provides a return path for ICCP currents protecting the propeller and shaft. Without it, the ICCP system will not "see" the large exposed metallic propellor and will not provide enough current for adequate protection. A diagrammatic representation of a shaft grounding system is show in Figure H.

In the scenario presented here, the lack of grounding on the shaft, hence lack of CP on the propellors, caused the NAB propellors to be unprotected in the seawater. To add to the corrosion demand on the unprotected NAB propellors, the nuts used to connect the propellor blades to the hub were made from grade 410 stainless steel, which is not an appropriate grade for constant immersion in seawater. When the shipbuilder saw the rapid corrosion on the nuts, and without yet an awareness of the inadequate shaft grounding, they assumed it was due to the low grade of stainless steel. As a solution, the ship builder replaced the nuts with an appropriate marine-grade stainless steel: super duplex 2507.

Unfortunately, by changing the nut material, they had inadvertently changed the galvanic system completely. The original stainless steel 410 nuts were anodic to NAB and had therefore been protecting the propeller (cathode) from corrosion. Now the NAB propeller blades were the anode, and the 2507 nuts were the cathode. So, without any ICCP or accidental sacrificial anode CP, these NAB propeller blades corroded. Typically, a ship's propellor is not a consumable item, but the blades on this vessel had to be completely replaced after only 2 years in service. The images in Figure I show the excessive degree of pitting and general corrosion seen on these blades, with the super duplex nuts remaining in pristine condition.

After the propeller was replaced, and once the entire system was considered, including the galvanic material interactions, CP system and shaft grounding, it was finally determined that the shaft grounding was inadequate to return CP currents from the anodes to the hull via the propeller. This meant that the propeller/nut galvanic system was completely isolated from the ship hull and CP system, and the most active of the pair was destined to corrode.

So, what caused this shaft grounding to be so inadequate? There appears to be multiple factors at play, all relating to poor installation and workmanship. The silver/carbon brushes were not aligned correctly, so only the carbon part of the brush (not the more electrically conductive silver part) was in contact with the shaft. The shaft brushes were then connected to the hull through a very long run of small gauge wire. The termination point was installed on a painted structure via the use of crimped connectors (Figure J). All these factors would have caused a high resistance path back to earth and were very easily avoidable mistakes that ultimately lead to the replacement of several very expensive components. Once repaired, the system functioned correctly and has not had a problem since.

Figure 10: Images of NAB blades, showing general and pitting corrosion. Finger for scale. The super duplex nuts can be seen in pristine condition in the left-hand image.

Figure 11: Earth cable termination point – note the small gauge wire and crimped connectors.

CONCLUSION

CP of Navy ships has existed for 200 years and is an incredibly effective method for preventing corrosion of ship hulls and appendages. Despite this, problems with these systems can still occur. The Royal Australian Navy faces unique challenges in managing CP systems on their vessels, primarily due to the extended periods spent in port compared to commercial vessels and their unique operational profiles. The complexity of the interactions between various systems, such as galvanic couples, wharf CP, MGPS can often make diagnosing and solving issues with CP systems challenging. In this paper we have presented some examples of problems relating to CP systems that have been observed in Royal Australian Navy vessels, and the methods that can be used to mitigate them.

ACKNOWLEDGMENTS

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AUHOR DETAILS

Kate Dylejko is a corrosion engineer at the Defence Science and Technology Group, specializing in minimizing and controlling corrosion on Navy platforms. With roots as a mechanical engineer in armoured vehicles since 2006, she transitioned to corrosion 11 years ago, leveraging computational modelling to optimize cathodic protection systems for Navy vessels. Kate's expertise spans various facets of corrosion, with a keen focus on cathodic protection systems for maritime platforms. Her research includes electrochemical studies on calcareous deposits and corrosion potential monitoring across Navy vessels and wharves. Actively contributing to the Victorian branch of the Australasian Corrosion Association, Kate recently achieved certification as an AMPP CP2 Cathodic Protection Technician, reinforcing her commitment to advancing corrosion control technologies.

Wayne Neil is a corrosion scientist in the Defence Science and Technology Group, where he leads a team specialising in maritime corrosion. His research focuses on technologies to mitigate and prevent corrosion on a broad range of areas within vessels for the Royal Australian Navy. With 15 years of experience in Defence, Wayne specialises in microbially influenced corrosion; corrosion of marine alloys including marine grade aluminium, copper nickel, stainless steels and high strength steels; environmentally friendly corrosion inhibitors; and corrosion of magnesium alloys. He is the current ACA Victorian Branch President.

Evolution of Fouling Release Coatings

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Keywords:

foul release, antifouling, biocides.

Note on keywords:
Examples such as steel, seawater, adhesive, protective coating, etc. are example words that denote relevancy to the specific part of the industry and the contention of the paper. Keywords should be complementary instead of cosmetic to the Abstract and can be used by other academics or researchers to locate and cite your paper if necessary. Abbreviations are appropriate if they are renown industry-wide; otherwise, they are to be avoided where possible. The maximum number of keywords allowed is 5.

ABSTRACT

The challenge of keeping a vessels' underwater hull free of macro fouling has been with us for thousands of years, ever since man invented boats for transport, commerce and leisure. The drive to improve the protection of the underwater hull led to the development of coatings containing more and more effective biocides, eventually leading us to a conundrum; "How do we continue to keep the hull clean and at the same time reduce the negative impact these developments may have on the environment in which we work and play?" To answer this question this paper looks at the development of biocide free, foul release coatings, how they were imagined, their development, their impact on the use of conventional antifouling coatings and their new found importance in the modern era of transport and our focus on the reduction of CO2 emissions.

INTRODUCTION

This paper seeks to understand the need for underwater hull protection, the development of various options from copper and lead sheeting to coatings containing biocides and ultimately the development of niche coatings that contain no biocides, improve vessel performance, reduce maintenance costs and assist in protecting the environment and the reduction of CO2 emissions.

History of Fouling and Protection

As far back as 410BC and probably beyond there are records of man's attempts at underwater hull protection. Lead sheeting was one of the ways they tried to keep the hulls clean. Around the 1500's copper sheeting came into use over the timber hull combined with tar or grease. Around the 1700's the iron vessels, when coated with copper sheeting, developed severe corrosion often leading to such degradation of the hull that the vessel was unusable. This became such a problem that the English Admiralty almost completely stopped building iron ships in favour of timber. In 1850 the first of a breed of new coatings was developed containing copper sulphide and later, mercury and arsenic were added. These two were later excluded in favour of copper in the form of cuprous oxide and in the early 70's a breakthrough came with the development of SPC (Self Polishing Copolymer) combining the new resin technology with cuprous oxide or cuprous thiocyanates and Tributyl Tin (TBT). These combinations proved extremely effective with 95% predictability outcomes, but it was later discovered TBT had a very detrimental effect on oysters which led to a banning of TBT in antifoulings in 1989 for vessels under 75 feet.

The IMO issued a directive stating that in 2003 a total ban of any further application of antifoulings containing TBT with an agreement that from 2008 there would be no vessels using an antifouling containing TBT.

This resulted in a loss of performance of the antifouling coatings and combined with rising fuel prices and an emerging awareness of the effect on the environment, new ways were being explored to keep shipping costs viable. This led to renewed focus on a technology that had been developed back in the late 70's, biocide free, low surface energy coatings, fouling release.

Evolution of Fouling Release

In 1977, Alexander Milne secured a patent on a biocide free coating product combining silicone elastomers and silicone polymer or oils. This formed the basis of what we see today. During the 80's a lot of work went into solving some of the issues with this technology such as:

- Suitable priming systems that would protect the substrate and allow adhesion of the silicone coatings
- Toughness and durability for the marine environment
- Practicality of use. Pot life/shelf life/ spray and roller application
- Prevention of sagging when using airless spray
- Maintenance and repair procedures.
- One of the first applications was in 1987 on a US Sealift Command container vessel.

It was determined that this technology was suitable for vessels constantly in use and operating at higher speeds to allow the surface to self-clean. It was trialled on recreational craft but proved ineffective as these vessels spent 80%-90% of their time static on moorings or marina berths, allowing the growth to settle on the hull and the resultant excess cleaning damaged the coatings, further reducing its effectiveness.

With the advent of the SPC antifouling technology and the subsequent reliable high performance, interest in the biocide free coatings waned. There seemed little need for the silicone technology as fuel costs were controlled and dockings were less expensive with the vessels being cleaner at the 5 year survey period. When the TBT component was banned and fuel costs rose a new focus came into place.

Development of Biocide Free Systems

Originally the systems were cumbersome:

Anticorrosive epoxy primer- Epoxy intermediate- Silicone tie coat- silicone colour coat- Silicone clear finish coat

Anticorrosive epoxy primer- Epoxy intermediate-Silicone tie coat- Silicone coloured finish coat

They were then refined further:

Anticorrosive epoxy primer- Silicone tie coat-Silicone colour finish

Benefits

The advent of this technology brought many benefits to the vessel owner/operator over conventional antifouling

- Extended docking periods
- No need to apply full coat at next docking
- Hull is cleaner longer
- Extended and safer manoeuvrability
- Smoother finish results in reduced fuel usage
- Lower risk of transporting marine organisms to new and possibly vulnerable environments
- No biocides being leached into the water

Major paint companies all have an offer in the biocide free sphere. Some are 3 coat application, some 4 and others have combined biocides with the silicone to help improve idle time performance.

What is the Future for this Technology

The initial motivation for this technology was fuel saving and then protection for the marine environment from possible harmful biocides and it could begin to replace conventional antifoulings as more pressure comes on globally to ban copper and other biocides. This of course would mean the maintenance of vessels and particularly the annual slipping of pleasure craft, would have to be changed dramatically.

The new and immediate impact on the industry has been the declaration in January 2023 by the IMO that all commercial vessels of certain size would have to be measured and rated relative to their carbon emissions or, carbon footprint.

The goal of the IMO: Decarbonisation

Reduction in power (fuel usage) Energy Efficiency Existing Ship Index (EEXI) and

Annual reduction in CO2 emissions. Carbon Intensity Indicator Rating (CII)

The IMO has set a target of 40% reduction in CO2 emissions (2008 v 2030)

This requires operators to first determine what their rating is by measuring their GHG (Green House Gas) output based on miles travelled, speed etc and then put in place a plan with the IMO that outlines how, if they are rating low, they are going to improve their rating. This will then allow organisations wanting to engage freight carriers to, if they desire, award contracts based on lower GHG emissions meaning some carriers may lose business unless they comply.

As we have seen, fouling release coatings provide the mechanism to improve operators' ratings by reducing the friction of the underwater hull coating. Fouling is minimised and, due to the slipperiness of the coating, the vessel requires less power to achieve the same speed resulting in reduction in fuel, ergo reduction in CO_2 emissions.

Summary

The need for ships as a form of global transport for people and goods continues to grow. This brings into greater focus the importance of protecting the marine environment while, at the same time aiming to stay in touch with the concerns over CO_2 emissions. The challenge of protecting the underwater hull from infestation of marine growth while looking after our environment has been ongoing for more than a thousand years and new technologies continue to emerge to meet these needs.

Silicone coatings certainly offer an alternative to conventional antifoulings and work hand in hand to provide the solutions for a more sustainable shipping fleets.

CONCLUSIONS

As continued focus comes on the inclusion of biocides in our coatings and the on going demand for the reduction of these we will see an even greater push for biocide free coatings and particularly foul release technology to replace conventional antifouling.

AUTHOR DETAILS

D. Harvey is the corresponding author of this paper. He is Marine Manager for ANZ at PPG Industries, a position he has held since 2008. He is responsible for the strategy, direction and implementation of the PPG marine business in Australia, PNG and the Pacific.

Sustainably Led Asset Management: A Pacific Case Study Queens Wharf, Lautoka Fiji

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Electrochemical Chloride Extraction, Cathodic Protection, Durability, Sustainability, Asset Management

ABSTRACT

The presence and ingress of chlorides, particularly in marine environments, is one of the main factors responsible for the deterioration of steel reinforced concrete structures. Across the pacific, where the conditions are optimal for chloride induced corrosion, and substantial maintenance funds are limited, innovative and preventative approaches are required to ensure optimal value, and long-term durability. Through this case study, the reemergence of Electrochemical Chloride Extraction (ECE) and the retrofitting of water base anode Impressed Current Cathodic Protection (ICCP) Systems are two ways preventative intervention have been utilised to curb the progression of deterioration across Queens Wharf, Lautoka, Fiji.

INTRODUCTION

Lautoka Port is Fiji's second largest commercial port and is one of the two primary import/export ports of the country, along with Suva. The main wharf comprises two berths. The southern berth was constructed in 1959 and a northern berth was added in 2005 (refer Figure 1). The two different wharf sections are of a different construction form which is described below.

The primary objective of the project was to (a) determine the current condition of the structures, (b) develop remediation plans for the rehabilitation of the port, and (c) execute the works via an option engineering design amendment and verification process.

Condition inspections were conducted by Cardno in 2018/2019 in accordance with the Ports Australia Wharf Structure Condition Assessment Manual (WSCAM) [1]. Following

Figure 1: Queens Wharf, Lautoka, Locality Plan

a detailed design stage, the works were tendered initially in 2020 via a prequalification panel, and then by invitation in 2022 following the easing of travel restriction following the COVID-19 pandemic.

This case study will focus on the utilisation of sustainable innovations and option engineering to maximise the long-term durability for Pacific based infrastructure, in an economic environment where environmental protection and value for money are paramount considerations under a limited funding model.

It should be noted that the systems that are discussed following were installed in addition to the completion of traditional concrete repairs to already delaminated and spalled locations. However, discussions around traditional concrete repairs do not form a focus of this case-study as presented.

CONSTRUCTION DESCRIPTION

Queens Wharf (1959 Section)

The older section of the wharf was constructed in 1959 (see Figure 2). This section typically consists of a reinforced concrete deck integral with reinforced concrete deck beams. The deck is supported by circular concrete piles with a large (1.07 m diameter) concrete cap at the top of each pile. The concrete cap typically extends from deck level about 1.5 m down. There are three rows of square concrete piles around the outside of the circular piles. The concrete deck is typically 305 mm thick. The southwest corner of the wharf has been strengthened with an insitu deck thickening for the purpose of crane loading. The west side of the wharf is the only large vessel

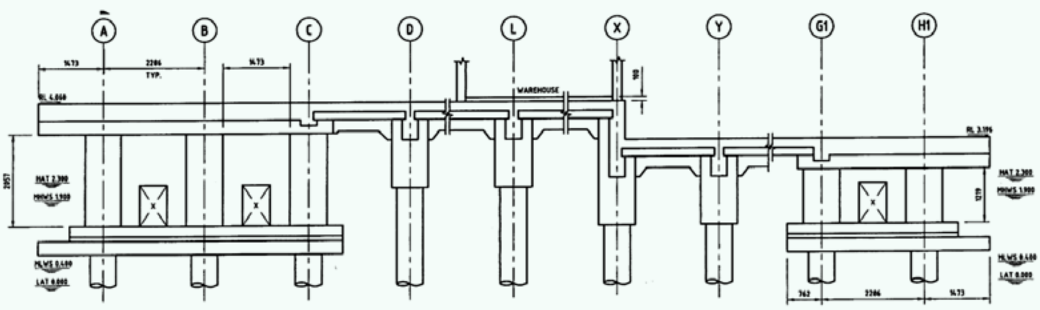

Figure 2: Queens Wharf (1959 Section) Cross Section

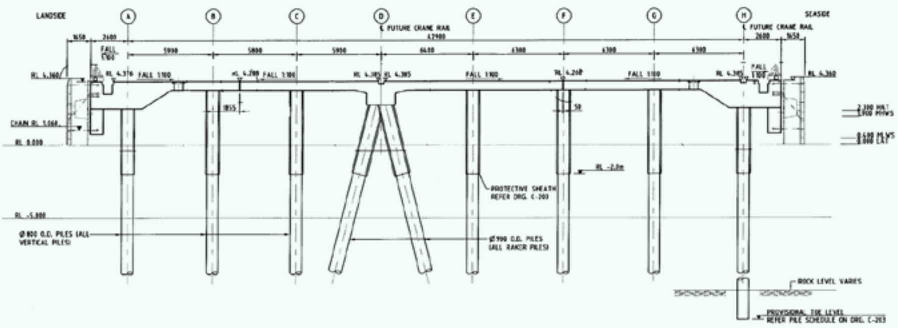

Figure 2: Queens Wharf (2005 Section) Cross Section

berthing face of this wharf and it has 'V' fenders spaced at approximately 10 m. The eastern side of the wharf has tyre fenders for the berthing of small and/or recreational vessels.

Queens Wharf (2005 Section)

The new section of the wharf was constructed in 2005 (see Figure 3). This section typically consists of a reinforced concrete deck supported by vertical steel circular hollow section (CHS) piles. Piles are typically 900 mm diameter and are covered with a 20 mm thick HDPE sleeve. The steel piles have a concrete cap which creates a moment connection into the deck. The centre row of piles consists of 20 pairs of raker piles and the two pile rows of berthing faces include 6 pairs of raker piles. The fenders in this section are cone fenders with large HDPE face plates and upper and lower chain supports. There

Condition State	*Generic Description*	*Expected Rem. Life (% of original design life)*	*Actions*
1	New with no visible defects/damage.	100	No repairs required. Inspection at next scheduled inspection
2	No or very minor defects which do not affect the overall integrity or durability of the element or component	55-100	No repairs required. Inspect at next scheduled inspection.
3	Limited defects present may affect the long term durability of the element or component. Minor deterioration of protective coating or parent material is evident.	40-55	Inspect at next scheduled inspection Continue planned and preventative maintenance. No repairs required.
4	Defects present may have minor impact on integrity. The short term durability of the element of component may be affected. Localised areas of moderate to advanced deterioration may be present.	25-40	Further testing is recommended and mostly reactive maintenance and some minor upgrades. Priority of repairs is low.
5	Defects present may have minor impact on integrity. The short term durability of the element of component may be affected. Localised areas of moderate to advanced deterioration may be affected.	15-25	Maintenance; upgrade or rehabilitation works are required within 5 years or as dictated by expected remaining life. Structural assessment is recommended.
6	Advanced deterioration Defects present likely to have major impact on integrity. Further deterioration will compromise the safety of the structure.	0-15	Rehabilitation or renewal required immediately. Structural assessment is recommended.
7	Very advanced deterioration present. Defects present likely to have an extreme impact on integrity and may constitute failure of the element.	0	Rehabilitation required immediately or replace component/ asset. Structural assessment is recommended where rehabilitation works are to be undertaken.

Table 1: WSCAM Generic Condition Rating Scale

are deck thickenings on the three piles rows with rakers to provide additional strength for berthing.

ASSESSMENT REGIME

During the 2018 inspections, engineers completed on-water and on-deck inspections in accordance with the Wharf Structures Condition Assessment Manual (WSCAM) condition rating scale.

The inspection was primarily visual in nature, however, delamination investigation (i.e. hammer tests) on abutments was also carried out. Representative photos and video were taken during the inspections to show defect types recorded and allow for cross referencing to previous reports and diving inspections.

The WSCAM condition rating scale utilised gives a comparative structural component rating of 1-7 as detailed below in Table 1.

In addition to the visual inspection, a dive inspection was conducted across selected representative piles, whereby selected piles were cleaned using hand tools to remove localised marine growth. During the same inspection, existing pile repair and protection systems were inspected with reference to condition, construction techniques, and levels.

ASSESSMENT FINDINGS

Queens Wharf (1959 Section)

A comprehensive structural assessment was conducted on the concrete piles and beams of the aging wharf. Circular concrete piles were generally in fair condition (WSCAM 3-4), though some showed significant cracking, especially near the pile caps, which were occasionally found to be severely corroded and spalled. Marine growth was prevalent below the waterline. In certain areas, such as pile row 5, significant defects were observed, with many piles showing extensive cracking and delamination, possibly due to poor construction materials.

The surrounding square piles were mostly in good condition (WSCAM 3), with some minor to moderate cracking. The seaward concrete walls between these piles were generally defect-free, whereas the shoreward walls exhibited cracking and delamination. The platform between square piles was in good condition but showed minor corrosion. Notably, square piles connecting the old and new wharf sections had been repaired, presenting minimal defects.

Longitudinal and transverse beams under the deck were in good condition (WSCAM 3), though areas

Figure 4: Typical under wharf inspection observations of the original 1959 section.

such as pile rows X-H1 showed severe cracking and delamination. Several beams had undergone repairs, including shotcrete applications, though some repairs had begun to fail due to continued reinforcement corrosion, leading to further delamination and spalling.

The deck soffit displayed localised defects, especially on the eastern section, where large areas of spalling with corroded reinforcement were found. In some areas, previous repairs were also failing, contributing to further cracking and delamination. Notably, significant deterioration was observed around piles D3, D7, G33, I21, S31, T9, and T47, attributed to altered structural loading.

The wharf deck was generally in good condition, though some recent repairs and impact damage were noted. The 'V' fenders were in excellent condition (WSCAM 2/3), having been recently replaced. Bollards on the western side were used for larger vessels, while smaller bollards on the eastern side, typically used for smaller vessels, were mostly in good condition, although one had failed.

The approach bridge deck and soffit were in good condition, but the beams showed significant cracking, despite recent repairs with shotcrete.

Queens Wharf (2005 Section)

This assessment evaluated the condition of steel piles, the concrete deck, and the fender system at the wharf. Steel piles are sleeved with HDPE from the connection point to below the water level, and above-water sleeves are in good condition with minimal marine growth. However, gaps at the top of the piles expose the steel to seawater, and the underlying condition of the piles was unknown due to the sleeve. Below the HDPE, divers visually observed Accelerated Low Water Corrosion (ALWC), which is an aggressive form of corrosion near the low-water line. ALWC was found on all piles, with corrosion depths ranging from 2-5 mm.

The concrete deck soffit was generally in a good condition (WSCAM 2), though minor cracking, delamination, and spalling were observed near construction joints. Reinforcement in these areas was often found close to the surface. Erosion of the concrete was noted near deck penetrations, causing localised damage. Concrete deck thickenings showed minor rust staining, likely from tie wires. Some cracks were observed between piles on deck-thickening beams, extending through the full depth of the beam.

The fender system was inspected at low tide to observe the condition of the panels and supports. While the concrete panels were in good condition, the steel fender frame was in poor condition (WSCAM 6), with significant corrosion and surface rust. Some fender panels displayed corrosion, and several fender chains had failed due to severe corrosion and compression forces. Many fender dampers were buckled or failing, compromising their functionality. Fender chains, which showed multiple failure modes, were attributed to the improper alignment of fender panels during berthing.

The wharf deck was found to be in average condition, with debris accumulation contributing to potential wear. Areas where cranes and machinery operate were coated with a thick oil and rubber film, obscuring the deck's condition. Significant kerb damage was noted along the seaward side, likely caused by forklift impacts. The service pit on the western side was also in poor condition, which may lead to accelerated deterioration of the utilities within.

Overall, while many areas of the wharf's structure remain in serviceable condition, the steel piles' exposure to ALWC, fender system failures, and kerb damage highlighted the required attention to maintain the structural integrity and functionality of the wharf.

Initial Tender Scope

Based on the inspections and recommendations of the Cardno Inspection Report, the Fiji Port Authority issued tender documents with a prescribed scope of works, itemised across the original 1959 section, and the newer 2005 section as detailed below in Tables 2 and 3.

Under the contracted scope of work, tenderers were invited to submit conforming tenders, but also encouraged to submit alternatives based on

Figure 5: typical under wharf inspection observations, and observed pile condition (showing alwc) of the newer 2005 section

value for money, cost reductions, advantages regarding ongoing maintenance and durability, and sustainability and environmental protection.

These alternatives were further detailed and explored during an extensive post tender interview and negotiation stage whereby the preferred contractor worked collaboratively with the client, and client-side engineer in a detailed optioneering process of scope and contract refinement.

Table 2: Tender Scope – 1959 Section

Description Remediation (1959 Section)	QTY	Unit
Pile / Pile Cap (Circular) Concrete Patch Repair. This item is to include concrete breakout and repair to original profile (including replacement of reinforcement and installation of patch anodes).	34	No.
Pile Cap (Square) Concrete Patch Repair. This item is to include concrete breakout and repair to original profile (including replacement of reinforcement and installation of patch anodes).	30	No.
Beams Concrete Patch Repair. This item is to include concrete breakout and repair to original profile (including replacement of reinforcement and installation of patch anodes).	75	m^2
Deck Soffit Concrete Patch Repair. This item is to include concrete breakout and repair to original profile (including replacement of reinforcement and installation of patch anodes).	200	m^2
Bridge Beam Concrete Patch Repair. This item is to include concrete breakout and repair to original profile (including replacement of reinforcement and installation of patch anodes).	5	m^2
Install new stainless-steel ladders	4	No.

Table 2: Tender Scope – 1959 Section

Description Remediation (2005 Section)	QTY	Unit
Wrapping of steel piles with protective jacket from seabed level to existing protective sheath level (approximately RL -5.0 to RL -3.0)	248	No.
Install new stainless-steel ladder in accordance with details on PM-3050.	5	No.

Option Engineering and Executed Scope

Shortly after award of the contract, the project team undertook a detailed Whole of Life (WOL) cost and option analysis whereby the following factors were considered:

- The identified repair quantities based on the 2018/2019 condition assessment, which also formed the basis (including contingency areas) for the 2022 tendered scope
- The "as-surveyed" repair quantities, based on 2022 onsite visual and delamination assessment

- Overall deterioration growth rates, and projected repair expenditure required over a 30-year service life
- Preventive maintenance interventions to reduce the overall 30-year expenditure, and maximise project value for money
- Alternative methodologies to achieve specified project outcomes in a more innovative and sustainable way

The comparative analysis of deterioration growth rates showed an approximate growth of required repair areas from 2% of the total wharf surface area in 2018, to approximately 6% of the total wharf surface area in 2022, and approximate growth rate of 1% per annum.

Using the initial contract sum and rates as a basis, and allowing for deterioration growth and CPI adjustments, a value was calculated across the 30-year service life, that accounted for treatment/repair across only 36% of the total wharf area (assuming a repair regime based on reactive concrete repairs only).

However, given the project teams ambition to implement sustainable and innovative technologies in a preventative manner, options including implementation of Electrochemical Chloride Extraction, and retrofitting of an existing, yet non-operational water anode Impressed Current Cathodic Protection (ICCP System) allowed the client to rationalise a maintenance plan that would treat/repair ~80+% of the total wharf area for approximately 40% of the calculated 30-year expenditure.

Implementation of Electrochemical Chloride Extraction

The primary post project award Value Engineering Proposal for the Queens Wharf Rehabilitation project focused on the application of an Electrochemical Chloride Extraction System, designed to halt and remove the causing agent of reinforced concrete corrosion. ECE offers a more comprehensive solution than the initially nominated traditional galvanic patch anode systems by protecting all concrete elements identified (via the presence of repair quantities) affected by corrosion, not just localized areas adjacent to repairs. This innovative approach, previously and successfully implemented across Australia, presented significant life-cycle cost savings for Fiji Ports Corporation Limited (FPCL).

In general terms Electrochemical Chloride Extraction (ECE) is a technique used to mitigate the damaging effects of chloride-induced corrosion in reinforced concrete structures. Chlorides, often from saltwater, penetrate concrete and initiate corrosion of the embedded steel reinforcement, leading to structural damage over time.

In ECE, an electrical current is applied between the reinforcing steel (acting as a cathode) and an external temporary, and reusable applied surface mounted anode system. Using a conductive electrolyte, high output DC current is applied across the structural elements for a duration from 10-20 weeks. This process helps to migrate the chloride ions away from the steel reinforcement and toward the external anode (see Figure 6), with performance assessed against compliance with *NACE/AMPP SP0107-2021: Electrochemical Realkalisation and Chloride Extraction for Reinforced Concrete [2].*

The ECE implementation led to both immediate contract savings and long-term reductions in

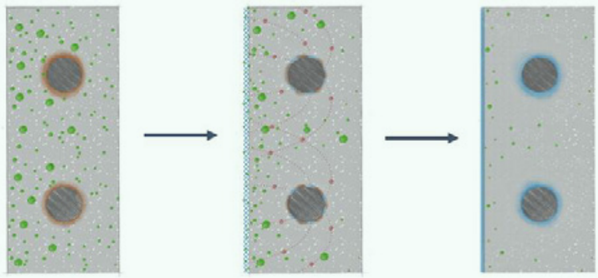

Figure 6: Schematic diagram illustrating the process of ece: (A) Pre-treatment indicating the presence of chlorides throughout the concrete matrix, and corrosion of the steel reinforcement. (B) Suruface applied treatment indicating the current flow, the extraction of chlorides, and the transition to repassivation. (C) Treatment completion, and the application of a barrier coating.

maintenance costs over the nominated 30 years. Specifically, the implemented solution capitalised on the potential savings through the substitution of the need for galvanic anodes and priming rebar during repairs, whereby these funds were reinvested into wider ECE application across not only the identified repair areas, but across the entire element nominate for treatment, including both repaired and non-repaired areas.

The life-cycle cost analysis predicted a substantial reduction in ongoing repair costs, ultimately extending the service life of the Queens Wharf structure and minimizing the risk of future repairs. Fiji Ports Corporation Limited (FPCL) adopted a recommendation for a phased application of the ECE system, beginning with areas heavily trafficked by machinery, followed by a broader roll-out across other structural elements, depending on the observed scope of repairs.

The proposal as implemented enable the project delivery team to balance immediate savings with long-term structural protection, aligning with FPCL's operational needs, whereby an initial treatment area of 810 m2 was extended to 1,650 m2 (an increase of over double), with a nominal expenditure increase of less than 10%.

Retrofit and Upgrade to Water Anode ICCP System

During the tender period, and prior to award, Marine & Civil Maintenance (MCM) identified significant cost-saving opportunities across the project, most notably an option that involved the elimination of the proposed encasement/jacketing of piles for corrosion protection by patch welding of corroded areas, and upgrading and recommissioning an existing, yet non-operational Impressed Current Cathodic Protection (ICCP) system, as part of the 2005 section scope of work.

This approach directly addressed the issue of Accelerated Low Water Corrosion (ALWC), which was at the time reducing the pile thickness in sections identified for repair. Commonly adopted as an industry-standard solution for managing corrosion in such cases, ICCP has be demonstrated successfully through various implementations, notably at the Port of Melbourne, Australia.

Under the alternative scope of work, the follow work activities were detailed and executed.

1. Comprehensive System Audit: Inspection and auditing of all existing ICCP components, including Transformer Rectifier Units, junction boxes, anodes, cables, and reference electrodes.
2. System Repair and Upgrade: Restoration and replacement of any damaged components in the existing system.
3. Enhanced Monitoring: Installation of additional reference electrodes to improve data collection and transparency in system performance.
4. Advanced Control System: Installation of a new Transformer Rectifier Unit equipped with remote monitoring and control capabilities for both on-site and off-site operation.
5. Long-Term Maintenance: Provision of a 10-year comprehensive maintenance and monitoring plan to ensure the system's ongoing operational effectiveness, which provides enhanced protection and transparency compared to the nominated pile jacket system.

This proposal was externally assessed by the client and their engineers and agreed to be a more efficient and cost-effective alternative to traditional pile encasement, ensuring the client long-term protection from ALWC and offering FPCL a robust, verifiable, sustainable, and cost effective solution for corrosion management.

Key to this solution was the removal of the single output, 1000 A Oil Cooled manual control system, and replacement with a project specific developed, seven (7) zone output Transformer Rectifier Unit (TRU). This enhanced system was manufactured complete with remote and local monitoring and control functionality, additional reference electrodes for remote monitoring, and installed within a temperature controlled server room.

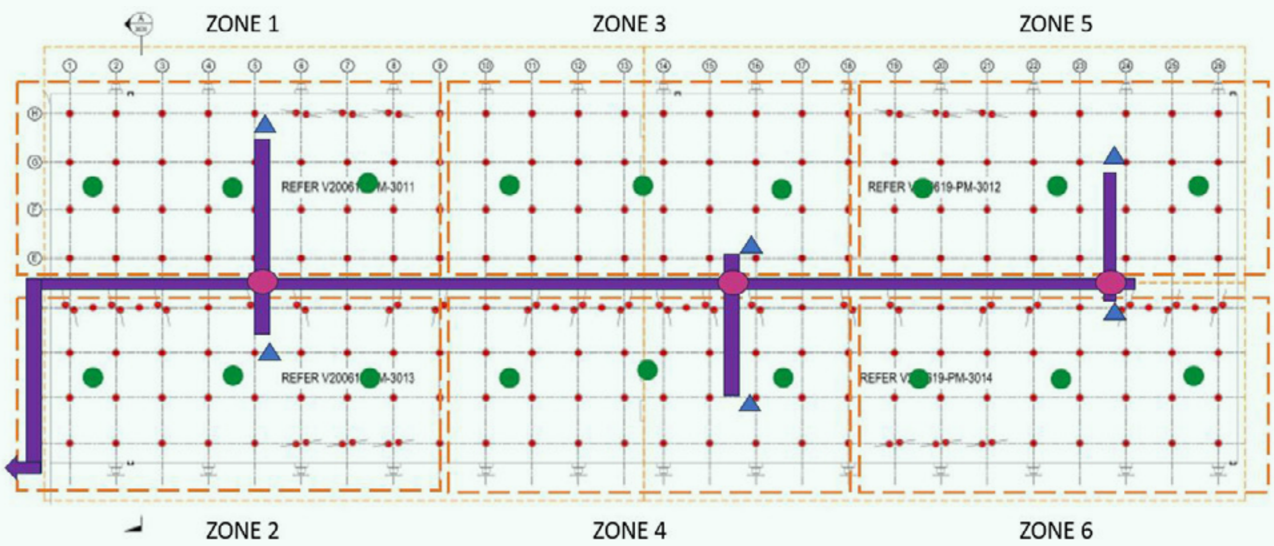

Figure 7: Amended system zoning and monitoring points

As part of this process, the single zone system was rezoned into a total of seven (7) independent outputs (see Figure 7) across the 2005 section of the wharf (six zones), and a single additional single zone to protect the approach bridge, adjacent to the 1959 section, allowing for great transparency, control and assessment of the system performance.

Project Sustainability – Cost and Environmental Outcomes

The advantages of innovative maintenance over complete rebuilding of concrete wharf structures extend beyond qualitative benefits, with significant reductions in carbon dioxide emissions being a critical factor. On average, maintenance activities produce 183% fewer greenhouse gas emissions per square meter compared to new construction [3,4]. Furthermore, it has been found that for every square meter maintained, approximately 3.3 tons of CO2-equivalent emissions are avoided [5]. In practical terms, this means that repair and remediation efforts drastically cut down on the carbon footprint of infrastructure projects, highlighted by global metrics whereby concrete production is responsible for 8% of global anthropogenic greenhouse gas emissions [6].

As an example, eliminating the need for HDPE pile jackets contributed to these reductions, as traditional pile jackets require manufacturing and installation processes that emit additional carbon. By reutilising the existing ICCP system, the project team was able to eliminate approximately 2.5 kg of carbon dioxide per kg of HDPE avoided, and a further 2-3 kg of carbon dioxide per man hour of avoided labour.

With regards to the concrete structural elements, by utilizing advanced techniques such as Electrochemical Chloride Extraction and Realkalisation, the lifespan of the existing structure is extended without resorting to high-emission material-based reconstruction, resulting in a 91%+ reduction in carbon emissions, as compared to a rebuild scenario that was possible without intervention.

Electrochemical Systems Assessment

At the time of writing this paper, a total of six sub-stages (Stages, 1, 2A, 2B, 2C, and Stages 4A, and 4C), corresponding to 60 unique locations, and 600 chloride content samples have been taken and assessed, analysed as %w/w cement.

From this data set, all 60 locations have achieved Criterion A in accordance with *NACE/AMPP SP0107-2021: Electrochemical Realkalisation and Chloride Extraction for Reinforced Concrete* [2], corresponding to a chloride concentration below 0.4% w/w cement within a radius of 25mm of the steel reinformcent, compared to an average initial baseline concentration at the level of the steel reinforcement of 0.7-0.9 % w/w cement, and a concrete cover concentration typical ranging from 1-2.5% w/w cement.

With regards to the ICCP system operating and protecting the steel piles of the 2005 section, this system was completed and commissioned in February 2024.

With an average natural potential measured across all piles in the range of -592 to -628mV (measured against a Ag/AgCl sea water reference electrode), all piles are now fully protected in accordance with *AS2832.3 Cathodic Protection of Metals Part 3: Fixed Immersed Structures*, section 2 [7], with a measured potential at all test points, more negative than -800 mV (with respect to a Ag/AgCl sea water reference electrode), and closely approaching the suggested protection level for ALWC of -850mV (with respect to a Ag/AgCl sea water reference electrode) suggested in literature [8].

Discussion

The adoption of innovative techniques like Electrochemical Chloride Extraction (ECE) and the retrofitting of an Impressed Current Cathodic Protection (ICCP) system, reflects a significant shift in the Pacific towards sustainable asset management and value engineering.

The observed chloride concentration reductions, and the subsequent predicted reduction in corrosion activity, enabling an extension of structural lifespan, underscores the importance of preventive measures over reactive repairs. These technologies not only align with environmental goals by reducing greenhouse gas emissions and material usage but also provide long-term financial savings.

The optioneering process, which encouraged value engineering and collaboration between contractors and the client, played a pivotal role in delivering these sustainable solutions. This model of engagement demonstrates the potential for innovative engineering to not only solve current issues but to pre-emptively address future deterioration, thus maximizing the lifespan and functionality of vital infrastructure like Queens Wharf.

CONCLUSION

The Queens Wharf rehabilitation project exemplifies the potential for integrating sustainable technologies in asset management. The application of ECE and ICCP has demonstrated both environmental and economic advantages by reducing future repair costs and extending the service life of the wharf. This case study highlights the importance of adopting preventive maintenance approaches, particularly in regions where resources are limited, and environmental protection is crucial.

Moving forward, the continued success of this project will depend on the robust monitoring of these systems and their adaptability to emerging challenges. Nevertheless, the outcomes of this project suggest that similar approaches could be effectively applied across other aging infrastructures, particularly in coastal and marine environments. This proactive strategy not only safeguards structural integrity but also supports broader goals of sustainability and resource efficiency, offering a template for future infrastructure projects in the Pacific and beyond.

ACKNOWLEDGMENTS

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With vast industry experience, Blane is a well-regarded technical leader and an active member across numerous associations and institutes. His recent roles include serving as a Director of the Australasian Corrosion Association (2019-2022) and a visiting research supervisor with the University of New South Wales (UNSW), Sydney, Australia.

Blane's contributions to the field of corrosion technology and structural remediation are widely recognized, and his research and expertise continues to influence best practices and advancements in the industry.

Protecting Concrete from Corrosion: Enhancing Durability with Advanced Sealing Solutions

By Chesterton

Concrete, the backbone of modern construction, is valued for its strength, versatility, and cost-effectiveness. Despite its durability, concrete is inherently porous and vulnerable to environmental stressors like moisture, chemicals, and temperature changes. One of concrete structures' most significant challenges is corrosion, which can weaken their integrity and lead to costly repairs.

Understanding Corrosion in Concrete

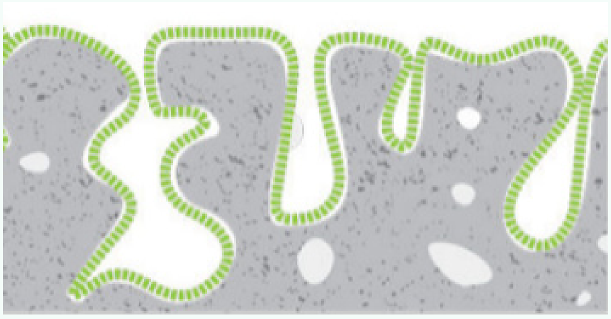
Corrosion occurs when external agents such as water, chlorides, or acids penetrate concrete's porous surface. These agents can corrode embedded steel reinforcements, causing cracking, spalling, and eventual structural failure. The presence of aggressive chemicals and saltwater in industrial and marine environments exacerbates this issue. Australia alone incurs billions in annual maintenance costs due to corrosion in infrastructure and industrial applications.

Advanced Sealing Solutions

Sealing technologies have become essential to protect concrete from corrosion. Sealers form a protective barrier, reducing porosity, increasing surface durability, and preventing the ingress of corrosive agents.

Sealers are categorised into two main types:

1. **Penetrating Sealers:** These infiltrate the concrete, forming a chemical barrier within the surface to block water and chloride penetration. Silicates, silanes, and siloxanes are common examples, particularly effective in industrial and marine environments.



2. **Film-Forming Sealers:** These create a surface coating that resists chemicals, abrasion, and UV exposure. Acrylic, polyurethane, and epoxy-based systems are popular in industrial settings due to their durability and ease of application.

The Importance of Surface Preparation

Proper surface preparation is critical for sealers to perform effectively. This includes cleaning surfaces to remove contaminants, repairing cracks, and eliminating old coatings. This step is paramount for maintaining adhesion and avoiding premature failure of the protective barrier.

Applications Across Industries

Concrete sealing is crucial across various industries:

- **Residential:** Protects patios, driveways, and pool decks from stains, freeze-thaw damage, and wear.
- **Institutional:** Safeguards parking garages, bridges, and marine structures from chloride intrusion and environmental wear.
- **Industrial:** Enhances chemical and abrasion resistance for floors, cooling towers, and containment areas exposed to harsh chemicals.

Chesterton's Expertise in Concrete Sealing

Chesterton has been at the forefront of corrosion protection for decades. To support engineers, architects, and facility managers, Chesterton offers a comprehensive white paper, "Concrete Sealing Solutions" This resource provides detailed insights into sealing technologies and best practices for extending the lifespan of concrete structures.

Download the White Paper Today

Protect your concrete assets and extend their durability with advanced sealing solutions. Download Chesterton's white paper to learn about the best sealing technologies, application techniques, and maintenance strategies.

Download Now

Adopting proper sealing methods can mitigate corrosion risks, reduce maintenance costs, and ensure that concrete structures endure.

Download the White Paper

40 Years of offshore performance – Hutton TLP case study

By AkzoNobel

Project Overview

The Hutton TLP (Tension Leg Platform) structure, initially operated in the Hutton field located in the North Sea, was the first of its kind to be constructed and installed globally. Construction started in 1982 by ConocoPhillips at Highland Fabricators. The Hutton TLP is unlike any nearby oil platforms, as when in situ, it had no massive underwater steel structure. Instead, 16 steel tethers help to anchor the platform to the ocean floor.

Project background

The structure was designed for a minimum service life of 20 years in a water depth of 148 metres (486 feet). The North Sea posed a challenge as it can be extreme and hostile and as such requires a high-performance coating system to be specified. During construction, we recommended using a newly formulated glass flake epoxy for the tubular splash zone sections. Construction began in 1982, and the project went on to consume 40,000 litres of protective coating for the tubular sections.

The first assessment

In 2011, the first visual assessment of the Hutton TLP took place. The high build glass flake epoxy was reported to be in excellent condition after almost 30 years in an ISO 12944 CX environment with less than 1% estimated corrosion over the coated splash zone.

The second assessment

11 years after the initial assessment, and with the support of Nerida Decommissioning, AkzoNobel conducted a second assessment of the coating system to independently verify and report the results. Interzone 1000 meets the ISO 24656 specification standard on the use of a minimum 20% lamellar, non-micronized glass flake epoxy for category V corrosion protection, which is the highest performance category and the lowest breakdown factor for the entire lifetime expectation.

- **Visual Inspection:** A visual inspection of the steel showed no sign of coating breakdown, there was also no evidence of defects or cracking even when inspected under 40x magnification.
- **Adhesion:** Checks were performed in accordance with ISO 4624 using a self-aligned automatic adhesion tester – adhesion was shown to be between 11-13Mpa which is well above industry expectations. The mode of adhesion failure in the tests occurred between the system layers indicating a higher degree of adhesion between the coating system and substrate.
- **Electrochemical Impedance Spectroscopy (EIS):** An EIS test was conducted which is used as a non-destructive technique to determine a coating's barrier properties and potentially indicate substrate corrosion processes under the film. Impedance measurements were recorded, and it was reported that the EIS results were in a high order of magnitude and indicate that the coating is continuing to act as a barrier.

With the long-term projection of growth in the offshore wind energy industry, the findings provide greater certainty for owners, engineers and specifiers on the choice of technology to protect and deliver against lifetime expectations. The Interzone epoxy technology continues to be one of the best solutions for fabricators and applicators to apply and supports HSE goals when compared to alternative technologies.

Reflecting on the 40-year offshore performance track record of high build epoxy pigmented with >30% lamellar glass flake, AkzoNobel reinforce the message that its epoxy solutions remain the trusted and go-to technology for meeting lifetime performance expectations.

Hutton TLP Coating Notes

The coating system described in the AkzoNobel Case Study, that was applied in 1984 to the splash zone section of the 48m high 30,000 tonne Hutton Tethered Leg Platform, is shown in the table below. The submerged risers, tethers and flare booms were coated with thermal spray aluminium with an average thickness of 220 microns and a silicone sealer.

After 17 years in service, the platform was decommissioned and its 19,000 tonne topsides were removed and recycled in Murmansk in 2002, and the remaining jacket structure (pictured) was moored in Scotland's Cromarty Firth (near Inverness) until 2021, when it was towed to the Queens Wharf in Invergordon to be recycled.

Coating	*DFT (µm)*
Epoxy Shop Primer	25
Glass Flake Epoxy	500
Glass Flake Epoxy	500
Glass Flake Epoxy	500
2k PU Finish coat	75

Editorial Notes prepared by W Mandeno

AI Technical Event

The event was a great success, bringing together young corrosion professionals from academia and industry to share their experiences. It was a great time to relax and enjoy the opportunity to forge closer relationships with experienced ACA members. Several YCG members commented to me that they found Geoffrey Will fascinating. It was a balance of old and new approaches to corrosion coming together, something that everyone appreciated. He highlighted how important it is to leverage new AI tools intelligently and understand that a trained corrosion expert is still very much needed. Ultimately, AI tools for corrosion analysis enable us to remove tedious processes from our work so that we can focus on the more interesting aspects.

Burgers and Bowls

The young corrosion group took some time to relax and have a bit of fun with some bare foot bowls, beer, and burgers. Our guest speaker Matthew Brown (AkzoNobel) gave a short technical presentation on corrosion in all its forms, specifically focusing on the importance of coatings for corrosion prevention and maintenance. It was great opportunity for us all to learn from the depth and breadth of his experience, particularly from the perspective of prevention through effective use of protective coatings. After his talk, we took to the lawn to play a few rounds of bowls and over a few beers. I'm definitely looking forward to next time.

2025 Outlook

YCG events were a real highlight for my 2024, and I'm looking forward to what we can do next year. The Queensland branch will continue to grow with technical and social events throughout the coming year, with opportunities to network and learn more about corrosion while having fun. This is something that is too good to pass up. We look forward to welcoming new professionals and students in 2025.

The ACA Newcastle Branch had a successful and engaging year in 2024, hosting four events with strong attendance at each. One of the key highlights was their Technical Breakfast session, which featured three expert speakers presenting the latest case studies on the application of cathodic protection for reinforced concrete structures. These presentations, given from the perspectives of an asset owner, consultant, and specialized contractors, were well-received by the 35 attendees, making the session a great success.

The branch also collaborated with GMA Garnet to host an informative gathering where Peter Gunness shared valuable insights on abrasive blasting. His presentation, "How to Blast Faster, Cleaner, and Safer with Less," covered important topics such as the properties of abrasive blast media, engineered blends, steel preparation, and sustainability practices. This event offered attendees a deeper understanding of surface preparation and the opportunity to network with industry peers.

Another major highlight of the year was the end-of-year event, a Newcastle Port Marine Structures Site Tour, where 39 attendees gained insights into the Port of Newcastle's approach to maintaining marine structures in a corrosive environment. The tour covered topics such as ageing structures, types of structures, and strategies for remediation and preventative maintenance to ensure the ongoing functionality of these critical facilities.

The Newcastle Branch continues to prioritise quality events, featuring top-tier guest speakers and strong participation. With plans to maintain this successful model, they look forward to another year of valuable and engaging events in 2025.

SA Branch Christmas Event

We ended the year on a high note with our South Australia Christmas Event on December 6th!

When the hotel that we booked for the Christmas dinner months ago cancelled on us the day before, Adam Levi, SA's membership officer, did an awesome job finding an alternative venue within hours! The Commercial Hotel in Port Adelaide took great care of us, had the tables nicely decorated, and the food surpassed all expectations!

It was great to have a mix of ACA members at the event. Many familiar faces with decades of membership joined us, and a good number of new members attended the ACA event for the first time.

After the dinner, we walked the short distance to the Pirate Life Brewery, where we tasted some of their beers on tap. In the warm night, some of us stayed until late, enjoying a balmy evening filled with laughter, connection, and celebration.

Thank you to everyone who joined us to celebrate the end of the year. See you next year!

The ACA Victoria Branch had a busy and successful year in 2024. They hosted several YCG events, including a social lawn bowls that brought together the younger and older generations for some friendly competition, as well as a site visit in collaboration with Inductabend, offering a detailed tour of their manufacturing facility..

The VIC Branch also held their AGM, with strong member attendance to vote in the new committee and discuss plans for the year ahead. Additionally, they hosted a technical session on Case Studies and Failures, featuring three distinguished speakers: John Everton from SRG Global Asset Care, Sarah Furman from Aecom, and Nathan Way from Infracorr, presenting to an audience of 25. The highlight of the year was their annual Round Table Conference, which featured an inspiring keynote by Tracey Gramlick from Standards Australia. The Victoria Branch extends their gratitude to the committee, speakers, members, and guests for their dedication to these events. Looking ahead to 2025, they are planning a calendar of events that will continue to provide valuable insights and knowledge.

The ACA Western Australia Branch had a successful year in 2024, hosting five in-person events. The year began with a well-attended Technical Breakfast, where 23 participants gathered to hear Margarita Vargas from Anti Corrosion Technology present on "Decision-making Based on Corrosion & Material Failure Analysis." The WA Young Corrosion Group also held a social networking event at Strike Bowling, offering a fun opportunity for friendly competition, food, and great conversation.

As the year progressed, the branch hosted two key events focusing on corrosion and subsea issues. The first featured guest speaker Raymond Bosman, who presented "Rust Never Sleeps: Strategies for Subsea Corrosion Control with Flow Assurance." His presentation provided a high-level overview of subsea corrosion and how flow assurance plays a vital role in integrity management for the offshore oil and gas industry. The second event, in collaboration with Vertech, brought together several expert speakers to discuss "Corrosion of Subsea Equipment and the Appropriate NDT Techniques to Identify It."

We would like to extend our thanks to our committee, members, and guests for making 2024 a knowledgeable and rewarding year. We look forward to more exciting and informative events in 2025!

The ACA NSW committee gathered to reflect on the year that had passed, taking a well-deserved moment to enjoy some drinks together. This gathering provided an opportunity for members to not only celebrate the achievements and milestones of the past year but also to engage in meaningful discussions about the future. With the aim of continuing to build on their success, the committee brainstormed and shared ideas to create a dynamic and impactful program for 2025, ensuring that the coming year will be one of growth, collaboration, and exciting new initiatives.

Benjamin Biddle , President, QLD Branch

Professional exposure to physical challenges for getting the job done on operating assets is well rounded across multiple industries, environments and cultures, with 30 years practical background in maintenance and new construction works. Working knowledge includes: Contract Specification Development; Commercial Evaluation; Contract Administration; Quality Control; Works Management; Lease and Property Management; Asset Integrity and; Total Asset Management philosophies. Expertise in analysing business processes and conducting strategic review of market opportunities to support sustainable business growth.

Q1.

Where do you work? Describe your job.

I am a Regional Specification Sales and Business Development Manager for AkzoNobel's Marine and Protective coatings business, for our International brand across South Asia, Korea and Japan. I am based in Brisbane and responsible for a team supporting specification sales, specialist products and technical sales across the region.

Q2.

Can you share your journey into the corrosion industry? What motivated you to become involved?

From an early age, I gained hands-on experience working alongside my father, a skilled boilermaker, on the family-built Greyhound complex. When he was welding, I would follow along behind both prepping and painting. On leaving the farm, I began my professional career as a structural maintainer for Brisbane City Council, focusing on painting the Story Bridge and other heritage structures in the city. This experience ignited my passion for the preservation of assets and iconic structures through the application of protective coatings.

Q3.
Who or what has influenced you most professionally?

My father's background instilled a deep interest in the preservation of significant steel structures. At aged 18, a motorbike accident changed my career path from manual work to technical pursuits within the industry.

Throughout my career, I have been fortunate to have several formidable mentors who generously shared their expertise in passive fire protection, anti-corrosion coatings and specialist lining systems. Additionally, the community and training provided by the ACA have been instrumental in advancing my technical knowledge over the years.

Q4.
What has been the most challenging project you've worked on and why?

I enjoyed the challenge of embracing new languages and cultures when I was posted overseas into South-East Asia for 7 years. This allowed me to gain exposure to the major fabrication facilities across the region and I have had the privilege to work across an array of projects.

I find the specification process can be the most challenging part of a project for many customers, but we can support them by working closely to understand their requirements and how our coatings can meet their needs. Although challenging, I find it particularly rewarding supporting quality outcomes and being a genuine partner to our customers.

Q5.
What do you see as the biggest challenges facing the corrosion industry today?

The absence of a standardized national delivery model and the limited adoption of nationally accredited trade qualifications for Industrial and Specialist Coatings in Australia (and beyond) present significant challenges. Attracting young Australian workers to these demanding industries has historically relied on the recognition of trade qualifications to ensure that skill sets are properly acknowledged and compensated, with career pathways supported through government initiatives and training frameworks.

While the benefits of improved workmanship and enhanced asset longevity for existing and future infrastructure are well recognized, the primary drivers in my opinion, are improved worker safety and the minimization of environmental impact. These can be achieved through a better understanding of correct material handling, which is important and best addressed through a national trade qualification and apprenticeship scheme.

Q6.
Have you noticed any emerging trends in corrosion that the industry should be aware of?

Australia's new sustainability reporting legislation, introduced by the federal government, is set to begin phasing in from 2024. This legislation underscores the critical role that protective coatings can play, from the point of manufacture through to delivering asset longevity as a liquid engineering material.

At the core of sustainability, the health of workers and the environment are paramount. However, regional variations in legislation and schemes, along with differing methods of quantification and control, currently complicate the establishment of a uniform measurement system for corrosion prevention systems.

Q7.

Where do you see the future of corrosion mitigation and management heading in the next decade?

The continued development and improvement of virtual reality training tools for blasters and painters, as it offers an excellent complementary assessment and learning solution. These digital tools enable training organizations to teach and assess skills without the need for expensive and space-consuming kit setups, providing greater flexibility in skills development and competency validation. The advancement of automation, robotic application, and inspection technologies represents an exciting and progressive area of development, supporting the delivery of quality outcomes.

Q8.

What advice would you give to someone just starting their career in the corrosion industry?

Be hungry to learn and develop. There is a range of opportunities and challenges within the wider industry. Engagement and participation with industry organisations such as the ACA is a great way to widen your exposure and professional network.

Q9.

What has been your greatest professional achievement?

I have been fortunate to engage in numerous diverse projects within our industry. One notable project involved commissioning an art management initiative to tackle repetitive graffiti issues. By engaging Aboriginal artists, we effectively addressed the demands and costs associated with ongoing paint-outs. Coordinating with local elders and considering cultural requirements, while supporting the artists in approaching such a large canvas, was incredibly rewarding. A decade after the project's completion, the University of Queensland recognized and nominated the artworks as culturally significant to the state government.

Q10.

How has being a member of the ACA benefited you professionally or personally?

My initial engagement with the ACA began in 1995 when I sought to enhance my knowledge and industry qualifications. I started under the then ACA Coating Inspectors Ticket and progressed through courses such as Corrosion Fundamentals and Coating Selection and Specifications, which I found particularly valuable, before completing the AMPP CIP Peer Review.

Upon relocating to Western Australia in 2008, the ACA facilitated my seamless transition by connecting me with a trusted professional network. Within 18 months, I proudly assumed the role of WA Branch President.

My involvement with the ACA has provided numerous benefits, including access to professional interactions with mentors, industry peers, and friends, as well as connecting with a community of like-minded professionals and industry relevant training.

During the ACA Corrosion and Prevention Conference 2024 in Cairns the ACA's Young Corrosion Group (YCG) held its first National YCG Steering Committee meeting.

The National YCG Steering Committee consists of each state's YCG chair and looks to meet bimonthly to discuss all things YCG.

The aims of the committee are to grow the YCG presence across the member base, provide support to YCG committees and connect chairs to each other to ensure best practise.

Austin Bennett (National YCG Chair) has spent the last 12 months rewriting the National YCG framework and has worked closely with the ACA to get the steering committee revitalised after a dormant period.

The first meeting included representation from all states (Except NT & TAS) and included New Zealand, the committee reviewed the framework and discussed any improvements that could be made.

We also discussed changes we would like to see made which would make the YCG more relevant with members including increasing the value proposition of becoming a YCG member. The committee is currently looking for comments from members to advise what benefits they would like to receive as YCG members.

Austin is working closely with the ACA Head Office to consolidate committee members minutes and agendas with head office via a share drive to ensure safe keeping of documents in the case of a YCG chair leaving the industry without passing on information to their vice chair.

The committee will meet again in January 2025 to further the development of the YCG and extend our outreach to those members (Both individual and corporate) who are yet to connect with the YCG.

If you have any colleagues under the age of 35 who are interested in becoming a YCG member or would like to come along to some social events, please do not hesitate to get in touch.

Anthony Roccisano

Anthony Roccisano is a Postdoctoral Fellow with the Australian Research Council (ARC) Industrial Transformation Training Centre in the Surface Engineering for Advanced Materials (SEAM) with the University of South Australia (UniSA). Anthony earned his PhD in mechanical engineering from the University of Adelaide in 2020, studying the impact of manufacturing processes on the Stress Corrosion Cracking (SCC) susceptibility in pipeline steels. After completing his studies, Anthony joined UniSA's Future Industries Institute as a postdoctoral researcher working on industry projects investigating wear and corrosion. In addition to research, Anthony lectures engineering students on material science, introducing the fundamentals of corrosion to the next generation of engineers.

Anthony has a special interest in materials science, particularly in steel processing and performance and researches the corrosion susceptibility of materials repaired through additive manufacturing. Anthony holds the position of Vice President at the South Australian branch of the Australasian Corrosion Association and was awarded the National YCG award at the 2024 Corrosion and Prevention Conference in Cairns.

Q1:
What is your current ACA membership level?

I am currently an individual member.

Q2:
What is the Young Corrosion Group (YCG)?

The YCG is a working group comprised of ACA members that are under 35 years of age.

Q3:
Why are you a member of the YCG?

I am a member of the YCG because of the opportunities it gives to meet colleagues across Australasia and become a more active member of the ACA.

Q4:
What inspired you to pursue a career in Corrosion?

In my final year of my undergraduate degree, I had the opportunity to take a corrosion elective and really enjoyed the content and how universally applicable it was to nearly all industries. After finishing my undergraduate degree, I had to opportunity to undertake a post graduate degree investigating Stress Corrosion Cracking in pipeline steels.

Q5:
What are some important corrosion-related issues facing your industry today?

By some estimates, the global cost of corrosion is approximately 3% of global GDP and impacts almost every sector. One important corrosion related issue facing industry today is the remediation of corrosion damaged components through additive manufacturing. Additive manufacturing processes such as thermal spray and laser cladding offer the ability to remediate loss of material due to corrosion as well as provide a corrosion resistant coating at the surface to minimise corrosion in the future. Ongoing investigations into different corrosion mechanisms, substrate materials, coating materials and coating technologies are enabling lower cost repairs in many industries.

Q6:
How do you think the ACA and YCG support young people in the corrosion industry?

The primary strength of the ACA and the YCG is the strong membership base of experienced corrosion professionals that are open and willing to share their knowledge, time and expertise. The ACA and YCG support young people in the corrosion industry by creating opportunities for the young members to meet and interact with more experienced members, facilitating transfer of knowledge, growth of professional networks and access to new job opportunities.

Q7:
How can others interested in the YCG, join?

For all interested in joining the YCG, reach out to your Branch YCG representative who will be happy to have you on board.

2024 A Year In Review

Founded in 1996, by the Australasian Corrosion Association (ACA), the Coatings Technical Group (CTG) mission is:

To share ideas, project studies, technologies and market trends amongst asset owners, designers, manufacturers, suppliers and equipment providers to the protective coating industry that serve the protection or restoration of corrosion affected structures throughout Australasia including New Zealand.

I write this message thankful for the support of volunteers who contribute to our committee through reviewing award nominations, reviewing Standards, developing technical content and events.

Current projects

The past year has been active for the CTG where members have been actively working on latest innovations, product developments, industry issues and specifically:

- Development of AS/NZS 2312.3 being the *Guide to the protection of structural steel against atmospheric corrosion by the use of protective coatings - Part 3: Thermal spray coatings*. A draft of this document has completed its Public Review stage and is now likely be published in early 2025.
- A review is in progress of AS 3894.1 being the method for *Site testing of protective coatings. Non-conductive coatings - Continuity testing - High voltage (brush) method*. This was last reconfirmed 2013.
  AMPP revised their equivalent *Standard in 2024, SP0188 Standard Practice for Discontinuity (Holiday) Testing of New Protective Coatings on Conductive Substrates*. Comments from industry suggested AS 3894.1 also needed a revision.
- A project has been established to review 143 aged Australian Standards that align under Standards Australia committee CH-003. These include the AS 1580 series, 3730 series, 3750 series, 3894 series, 4049 series, 4361 series, 4548 series and a few others.

Conference 2024

The group also contributed to a strong representation of coatings related technical presentations and conducted an industry forum at the Corrosion and Prevention conference in Cairns recently.

We were proud to have one of our members, Oscar Duyvestyn as Convenor of the conference.

2025 Coatings Roadshow

In 2025 we look forward to progressing the current work and rolling out a coating and applicator's roadshow for Australia and New Zealand as follows:

- Sydney — Tuesday 6th May 2025
- Perth — Tuesday 13th May 2025
- Auckland, NZ — Monday 21st July 2025
- Christchurch, NZ — Thursday 24th July 2025

There is a call for sponsors and presenters on the ACA website for those who are interested.

Award Nominations are open

The CTG also welcomes nominations for the Victor Nightingall Award that is given in recognition of distinguished achievement in the development, manufacture or application of protective coatings, or advancement of the protective coatings industry. The Award was established in 1998 by the ACA's Protective Coatings Technical Group in honour of the Australian, Victor Nightingall, who invented the world's first inorganic zinc silicate coating.

CTG Committee

I ask you to support our committee members by thanking them for their contribution through the CTG:

CONTACT	COMPANY	TYPE	LOCATION
Austin Bennett	Universal Corrosion Coatings	Coatings - Supplier	Melbourne
Chris Eldred	Dulux Australia Ltd	Coatings - Manufacturer	Melbourne
David Anderson	Universal Corrosion Coatings	Coatings - Supplier	Melbourne
Dean Wall	Jotun	Coatings - Manufacturer	Launceston
Denis Wright	Sparc Technologies	Coatings - Additives	Adelaide
Donovan Slade	Pacific Urethanes	Coatings - Manufacturer	Melbourne
Justin Rigby	Remedy Asset Protection	Inspection (Coatings)	Melbourne
Matt O'Keefe	AkzoNobel	Coatings - Manufacturer	Brisbane
Oscar Duyvestyn	Remedy Asset Protection	Durability Consultant	Cairns
Peter Dove	GHD	Engineering	Melbourne
Peter Golding	Galvanizers Assoc Australia	Galvanizing	Newcastle
Rob Butcher	Hempel	Coatings - Manufacturer	Adelaide
Willie Mandeno	WSP	Coatings - Consultant	Wellington NZ

Nomination forms to join our committee are available at Join a Technical Group - The Australasian Corrosion Association Inc.

Looking forward to further advancing the Coatings Industry in 2025.

Justin Rigby
Chairperson - CTG

History of the Annual Technologists' Picnic

Year, Title, Speaker, Location

2023 *"Cochlear Implants: Past, Present and Future"*, Claire Hartmann, Sovereign Hill

2022 *"The design parameters of bicycles used for travel, with an historical perspective."*, Noel McFarlane, Sovereign Hill

2021 *"History of the Spencer Street Bridge"*, Fiona Campbell, Local History Librarian, East Melbourne Library, Sovereign Hill

2020 *"Surface Engineering: 'Designing the Face' that interacts with demanding environments."* Prof Chris Berndt, SEAM Virtual

2019 *"Drones and Airborne Sensors – Opportunities for both Industry and Research"*, Dr Rohan Clarke, Sovereign Hill

2018 *"From Discovery to Innovation; from helping business to creating new businesses."*, Prof Peter Hodgson, Sovereign Hill

2017 *"Älbins Performance Systems"*, Stephen Macdonald, CEO, Albins Performance Transmissions Pty. Ltd. Sovereign Hill.

2016 *"Bastion Cycles"*, Ben Schultz, Sovereign Hill

2015 *"Energy Efficient Housing"*, Helen Bernard, Sovereign Hill

2014 *"Baum Cycles"*, Darren Baum, Sovereign Hill

2013 *"Australian Solar Industry"*, Paul Scerri, Ballarat Mechanics Institute

2012 *"Making Waves in Power"*, Keith Bowyer, GM, Ocean Power Technologies,, Sovereign Hill

2011 *"Manufacture of Large Diameter Pressure Pipelines using Induction Heating"*, John Rea, GM, Inductabend, Sovereign Hill

2010 *"Corrosion Mitigation in Marine Superstructures in the Offshore Oil and Gas Industry"*, Peter Dove, Principal Materials Consultant, GHD, Sovereign Hill

2009 *"The Construction of the Goldfields Super-pipe"*, Peter Darveniza, Project Manager, Bendigo-to-Ballarat water pipeline, Sovereign Hill

2008 *"Membrane technology and the urban harvesting of water"*, Prof Stephen Gray, Victoria University, Sovereign Hill

2007 *"Solar Power Concentrator Systems"*, Dr John Lasich, Technical Director, Solar Systems, Sovereign Hill

2006 *"Gekko Systems and the Ballarat Goldfields"*, Marc Amos and Alvin Johns, Gekko Systems, Sovereign Hill

2005 *"Consulting and the Curate's Egg"* (Frustrations and successes in corrosion consulting.) Dr Graham Sussex, Sussex Materials Solutions, Sovereign Hill

2004 *"From water closets and cannon to outdoor sculpture via a padded cell – the world of objects conservation", Jenny Dickens, Heritage Victoria, Sovereign Hill*

2003 *"Reducing Central Victoria's Greenhouse Gas Emissions to Zero by 2020"*,T erry White, Central Victorian Greenhouse Alliance, Sovereign Hill

2002 *"Engineering the world's fastest bike."*, (for Kathy Watt), Ass Prof Lachlan Thompson, RMIT, Sovereign Hill

2001 *"The Stanwell Magnesium Project : Magnesium Technology Developed in Australia"*, Dr Bill Kruesi, Research and Development Manager, Sovereign Hill

2000 *"Thompsons of Castlemaine"*, Mike Williams, MA Thesis, Castlemaine

1999 *"How Do We Make Partnerships Work?"*, Prof Peter Hodgson, Deakin University, Hepburn Springs

Materials Australia

26th Annual Technologists' Picnic

Date: Friday 28th February 2025

Time: 6:30pm for 7:00pm

Venue: The Charlie Napier Hotel within the grounds of Sovereign Hill Outdoor Museum, Golden Point VIC 3350

Cost: $65 for a two-course meal. Drinks at bar prices.

RSVP: Monday 24th February 2025

Guest Speaker: Adam Hassell

Adam is a former simulation engineer who has spent the last 12 years applying that background to the foundry industry. Hasco Foundry, the family business, had humble beginnings in the back yard of his grandfather's house where it grew from a hobby foundry into a successful business. Fast forward a few decades and it now uses sand 3D printing technology to revolutionise the way it produces castings.

We have a diverse range of customers ranging from defence and automotive to art and restoration. Join us for a presentation about the history of the foundry, and how it has reinvented itself to take advantage of new technologies like 3D sand printing. In particular, we'll look at how a V12 engine block morphs from an idea into horsepower, all made in country Victoria.

These annual dinner-meetings have customarily been supported by members of the Australasian Institute of Mining and Metallurgy, the Australian Foundry Institute, Materials Australia, Engineers Australia, and the Australasian Corrosion Association. Interested members of the general public are also encouraged to attend.

AFI Australian Foundry Institute

Australasian Corrosion Association Inc.

AusIMM THE MINERALS INSTITUTE

CLICK HERE TO REGISTER

Applicators & Coatings 2025

ROADSHOW

Auckland | Christchurch | Sydney | Perth

THE EVENT

The Applicators and Coatings Roadshow is a joint event delivered by our Applicators and Coatings Technical Groups. This will be a fantastic opportunity to bring the industry together, raise awareness of new technologies, maintain and develop new Standards, support training opportunities and more!

LOCATIONS & DATES

Auckland - Monday 21st July | Venue TBC

Christchurch - Thursday 24th July | Venue TBC

Sydney - Tuesday 6th May | Venue TBC

Perth - Tuesday 13th May | Venue TBC

Presented by:

Applicators Technical Group

Coatings Technical Group

WHAT'S ON

Let's bring the industry together, raise awareness of **new technologies**, **product development**, maintain and develop new **Standards**, support **training opportunities** and more!

Activities

- Technical Presentations
- Equipment Demonstrations
- Professional Skills Development
- Forums and Q&A sessions
- Social events

*Event schedule available on the website.

Time
8:00AM to 6:00PM
(All Day Event)

Price
Starting from
$200.00 inc GST
(includes food and drinks)

Equipment Demonstrations

Industry leading companies are joining us to share the latest industry machinery updates and how they operate on-site. Equipment Demonstrations are a performance masterclass not to be missed.

Professional and Skills Development

Roadshow attendees have a unique chance to be amongst top industry leaders and learn from their knowledge and experience.

CALL FOR SPEAKERS, SPONSORS & EXHIBITORS

We still have a limited number of presenter and sponsor opportunities available for both of these events and will still be accepting abstracts from potential speakers until Friday 28th February 2025.

FIND OUT MORE

News from the ACA Foundation Chairman

Wayne Burns, Chair – ACA Foundation Limited

The ACA Foundation (ACAF) has had an exceptional 2024 year. With the continued long-standing support for our Scholarship Sponsors as well as our Centurion donors, in 2024 we saw 50 applications for scholarships. We were pleased to award nine scholarships on behalf of our scholarship sponsors and look forward to having many more scholarships available for the 2025 year.

Following COVID, Board members have worked tirelessly to recover missing data and re-establish accounting and financial systems. Following several hick ups we have established new facilities. All of this has been achieved through volunteer contributions by all directors and assistants.

Despite all the changes, ACAF directors worked energetically at the recent ACA Annual conference in Cairns, networking with many industry leaders. We have had a great response to our many meetings and look forward to a strong and restructured ACAF Board and its committee members in 2025.

Our FOCUS is on fostering corrosion awareness across the wider community with an increased capacity for making informed decisions on corrosion mitigation and prevention.

The growth and success of our scholarship programs is totally reliant on the donations and support provided by Corporate organisations as well as the many ACA members. Their continued generosity to continue to support our scholarship programs and the Centurion programs is most appreciated.

Additional Expertise – New Directors

ACAF continues to develop a stronger Board of Directors that is focused on the future. The ACAF Board is delighted to announce the recent appointment of Brian Kaye as a new director to the Board. In addition to the appointment of Geoffrey Will in October we are pleased to welcome Brian to the team. They will both enhance the ACAF development opportunities.

Brian Kaye has 35 years' experience in the concrete repair remediation industry and until recently has been an active board member of ACRA. Brian is an experienced Technical Consultant / Business Development manager. Brian's career has included project management in many aspects of concrete rehabilitation. His expertise spans relationship building across many services including Marine, Water, Transport and Energy providers. Brian's expertise will ideally complement the overall approach to future growth of the ACAF Scholarship and Government / Industry support planned by the ACAF.

Through further recruitment actions ACAF aims in securing additional directors who come from mainstream industry.

Future Objectives:

- **cKits -** ACA Foundation delivered more than 150 corrosion education cKits to secondary schools prior to COVID. During 2025 it is planned to raise funding to produce an Australian & New Zealand cKit that can then be distributed to science teachers in most secondary schools (with government assisted funding).
- **Scholarship Expanded Programs -** Commencing in 2025, ACAF plans to expand its scholarship programs to be able to offer many more scholarships. Within 3 years It is planned to grow the program to 30 annual scholarships

that can be offered to the community generally in Australia, New Zealand and Pacific Islands region.

- **International Exchange Student Program –** In 2025, our ACAF International Committee shall continue to generate opportunities and conditions globally to encourage the development of an international student exchange program. Discussions are currently underway with organizations in USA, UK and Europe who can manage such an exchange program with the ACAF family. It is envisaged that by 2028 the program will have matured into a working facility.
- **All At Sea -** The ACAF developed education program All At Sea is being utilised by teachers of high school students across Australia and New Zealand. ACAF Education committee plans to expand the acceptance and use of this program in future years.
- **ACAF Ltd – A Registered Incorporated Tax-Deductible Charity** In 2010, ACA Foundation Limited became a registered Charitable Organization with TAX DEDUCTABLE Status for donations. This facility greatly improved the value of donations to our sponsors.
- **ACAF Centurion Program –** Initiated in 2010 the Centurion Program encourages individuals, corporations or community-based organisations – to become donors for local and international scholarships. The program facilitates the expansion of knowledge and allows their careers in Corrosion Engineering, Corrosion Management or Specialist Corrosion Integrity and Prevention Programs to blossom and flourish. The continued support of Centurion Donors is essential to the viability of future scholarship programs and this year funded the new Mike Rutherford Memorial Scholarship.
- **ACAF Corporate Donors –** The ACAF has been very fortunate in gaining the support of corporate organizations who provide long term commitments to support ACAF Scholarship Programs. The scholarship committee plans are to work with scholarship sponsors to enhance the relationship and interface fo Scholarship Sponsors and the Scholarship Award recipients.
- Scholarship History **–** Since its introduction of Scholarships in 2000, ACAF has now delivered more than 145 scholarships to ACA and community members, in the form of :
  - ACA/AMPP training scholarships
  - ACA Conference attendance scholarships
  - International education travel scholarships
  - Future Leaders Forum Program
- **Updating your Centurion & Donors Support** The ACA Foundation is proud of our members-based Centurion donor program. Members renewing or joining the Centurion program for 2024/2025 will now receive a Centurion Badge plus a Centurion Certificate as an acknowledgement of their support.

If you are a company or corporation and you could provide a scholarship program over a 5year term. Open this link to make contact with one of our ACAF directors to discuss the opportunity further.

- Be part of the future development of our Corrosion Prevention people's careers.
- International exchange programs are coming.
- The expertise of our young community must grow & foster future international participants in our Australasian businesses – this rests with your support.
- ACA Foundation continues to seek additional Board members as well as nominees for specific committees. We also look to appoint a Young Person as a trainee for the Board membership.

We need support from Centurions, Industry & the Business Community to help grow the expertise of our our future generations and to ensure continued viability of the ACA.

We thank everyone for taking the time to read to our message. We look forward to your continued support of our scholarship program. As a Centurion Donor or as a Corporate Scholarship donor for longer-term you can make a difference for the community at all levels.

The ACA Foundation gratefully acknowledge the generous sponsors of our 2024 Scholarships: Denso (Australia), Infracorr Consulting, Marine and Civil Maintenance, Phoenix Solutions, Universal Corrosion Coatings & the ACA Foundation Centurions.

Revision of AS 3894.1 HV Holiday Test Method

Article based on presentation by Willie Mandeno to the ACA Coatings Technical Group forum at C&P24 in Cairns, November 2024.

Barrier coatings are used to protect the external surfaces of buried steel pipelines and the internal surfaces of steel storage tanks.

To be effective these need to be a continuous non-conductive film that is free of defects such as voids and pinholes, known in our industry as 'holidays'. The common test method for coatings thicker than 500 microns is to create a voltage between the substrate and a test electrode that is passed over the surface. The voltage is set so that a spark will be created at any defect. The value of this test voltage has been very controversial with concerns that if set too high, it could damage a sound coating by burning through it.

The background to this article was that in 2023, a South Australian Coatings Consultant Dennis Richards prepared a discussion document titled 'Issues with AS 3894.1'. This included pointing out that a literal interpretation of this Standard, required the test voltage to be doubled if the volume solids of a coating was increased from 79% to 80%. Standards Australia referred this to the ACA Centre who referred it to the Coatings Technical Group, which has since resulted in Standards Australia establishing a project to revise this standard. Rob Francis noted that this topic had been debated within the ACA over 30 years ago, following the pioneering work by Geoff Cope for the Australian Gas Association.

Figure 1. High Voltage 'Spark' Testing (Photo credit: KTA University)

Listed below are some of the papers presented to ACA Conferences with their conclusions that dispelled some of the myths about the risk of coating damage, but have since been forgotten by many in our industry. There are other papers in the literature where the dielectric strength or voltage resistance of coatings and air have been investigated, eg the 1960 master's thesis by JH Gustafson. Also listed are some current standards available for specifying holiday testing.

Previous ACA Conference papers

- ACA 1988: Cope G & Luke A, Holiday Detection for Fusion Bonded Epoxy Pipeline Coating (recommended 15V/micron)
- ACA 1991: Cope G, High Voltage Testing of Heavy Duty Coatings - Recent Advances (found variations on temperature and RH play a minor role and that most coatings can withstand a substantial test voltage before breakdown)
- C&P 2009: Edmond L, Cope G, Bryson A, Ackland B & Forsyth M, An Evaluation of Holiday Detection Voltages for FBE Coated Pipe (found saturated FBE could withstand >13V/micron)
- C&P 2018: Cicak I, Tan M, Cope G & Jin L, Determining the Required Voltages for Holiday Testing of Dual Layer FBE Coatings (recommended AS 3894.1 voltages for FBE and DLFBE be derated by 65% and that repetitive testing did not cause breakdown).

Standards for Holiday Testing

- AS 3894.1-2002, Site testing of protective coatings, Method 1: Non-conductive coatings – Continuity testing - High voltage (brush) method
- ASTM G62-23, Standard Test Methods for Holiday Detection of Coatings used to Protect Pipelines

- ASTM D1562-21, Standard practice for Discontinuity (Holiday) Testing of Nonconductive Protective Coating on Metallic Substrates
- NACE SP0188-2024, Discontinuity (Holiday) Testing of New Protective Coatings on Conductive Substrates
- NACE SP0274-2011, Standard Practice for High-Voltage Inspection of Pipeline Coatings
- ISO 29601:2011, Paints and varnishes – Corrosion protection by protective paint systems – Assessment of porosity in a dry film

Figure 2. Example of HV Holiday Testing Equipment (Photo credit: PCWI)

In 2012, at an ACA Coatings Seminar in Sydney, Ted Riding produced a graph that compared the test voltages vs dry film thickness recommended by these Standards. He has updated this, and it is included below as Figure 2. The new SP0188 curve is the upper dark blue line with the old standard values being the yellow stepped line. The red line is ISO 29601, the brown line the 'rule of thumb' and the green line is ASTM D5162

The pink dashed curves are from AS 3894.1 with the coating adjustment factors.

The last revision of AS 3894.1 was in 2002 with the formula for calculating test voltage given below and its table in Appendix D giving the adjustment factor according to generic types based on volume solids reproduced as Table 1.

$V = (250 \times \sqrt{d})/f$

AMPP Conference 2022 Paper

Paper No. 17662 by Walker C, O'Dea V, Bell J & Tormes J, Why Voltage Matters for High Voltage

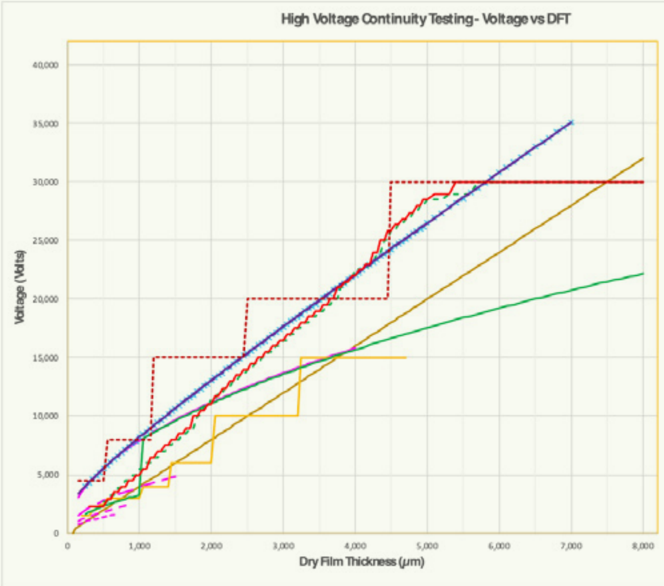


Table 1: Test voltage Adjustment Factor

testing on Steel, that triggered the recent change to the widely used NACE Standard Procedure SP0188, was presented to the AMPP Conference in 2022.

Research by Walker et al found no scientific basis for the 'rule of thumb' of 100 volts/mil (or 4V/micron) that could lead to undetected holidays or discontinuities where DFT <1500 microns. Also, that the dielectric strength of most protective coatings and linings for chemical containment or immersion service was generally >20V/micron, with many greater than 40V/micron. Interestingly they made no reference to similar testing carried out in Australia many years before this!

They recommended a testing voltage = $1250\sqrt{t}$(mils) $=250\sqrt{d}$ (microns) as used in NACE SP0274-2011, Standard Practice for High-Voltage Inspection of Pipeline Coatings to achieve consistent holiday detection. This is the same formula as in AS 3894.1 but without the adjustment factor. They also noted that a 45% greater voltage was required when using conductive neoprene rubber electrode compared to the preferred wire bristle brush, and that a typical value for the di-electric strength of air was 78 volts/mil or 3 V/micron.

AMPP revise SP0188

NACE RP0188-1988 was first revised in 1999, then reaffirmed as NACE SP0188-2006. The latest revision was published in January 2024 and is based on research by Walker et al, and Paschen's Law that is used to calculate the voltage required to create a spark in air. It now specifies a test voltage that equals 1.5x dielectric strength of air (calculated using Paschen's Law over the DFT distance), plus 1500 volts. The formula is shown below.

V=1500 + 1.5(9170 + (63d) + (293√d))

Table 2 shows examples from the range of thicknesses included in SP0188's Table A1, with recommended voltages compared with those in the now superseded 2006 version*. Also included are the Voltage vs Thickness ratio, showing how this decreases as thickness increases. Note that all are above the old 'rule of thumb' 100V/mil, especially for thinner coatings.

d (Mils)	d (microns)	Voltage (kV)	Volts/ mil	*2006 (kV)
10	254	4.1	410	1.5
40	1016	8.3	208	3.0
150	3810	21.3	142	15
274	6960	34.9	127	N/A

Table 2. Comparison of current and previous recommended voltages

ACA Coating Technical Group Proposed Amendments

AS 3894.1 should be retained rather than adopting the AMPP or ASTM Standards with the following editorial changes;

1. Remove Tables D1 & D2 and Figures D1 & D2, and the reference to coating material rating 'F' in Clauses C3.2.2 and D2.
2. In Clause 10(j), change AS/NZS 3894.1 to AS 3894.1 (NB. the 1991 Standard was de-jointed when updated in 2002)
3. In Clause A2, correct "Australian Corrosion Association" to "Australasian Corrosion Association" (or delete?). Also update inspector certification by NACE to AMPP.

Multiple applications of the test probe should be encouraged to increase the probability of finding defects. (Not specifically prohibited by AS 3894.1).

Test voltages should be set based on actual thickness being tested if, above the specified minimum. (Clause D2 recommends this when actual DFT is >25% of specified.) Alternatively, (as suggested by Ted Riding), specify a test voltage based on the expected DFT range as shown in Table 3 and as a red dashed line in Figure 2.

Typical Thickness Range (µm)	Suggested Voltage (kV)
150 - 500	4.5
500 - 1200	8.0
1200 - 2500	15.0
2500 - 4500	20.0
4500 - 8000	30.0

Table 3. Voltage vs DFT Range

Revised SSPC-SP 2 & SP 3

These standards for surface preparation, by hand and power tool cleaning, were reissued by AMPP on 27 November 2024 with the following rationale:

"This standard was last revised in 2018. Although the cleanliness requirements for the prepared surface have not been changed, the standard has been reorganized to conform to AMPP editorial requirements, references have been updated, and Section 8 (Notes) has been moved to an appendix."

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2025 Training Calendar

AMPP Coating Inspector Program Level 1	
NSW - Sydney	13-18 Jan 2025
WA - Perth	10-15 Feb 2025
QLD - Brisbane	24 Feb-01 Mar 2025
VIC - Melbourne	31 Mar-05 Apr 2025
WA - Perth	05-10 May 2025
SA - Adelaide	16-21 Jun 2025
NZ - Auckland	07-12 Jul 2025
NZ - Christchurch	28 Jul-02 Aug 2025
WA - Perth	04-09 Aug 2025
NSW - Sydney	18-23 Aug 2025
NSW - Newcastle	29 Sep-04 Oct 2025
Western Australia	13-18 Oct 2025

AMPP Coating Inspector Program Level 2	
WA - Perth	17-21 Feb 2025
QLD - Brisbane	03-07 Mar 2025
VIC - Melbourne	07-11 Apr 2025
WA - Perth	12-16 May 2025
SA - Adelaide	23-27 Jun 2025
NZ - Auckland	14-18 Jul 2025
WA - Perth	11-15 Aug 2025
NSW - Sydney	25-29 Aug 2025
NSW - Newcastle	06-10 Oct 2025

AMPP Cathodic Protection Level 1 Tester	
VIC - Melbourne	03-07 Feb 2025
QLD - Brisbane	12-16 May 2025
WA - Perth	07-11 Jul 2025

AMPP Cathodic Protection Level 2 Technician	
VIC - Melbourne	10-14 Feb 2025
QLD - Brisbane	19-23 May 2025
WA - Perth	14-18 Jul 2025

AMPP Cathodic Protection Level 3 Technologist	
Online/AEST	28 Apr-02 May 2025

AMPP Cathodic Protection Level 4 Specialist	
Online/AEST	05-09 May 2025

ACA Corrosion Technology Course	
VIC - Melbourne	02-06 Jun 2025
NSW - Sydney	01-05 Dec 2025

ACA Coating Selection and Specification	
Online/AEST	05-07 May 2025

ACA GAA Hot Dip Galvanizing Inspector Program	
WA - Perth	08-09 Apr 2025

AMPP Corrosion Under Insulation	
Online/AEST	02-06 Jun 2025

AMPP Concrete Coating Inspector	
VIC - Melbourne	30 Jun-04 Jul 2025

ACA ACRA Concrete Structures and Buildings	
Online/AEST	17-18 Mar 2025

AMPP Craftworker Series (CWS) C6/C7/C12	
SA - Adelaide	19-24 May 2025
SA - Adelaide	15-20 Sep 2025

Click here to review the Training Schedule:
www.corrosion.com.au/training/training-course-schedule/

Course Spotlight:
AMPP Concrete Coating Inspector Program (CCI)

More information & Registration

Overview:

The objective of the AMPP Concrete Coating Inspector (CCI) course is to thoroughly train individuals in the proper methods of inspecting surface preparation and installation of protective coatings on concrete structures and facilities.

Who should attend

Applicators, Inspectors, Contractor Managers, Specifying Engineers, Technical Representatives, and Material/Equipment Suppliers involved in the Concrete Coating industry.

Course highlights:

- Inspection and treating substrate problems which affect coating quality.
- Inspection of ambient and substrate conditions
- Inspecting surface preparation equipment
- Inspecting and testing abrasive blast media
- Safety hazard inspection
- Inspecting surface preparation
- Inspecting coating application on concrete
- Coating specifications
- Simulated pre-job conference
- Inspection procedure development
- Simulated project inspection

Joining the Australasian Corrosion Association offers a whole host of benefits for indviduals seeking to advance their careers and expand their networks.

Membership provides access to a wealth of resources including cutting-edge industry research, professional development opportunities through workshops and seminars, and exclusive updates on trends and regulatory changes.

Networking events and conferences enable members to connect with peers, mentors, and industry leaders, fostering valuable relationships and collaborations.

By joining the ACA, you gain a competitive edge, stay informed, and enhance your professional growth and opportunities.

Become a Member

MEMBER BENEFITS

KNOWLEDGE BUILDING

The ACA's trainings and development pathways cater to a variety of skillsets , from entry-level corrosion novices to those seeking advanced specialist training. Training arrangements have flexible capacities and are both locally and internationally recognised for their quality, accreditation, and applicability. The Annual Corrosion & Prevention Conference offers an array of technical initiatives, including industry and research programs, social functions and awards ceremonies to highlight innovation in the corrosion industry. Our Branches offer a year-round calendar of events, including seminars, on-site visits, technical presentations, networking events, Young Corrosion Group events, and more.

RESOURCES

Joining ACA gives you access to our library of resources, papers, and material expertise to assist your business and further your career. The ACA sends out weekly newsletters, social media updates, and one-off packages about news and events to keep members informed. Members also have the option to promote their own people and initiatives through our updates. The ACA has accrued over 2,000 case studies, research papers, technical articles, presentations and more covering a range of subjects written by some of the most respected industry experts. Members can also access papers, publications and seminars from the European Federation of Corrosion.

COMMUNITY

ACA is committed to building an active, engaged, and passionate membership. Networking is both online and in-person; meet people online through seminars, discuss the future of corrosion with your peers at a convention, and join the AGM and other Branch events. Join one of the ACA Committees to become more involved, learn new skills, and access career opportunities with some of the most ambitious and connected in the industry. The ACA acts as your voice and representation; we engage with governmental organisations, other non-for-profits, big business, and others to get the best outcomes for our industry and our Membership. Members can use our Corrosion Control Directory to contact the best industry person to meet your needs or ask your questions.

RECOGNITION

Get involved in the ACA's scholarship program and picking up new skills through the Association's direct financial and administrative support. Obtain certification as either a Corrosion Technician or Corrosion Technologist to receive extended public recognition for your qualifications. Use ACA's logo to demonstrate your qualification. Sign into ACA's website, build your personal profile, and connect with likeminded peers within the corrosion industry.

MEMBER BENEFITS

Membership Benefit	Diamond	Platinum	Gold	Silver	Bronze	Individual
Number of Corporate Delegates accessing benefits (Delegates receive the same benefits as individual members)	30	12	8	5	3	1
Additional Young Corrosion Group (YCG) Delegates YCG Delegates receive the same benefits as individual members. YCG should be students or in early stage of their corrosion career (under 35 years)	Unlimited	10	5	3	2	✗
Join our Technical Groups Applicators Technical Group, Cathodic Protection Technical Group, Coatings Technical Group, Concrete Structures & Buildings Technical Group, Oil & Gas Technical Group, Young Corrosion Group, Water Industry Group.	✓	✓	✓	✓	✓	✓
Discounted prices for Training, Events and Conference attendance for Delegates Upskill with member prices on ACA and AMPP Training Courses, ACA events and our Annual Corrosion and Prevention Conference	✓	✓	✓	✓	✓	✓
Access to our online Corrosion & Materials Journal (Quarterly) Receive four (4) online issues of the Corrosion & Materials Journal for all members, featuring technical articles, latest news, new products, and industry events.	✓	✓	✓	✓	✓	✓
Access to Exclusive ACA Member resources Over 4,500 Technical Papers, Webinar Recordings, 2,000 past ACA conference papers, recorded presentations from ACA events, past issues of Corrosion & Materials, technical articles, case studies and more.	✓	✓	✓	✓	✓	✓
Access to past Conference papers from the European Federation of Corrosion (EFC) congress & access to be appointed on Membership of EFC Working Groups	✓	✓	✓	✓	✓	✓
Access to local, Australia wide & New Zealand networking Branch & Technical Group events	✓	✓	✓	✓	✓	✓
NEW **Exclusive Membership Portal** Renew and pay your membership dues, download invoices, access ACA events and training, update your details, review past training or events, access the technical library, read C&M Journal, and, for corporate members, manage corporate membership. *NEW*	✓	✓	✓	✓	✓	✓
Entitlement to use the ACA Corporate Partner Logo on company's promotional material By submitting a Membership Application Form, you acknowledge that you have read and understood the ACA Terms & Conditions and agree with and consent to the practices described.	✓	✓	✓	✗	✗	✗
Free listing in the Corrosion Control Directory on the ACA website	✓	✓	✓	✗	✗	✗
Priority for annual Branch and Technical Group Sponsorship Opportunities	1st	2nd	2nd	3rd	3rd	✗
Acknowledgement at the Conference + Awards Dinner	1st	2nd	2nd	3rd	3rd	✗
Preferential Lead Service	1st	2nd	2nd	3rd	3rd	✗
Discounts on Advertising	✓	✓	✗	✗	✗	✗
Company Name, Logo and Website listed on Corporate Members Page Linked to your website.	✓	✓	✗	✗	✗	✗
Company Logo used on the homepage of the ACA website	✓	✗	✗	✗	✗	✗
One free advertorial on ACA website & feature in global mail out on sign-up	✓	✗	✗	✗	✗	✗
One annual special feature in Corrosion & Materials Journal	✓	✗	✗	✗	✗	✗