CORROSION

& Materials

Vol 46 No.4

STEEL & COATINGS INNOVATION

THE AUSTRALASIAN CORROSION ASSOCIATION INC.

Official Publication of The Australasian Corrosion Association Inc

Dear ACA Members,

I am delighted to advise that our project to change our governance structure to better reflect a contemporary association that operates across Australia and New Zealand, is quickly concluding.

As I write this message, we have a planned Town Hall meeting on 2 October to answer any questions or comments from our broader membership on any of the details of adopting the new constitution. This is after we have had in-depth discussions with the ACA Council and ACA Branches throughout the region.

On the 9 of November, we have scheduled a Special General for all members to join and vote for or against the proposed structure. The invitation for the Special General Meeting will be sent out to all active ACA members in October.

I would like to highlight to you the summaries that will help you be better informed of the changes are all located here: PAGS (Project to Align Governance to Structure) - The Australasian Corrosion Association Inc.

One of the key differences of our new structure is that all financial members of the ACA will be invited to vote for Board Directors if the new constitution is adopted. Instead of the ACA Council being the 'electoral college' for voting for Board Directors, the Council will play an active role in the Nominating Committee.

I am looking forward to seeing a lot of ACA members and colleagues at the Corrosion & Prevention Conference in Melbourne in November. Our conference is always a special event to reconnect directly with our corrosion community.

In the meantime, is you have any queries please contact me on kingsley.brown@corrosion.com.au

Kingsley Brown

ACA Board Chair

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Greetings Fellow Corrosionists,

I look forward to catching up with all of you in person at our Corrosion & Prevention 2025 Conference, being held at Marvel Stadium in Melbourne, between November 9th to the 13th. We have a jam packed 3 days of presentations relating to our theme of "Materials Protection for the Future". I heard that our Conference committee was inundated with abstracts, and the Exhibition stands were eagerly snapped up; who are now listed on the conference website. All of which reinforces the importance of this event on the both the Australasian and global stage.

The conference includes an Applicator Day on November 13th, which builds upon the Applicator and Coatings Roadshows that concluded in late July, in my hometown of Christchurch, New Zealand. The Roadshows were a roaring success with a combined total of over 250 attendees at the Sydney, Perth, Auckland and Christchurch events. The combination of technical presentations and live equipment demonstrations were well received, and I look forward to the Applicator Day which I am sure will be as informative and exciting.

In other news, our Constitution is in the final stages of its revision, having undergone a collective detailed review by the ACA Board, Centre and Council. On October 2nd, a Governance Structure Town Hall will provide an overview of the changes and a chance for you to consider these changes, with the aim to ratify the Constitution in Melbourne at the conference.

As mentioned above, I look forward to meeting with you in person and the chance to enjoy conference networking, the technical presentations and forums, and at the exhibitions to learn about the latest developments in our respective fields, in the world of corrosion.

Raed El Sarraf

ACA President.

CEO'S MESSAGE

Dear ACA Members

The momentum for the ACA Corrosion & Prevention Conference at the Marvel Stadium in Melbourne 9-13 November 2025, is really accelerating.

This is going to be a big conference in Melbourne. Last year we hosted the inaugural Confidential Asset Owner Session in Cairns, and this session along with a full day program will again be offered to Asset Owners in Melbourne. This is a free ticketed event for Monday 10 November for targeted asset owners. We are already receiving a very good response from invitations.

For all our regular conference goers, please book your accommodation as early as possible, as it is a very big week in Melbourne with multiple international music concerts and the Spring Racing Carnival. Please register for the conference at:

Corrosion & Prevention 2025

In late July we moved offices to 11 Roosevelt Street, Coburg North, Victoria 3058.

The team loves the newly renovated property with large windows for natural light and an open plan office layout. There is a large clean warehouse facility which has been set up to more effectively manage our training kits.

Kamil Kaya is our new Warehouse Coordinator, who replaces Steven Tran. Kamil is an experienced warehouse and logistics professional who is interested to learn more about corrosion and the technical aspects of our training. Kamil was also a sea captain in his previous career, so he has seen the impacts of corrosion in the maritime environment.

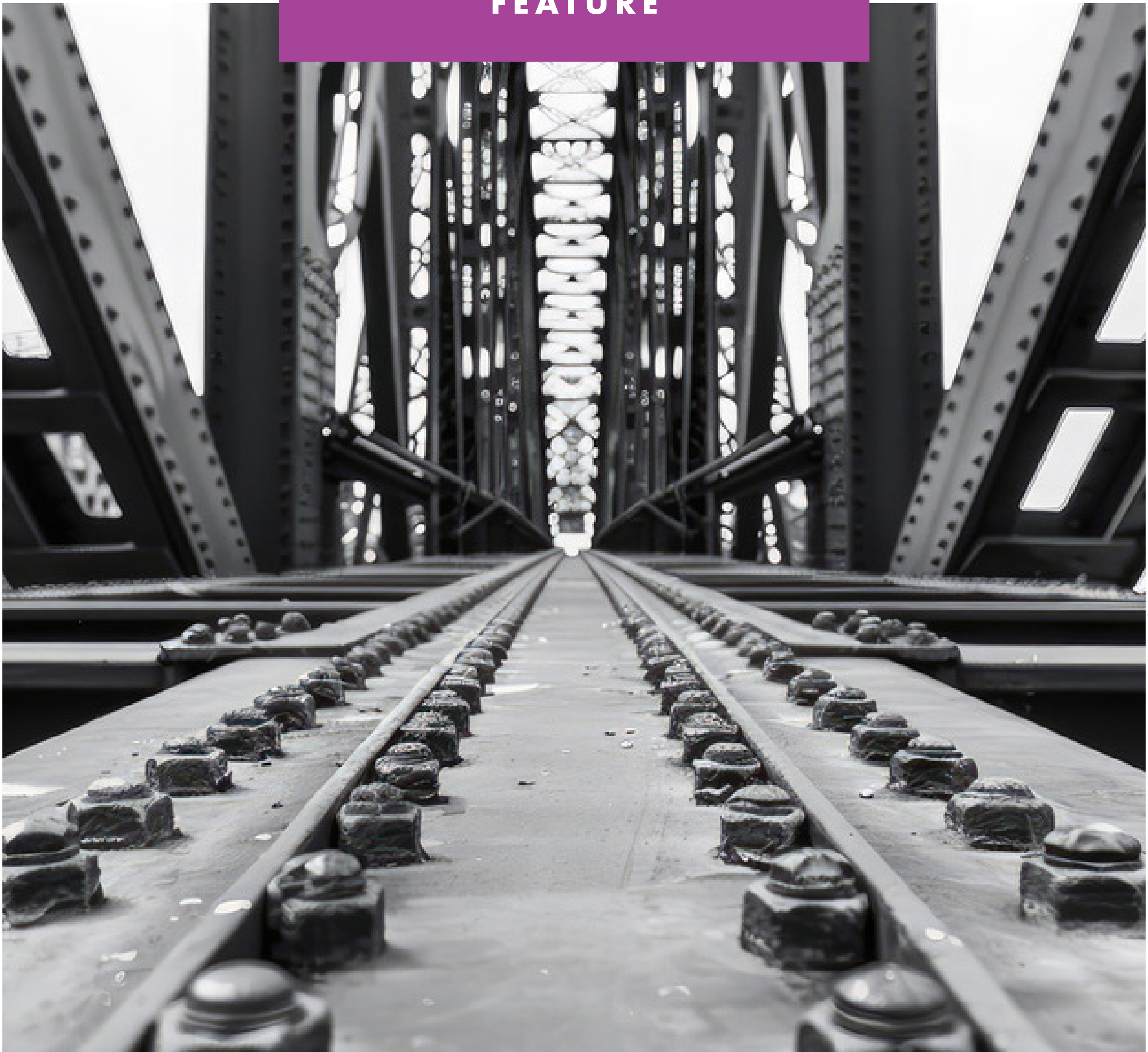
Unfortunately, we don't have training facilities at our new office. We are on the hunt for new large and convenient training rooms in Melbourne (at least 120 square metres) if any members have suggestions for excellent facilities (or corporate training rooms) at reasonable prices. The key considerations include: early access to the facilities (from 7.30am in the morning); secure storage of our training equipment; access to good catering; accommodation nearby for visiting instructors; and potential parking nearby for up to 24 students.

If you have any suggestions on training facilities, please get in touch at maree.tetlow@corrosion.com.au

All the best

Maree Tetlow

ACA CEO



People Power in Corrosion Management – Training, Communication, and Continuous Improvement

By Masoud Mike Dehghan –
Operations Director, Mechanical Integrity Engineering Services

Introduction

Throughout this series, we've explored the technical facets of corrosion management, from policy development to risk assessment and mitigation strategies. However, the effectiveness of these technical measures is significantly influenced by human and organizational factors. This final article delves into the essential roles of Training and Competency, Communication and Reporting, and Continuous Improvement in establishing a resilient corrosion management framework.

Training and Competency – Building Expertise

A well-trained and competent workforce is the cornerstone of effective corrosion management. Ensuring that personnel possess the necessary knowledge and skills to identify, assess, and mitigate corrosion risks is vital for maintaining asset integrity.

Key Aspects:

- **Structured Training Programs:** Implement comprehensive training courses covering corrosion fundamentals, inspection techniques, and mitigation methods
- **Certification and Accreditation:** Encourage personnel to obtain industry-recognized certifications to validate their expertise
- **Continuous Learning:** Promote ongoing education to keep up with evolving technologies and best practices.

Case Study: Enhancing Competency through Training

A South African oil and gas company recognized gaps in their corrosion management practices due to limited staff competency. By critically assessing their workforce capabilities, they identified the need for more robust training and competency frameworks. Recommendations included structured training programs, certified professional development, and formalized corrosion management procedures to improve outcomes. Strengthening personnel expertise was seen as a key step towards better asset reliability and operational safety.

Reference: Njomane L & Telukdarie A. "Corrosion Management: A Case Study on South African Oil and Gas Company." Proceedings of the 2nd European International Conference on Industrial Engineering and Operations Management, Paris, 2018

Communication and Reporting – Facilitating Information Flow

Effective communication and reporting mechanisms are crucial for timely decision-making and coordinated responses to corrosion-related challenges.

Key Aspects:

- **Transparent Reporting Systems:** Establish clear protocols for documenting and sharing inspection findings and maintenance activities
- **Interdepartmental Collaboration:** Encourage collaboration between engineering, operations, and maintenance teams to ensure a unified approach to corrosion management
- **Feedback Loops:** Implement systems that allow for feedback and continuous improvement based on reported data.

Case Study: Improving Communication Channels

An energy sector company identified that poor communication between departments led to delayed responses to corrosion issues. By developing integrated reporting systems and regular interdepartmental meetings, they improved information flow, resulting in more proactive maintenance and reduced downtime.

Reference: www.icorr.org/wp-content/uploads/2024/08/Reviewing-Several-Corrosion-Management-Cases_Ali-Morshed-ACF-27-08-24-Aberdeen.pdf

Furthermore, Shell has implemented digitalisation and artificial intelligence to gather and process data from equipment, improving analysis and reporting. This enables remote support and allows for quick action in unsafe situations.

Reference: Shell Global. "Safety." Retrieved from https://www.shell.com/sustainability/safety.html

Continuous Improvement – Evolving Practices for Better Outcomes

Continuous improvement involves regularly evaluating and enhancing corrosion management practices to adapt to new challenges and technologies.

Key Aspects:

- **Performance Monitoring:** Track key performance indicators (KPIs) to assess the effectiveness of corrosion control measures
- **Regular Audits and Reviews:** Conduct periodic assessments to identify areas for improvement
- **Incorporating Innovations:** Adopt new technologies and methodologies to enhance corrosion detection and prevention.

Case Study: Implementing a Continuous Improvement Framework

A gas production offshore platform in the Mediterranean Sea faced recurring corrosion issues. By establishing a comprehensive corrosion inspection and maintenance anomaly management system, they created a feedback loop that facilitated continuous improvement, leading to a significant reduction in corrosion-related incidents.

Reference: https://doi.org/10.3390/ASEC2021-11153.

Comprehensive Summary: The Corrosion Management Framework

Over the course of this series, we've outlined a holistic approach to corrosion management, encompassing the following elements:

1. **Policy and Leadership:** Establishing a clear vision and commitment from top management to prioritize corrosion control.
2. **Planning:** Developing strategic plans that integrate corrosion management into the overall asset management framework.
3. **Data Gathering and Analysis:** Collecting and interpreting data to inform decision-making processes.
4. **Inspection and Monitoring:** Implementing regular inspections and monitoring systems to detect corrosion early.
5. **Risk Assessment:** Evaluating the likelihood and consequences of corrosion to prioritize mitigation efforts based on criticality.
6. **Mitigation and Repair:** Applying appropriate techniques—ranging from coatings and cathodic protection to advanced alloy cladding and composite wraps—to prevent or address corrosion damage.
7. **Training and Competency:** Ensuring personnel are equipped with the necessary skills and certifications to identify, assess, and respond to corrosion threats.
8. **Communication and Reporting:** Establishing transparent, collaborative channels that enable efficient information sharing across departments and disciplines.
9. **Continuous Improvement:** Using audits, performance monitoring, and new technologies to evolve corrosion practices over time and maintain long-term effectiveness.

By integrating these elements, organisations can develop a robust corrosion management system that not only protects assets but also enhances safety, compliance, and operational efficiency.

Conclusion

Corrosion management is a multifaceted discipline that extends beyond technical solutions to encompass human and organizational factors. By investing in training, fostering open communication, and committing to continuous improvement, organizations can build a resilient framework that effectively mitigates corrosion risks.

This comprehensive approach not only protects physical assets but also enhances operational safety, environmental stewardship, and long-term sustainability. As corrosion challenges continue to evolve, so too must the strategies used to combat them—ensuring that industry remains one step ahead of this silent threat.

Corrosion Case Studies Starting with Stainless Steels

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Keywords:

stainless steel, unexpected failures, sulphuric

Abstract:

This paper starts with two case studies about longitudinal cracking of a carbon steel heating element and then considers what should be well known – the appropriate materials for concentrated sulphuric acid. It then considers 7 notionally simple corrosion problems with stainless steel, viz: nitric acid attack on 304, crevices and chlorides, the effect of sulphide inclusions, surface roughness effect on corrosion resistance, when galvanized strapping is a poor choice, a few words about recognising microbial corrosion and finally the effect of two separate errors, one a simple connection error delivering an aluminium corrosion rate of 3.7m/year and the second an untested modifications of a known coating system.

1. INTRODUCTION

Corrosion is recognised as an inter-disciplinary specialisation encompassing materials, chemical processes, physical and chemical investigation techniques and even biological activity. This means that failures due to corrosion may be initially assessed by persons with fairly narrow expertise in plant design and operation. This limits their capacity to recognise weak points in design or operation and resolve critical issues for specific materials although the root cause may be well recognized in the corrosion literature.

The first major failure is of longitudinal cracking of heating water pipes in a process cleaning plant. The second is leaks at a concentrated sulphuric acid delivery farm due to poor material and design decisions. A third significant example is the rapid corrosion failure of stainless steel vessels in a counter current scrubber/reclaimer apparently when a decision was made to change the process flow and reclaim the process waters, i.e. only benign water to be discharged. Several examples are also presented of stainless steel failures occurring because of the mystique of stainless steel where its resistance to chlorides and/or chlorine are significantly overestimated especially in the presence of crevices. These include an inhibitor manufacturer who used a solid product which was dissolved in hot nitric acid and the fumes rapidly attacked 304, attack of a roll grooved coupling of 316 groundwater pumping lines, screwed fittings in seawater plus soft and/or oversize gaskets in flanged couplings. This is followed by 4 examples of specific corrosion/failures. Firstly, the consequences of contact between zinc and stainless steel at elevated temperature are considered – along with the adopted solution. The second is a very brief interlude on testing techniques to assess the presence of (mainly) SRB in corrosion failures – rather than fall back on "the cause is not obvious so it must be microbial." The penultimate error is the result of collecting the wrong chemical in an aluminium tanker. And finally, the unfortunate consequences of an on-the-fly modifications to a proven coating system to speed production.

Cracking of Carbon Steel Heating Pipes

Introduction

A contract powder coating business operated with a process line including an overhead spray wash/primer treatment above a recycling collection bath. The re-circulating fluid was heated to about 60°C by a grid of 2"schedule 40 carbon steel pipes as shown in Figure 1. The pipes contained hot water at 1.05MPa and between 140°C to 160°C. The process fluid was alkaline and caused significant scaling on the pipes. It contained a proprietary formulation based on zinc and nickel phosphate and nitrate with a fluoride activator. It was pumped from the 10.6kL stainless steel rectangular tank through the overhead sprayers at a rate of 3.5kL/min. The pipes were washed every 4 to 6 weeks and descaled using inhibited 40°C hydrochloric acid once a year for 4 or 5 hours.

After approximately 13 months operation, longitudinal cracks appeared in the pipes which allowed boiler water to dilute the process fluid. This lost process fluid, cost dollars and also significantly slowed production with time lost replacing pipes. A consultant looked at some cracked samples and, after examination, suggested a hydrogen cracking mechanism and remedial treatment – which was not implemented. The cracking continued and required further investigation.

Investigation: Metallurgical

Several 2" cracked pipe samples were collected during a site visit and Figures 2 A and B show the deposited scale and longitudinal cracks – but none that were circumferential. The scale was layered but the initial layer was quite adherent as indicated by the variation in coverage and layer splitting seen in Figure 2. A section was carefully abraded to remove the scale but no obvious pitting was observed. Figure 3 shows the interior of a split pipe sample with one longitudinal crack in the top section only.

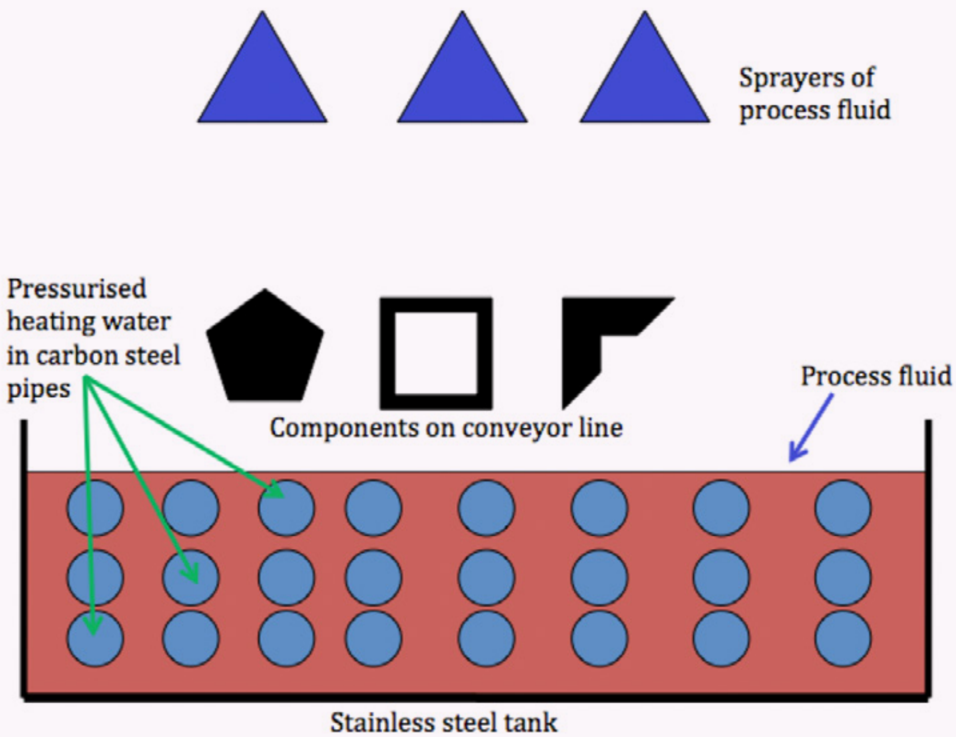

Figure 1: Layout of spray bath and heating pipes

Figure 2 A & B: Pipe with only longitudinal cracks and layered scale

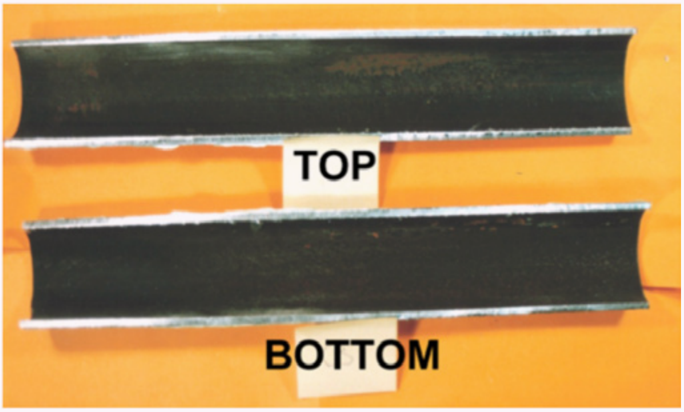

Figure 3: Split section of pipe with magnetite scale from boiler water plus some post removal rust

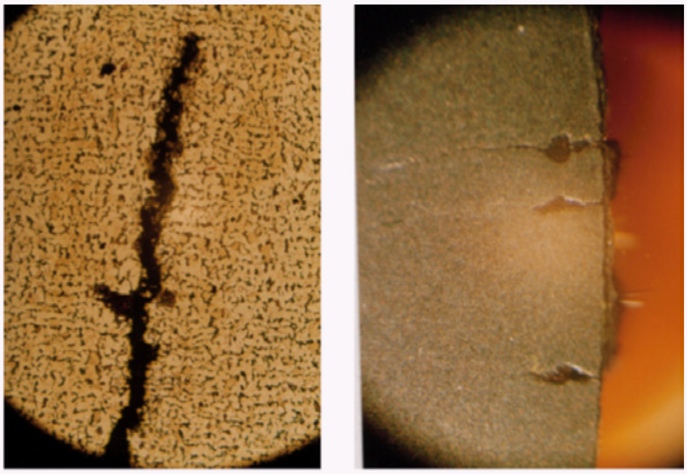

Figure 4 A & B: Cracks in typical carbon steel microstructure

Cross sections were taken, polished and etched with Nital prior to magnified examination as shown in Figures 4A and 4B. The arc on the right in Figure 4B is the outer surface of the 2" pipe diameter – note the "bulbs" in the cracks all about the same depth into the crack.

Investigation: Mechanical and Chemical

Spectrographic chemical analysis found: carbon 0.18%, manganese 0.43%, silicon 0.21%, phosphorous 0.018%, chromium 0.05%, nickel 0.02%, aluminium 0.005% and sulphur, molybdenum and copper <0.01%, i.e. an unremarkable carbon steel.

Tensile and hardness tests were carried out on two samples. Results are shown in Table 1.

Test	Values
0.2% yield stress (MPa)	339, 351: average 345
Tensile strength (MPa)	487, 485: average 486
Elongation (%)	28, 28: average 28
Hardness (HV10)	134 SD = 4: corresponding to a UTS ~ 437 MPa [vs. actual 486]

Table 1: Mechanical tests on carbon steel pipe

Discussion: Cause of cracking

The elongation at fracture and hardness are not consistent with hydrogen cracking.

The bulbs in the cracks are presumably from exposure to the inhibited hydrochloric acid wash (which provides a time scale for crack growth). The bulb occurs because the inhibitor at the base of the crack is exhausted during the 4 or 5 hours of the descale process.

The strength and chemistry and observed microstructure (Figure 4A) are consistent with low carbon steel.

There were no obvious pits in the (admittedly small) area examined so that is not a stress concentration mechanism. However, there are multiple crack starts (Figure 4B) and relatively few that progressed to failure. These are clear indications that there has been cyclic stress and corrosion fatigue.

The orientation of the crack growth shows that the stress overload is circumferential, i.e. a hoop stress.

However, the boiler water pressure is 1.05MPa and for a schedule 40 pipe with nominal 2” OD, the standard calculation of hoop stress by (Pressure*External radius)/(Wall thickness) gives ~8MPa which is much too low to give a significant fraction of the 0.2% yield stress, i.e. it is not the source of the fatigue failure. In addition, the stress change during daily operation is not very cyclic anyway. Further, standard design tables show that from ambient (25°C) to 160°C, there is minimal change in design strength for carbon steel.

Deeper analysis using the formulations of Roark (1), considered the cantilevered load between the water pipe supports, i.e. the pipe weight causing elliptical distortion, gave ~50MPa outer fibre stress which is still a small fraction of the 0.2% yield stress. Also, the pipe did not seem distorted and a cantilever would not cause the longitudinal cracks observed. It is also not obvious why the pipe load would vary even with routine draining of the pipe. And finally, draining a heating pipe makes no corrosion sense as it would almost certainly cause internal oxygen corrosion issues.

However, investigation of the volume of fluid in transit compared to the tank volume showed that about a third of their solution would be in circulation and that would cause most of the top row to be exposed. It is not unreasonable to assume that a sprayed solution would cool from the circulated 60°C to about 30°C when it hits the pipe wall at (say) midpoint of circulation temperature, i.e. 150°C. This gives a through wall change of 120°C across a 4mm wall. Roark (1) gives ~190 MPa thermal stress which is more than 50% of 0.2% yield stress and it varies, i.e. it provides cyclic thermal stress for fatigue cracks to grow from the surface defects in a standard pipe finish. Hence, normal operation would provide a significant cyclic hoop stress and cause the corrosion fatigue failures.

Possible remedial actions

- Heat the solution to reduce the ΔT? No, because of the risk of exceeding 60°C and with halide in the solution, it is possible the stainless tank would suffer stress corrosion cracking. There would also be significant water loss by evaporation changing the solution concentration.
- Drop the boiler water temperature? Doubtful that sufficient temperature drop could be achieved but it is precluded because of loss of heating speed and efficiency.
- Reduce pump circulation so pipes are always covered? No, this would significantly slow production.
- Add 100mm freeboard to the stainless tank so pipes are always covered?

The last suggestion was adopted and ran satisfactorily for 17 years until the factory was decommissioned.

Storage of Concentrated Sulphuric Acid

Introduction

Concentrated sulphuric acid (>98%) is one of the most widely used chemicals for industry. It is unsurprising that there are multitudes of publications on materials for containment and handling including standards/codes by NACE - renamed AMPP (2) - and MTI (3). Understandably, there are significant storage and distribution facilities to supply acid.

A major sulphuric acid distribution facility was constructed at an offshore tropical port using carbon steel pipework and tanks. Within 1 year there were leaks in a 65DN S80 pipe which were adjacent to a truck loading pump designed to deliver 80 m^3/hour from a 150DN header. Understandably, the client wanted to know if there was a design or operational issue and regardless, what was the extent of the rectification possible.

Investigation

A simple calculation from throughput and internal diameter showed the laminar flow velocity was ~1.3m/sec in the 150DN header and 8.1m/sec in the 65DN pipe. Both velocities substantially exceed the ambient temperature limit of 0.9m/s for carbon steel and points to a limited life with laminar flow. However, the rapid failure also points to turbulence enhanced velocity adjacent to the pump as well as possible contributions from protruding weld beads, sharp radius elbows or misalignment of the pipe joins – these possible factors were not determined as a site visit was not possible.

Another possible accelerating factor is higher tropical temperature compared to an assumed 25°C ambient with a nominal acceleration of X2 per 10°C rise. Published data shows that with 98% acid, carbon steel would corrode at ~0.13mm/year at 25°C or, if exposed to direct, wind sheltered sun at 50°C, a generally unacceptable rate of 0.5mm/year. Concentration variations between 99.5% and 95% are nominally reasonable although the lower concentration is marginal. However, the localisation adjacent to the pump outlet indicates that it was local shear effects and not temperature that was the major factor in the scouring of the nominally protective but friable ferrous sulphate film. One positive feature was that photographs showed the pump was sheltered from the sun so local solar radiation on the pump and adjacent pipe were not considered to be a factor. Since the metal loss was general, the client was advised that ultrasonic testing should be concentrated immediately downstream of pumps, welds, tees or sharp elbows.

Because of concerns about the design and installation, standard dehumidification measures were emphasised including effective humidity traps on vents and measures to ensure pipework remained full of concentrated acid or, if they were drained, they were purged with dry air or nitrogen and sealed. External white painting was also recommended to avoid solar heating with the risk of thermal circulation and hydrogen bubble grooving.

Alternative materials were also canvassed for the client. Austenitic stainless steels such as 304L and 316L are widely used for sulphuric acid between 95% and 99.5% at ambient temperatures and moderate velocities. Table 2 (3) shows laboratory corrosion rate data (in mm/yr) for pure acid without abrasive particles with 304 or 316 at 93.2% and 99.3% concentration and for both 46°C and 79°C.

Concentration	*93.2%*				*99.3%*	
Temperature °C	*46°*		*79°*		*79°*	
Grade / velocity	*304*	*316*	*304*	*316*	*304*	*316*
1.5m/s	<0.03	<0.03	<0.1	<0.08	0.15	0.05
4.5m/s	<0.03	<0.03	<0.15	<0.01	0.15	0.05
10.7m/s	<0.03	<0.03	1.9	0.1	0.15	0.08

Table 2: Laboratory corrosion tests with sulphuric acid on 304 and 316 (3)

It is conventional to select low carbon (L) or dual certified grades to permit welding of thick wall pipework without risk of sensitisation, i.e. chromium carbide precipitation, which could cause accelerated attack at elevated temperatures. There is minimal price differential between low and standard carbon grades although the low carbon grade has slightly lower guaranteed minimum 0.2% "yield" strength. In ambient pressure pipework, this is not normally a problem.

In a tropical marine environment, both 304L and 316L would require some maintenance, i.e. wash down with water, to avoid rust stains (tea staining) but 304 would suffer much worse staining and would require more frequent washing. If the pipework was painted white to minimise solar heating, then 304L would be acceptable as the paint would provide the external corrosion protection. However, if the pipework is painted, mechanical damage to the paintwork would require routine rectification on an on-going basis. Even in the absence of mechanical damage, the aesthetic degradation from UV and other environmental factors would require recoating after 10 to 15 years. Note that if the surface temperature of the pipe reaches 60°C routinely (as in the Middle East), then regardless of whether it is 304L or 316L, the pipework should be painted to exclude chlorides and mitigate the risk of chloride induced external stress corrosion cracking from residual stress zones such as welds.

Scrubber to Recover Nitric Acid from Process Exhaust

Introduction

A manufacturer of an inhibitor treatment had operated their 304 stainless production line reasonably successfully for about 10 years using the country town water supply. The chloride level was below the 200ppm recommended for 304 and they cleaned up the process waste to the discharge levels required by the EPA. Because of increasing water charges they decided to concentrate on recycling their waste with an ill defined target of about 20% of input. There were some teething issues but the process seemed satisfactory. Then some alterations were required in the tankage and subsequent

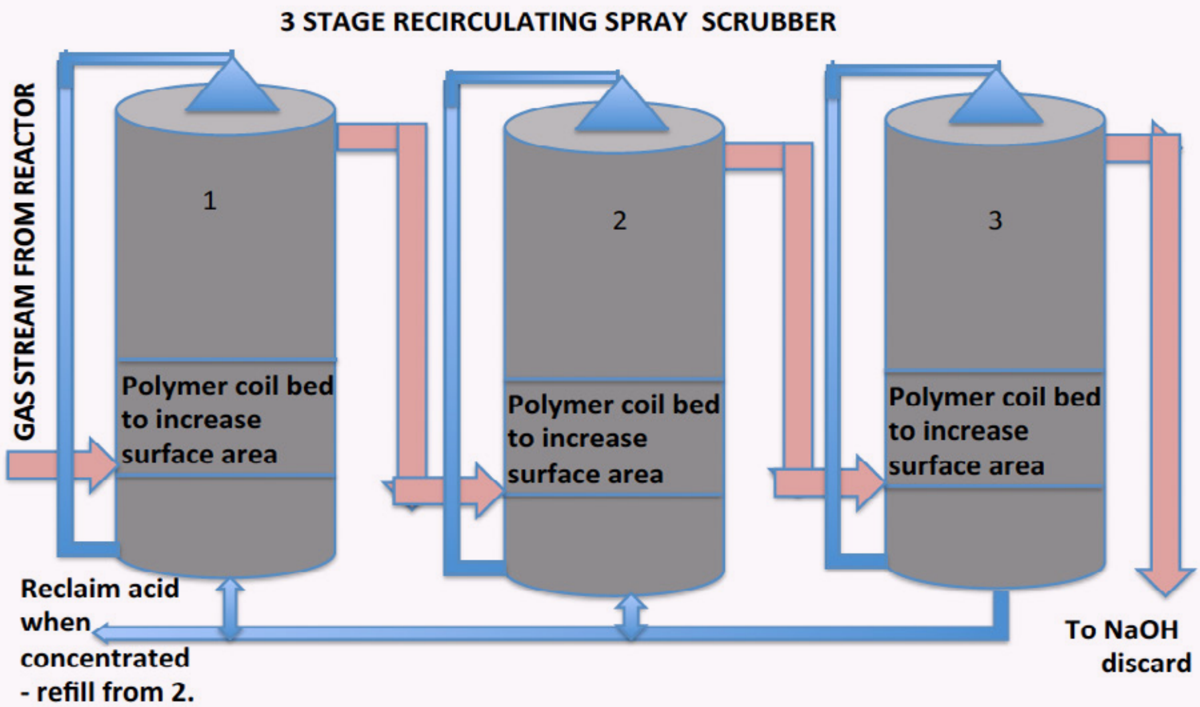

Figure 5: Three in series scrubbing tanks with acid concentration increasing from tank 3 to tank 1.

Figure 6A: Exterior of perforated scrubber vessel

Figure 6B: Interior of discarded tank with perforations and erosion markings

corrosion caused some leaks after the fluid in the nitric acid scrubber line turned green and holes developed in a new tank within weeks. At that point they asked for advice.

Investigation

The process is shown in Figure 5. It is a countercurrent gas and scrubbing fluid through several stages with each stage recirculating from the basin to the top spray as shown in the diagram. The flow rate was such that the recirculating flow in each vessel is about X3 the gas stream flow, i.e. scrubbing was quite effective according to their waste stream pH data. Discussion revealed that when replacing tank or pipework, there was no pickling of welds nor abrasion to remove heat tint. When the nitric acid level in vessel 1 reached the trigger level, it was isolated and the acid was pumped to process storage and the vessels refilled from later stages.

Figure 6A shows an external view with multiple perforations generally associated with welds while Figure 6B illustrates the interior surface of a tank discarded because of leaks. The wear patterns suggested some abrasion was occurring and it transpired that collecting the site water included some sand and hence there appeared to be erosion as well as the corrosion shown by the green colour and the perforations.

Discussion: Cause of Rapid Attack/ Remedial Actions

The extremely rapid attack was unexpected in a nominally oxidising circulating environment with nominally nitric acid as the process fluid even with some levels of chloride. It prompted thought of auto-catalytic attack by hot nitric acid - but the concentration was too low – and even brief consideration of trans-passive breakdown. However, the lack of post weld passivation treatment was regarded as a significant issue and lead to NTIS work (4) on the effect of chromium content on nitric acid attack on stainless steel as seen in Figure 7.

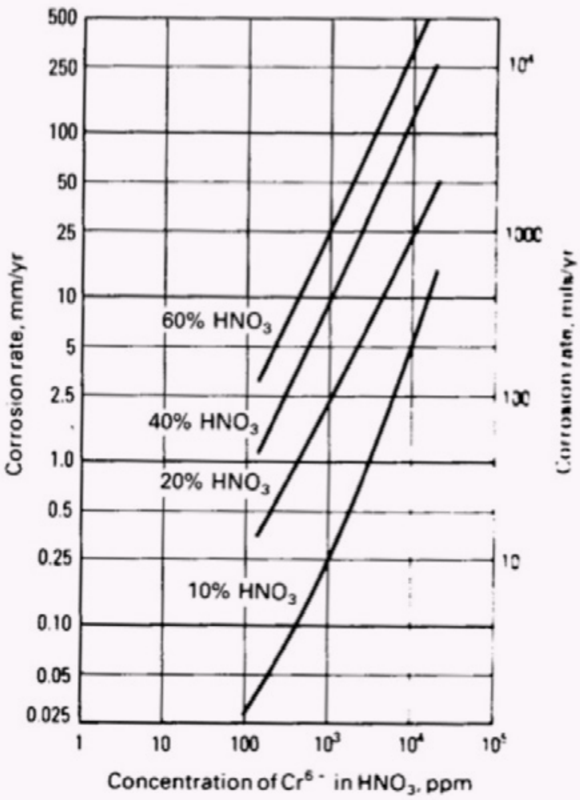

Figure 7: Corrosion rate stainless steel with Cr6+ and HNO_3 concentration (4)

In the oxidising environment, it is expected that any dissolved chromium will be in the 6+ valence state. The initial source of chromium was assumed to be the heat tint left from fabrication and any iron dissolved from the heat tint would presumably be in the Fe^{3+} state but is not a significant contributor to the attack rate.

Recommended remedial actions included pickling welded areas, passivating all wetted areas prior to commissioning and periodic monitoring of chloride and chromium levels at the inlet of the scrubbing fluid to the process vessels. While it is a secondary issue, controlling the particulate matter (apparently sand) in the scrubbing fluid would also be desirable to minimise wear of the relatively soft 304 stainless steel.

Crevices and Stainless Steels

Introduction

Unsurprisingly, crevices are the first location of corrosion initiation in fabrications especially in stainless steel. In tests with oxygenated chloride containing waters, crevices will initiate corrosion up to 30°C lower then pits will form on an open surface. (5) A detailed, illustrated discussion of crevices is given by ASSDA. (6) The first example below illustrates the blind faith of many in the corrosion resistance of stainless steels. The other two show how excessively soft gasket materials will substantially increase the corrosivity of the fluid in a tight crevice.

High Chlorides and Crevice Corrosion

Rolled groove pipework is routinely used in buildings because it is light and easy to assemble (and remove)

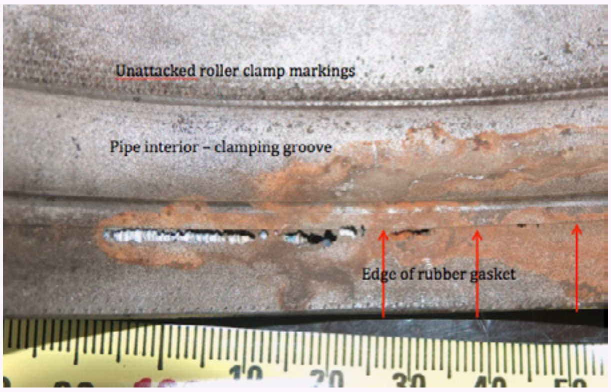

Fig 8: 1 year underground exposure of rubber end seal of rolled joint 316L pipe in saline groundwater: Ph8, chloride 7000ppm <10ppm Mn^{2+}

in building installations. The groove is rolled on stock sizes or, quite commonly, cut and grooved on site. The hatched appearance above is caused by the clamping rollers and, despite the surface damage, there is no initiation of corrosion. The water seal is achieved by a rubber gasket pushed about 10mm onto the pipe end and then two pipes are clamped externally. The line of holes are corrosion along the open crevice internal mouth of the sealing gasket . The pipe exterior at the gasket edge was not attacked. The obvious solution to this attack was to substitute a super duplex or even, given the slightly alkaline pH, a standard 2205 - with a notional chloride limit of 3,600ppm at pH7 in the absence of significant oxidising metal ions. An alternative, less durable, suggestion was heavy hot dipped galvanized.

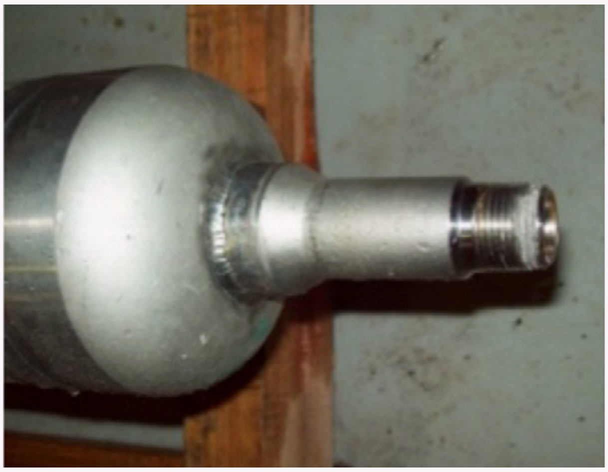

Fig 9: PTFE tape sealing (and corroding) 2507 Super duplex in seawater

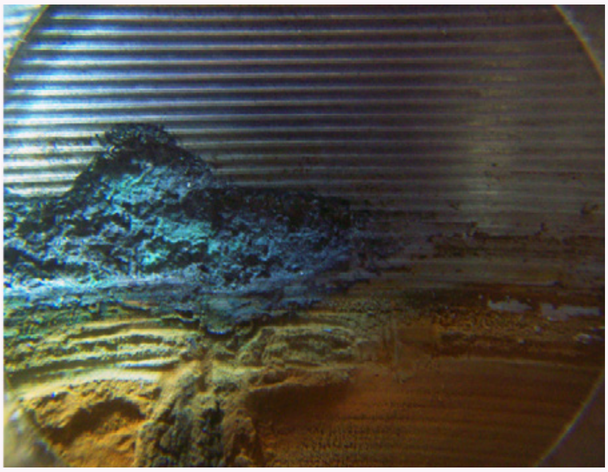

Fig 10: Unfilled PTFE and gramaphone 2507 face after 10 months in seawater – circle is 30mm diameter

Figures 9 and 10 show the effect of seawater on super duplex if the contact is in a tight crevice. The tape seal connection caused some excitement when an air scour valve which was screwed into a pressurised header, let go and launched about 500m into the air. No injuries or damage (apart from the hole in the roof) but an example of how aggressive tight crevices can be.

There is a related issue with elastomeric, thick gaskets between flanges. This is that, if the gasket protrudes into a water stream, there will be a very tight crevice at the boundary between the gasket compressed by the edge of the flange and the freely expanded protrusion into the fluid stream. In high chloride waters this provides an ideal location for crevice attack while in raw, unchlorinated waters, this crevice provides a stable microbial colonisation location especially if some ferrous corrosion product is present.

Unwanted Precipitates Such As Manganese Sulphide

Introduction

In carbon and stainless steels, there are both manganese and sulphur and, depending on the cooling rate, it precipitates as various sizes of manganese sulphide (MnS). This has two effects. Around the precipitate some chromium diffuses into the zero chromium precipitate and causes a ring of lower chromium available for oxide formation. This is similar to the carbide sensitisation effect – although carbides take up to 4:1 chromium atoms: carbon atom compared to 1:1 for sulphur. The second effect is that MnS is conductive and so can act as a local cathode to drive multiple initial corrosion sites. Argon Oxygen Decarburisation (AOD) allows extremely low sulphur although not with product forms (generally bar) intended for machining. The standard austenitic limit is 0.03% sulphur although sheet may be 0.001% and bar may be up to ~0.02% for ease of machinability.

Effect of Various Sulphide Levels

Figure 11 [7] shows the effect of changing sulphur levels on the susceptibility to corrosion after the same surface preparation. It demonstrates that the same sulphide effect can occur from low chromium austenitics to high chromium super austenitic alloys, i.e. the low sulphur levels typical of sheet are not as

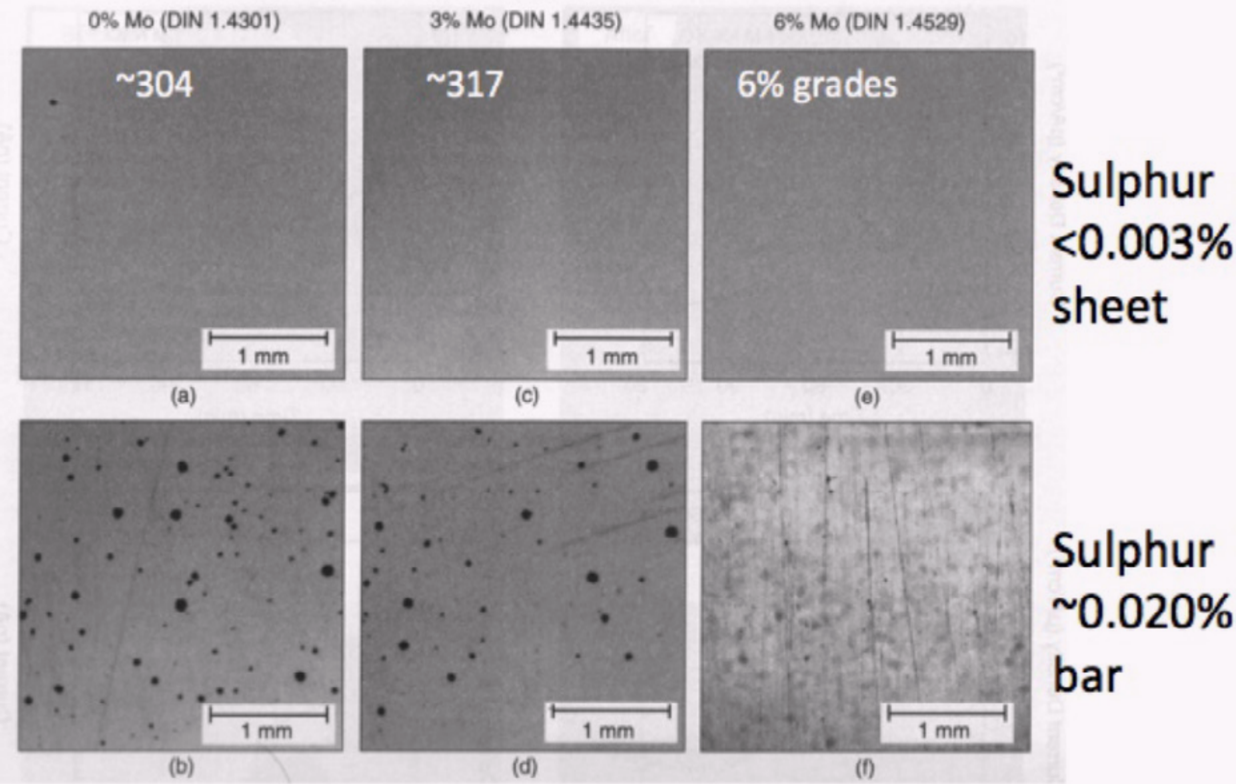

Fig 11: Low change in sulphur print (Mn precipitates) with corrosion resistance (7)

susceptible to corrosion as bar stock, quite apart from the post anneal pickling that is applied to cold rolled 2B sheet.

As pointed out by Sedriks [8], machining or abrasive polishing across the rolling direction for sheet or plate will (as shown in figure 12) intersect more elongated stringers and provide more initiation points for corrosion unless the surface was acid passivated after the mechanical treatment.

At a practical level, if including posts in bar product (with high sulphur to ease machining) and rectangular hollow section (RHS) of cold rolled sheet (low sulphur), it is critical to passivate both as otherwise, as seen in Figure 13, the bar product will rust stain – unless it is very regularly washed. The bar (left of Figure 13) also appears to have suffered the common preferential end grain attack.

Note that the Pitting Resistance Equivalent (PRE) ranking tool for stainless steel does NOT include sulphur although acid passivation treatments will remove the corrosion initiating inclusions as it also improves the Cr:Fe ratio on the open surface and hence raises corrosion resistance.

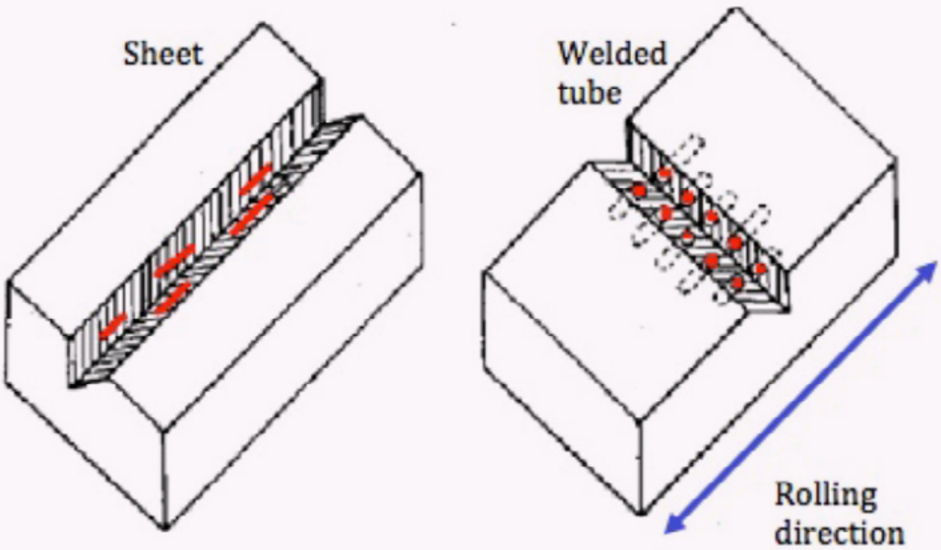

Fig 12: More initiation sites - polishing across rolling (8)

Figure 13: Contrast high sulphur (left) and low sulphur (right) with similar washing after one year but no prior pickling

Abrasive Finishing and Corrosion Resistance

Introduction

The improvement of corrosion resistance of stainless steels is inherently recognized when comparing the superior performance of a mirror polished finish to a mechanically abraded surface. However, it was only relatively recently codified by a 2K finish (EN 10088.2) with a transverse roughness of no more than 0.5µm R_a was recognized as significantly more resistant than a 2J finish and suitable for more aggressive environments. Because of the vagaries of lubrication, age of (and applied pressure to) the abrasive as well as its strength/hardness, the specified grit size is typically not codified. ASSDA [9] in its FAQ 6 has recommended 320 grit but other grit sizes are common. ASTM A480 [10] lists a series of abrasive finishes including #4 which equates to the EN standard 2J but does not link grit size to specific finishes even in non-mandatory notes. The often specified 0.8µm R_a is a cleanability requirement set by the US 3A [11] code where hygienic cleaning also serves the purpose of removing aggressive contaminants and hence improving corrosion resistance.

Tea staining

The browning and spots of corrosion product on stainless steels exposed to sea salts or aggressive industrial fumes look like the stains from spilt tea – hence the non-pejorative name. Atmospheric stainless steel corrosion is initially micrometres of metal loss in pits but, because iron is more than 70% of stainless steel and aged rust is dark brown, the label has spread – no pun intended. If tea staining is ignored, the surface will roughen and will eventually require repolishing to a smoother finish and hopefully better maintenance. Unless there was a significant error in specification, e.g., 304 specified for a critical finish in a marine atmosphere, refurbishment and tighter maintenance will usually provide excellent service.

Figure 14A illustrates the difference in corrosion resistance of 316 as cold rolled, annealed (and pickled) 2B compared to abraded #4 finish in a severe marine atmosphere and showing signs of abrasion related corrosion. The 2B finish is both smoother and has been chemically passivated during production compared to the abraded #4. Figure 14B shows the difference in roughness and corrosion resistance in a reasonably severe marine environment. Regular washing will help but the intervals can decrease with the lower levels of salt deposition.

While it is not recommended, light oils on stainless surfaces are used as a barrier to corrodents although they pickup grime and the shine is decreased. Interesting evidence of the beneficial effects of grease from human hand secretions can be seen on the bright top of abraded stainless posts in public transport entrances or the top rail of stainless safety railings beside marine staircases.

Finally, a passivating treatment is often

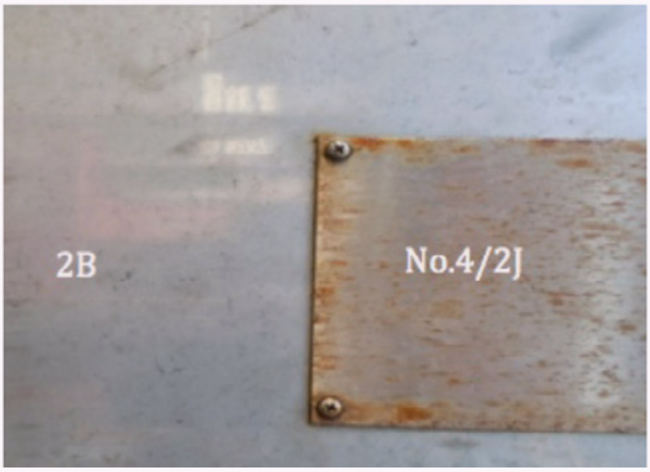

Fig14A: Cold rolled vs abraded: 2b smoother and pickled

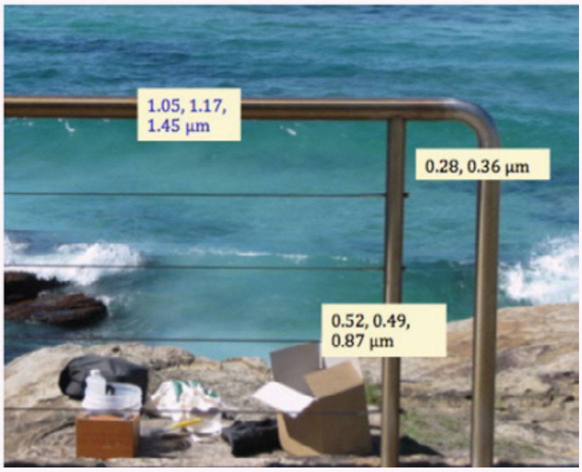

Fig14B: Smooth → mid → rough surfaces → worse recommended for very critical abraded applications although the acid concentration is generally left to the contractor – or a specifier – while the chemical treatment standards leave a wide range of concentration, temperature and time. This is presumably because of the wide variety of conditions encountered. The data in Figure 15 [12] illustrates that about 30% nitric acid offers the best result. Fortunately, this is about the concentration of nitric acid provided in many passivating pastes.

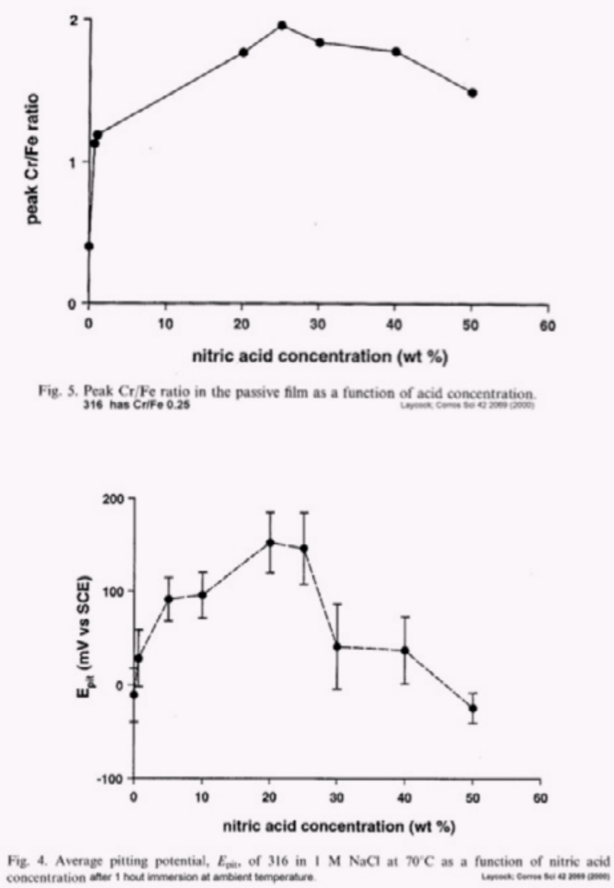

Figure 15: Degree of passivation by either Cr:Fe ratio in the surface or the pitting potential [12]

VIGNETTES OF SPECIFIC CORROSION PROCESSES

Liquid Metal Embrittlement

Introduction

The intergranular cracking of steels and stainless steels in contact with low melting point alloys has been known by corrosion scientists for well more than half a century (13). In the case of zinc and austenitic stainless steels, it is generally associated with welding an austenitic stainless steel to a plain steel that has either been galvanized or painted with a zinc rich primer. Weld procedures usually require removal of zinc (even for zinc fever avoidance when welding galvanized steel) although the poor mechanical removal of zinc in grooves is not always appreciated. Less well known is solid metal embrittlement at temperatures below zinc's melting point.

Investigation

The client operated induction bending equipment which was mainly used for stainless steel pipework. The items were mounted onto a stand which moved through the induction hoop and were heated locally to about 950°C, bent through the specified angle and then immediately quenched with a water spray.

They were supplied with a 250mm super austenitic 6% Mo pipe for a swept bend through 45 degrees. It was delivered tied to a timber skip by galvanized straps – having been told not to use carbon steel strapping. Apparently because of concerns about cracking following issues with bending carbon steels, the client required dye penetrant testing of the outside of the bend prior to acceptance.

The bend proceeded but, after testing there were multiple linear indications on the outside of the bend (Figure 16A). A sample was cut out including a significant crack. The crack was broken open and the fracture face was examined in a scanning electron microscope and analysed with a 25kV electron beam. The produced X-rays were analysed with the EDAX detector and provided the spectrum shown in Figure 16B. It has the expected Iron (Fe), Chromium (Cr), Nickel (Ni), Molybdenum (Mo) and Copper (Cu) of the 254 plus minor levels of expected Silicon, Calcium, Titanium - possibly from paint. However, there is a significant zinc peak showing that the fracture face has zinc deposited on it, i.e. there is no intercrystalline bonding once the zinc penetrates along the grain boundaries and the pipe cracked because of liquid metal embrittlement (LME) in tension zones.

This was an expensive ***Lesson Learnt*** but it led to a procedural change to require pickling of all austenitic alloys before they were induction bent even if they arrived tied down with polymeric straps.

Fig 16A: Cracks ringed

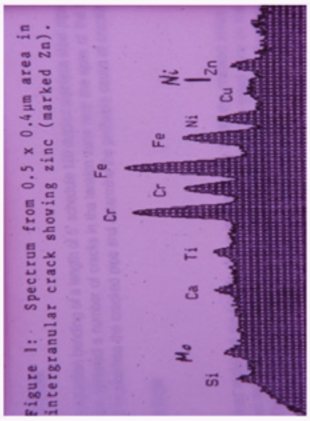

Fig 16B: EDAX spectrum: Zn peak evidence of LME

Is This Attack Due To Microbial Action?

Introduction

In recirculating cooling water circuits in buildings using cooling towers, it is not uncommon the find non-magnetic black sludge corrosion product over a bright (actively corroding) carbon steel surface under tubercules if the inhibitor/biocide treatment has not been sufficient to control attack. There is rarely sufficient black material for detailed chemical analysis and the "add a drop of HCl and sniff for rotten eggs" test is not prudent. The standard remedial treatment is revision of the biocide/ inhibitor treatment and, in more severe cases, a chemical descaling program followed by tighter, possibly automated, chemical control. If sulphur related MIC is suspected and there is an absence of specialist microbiological expertise, chemical analysis of corrosion product by fusion can be useful if supplemented by LECO combustion to determine concentration of carbon (from dead microbes) and sulphur (from sulphides). This methodology is also applicable for attack of stainless steels especially if there are heat affected areas. And the seductive "microbes grow exponentially" is not the only reason for very rapid attack.

However, it is not simply ferritic materials that are susceptible to microbial attack as there is strong evidence that stagnant water with near potable chemistry will corrode copper pipework if it is stagnant for extended periods without adequate levels of biocide – which is usually chlorine (14).

Investigation - Pipe

The water supply for a country town and its milk processing factory was a bore. The bore water was aerated, filtered and chlorinated before distribution to the town network including the factory on the opposite side of the town. It did not operate continuously. As part of compliance to Australian drinking water guidelines, the pH (8- 8.6), TDS (790-1000mg/L), hardness (140-190mg/L as $CaCO_3$) and chlorine (<0.1 – 1.0mg/L) were measured regularly at the supply outlet although there were undefined periods when the chlorine dosing (expected to be in the range 0.2 -0.5mg/L) was not operative.

The horizontal feed in the factory was a 1.6mm 150mm diameter spiral welded 316 pipe. It perforated within 12 months with large "fluffy" deposits along the circumferential weld. The line was drained and a sample was later cut out (Figure 17). There was no attack of the factory welded and pickled spiral weld. The nodules along the weld were hard and unlike the "fluffy" appearance when wet. Fusion analysis of the corrosion product shown in Table 3 indicates that a high silicon 316LSi was used as a consumable. There was significant heat tint either side of the weld indicating poor (or no) gas purging and (not shown) the root bead was quite uneven. There were short plumes of corrosion product on both sides of the weld indicating low flow rates. The Loss of Ignition is assumed to be primarily carbon and is high enough to be sourced from microbes rather than the carbonate hardness.

Fig 17: corrosion on untreated circ. weld but not on pickled spiral weld

Fig 18: Corrosion of circ. Weld in 316 tank with raw water - note rainbow heat tint (Boulton, Nickel Institute)

TABLE 3 CHEMICAL ANALYSIS OF FUSED CORROSION PRODUCT (%)						
Iron	Chromium	Nickel	Silicon	Calcium	Phosphorous	Ignition Loss
54	15	1	3.5	2	0.8	21

The ***Lessons Learnt*** by comparing the pristine spiral weld and the perforated circumferential weld is that heat tint must be controlled by inert gas purging or else pickling the welded area to remove heat tint. The latter option would have required flanged connections. The attack was too rapid for ambient temperature pitting without an accelerating factor which the analysis indicates was microbial activity initiating during periods with low levels of the chlorine biocide.

Investigation – Raw Water Storage Tank

Figure 18 shows a corroding section of a large circular raw water tank manufactured in stainless steel. The tank started to leak well within a year of fabrication while it was storing inlet raw water to a potable water treatment plant. There were sufficient leaks that jokes were made about the free shower for workers! It appears from the rainbow bands that there was no significant removal of the weld heat tint post welding which lead to rapid colonisation and corrosion. Wider images showed multiple corrosion product plumes both up and down as the water circulation changes from down during the cold nights and up in the warmer afternoons.

The ***Lessons Learnt*** are either strip polish and then passivate welds and, if the tank is not regularly circulated, ensure that the water is treated with biocide – which is generally a low dose of chlorine.

Did We Collect From The Correct Discharge Port?

A contract tanker was to collect waste brine from a food processing plant for post processing. The documentation was minimal but the driver had collected from similar locations before and connected the hoses, filled his tanker and left without site approval as it was late in the afternoon. The time of day meant the truck was parked at his depot overnight before delivery the next morning. The day shift came on at 6am and noticed water running across the parking bay which was traced to a leak from a hole in the 6mm wall of the aluminium tanker barrel. A quick look into the tank showed heavily attacked surfaces (Figure 19). Further investigation showed the collected fluid was mid concentration sodium hydroxide. Given the severe damage from the approximately 3m/year corrosion rate, the barrel was scrapped and collection instructions toughened.

And the ***Lesson Learnt?*** Check your documentation before loading your tanker.

Fig 19: Aluminium sheet after 14 hours in mid strength NaOH

Let's Tweak The Formulation For Cold Climate Curing

Introduction

In a new factory which would have several furnaces and aggressive fumes – even with extensive extraction - the coating system for the carbon steel channel lintels was specified as a solvent based zinc rich epoxy followed by an intermediate epoxy coating and a decorative top coat for chemical rather than UV resistance. The project was, as usual, scheduled to a tight timetable and some very cold weather caused significant delays in curing the spray applied primer coating. After discussion with the coating supplier, a chemical "tweak" was designed to accelerate the zinc coating cure and it seemed to work. However the coatings were often substantially above recommended DFT because the independent inspector insisted that all individual thickness readings must meet the minimum and the contractor was in no position to dispute given the existing delays. The plant was commissioned but within 6 months blistering and cracking was observed in the lintel coating.

Site Investigation

An elevated platform was used to inspect a blistered area and it was noted that the blistering was worst at the flange to base areas.(Figure 20A). DFT measurements showed higher readings in this area but even in the centre of the channel, the thickness was around the maximum recommended value. A cross hatch test was then carried out which produced a strong solvent odour. In order to assess the coating adhesion, the coating was firmly rubbed and sheets of paint detached revealing the primer with the cure line patterns shown in Figure 20B.

Fig 20A: Blistering in thick coating zones

Fig20B: Base coat revealed showing virtually no adhesion to primer

Conclusions and Lessons Learnt

The rapid cure modifications to the intermediate and top coatings did not allow the solvent to escape from the primer coating. Eventually the ambient temperature rose and the released solvent coalesced and blistered the thickest parts of the coating first but the entire inter-coat adhesion was compromised requiring a strip and recoat.

The ***Lessons Learnt*** are quite obvious but probably easier to say than implement:

- Plan for coating application at a reasonable temperature
- Do not modify a known coating system without rigorous testing in worst case conditions
- Select a qualified coating inspector familiar with the coating specification.

Acknowledgments

Collegiate assistance from members of ASSDA, the Nickel Institute and the ACA had been freely offered and gratefully accepted over the years. For this presentation, Les Boulton, formerly of the Nickel Institute, provided the image in Figure 18 and Alex Gouch, via his participation on the ASSDA Technical Committee, provided Figure 14B.

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Author Details

Graham Sussex has worked in corrosion since 1979, first at UMIST and then ETRS for 5 years. In 2001 he set up SMS Pty Ltd whose major client is the Australian Stainless Steel Development Association and, over the last decade, the Nickel Institute. The NI work includes presentations and responding to both the NI and ASSDA technical advice lines. Apart from industrial corrosion work, Graham has an on-going interest in welding issues, water systems and concrete reinforcement. He has been a member of the ACA since 1981 and is a NACE/AMPP life member.

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Steel Protection in Australia: Rethinking Coatings for Long-Term Resilience

Steel is the backbone of Australia's industrial and infrastructure landscape — from the vast conveyors and chutes of the Pilbara mining region to marine structures along our extensive coastlines. Yet across sectors, corrosion and abrasion continue to erode performance, safety, and budgets.

In Australia's harsh operating environments, traditional paint-and-primer approaches are increasingly challenged by the dual demands of longevity and sustainability. In response, the coatings sector is evolving — with innovations that are shifting the role of protective systems from passive barriers to active enablers of asset life extension.

From Barriers to Engineered Protection

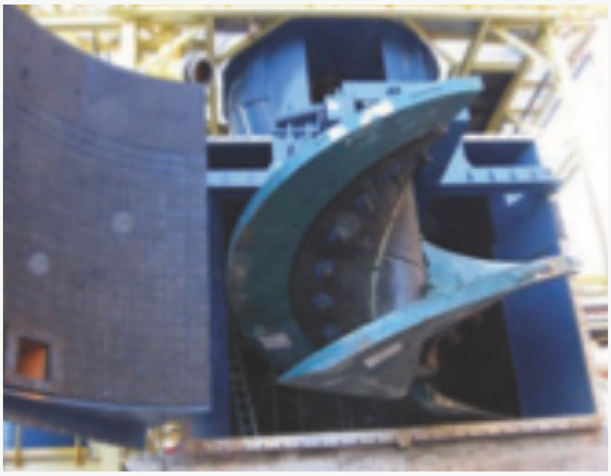
Historically, protective coatings were designed simply to keep corrosive agents away from the substrate. While effective in moderate environments, these systems can degrade quickly when faced with high-velocity particulates, chemical attack, or thermal cycling — all common in Australian industry.

The next generation of coating solutions — such as high-build epoxy composites reinforced with ceramic or mineral fillers — combine corrosion resistance with mechanical durability. Systems in this category, including advanced ranges like Chesterton ARC's industrial coatings, are formulated to rebuild eroded steel surfaces, restore tolerances, and create impermeable barriers against both wear and chemical degradation.

In effect, these are not just coatings; they are engineered layers that enhance and extend the functional lifespan of steel assets.

Lessons from the Field

Consider a case from the heavy industrial sector: a steel saltwater strainer operating in a corrosive marine environment. Previously, it required replacement every two to three years due to severe material loss. By applying a sprayable, ceramic-reinforced thin-film coating — similar in approach to



Chesterton ARC's SD4i technology (now available in Rapid Cure for faster results) — surface integrity was restored, operational life was extended, and downtime was significantly reduced.

This example underscores an important point: **the right coating, correctly applied, can shift the maintenance cycle from reactive replacement to planned, preventative care. For asset owners, this means less disruption, lower total cost of ownership, and reduced material waste.**

Access the full case study here.

Australia's Unique Environmental Stressors

Designing a coating strategy for Australia requires accounting for its diverse and extreme operating conditions:

- Marine and coastal assets face high chloride exposure, driving pitting and crevice corrosion.
- Mining and mineral processing environments combine abrasive wear with chemically aggressive slurries.
- Agriculture and food processing involve chemical cleaners, fertilisers, and temperature swings.
- Energy infrastructure contends with elevated temperatures, high humidity, and corrosive flue gas condensates.

Each of these demands a tailored coating approach — one that considers not just corrosion resistance, but the full spectrum of mechanical and environmental stresses.

Sustainability Through Asset Life Extension

Beyond operational performance, coatings innovation has a clear sustainability impact. Extending the service life of steel assets reduces the demand for new steel production, cutting both material waste and the carbon footprint tied to mining, manufacturing, and transport.

Composite coatings, like those in the ARC range, often allow for in-situ rehabilitation rather than full replacement. This not only lowers environmental impact but also minimises the safety and logistical challenges of replacing large steel structures in remote locations.

Looking Forward: Smarter Protection

The future of steel protection may merge materials science with digital technology. Coatings embedded with sensors could one day provide real-time integrity data, enabling truly predictive maintenance.

For now, the shift is already underway — from viewing coatings as consumable, short-term barriers to recognising them as engineered, lifecycle-optimising assets. By adopting this mindset and exploring the potential of high-performance solutions like ARC's, Australian industries can protect critical infrastructure more sustainably and efficiently.

For further information on advanced steel protection strategies, or to discuss coating solutions tailored to your operating environment, contact the Chesterton team following this link.

160+ Years of Proven Durability

Located in the Clare Valley, South Australia, Bungaree Station is an operating cereal cropping and sheep grazing property that has been in the same family since the 1840s. Until the mid-1860s the shearing was completed in the open air or under timber shingles – neither of which were considered satisfactory for the sheep – and galvanized steel roofing was chosen to replace the timber shingles. This steel was purchased from the Wolverhampton Corrugated Iron Company, itself set up in the 1850s to supply the colonies with galvanized iron roofing, with Australia receiving the 'Emu Brand'. Back in the 1860s this steel was dipped as sheets, with the continuous galvanizing process many decades away. Given the difficulty is reaching the roof, no measurements were taken of these items. There is a reasonable chance the Emu Brand galvanized steel is the oldest in Australia as it pre-dates the Overland Telegraph line galvanized posts by 15-20 years.

The images show the internal face of the galvanized steel is in excellent condition, with only minor rusting at the edges, while the outside faces are in amazing condition for steel that has been fully exposed for over 160 years in a C2 location. Interestingly, other brands of galvanized steel, such as the UK Lysaght Orb were sighted and the coating thickness on these newer items dating from perhaps the 1870s to 1920s era, were measured at around 100 microns.

Bungaree Station is open to the public 7 days a week for self-guided tours and accommodation as is very conveniently located near to the famous Clare Valley wine district. It also has some vintage cars and mechanical equipment in mostly original condition and a wonderfully restored church, It is highly recommended by several of our members, including past-Chairman of the ACA, Paul Vince, who first recommended the GAA visit the site.

The Importance of Stripe Coating in New Build Ferries and Commercial Vessels

Constantin V Beldie
NACE 2 Certified Coating Inspector, Managing Director Sweep Marine Services

SEALINK FERRY 2 FOR POLARIS MARINE

Introduction

New build ferries and commercial vessels are among the most significant investments in the maritime industry. As anyone involved in shipbuilding knows, new builds are complex, costly, and often riddled with delays caused by design changes, modifications, and shifting operational requirements. In this environment, one aspect of asset protection stands out as essential yet often underestimated: **stripe coating.**

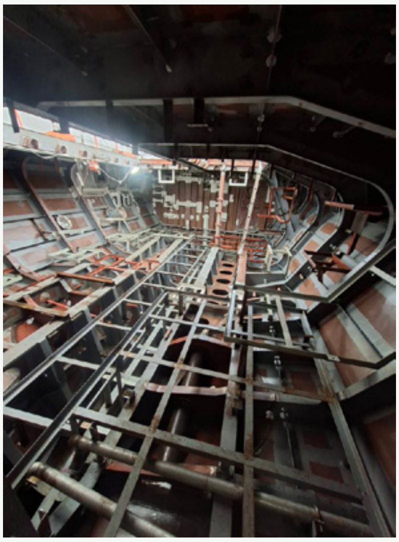
Why Stripe Coating Matters

Stripe coating is the manual application of paint on edges, weld seams, brackets, and hard to reach details before each full coat is applied. These areas are the most vulnerable to early breakdown because standard spray or roller application naturally leaves thinner films on edges and corners. Without stripe coating, these weak points become the first places for corrosion to appear.

On ferries and commercial vessels, bilges and engine rooms are particularly at risk:

- Constant exposure to heat, moisture, and vibration.
- Dense geometry, with frames, stiHeners, and new modifications.
- Difficulty in access, making later repairs costly and time-consuming.

By investing in stripe coating from the start, owners and operators ensure a durable, highperforming coating system that extends service life and reduces the need for disruptive repairs during operation.



Case Study: SeaLink Ferry 2 – Polaris Marine

Sweep Marine's **Sweep Workboats division** recently delivered the engine room coating system for *SeaLink Ferry 2*, a new build project for Polaris Marine.

The initial stripe coating began more than a year prior, but due to project delays, the work was interrupted. In the meantime, modifications were added to the bilge geometry, including new platforms and equipment trays. This created an uneven coating history and complicated conditions for the paint team.

Bringing Surfaces to a Level Plainfield

The team faced the challenge of ensuring all areas were brought back to a "level plainfield." This meant:

- Re-prepping surfaces so everything was uniformly in primer.
- Applying **two full stripe coats** over welds, brackets, and detailed geometry before any full coats.
- Carefully blending new modifications into the original system.

Before the second stripe coat was applied, a **pull test** was carried out to verify that the original stripe coat remained sound. The results confirmed strong adhesion, allowing the team to continue confidently.

Final Delivery

From there, the process continued systematically:

- Second stripe coat applied across all geometry.
- Full primer coats, with additional stripe coats between each system stage.
- Final topcoats, ensuring every weld, flange, and corner was fully protected.

The result was a **fully sealed, durable, and resilient engine room coating system**, able to withstand the harsh operating environment of a high-duty ferry.

Lessons Learned

This project demonstrates three critical points about stripe coating in new builds:

1. **Delays and modifications happen** — but consistent stripe coating ensures continuity in protection even when schedules change.
2. **Quality control is essential** — pull tests and thorough inspections verify adhesion and prevent coating failures down the line.
3. **Stripe coating saves money long-term** — the modest upfront investment avoids costly repairs and operational downtime once the vessel enters service.

Conclusion

Stripe coating is not an optional extra; it is a fundamental part of protective coating systems on new build ferries and commercial vessels. By stripe coating every coat from new build, shipyards and owners eliminate weak points, extend coating life, and safeguard the vessel's asset value.

The experience of Sweep Workboats on *SeaLink Ferry 2* underscores that, while shipbuilding projects may face delays and design changes, correct protective coating practices remain the backbone of long-term asset protection.

Julie-Anne Latham

Julie-Anne obtained an undergraduate degree in Materials Engineering from Monash University before earning a PhD focused on preventing corrosion of magnesium alloy AZ31 using ionic liquids. She also holds a certificate in Asset Management from the Institute of Asset Management (IAM), is a Certified Asset Management Assessor (CAMA) and holds auditor qualifications.

Following completion of her PhD, she joined the Strategic Asset Management and Advanced Materials team at AECOM, where she spent nine years assessing structures, many life-expired or approaching end of life. In this time she gained experience in asset management, contributing to the development of asset management strategies, asset management plans, maintenance strategies and frameworks, and levels of service. Her work in asset management experience has been able to leverage her experience in condition inspection, materials testing, and rehabilitation design for major infrastructure assets such as wharves, tunnels, bridges, buildings, wastewater treatment plants, and tanks.

Currently, Julie-Anne is part of the Asset Management Framework team at V/Line, Victoria's regional rail operator. Although her current role is not directly related to corrosion, her passion for the field remains.

Q1.
Where are you currently employed, and what does your role involve in relation to corrosion science, engineering, or asset integrity?

I am currently employed by Victoria's regional rail operator, V/Line. My role focuses on asset management rather than corrosion engineering or science. I collaborate with engineers and other professionals to enhance our asset management practices, focusing on the asset whole-of-life, which asset integrity forms part.

Q2.
Can you share your journey into the corrosion industry? What inspired you to get involved, and how did that path lead to your leadership role within the ACA?

My journey into the corrosion industry began during my PhD almost two decades ago when I joined the

ACA as a member. Over the years, I attended local Victorian branch events, using these opportunities to network and learn from industry experts. Even after transitioning to a role unrelated to corrosion, I remained connected to the industry by joining the Victorian branch as a committee member. My desire to give back to the community led me to become Junior Vice President, eventually rising to a Branch President earlier this year.

Q3.
Who or what has had the greatest influence on your professional development in the corrosion field?

I was fortunate to be inspired by Maria Forsyth, whose passion for corrosion was infectious during her university lectures. A summer work experience placement at the Defence Science and Technology Group allowed me to work with Bruce Hinton, further fueling my interest. My industry experience, particularly in ports and marine environments, deepened my appreciation for corrosion in reinforced concrete (a far cry from where I started with aluminium and magnesium!).

Q4.
What has been the most challenging corrosion-related project you've worked on, and what lessons did you take away from it?

My most challenging yet rewarding project was designing an impressed current cathodic protection (ICCP) system for a uniquely designed wharf built around 1920. The project involved overcoming accessibility issues and dealing with various repairs over the years. With guidance from experienced ICCP designers Philip Karajayli and Glenn Brewster, I learned to design, commission, and troubleshoot the ICCP system. This project also provided valuable experience in electrochemical in-situ tests and selecting locations for destructive testing.

Q5.
From your perspective as a Branch President, what do you see as the most pressing challenges facing the corrosion industry today—both locally and globally?

Although I am a few years removed from the industry, I believe that raising awareness among infrastructure design engineers about corrosion issues and ensuring adequate design to manage corrosion throughout an asset's lifecycle remains a significant challenge.

Q6.
Have you observed any notable trends, technologies, or shifts in the corrosion landscape that professionals and stakeholders should be paying attention to?

The corrosion industry has seen a significant shift towards technology, including remotely operated inspection machinery like drones and submersibles, remote monitoring, and machine learning. While these advancements offer benefits such as cost savings and improved safety, it is crucial to understand their limitations and validate their applications. The adoption of machine learning and generative AI requires careful validation to ensure accurate decision-making.

Q7.

As someone in a leadership position, how do you see the future of corrosion mitigation and management evolving over the next 5–10 years?

I anticipate a continued focus on environmentally conscious materials for coatings and inhibitors, along with advancements in monitoring technology and machine learning algorithms to enhance data analysis from monitoring systems.

The asset management field is also maturing, which will directly influence how corrosion management is integrated throughout an asset's lifecycle, particularly during the operations and maintenance phases.

Q8.

What advice would you offer to someone just entering the corrosion industry, especially those considering involvement in the ACA or local branches?

For newcomers to the industry, seize every opportunity to learn. Joining the ACA and participating in committee activities exposes you to experienced and passionate individuals. Attending technical events and engaging with industry experts will significantly enhance your understanding of corrosion.

Q9.

What would you consider your greatest professional achievement to date—either in technical work or your contributions to the corrosion community?

I am most proud of mentoring others in developing robust inspection and testing regimes for infrastructure assets. Being a trusted resource for scoping out investigations and earning the confidence of my peers is a significant achievement.

Q10.

How has being a Branch President for the ACA helped you grow professionally and personally? How do you use this role to raise awareness about corrosion and support the wider industry?

Serving as Branch President has been an excellent opportunity to test my leadership skills and learn event planning. It has allowed me to stretch my project management abilities in new ways and forge lasting connections within the corrosion industry. I aim to raise awareness and support the industry by organising high-quality events.

The Australasian Corrosion Association Inc (ACA) celebrates 70 years of history.

The seeds of the Association were sown in Australia in late 1954 when the Victorian State Electrolysis Committee decided that problems connected with cathodic protection could be solved by widening discussion to include the advice and cooperation of representatives from greatly differing disciplines.

A meeting was held and the motion passed that an Association be formed to deal with corrosion and that a committee within the structure of such an Association be set up to co-operate with the Electrolysis Committee in the matter of stray current electrolysis" This action led to a series of events which decided the whole future of the Association.

In 1955 the number of people interested in an Association was 50 - today we have nearly 1300 people as members of the ACA. A brief early history is noted on the next page.

On 21 August 2025, the ACA Victoria Branch hosted their Round Table Conference event that has proven to be a flagship tradition for over 60 years. This year's gathering was particularly special the ACA celebrates 70 years.

The 40 guests have the opportunity to listen to three esteemed ACA Life Members who shared their perspectives of the ACA's past 70 years, their insights and experiences from decades in the corrosion industry: The VIP guest speakers were Bruce Hinton, Dr Rob Francis and Richard Brodribb.

A special thanks to Julie-Anne Latham, the Victorian President, the ACA Head Office and the Vic Branch volunteers that made this evening so memorable!

1955

- **March:** Formation of the Melbourne Branch of the Australian Association for Corrosion Prevention (Mr A. F. Dunbar).

1956

- Formation of the Sydney Branch of the AACP (Cdr. J. F. Bell) (NOVEMBER)

1957

- "Australian Corrosion Engineering" became the Official Journal of the Association.

1958

- Formation of the Brisbane Branch of the AACP (Mr M.A. Simmonds) (SEPTEMBER)

1959

- Melbourne Branch acted as Interim Federal Body to amalgamate the three branches.

1960

- November: the First ANNUAL CONFERENCE held in Melbourne.
- Amalgamation of branches in Australia and Corrosion Prevention Association in New Zealand (represented by the late Mr A.S. Partridge) discussed at Council Meeting resulting in the combination of four branches Victoria, N.S.W., Queensland and N.Z. to form the AUSTRALASIAN CORROSION ASSOCIATION (Mr C. G. Robilliard)

1961

- June: Formation of the South Australian Branch (Dr W. T. Denholm) (October) Formation of Division in West Australia by Victorian Branch

1962

- Formation of the West Australian Branch (Mr P. J. Hill) (APRIL)
- Australasian Corrosion Association NZ Branch Incorporated was registered as an Incorporated Society in New Zealand.
- May: Formation of Division at Illwarra by N.S.W. Branch.

1963

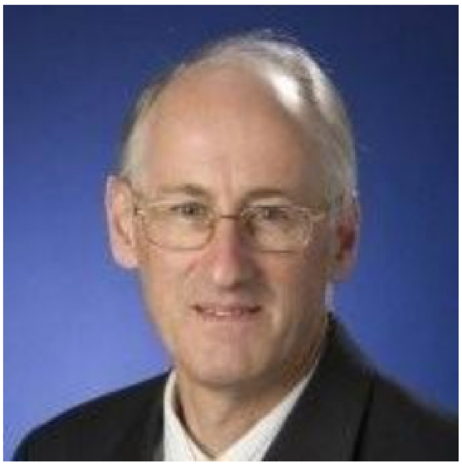
- April: Formation of Division and Branch in Newcastle by N.S.W. Branch

1971

- Formation of Division of Tasmania by Victorian Branch

1972

- Formation of the Tasmanian Branch.



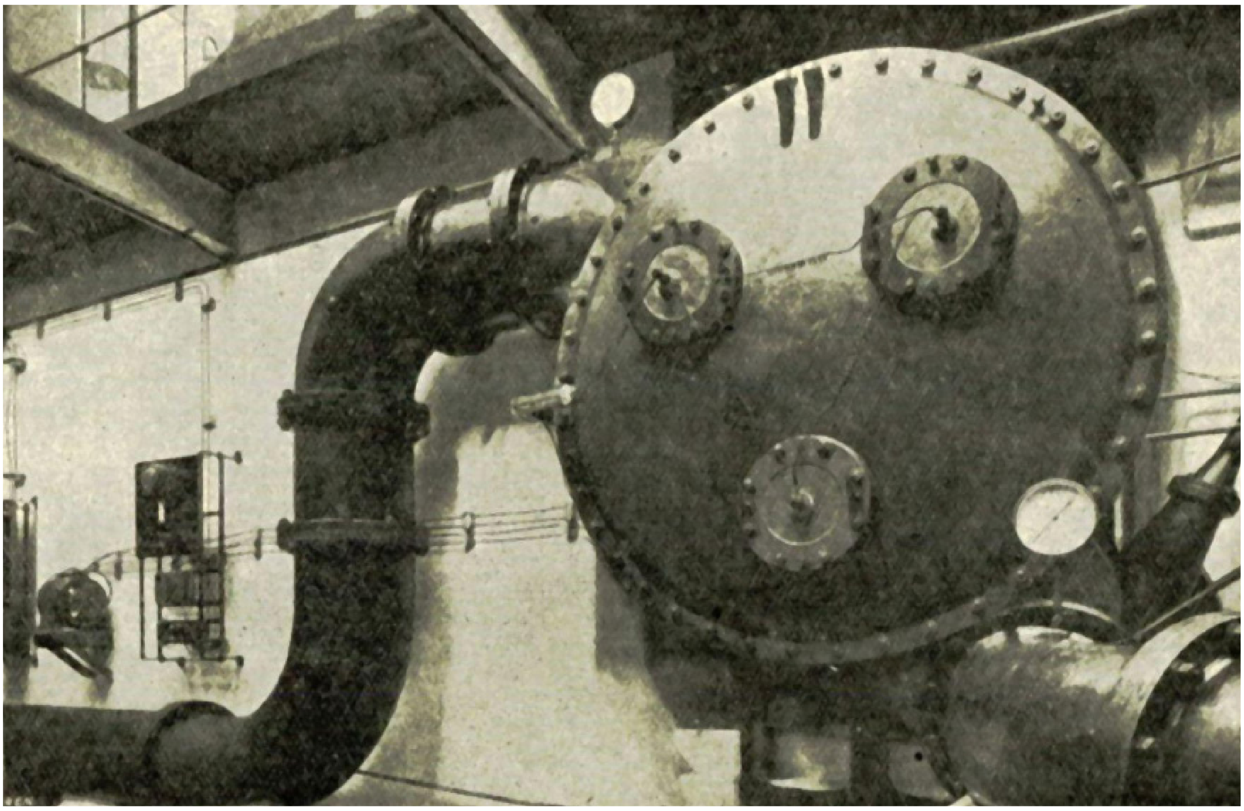
With four decades of expertise in atmospheric corrosion and protective coatings, Dr Rob Francis is a leading authority in corrosion mitigation.

***Presentation:** Local Corrosion Legends*

***Presented by:** Dr Rob Francis*

Australia has made a number of important contributions to corrosion and its control. Following are five legends from Melbourne who have left their mark on the corrosion industry locally and globally.

One of the earliest breakthroughs came from Elliott Cumberland *(1872–1933), based initially in St Kilda. In 1908, he developed the first commercial Impressed Current Cathodic Protection (ICCP) system, using iron anodes powered by a low voltage power supply to protect submerged boiler and condenser components. Initially applied to local steamships and later to power stations in Sydney, Elliott even proposed its use for internal water pipe corrosion in Kalgoorlie—though this idea wasn't adopted. He moved to the UK, founding the* Cumberland Engineering Company, *which continues to operate today. His system was embraced by both naval and civilian fleets across the UK and Europe, and he became wealthy enough to own property on a Surrey golf course—where a tournament still bears his name.*



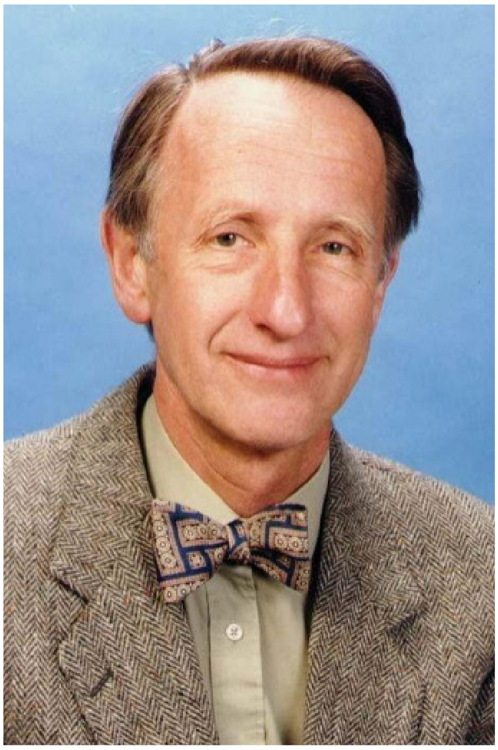
Cumberland's three anode ICCP system protecting a power station condenser

Another legend, Victor Nightingall *(1881–1947), worked from his home in Heidelberg, where he experimented with zinc dust and sodium silicate in an effort to create "artificial rock." This led to the invention of inorganic zinc silicate coatings. In 1939, he established the Dimet company, and his product "Galvanite" was used extensively on the Morgan–Whyalla pipeline, constructed in the early 1940s to provide water for the steel plant at Whyalla. The Engineering and Water Supply Department tested numerous coatings at the time and famously declared, "Nothing can hold a candle to Galvanite." Today, his innovation protects millions of square metres of steel, either as single coat or part of a coating system. The ACA "Victor Nightingall Award" is in recognition of distinguished achievement in the protective coatings industry.*

The Morgan-Whyalla pipeline was the first major structure coated with inorganic zinc silicate.

Percival Faraday Thompson *(1884–1951) made his mark by demonstrating the existence of a passive film on stainless steel in 1925 using electrochemical methods. His career spanned the Metallurgy Department at Melbourne University (1918–1941) and later CSIR, RAAF, and CSIRO at Fisherman's Bend (1941–1951). During World War II, he discovered that an inhibitor used in aluminium aircraft cooling tubes actually accelerated corrosion. Known for his emphasis on practical demonstrations, P F Thompson was one of Australia's first corrosion experts. His middle name, "Faraday," was inspired by his father's passion for electrical instruments and science, and there is a collection of his electrical instruments at the Melbourne Museum. Each year, the PF Thompson lecture is given by a person who has made a significant contribution to corrosion science and engineering in Australia.*

P F Thompson carrying out a demonstration in the 1920s.



In more recent history, Brian Cherry *(1935–2018) quantified the economic impact of corrosion in Australia, estimating it at around 1.5% of the Gross National Product. His findings highlighted the immense savings possible through corrosion control.*

Joining Monash University's Engineering faculty in 1970, Brian mentored generations of corrosion scientists and engineers and gained international recognition for his work, particularly in the field of reinforcement corrosion in concrete. He received numerous awards and served as editor of Corrosion & Materials. *The Brian Cherry Awards Forum is conducted annually for final year undergraduate and postgraduate students who are studying any aspect of corrosion.*

Finally, David Whitby *(1946–2000) played a pivotal role in promoting the Australasian Corrosion Association (ACA) as a professional society.*

In 1974, he founded AMAC Corrosion in Bayswater, producing CP anodes. In 1997, AMAC supplied 73,000 anodes for Libya's Man Made River project, the world's largest irrigation initiative. David Whitby championed young researchers through the AMAC award and leveraged Cherry's report to secure Victorian government funding for a Corrosion Centre. His efforts fostered ties with NACE, enabled ACA to hire full-time staff, and culminated in an international conference in Melbourne in 1996. The David Whitby Best Review Paper is awarded annually at the ACA conference.

*With nearly five decades in power conversion and infrastructure innovation, **Richard Brodribb** brings unmatched experience and energy to this year's event.*

Presentation: I have a confession to make. I am not a corrosionist. I only have sketchy knowledge of the topics that Bruce and Rob know so well—and as far as I'm concerned, Pourbaix and Tafel could well be members of a rock group. I'm a humble electrical engineer who designs boxes that deliver DC. I know only that DC is used to prevent corrosion on metal objects, and that people, some in our audience tonight, pay good money for these magic boxes.

So how did I end up here tonight with Bruce and Rob, as a life member of the ACA? It's a long story, but let me begin: It all starts with my mother, Dr. Lisa Brodribb, in the 1980s. Lisa was appointed by the state government to the board of the Corrosion Prevention Centre, which predates the ACA. I believe Geoff Cope and Wayne Burns were also on this committee. Dave Whitby, the colorful founder of AMAC, was certainly involved too. Knowing we were electrical engineers, Dave once asked about Cathodic Protection rectifiers—LB (my mother) boldly said, "Of course we can." Dave sent us our first enquiry, and we made it; it gave out DC and, apparently, it worked.

The orders kept coming, and soon we were making bigger rectifiers, including our first request for a potential control system from CMPS, where Brian Martin was working. Potential control uses a reference and voltage sensing—the half-cell voltage becomes more negative as the output current of the rectifier increases and that voltage is used to control the rectifier. Brian explained this to me, but I didn't believe him. I thought every input-related output should increase when the inputs are more positive; after all, if you fill *it should work and demonstrated it proudly to Brian. Naturally, it didn't work. Brian was so kind in explaining, in simple terms, where I'd gone wrong that I think finally understood it.*

About the same time, I joined ACA and the Vic Branch Committee. ACA Head Office was a modest affair then, with just a couple of staff. I'd known the ACA manager, Sally Nugent, from Monash, so I already had a connection to HQ. The Vic Branch Committee would meet over a few beers at a pub and discuss business—always pleasant and in good company. However, I missed one meeting and discovered, to my horror, that in my absence I'd been voted Treasurer. The GST had been in for a year or so, the books hadn't been audited, and the state of GST payments was confused, and so was I.

Fortunately, while I often say, "Engineers should never marry an accountant," my accountant wife, Bernadette, came to the rescue. Accounting only looks like it's just addition and subtraction, but it's more confusing than half-cell voltage shift once you get into the details.

With the finances on track, we started planning the International Conference. Vic Branch members like Peter Dove actively organized venues, partner programs, and social functions, including the Awards dinner at the National Gallery of Victoria. We raised the question of entertainment for the dinner with Sally and suggested a rock singer and dancing. Sally replied, very determinedly—there was to be NO DANCING. We danced anyway and "NO DANCING" became the Vic Branch's unofficial tagline for years.

National Corrosion Conferences were held in the state with the national presidency—Sydney, Melbourne, Hobart, Adelaide, Brisbane, Perth, but also Newcastle, Coffs Harbour, and, memorably, Tasmania once held its national conference in Darwin, which we temporarily renamed North North Hobart.

NACE/AMPP Presidents and their families attended the conferences and always seemed to enjoy Australia, and Australians enjoy going to NACE. The first time Bernadette and I attended a NACE conference in Houston was overwhelming—the sheer size, range of technical forums, sales exhibition, and number of attendees. We arrived at the hotel and had only been standing in the foyer for a few minutes when a voice rang out, "Bernadette!" There was a collection of First Ladies—the NACE President's wives—they all knew Bernadette from Australian partner programs, so we were instantly welcome.

Travel to remote sites has also been a rewarding part of my career. Some highlights include travelling to an island off the coast of Indonesian Borneo to fix a faulty rectifier. The customer called me and said, "You have to come to Borneo!" Knowing little about Borneo, I went to the local library to study up—finding books like "Through Borneo with Gun and Camera." I imagined myself as a sort of Cathodic Rambo leaping from the helicopter, voltmeter in hand. It wasn't like that at all. The mining company was a joint venture with BHP and the cafeteria served Australian food. The problem turned out to be a failed coil in the power transformer. I bought magnet wire from a local shop, found a coil winder in town, and sat in his lounge room while his wife cooked dinner.

He wound the coil on a hand jig, his son held the copper wire taut, and we exchanged only two words—Puturan (turns) and Thank you. I reassembled the transformer, it worked, and I went back home via the back via towns that were well know in my parent's time for the battles the Australians fought there at the end of WW2 - Balikpapan and Banjarmarsan.

Later, I flew out to oil rigs in Bass Strait, looking at Cathodic Protection systems. Special thanks to Esso for showing how important safety training is—and for the great platform food. We once provided a small rectifier for a pipeline, installed next to a large 1,000A rectifier for the jacket. Months later, the survey team discovered the 1,000A rectifier was missing. Contractors thought our little rectifier replaced the 1,000A monster, so they disconnected and scrapped it but the oil company needed a new rectifier so it all ended OK anyway.

Over time, I've met many people who taught me about corrosion—very nice, clever people with a common interest in solving modern society's big problems. I'd especially like to acknowledge the contributions of Prof Brian Cherry, Prof Ed Potter and Brian Martin, —and also to all the excellent presidents of the Victorian Branch over the years.

In conclusion, I've enjoyed being part of the corrosion community. To any young people here tonight—corrosion offers many opportunities, often in places you don't expect.

Figure 1. 1987 Asia Pacific Conference. Left to Right. Wayne Burns, Bruce Hinton, Graham Sussex, Bob Gration, Clive Funston, Dave Nicholas

ACA - Involvement and Memories over the Years

By Bruce Hinton

With over 40 years at the forefront of corrosion research in defence, Dr Bruce Hinton brings a wealth of experience and insight to this year's event.

A Career in Corrosion

Like many of us, I never really set out to have a career in corrosion. When I started my first job after graduation at the Aeronautical Research Laboratories (ARL) Melbourne in June 1969, I was investigating aircraft component failures which were mostly fracture caused by fatigue cracking sometimes initiated by corrosion. For me corrosion was of minor interest.

In 1975 to broaden my interests in corrosion ARL sent me to the International Conference on Metallic Corrosion in Sydney. I saw presentations from the eminent Australian corrosion people of the time Lou Keays, Brian Cherry, Graham Robilliard, and of course the inimitable Ed Potter. This was a career defining occasion as I became very keen on corrosion research. So much so that I applied and received an APS Scholarship to do a PhD at the Corrosion and Protection Centre (CPC) at UMIST Manchester England, the world centre for corrosion research at the time.

The CPC covered all aspects of corrosion science and engineering. It was a great working atmosphere with inspirational staff including Graham Wood, Dave Scantlebury, Vic Ashworth, Robin Proctor and George Thompson. Rob Francis, Peter Farinha, and Graham Sussex, notable Australian corrosionists were also there during my time at the CPC. At the end of three years in that environment, I was totally hooked on corrosion.

Introduction to the ACA

On my return to ARL in 1981, I was missing the wider corrosion community I had in Manchester. I think it was Ian Polmear who suggested I should join the ACA. I did and presented a paper at the 1982 ACA Hobart Conference. In those days at the start ACA Conferences, Ed Potter would give a very humorous, sometimes scathing 3-minute summary of every paper. I was amazed at Ed's ability. All presenters would worry about Ed's comments. I was also captivated by Ed's flamboyant style in presenting his scientific paper.

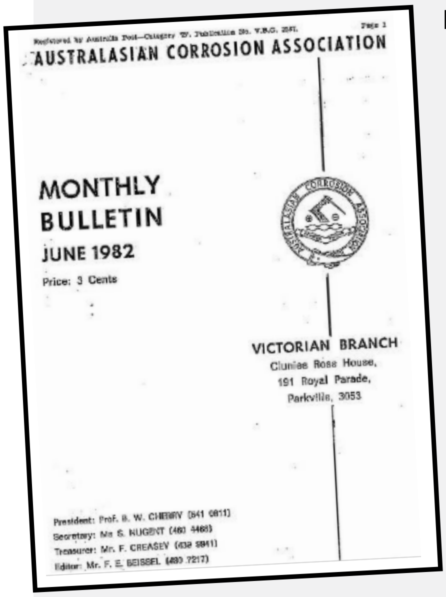
That Conference opened the whole new world of the ACA for me. I didn't know anyone at the Conference, but at a coffee break Brian Cherry introduced himself and asked me to join a few from Victoria for dinner at the Drunken Admiral Restaurant on the Hobart Docks. At dinner were Brian, Sally Nugent, David Whitby, Frank Burns and Peter Thorpe, all from the Victorian Branch Committee. They convinced me to nominate for Vic. Branch Committee in 1983.

Victorian Branch Committee

My first job on the Committee was to manage the ACA's 40 x 20 m outdoor exposure site in a Board of Works easement just below the West Gate Bridge, which was very close to my work at ARL in Fisherman's Bend. I had to periodically check corrosion specimens or painted panels from various companies. What I did not know when accepting the job was that I also had to mow the grass on the site every 6 weeks. I would bring my motor mower from home and at lunch time go and cut the grass. There was always lots of rubbish that had fallen from trucks or had been thrown from cars on the Bridge to be cleaned up before mowing. That was Ok, but the many snakes that moved out of the grass when the mower started scared the hell out of me.

The 1987 the 5th Asia Pacific Corrosion Conference was to be held in Melbourne and the whole Vic. Branch Committee was involved. Secretary Sally Nugent and David Whitby had the idea that to attract more attendees from Asia we should run a Refresher Course in Corrosion over the 2 days before the Conference. The late Stan Price and I were given the job of organising the Course notes, the five presenters including us, and the overhead cellulose acetate paper slides. The Course was a great idea; the only trouble was that for most of the attendees English was not their first language. Unfortunately, most of our time was taken up trying to explain the content of our slides and the course notes to the attendees. The Course and Conference were a huge success (Figure 1).

Some notable Committee members during my time on the Committee in addition to Sally Nugent, David Whitby and Brian Cherry were Henry Herzog, Ike Solomon, Trevor Richards, Geoff Cope, Peter Thorpe, Frank Burns, Ashley Fletcher, Rob Francis, John Tanti, Dave Anderson, Frank Creasey and Eric Beissel. All of these were experienced corrosionists from whom I learnt a lot by mixing with them at the monthly meetings at Clunies Ross House and later over dinner in Lygon Street. These people made a great contribution to the Victorian Branch. Eric Beissel and later Frank Burns would put together a monthly newsletter which was posted to all members (Figure 2).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AUSTRALASIAN CORROSION ASSOCIATION

MONTHLY BULLETIN
JUNE 1982
Price: 3 Cents

VICTORIAN BRANCH
Clunies Ross House,
191 Royal Parade,
Parkville, 3053

President: Prof. B. W. CHERRY (541 6811)
Secretary: Ms S. NUGENT (460 4468)
Treasurer: Mr. F. CREASEY (432 5941)
Editor: Mr. F. E. BEISSEL (480 7217)

Figure 2. Vic Branch Newslettter

Contributions to the ACA

I left the Committee in the1990s because of work commitments. When I retired from DSTO in 2010, I had more time to contribute to the ACA in the following roles.

- 2010 - 2019 ACA Best Paper Awards Committee – with Les Boulton, Irwin Gamboa and Rob Francis
- 2012 - 2019 Editor of "Corrosion and Materials" Journal with Brian Cherry and Willie Mandeno
- 2014 - 2019 Starting the Ed Potter Clock at Annual Conferences (following Brian Cherry)
- Brian Cherry Forum Award – Judging Panel Member
- 2017 - ACA Sydney Conference Technical Director

On the Editorial Committee, I learnt a lot from Brian Cherry about corrosion science and engineering. He was a great mentor to me over the latter part of my career, and one of the great corrosionists of our time. Being the ACA Conference Technical Director was very satisfying. Having to read every paper and attend many different presentations was a great educational experience.

Highlights

I have been very fortunate to receive from the ACA many Best Paper Awards, the Corrosion Medal, an invitation to present the P. F Thompson Lecture and of course Life Membership. It has been truly humbling to be recognised by these Awards, and I am sincerely grateful to the ACA. They have been highlights of my involvement with the ACA.

The Annual Conferences have also been very enjoyable and rewarding highlights. They have broadened my corrosion knowledge through reviewing papers, presenting papers and chairing sessions. By attending, I was exposed to new ideas, and I was able to expand my network of industry contacts. A bonus was making some very good friends through the Conference social occasions (See Figures 3 and 4), at the bar and at restaurant dinners after the technical sessions.

Back in the 1980s, the Conference would start on a Sunday with the Golf Day, then the Welcome Function and finish at lunch time on the Friday. On the Wednesday we would tour a nearby industrial plant. At a Conference in Perth in 1980s, a well-known NZ member suggested that a plant visit to the Alcoa aluminium refinery would be neither new nor exciting, and I agreed. That member suggested we go on the Ladies Program Day trip instead; a boat trip up the Swan River with lunch and a wine tasting at Sandalford Winery. Sounded great to me. It turned out that both of us and a prominent WA member were the only other male members on the boat. Naturally we discussed the various corrosion problems identified on the boat!!

Figure 3. Sydney Conference 1991. Back Row. Russel Taylor and Harvey Flitt. Front Row. Stan Price, Mat Cosgrave, Bruce Hinton and Brian Gleeson.

Figure 4. Newcastle Conference 1995. Back Row. Bruce Hinton, Unknown, Bernadette Brodribb, Unknown, Ed Potter. Front Row. Pat Rohan, Peter Trathen and Richard Brodribb.

Changes

I have seen many changes in the ACA over the past 44 years. In 1982 it was an organisation of professional corrosion people predominantly run by those in a voluntary capacity. The National Corrosion Centre was set up around 1990 and that raised the profile and importance of corrosion prevention with government and industry. In the 2010s the ACA became a business with a National Board and CEO. In the 2020s it became a company limited by guarantee. Another important initiative by the ACA many years ago was the development and presentation of accredited courses. This has connected the ACA with a whole range of industries. That role must continue with regular updating and assessment of course content.

I believe both the CEO and the Board are doing a very good job. I would like to see a well-developed publicity program to make the public, government and industry more aware of the importance of corrosion everywhere in our lives, and strong advocating for research and education funding in this area.

The ACA is still an organisation of enthusiastic people, and the contribution by volunteers is still vitally important. I believe volunteering makes the ACA function better and enriches careers and lives of members. I would encourage young members to get involved in addition to just paying subscriptions. The rewards are well worth the effort.

Conclusions

I have been very fortunate to have worked with some very talented people over my career at DSTO, Monash and Deakin Universities, and the ACA has played a very significant part in that career. Ian Polmear, Brian Cherry and Maria Forsyth have had a huge influence at all stages of that career. On reflection, the ACA has given me far more than I have given back to the ACA, and I sincerely thank the ACA for its contribution to my enjoyable and satisfying career and my life over the past 44 years.

As part of our ongoing commitment to remain current with industry developments, ACA Victoria organised a site visit to Valmont Coatings Industrial Galvanizers Plant to gain first-hand insight into the galvanizing process on the 24th September.

The visit began with a technical presentation by Alessia Gueli that outlined the fundamentals of hot-dip galvanizing, highlighting quality control measures, coating performance, and the environmental benefits of zinc protection. A key focus of the session was the recently updated AS/NZS 4680: Hot-dip galvanized (zinc) coatings on fabricated ferrous articles, which sets out the requirements for coating thickness, finish, and durability. The new revision was explained in detail by Ann Sheehan from GAA.

Following the presentation, a guided tour of the galvanizing facility was conducted. This provided valuable visibility of the end-to-end process, from surface preparation and fluxing, through to immersion in molten zinc and post-treatment. Observing these stages in practice reinforced the importance of quality control and consistency to achieve durable, compliant coatings.

The visit was highly informative, offering both theoretical and practical perspectives on galvanizing standards and practices.

On 29 September, the Newcastle Branch hosted a seminar featuring three key industry speakers:

Adam Hockey
Business Development Executive,
Dulux Protective Coatings

Presentation Title:
Compliance and Warranty for Protective Coatings

David Harrison
Market and Durability Engineer, Galvanizers Association of Australia

Presentation Title:
AS/NZS 4680:2025
Hot Dip Galvanized Coatings on Fabricated Iron and Steel Articles — Specifications and Test Methods

Glenn Tamone
Area Manager, BlastOne International

Presentation Title:
Innovations in Surface Preparation

The seminar theme was "updates to Australian standards and innovations in surface preparation"

The topics and presentations were all very well received and there was genuine interest in the latest developments in the different standards and how this could improve the industry moving forward as well learning about the latest technology in surface preparation.

Feedback from attendees was very positive. The event also allowed ample time for networking, with many attendees staying on to engage with the speakers before heading out for their working day.

Upcoming Event

Date: 4 December 2025

Location: The Stag & Hunter Hotel - 187 Maitland Road, Mayfield, Newcastle

Presentation: Igor A. Chaves;
Associate Professor of Civil Structural Materials Engineering | The University of Newcastle (UoN)

The ACA Newcastle Branch invites you to celebrate yet another successfully rusty year with a technical evening where the Critical Infrastructure Performance and Reliability (CIPAR) Group of the University of Newcastle will showcase various industry and government funded projects.

There is an urgent national need for rational assessment procedures, techniques, and criteria for the assessment of the remaining life performance of infrastructure of all types. Including buildings, bridges, roads, pipelines, water reservoirs, green infrastructure, power transmission towers, shipping, aircraft, railway systems, urban and land development, offshore infrastructure, and other infrastructure systems. Established June 2000, the CIPAR group has a strong national and international reputation within the academic community and industry, with an emphasis on infrastructure resilience. The core focus of CIPAR is bridging the gap between fundamental research and its practical applications. CIPAR is actively involved in senior industry advisory boards, professional body committees, and national or international standards review panels.

Registration Link: https://www.corrosion.com.au/events/upcoming-events/

Australasian Corrosion Association Networking Event and Launch of the NT Branch initiative in Darwin.

On 18 August 2025, the Australasian Corrosion Association (ACA) hosted a joint technical and networking event with Weld Australia at the Charles Darwin University (CDU) Dalana Campus in Darwin, NT, on the topic of Innovations in Welding and Corrosion Control.

The event, emceed by Dr Margarita Vargas, brought together industry professionals, researchers, and enthusiasts in the areas of welding, materials and corrosion management from NT and SA. The evening was championed and sponsored by Rana Everett, Director of Everett Consulting NT.

The evening's keynote presentation was delivered by Dr. Cedric Tan, who shared findings from his recently awarded doctorate on Corrosion Resistance of Hardfacing Alloys. His presentation offered valuable insights into the effects of heat treatment in the performance of high chromium cold sprayed hardfacing alloys exposed to challenging corrosive environments such as the encountered in mining and other industrial applications.

Dr Tan's presentation was followed by Weld Australia's demonstration of their state-of-the-art augmented reality welding simulator conducted by Ben Mitchell, Director Strategic Partnerships, and Lucas Bendo-Watson, Business Development Manager, based in South Australia. Their interactive display sparked dynamic conversations around innovation and training in the welding sector and outlined their broad range of services for manufacturing industries in Australia.

Special thanks to Dr Carla Eisemberg, Sara Sutcliffe and Danielle White from CDU Radicle Centre, a leading STEM Engagement Centre in NT, for generously hosting this event.

The ACA thanks all participants for their enthusiastic involvement and encourages interested professionals to become part of the NT Branch initiative. Together, we can shape the future of corrosion management in Australasia.

Upcoming Event

Date: 30 October 2025

Time: 5:00pm – 7:00pm

Location: MMC – 27 Mendis Road, East Arm, NT 0822

Tour Host: Owen Pike – Owner, MMC

Guest Presentation:
CDU Corrosion Research Student

Following the success of our August event on Innovations in Welding and Corrosion Control, the NT branch is pleased to invite members and guests to a special site visit at MMC. Attendees will enjoy a guided tour of MMC's cutting-edge fabrication and engineering facilities, followed by a technical presentation in their air-conditioned sandblast bay.

Held in collaboration with ACA's Young Corrosion Group (YCG), APGA's Young Pipeline Forum (YPF), and Engineers Australia, this free event is open to all, not just young members. Light refreshments will be provided.

Registration Link:
https://events.blackthorn.io/5j1hxgo7/5a2ZOb194Wr

Thank you to our Event Sponsors:

On Wednesday 30 July, a technical event was held in Cairns, where both local and out of state attendants from various professional backgrounds and industry gathered.

It was good to see a variety of topics covered by the presenters. Manoli Hnoudis from International spoke about passive fire protection whilst Nigel Spiller from AACT and Michael Kemp from Wagners jointly delivered a presentation on the use of composites as alternative to cold rolled steel members in corrosive environments and Oscar Duyvestyn from Remedy Asset Protection provided an introduction to recently published AS/NZS 2312 Guide to the protection of structural steel against atmospheric corrosion by the use of protective coatings, Part 3: Thermal metal spray coatings. After the event, the attendants took the opportunity to further discuss the presentations and make further acquaintance with others that they hadn't previously met. The knowledge sharing and networking event was perceived positive by all, and it was agreed that similar future events would be very much welcomed.

We thank the event sponsors Scape, International and Denso for their generous support.

The ACA Queensland Branch's YCG in collaboration with the APGA YPF had a joint event in South Brisbane on Tuesday 2nd September 2025.

The annual technical event provided a valuable opportunity for young corrosion professionals to come together in a relaxed setting, enjoying a meal and drinks while fostering a sense of community. This informal atmosphere set the stage for a series of engaging and high-quality technical presentations that enriched attendees' knowledge and professional development.

Guest speaker Richard Matheson from the Australian Stainless Steel Development Association shared his expertise on the lifecycle cost benefits of stainless steel and its important role in sustainability. He highlighted recent advancements in the structural design of stainless steel, emphasizing the material's advantages for long-term corrosion resistance and encouraging greater consideration of stainless steel in relevant applications.

Allistair Verth from Verbrec presented on the critical role of electrical isolation in cathodically protected pipelines. He detailed how non-metallic dielectric isolating joints prevent shorting of protection currents and explained that conductive impurities within pipelines can bridge these isolation gaps, compromise the cathodic protection system and increase corrosion risk.

Upcoming Event

Date: 17 November 2025

Location: East Brisbane Football Club

Presentater: Rex Sim
General Manager – Wrap Resources Australia

Topic: Unconventional Methods to extending the lifespan of your assets

Summary: My thoughts are to introduce 3 different approaches in the coating repair and remediation of pipelines, process piping, tanks, civil infrastructure and vessels with the use of viscous elastic coatings (VEC), corrosion passivators and lastly, engineered composite repairs (ECR). To be continued.....

Registration Link: https://www.corrosion.com.au/events/upcoming-events/

Thank you to our Event Sponsor:

Pacific Urethanes

On 24 July 2025, the South Australia Node of the Young Corrosion Group, in collaboration with the Future Industries Institute at UniSA, hosted a professional networking evening at the UniSA campus. With around 13 attendees, the event brought together early-career researchers, engineers, and professionals working in corrosion, materials science, and surface technologies.

Guests heard from Dr Andre Hatem of ASC, who shared insights into his work on corrosion in submarine systems and his collaborative research with industry partners such as LaserBond and the Southwest Research Institute. Mr Matt Ball from Sparc Technologies also presented on the innovative use of graphene in protective coatings and its potential industrial applications.

The evening offered a relaxed and engaging space for discussion, knowledge-sharing, and networking, providing valuable connections between research and industry for those at the early stages of their careers. A big thank you to our speakers, partners at UniSA, and everyone who attended and contributed to the success of the evening.

Featuring Philip Horsford, General Manager of Zerust Integrity Solutions and their local distributor Red Tail Group (RTG), the WA branch held a technical event on Thursday 10th July, where Philip presented "Volatile corrosion inhibitor (VCI) based integrity solutions". The discussion provided deep insights into pipeline casing protection, equipment preservation, and spare parts management. Through recent project case studies, Philip and David Chetty (RTG) demonstrated the practical effectiveness of VCI technology in preventing corrosion, offering valuable strategies for maintaining the integrity of critical infrastructure.

The event highlighted the growing importance of advanced corrosion prevention methods in industries where equipment lifespan and reliability are crucial. Philips presentation highlighted how VCI technology not only safeguards valuable infrastructure but also helps reduce long term maintenance costs and downtime, making it a critical component of modern integrity solutions. More than 30 attendees engaged in networking opportunities beforehand and discussions following over a refreshment and bite to eat. Overall, it was an enlightening evening for everyone involved and fantastic to see many familiar faces enjoying our technical ev ents.

A special thank you to our Event Sponsor, **Red Tail Group and Zerust Integrity Solutions**, and the WA branch committee for making this event possible.

Upcoming Event

Date: 19 November 2025

Location: Vertech Group Facility -
19 Walters Drive, Osborne Park, Perth 6017

Presentater: Craig Davies
Group Development Manager, Vertech Group

Topic: Using Robotic Tooling (ART) for Corrosion Under Insulation Detection

The WA branch invites members and guests to hear Craig Davies discuss how Automated Radiography Testing (ART) technology is transforming CUI detection, offering safer, more efficient, and cost-effective inspection solutions without removing insulation.

Ideal for professionals in asset integrity, inspection, and maintenance.

Registration Link: https://events.blackthorn.io/5j1hxgo7/5a2ZOb19Wo5

Thank you to our Event Sponsor:

Ata Aminfar

Ata is a Durability and Corrosion Engineer with experience across both industry and academia. He has worked on a wide range of projects involving cathodic protection, electrochemical remediation, and concrete durability for reinforced concrete and steel structures. His background spans condition assessments, corrosion mitigation design, and materials testing, supported by hands-on field experience and applied research. Ata holds a Master's in Civil Engineering from the University of Technology Sydney, where he also worked as a research assistant and casual academic, contributing to studies on reinforced concrete durability and concrete cancer. He is passionate about developing sustainable, long-term solutions that enhance the performance and service life of critical infrastructure.

Q1.

What is your current level of membership with the Australasian Corrosion Association (ACA), and how long have you been a member?

I am currently a professional member of the Australasian Corrosion Association (ACA) and have been an active member since 2023, when I joined the Young Corrosion Group shortly after beginning my professional career in corrosion and durability engineering.

Q2.

What state or region are you representing within the Young Corrosion Group (YCG), and what is your current role or position? How long have you been in this role, and in what ways do you contribute to the group's activities and goals?

I represent the New South Wales region within the Young Corrosion Group (YCG) as a committee member since 2023. In this role, I assist with planning and coordinating webinars, technical discussions, and social events that bring together young professionals, academics, and industry practitioners. My involvement has focused on facilitating *collaboration between early-career engineers and experienced corrosion specialists, while also helping to promote YCG initiatives through event write-ups and communications. Through these activities, I contribute to the group's broader goal of fostering professional development and knowledge exchange within the corrosion community.*

Q3.
In your own words, what is the Young Corrosion Group (YCG), and what role does it play within the ACA?

The Young Corrosion Group serves as the ACA's network for early-career professionals and students who are passionate about corrosion science, materials durability, and asset integrity. It plays an essential role in connecting emerging professionals with industry mentors, providing educational opportunities, and encouraging engagement with current research and practice in corrosion mitigation. In many ways, YCG represents the bridge between academic learning and real-world industry experience, nurturing the next generation of corrosion professionals who will carry forward the ACA's mission of advancing corrosion awareness and sustainable infrastructure management.

Q4.
What motivated you to become a member of the YCG, and what have you gained from being involved?

I was motivated to join the YCG because I wanted to connect with like-minded professionals who shared a deep interest in materials durability and corrosion control. My involvement has offered invaluable exposure to diverse perspectives within the field and helped me develop both technically and professionally. Through YCG events, I have expanded my professional network, deepened my understanding of practical corrosion management strategies, and gained insight into how research and innovation can be translated into field applications. Beyond technical benefits, the experience has also provided a strong sense of community and purpose within the broader corrosion industry.

Q5.
What inspired you to pursue a career in corrosion science, engineering, or asset integrity?

My interest in corrosion engineering began during my master's research at the University of Technology Sydney, where I investigated the combined effects of alkali–silica reaction and chloride-induced corrosion in reinforced concrete. This work made me acutely aware of how deterioration mechanisms compromise the longevity and safety of critical infrastructure. The complexity of these interactions inspired me to pursue a career at the intersection of structural and materials engineering, focusing on cathodic protection, electrochemical remediation, and sustainable durability design. I have since been motivated by the challenge of transforming this knowledge into practical solutions that extend the life of assets and reduce maintenance costs for our built environment.

Q6.
From your perspective, what are some of the most pressing corrosion-related challenges facing your sector today, particularly in the Australasian region?

The Australasian region faces several pressing corrosion-related challenges. Chief among these is the deterioration of marine and coastal infrastructure, particularly in tidal and splash zones where reinforced concrete and steel are exposed to aggressive chloride environments. The combination of aging assets, increased environmental exposure, and the need for sustainable life-extension solutions demands a balance between technical performance, cost efficiency, and environmental responsibility. The integration of renewable technologies, such as solar-powered cathodic protection systems, and the use of low-carbon materials and sustainable design represent emerging priorities as the industry strives to align durability practices with broader sustainability goals.

Q7.
How have the ACA and YCG supported your early-career development in corrosion? Are there any specific programs, events, or people that have helped shape your journey?

Both the ACA and the YCG have played significant roles in my professional development. Through training courses such as Corrosion and Protection of Concrete Structures and Buildings, I have strengthened my technical foundations, while webinars and seminars have exposed me to cutting-edge developments in corrosion science. The networking opportunities provided through YCG and ACA events have allowed me to connect with experienced professionals whose guidance has been instrumental in bridging the gap between academic study and industry practice. These experiences have reinforced my commitment to contributing meaningfully to the corrosion community and to continuously expanding my professional capabilities.

Q8.
What advice would you give to other young professionals or students who are interested in joining the YCG or pursuing a future in corrosion?

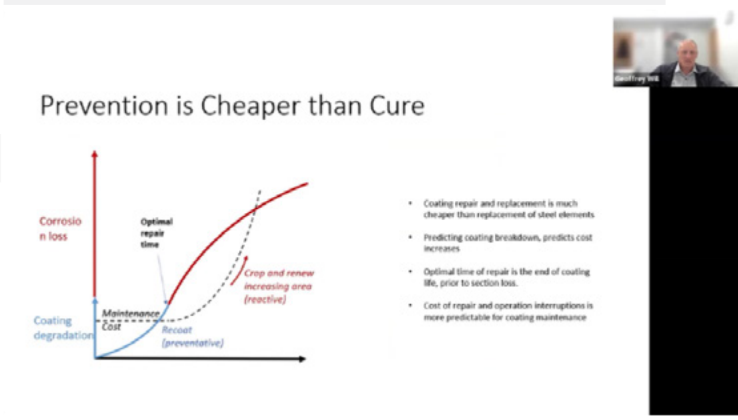
For young professionals and students considering a career in corrosion or joining the YCG, my advice is to engage early and embrace every learning opportunity. Corrosion is an interdisciplinary field that rewards curiosity, persistence, and practical experience. Attend seminars, ask questions, and seek mentorship from experienced practitioners who can provide valuable insights into real-world applications. Most importantly, approach corrosion engineering not merely as a technical discipline but as a means of ensuring the safety, sustainability, and longevity of the infrastructure that supports modern society.

Young Corrosion Group (YCG) Webinar

30 July 2025

On 30 July 2025, the ACA's National Young Corrosion Group (YCG) Steering Committee hosted an engaging online webinar titled *An Insight into the ACA's Young Corrosion Group + Expert Presentations on Corrosion in a Coastal Climate.*

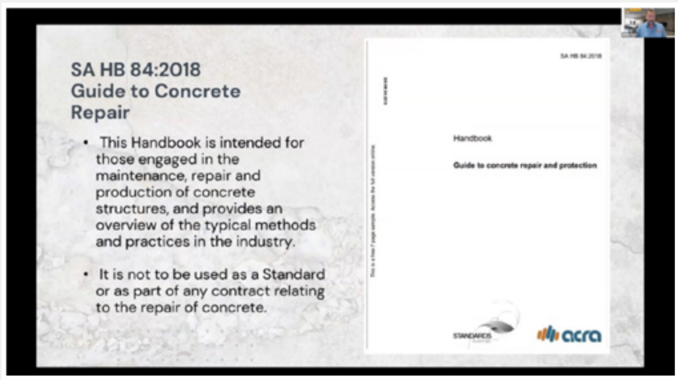
With over 30 registrants, the event brought together students, young professionals, and early-career researchers for a valuable session highlighting the challenges and innovations in coastal corrosion environments. The session began with an overview of the YCG's purpose and initiatives, followed by insightful technical presentations from emerging professionals across the region. Nate Berends (VIC) from Marine and Civil Maintenance shared a contractor's perspective on remediation in coastal environments; Joe Davies and Geoffrey Will (QLD) from Aurecon and the University of the Sunshine Coast explored the condition assessment of marine coatings using electrochemical impedance spectroscopy; Michael Widjaja (WA) from GHD discussed the practicalities of corrosion control and asset inspection in marine settings; and our colleagues from New Zealand, representing Lumen, contributed a regional perspective. The ACA extends sincere thanks to all presenters, the YCG Steering Committee, and attendees for making this knowledge-sharing event a success.

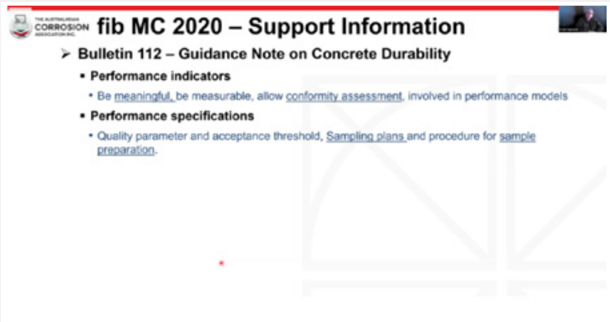


Concrete Structures & Building Technical Group Webinar

On 7 August 2025, the ACA's Concrete and Structures Technical Group hosted a focused technical webinar exploring recent developments in concrete durability and repair.

With 15 registrants tuning in from across the region, the session brought together professionals and practitioners interested in the future of concrete standards and best practices. The event featured two expert-led presentations. Frank Papworth from Building & Construction Research & Consultancy (BCRC) presented *Concrete Durability and the fib Model 2020*, offering insight into the model's application and global relevance in enhancing concrete durability benchmarks. Following this, Justin Rigby, Director of Remedy Asset Protection, delivered a comprehensive overview of the *Australian Standards Proposal for the Adoption of EN1504 for Concrete Repair*, highlighting the potential impact of aligning national standards with European best practices. The ACA thanks both presenters for their invaluable contributions, as well as all attendees for supporting this knowledge-sharing session.





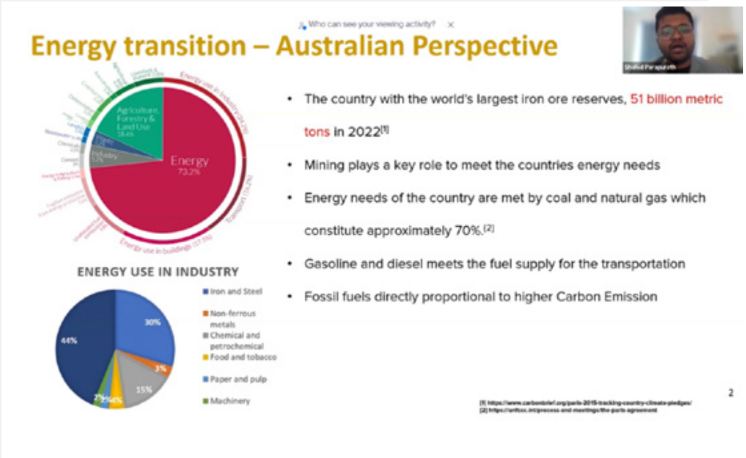
Oil, Gas & Energy Technical Group Webinar

Proudly Sponsored by Remedy Asset Protection | Venue: SA Water

The Oil, Gas & Energy Technical Group, on behalf of the Australasian Corrosion Association (ACA), held a successful national webinar on 18 September 2025 titled *Young Corrosion Professionals: Investigations and Innovations from the Lab to the Field,* attracting 55 registrations.

This engaging session featured three early-career presenters sharing research and practical case studies relevant to the oil, gas and energy sectors. Medhani Pathirana (Deakin University) presented on localised waterline corrosion using local electrochemical measurement methods and REM inhibitors. Lachlan Zilm (Santos) shared a detailed investigation into small bore fitting (SBF) failures caused by dropped object impact, highlighting integrity risks and plant-wide mitigation efforts. Shahid Parapurath (Curtin University) explored hydrogen embrittlement in high-strength steels and welds, focusing on safety challenges for hydrogen transport pipelines. The event offered valuable insights for those working in materials science, corrosion mitigation and pipeline integrity.

A warm thank you to our presenters, attendees, and event sponsors: SN Integrity, Intertek and Santos for their support.



News from the ACA Foundation Chairman

Wayne Burns, Chair – ACA Foundation Limited

The allocation of the ACA Foundation scholarships & training awards for 2025 have been determined by the ACAF education and scholarship committee. We could not have achieved this milestone without the superb support of ten corporate and individual donors this year to allow our scholarship program to expand.

ACAF Corporate Donors / Sponsors

The ACAF has been very fortunate in gaining the support of corporate organizations who provide long-term commitments to support ACAF Scholarship Programs. The restructured team in the sponsorship committee achieved miracles, and the expanded list of supporters is given below.

Denso Australia	Conference attendance or ACA Training (Student award)
Universal Corrosion Coatings (UCC)	Open Award Sponsor 2025, 2026 & 2027
UCC NZ	NZ Sponsor of the Ray Osborne Memorial NZ YCP Award.
Infracorr Consulting	Sponsor of Graduate / Student award 2025, 2026 & 2027
Marine & Civil Maintenance	Sponsor 2025, 2026 & 2027 + ACAF Function Sponsor
Freyssinet Australia	2025 Sponsor of Conference Attendance Award
Carboline NZ	2025 Sponsor – Conference or Training award
Metspray	2025 Sponsor – Conference or NZ Training award
ACAF Centurions	Sponsor of 2025 Mike Rutherford Memorial Award
Concrete Preservation Technologies	2025 Sponsor - Conference attendance or ACA Training (Student award).
CRL Australia	2025 Sponsor - Conference attendance or ACA Training (Student award).

Please visit https://www.corrosion.com.au/foundation/donor-spotlight/ for more information.

Scholarship Prospectus

ACA Foundation is proud of the achievements of its Scholarship program since it was launched in 2000. We have now delivered more than 140 scholarships to ACA and related community members. The Sponsorship Committee recognised the need for a document that reflects the benefits to sponsors of the program. We now have a Prospectus for existing and future companies and individuals considering becoming a Scholarship Sponsor in the future. (see the ACAF Web Site)

ACAF Centurion Program

- An important part of being able to deliver scholarships Is by way of support from members and the community, and this is derived from the ACAF Centurion Program. We are all aware that generating interest from young people to become engaged in our Corrosion Prevention Industry as a career path often can result from Community Scholarship programs.
- ACAF initiated the Centurion program so that individuals, corporations or community-based organisations can become donors for local and international scholarships. Young people can expand their knowledge and their careers in Corrosion Engineering, Corrosion Management or Specialist Corrosion Integrity and Prevention Programs.
- ACAF Centurion Donors can contribute as little as $100 per annum or greater amounts in support of future scholarship programs.

Updating your Centurion & Donors Support

The ACA Foundation is proud of our members Centurion donor program.

If you have been a Centurion supporter, please take this opportunity to continue your 2025/2026 membership by opening this link.

If you are a company, corporation you can provide a scholarship program over a 5year term. Open this link to make contact with one of our ACAF directors to discuss this opportunity further. Be part of the future development of our young people's careers. The future of our industry depends on the young corrosion practitioners we train and develop now.

The expertise of our young community to grow and foster future international participants in our Australasian business's rests with you.

We appreciate you taking the time to read our message. We look forward to your continued support as either a Centurion Donor or as a Corporate Scholarship donor for the longer-term.

We developed a TAFE endorsed training platform for delivery of a STEM program called **All At Sea** in 2012. This program was developed with corporate donations. Contact us to support such additional community-based developments.

ACAF Ltd – A Registered Incorporated Tax-Deductible Charity

ACA Foundation Limited is a registered Charitable Organization with TAX DEDUCTABLE Status for donations. This process enhances the benefits of donations from our sponsors.

Please consider becoming an ACA Foundation donor today for our young practitioners for the future benefit of our industry.

Interrogating the Witness: Weathering Steel Durability Assessments

J. Davies, J. Colwell, M. Hales

Keywords:

reinforcement corrosion, chloride, concrete, potable water tanks, capillary action

Abstract:

Weathering steel is a high strength construction material that requires very little maintenance over its lifecycle when designed correctly for suitable environments. When applying Australian Guidelines and Standards, usage environments are limited to where the atmospheric corrosivity classification is C3 or lower. For locations with corrosivity at the higher end of this range, witness coupon trials to determine location-specific corrosion rates are recommended to confirm durability. However, the typically short timeframe over which such studies are undertaken can limit confidence in the extrapolation of corrosion rates to design lives that may be up to 100-times longer. Application of composition-based modelling or access to long-term coupon data can improve confidence in extrapolations. Here, we present a modified composition-based model that incorporates environmental effects implicit in representative witness coupons that better represents corrosion of weathering steel than existing standard models in environments with corrosivity of C3 or higher. Additionally, we propose that the analysis of coupons to determine patina structure using X-ray diffraction (XRD) and visual assessment may give more insight into its protective nature and the potential long-term performance of the weathering steel.

INTRODUCTION

Weathering steels are a group of low carbon, high strength steel alloys with 1-5% of alloying elements, such as copper, chromium, nickel, phosphorus, silicon and manganese [1]. In suitable environments, they show much lower corrosion rates than conventional structural steel (carbon steel) due to the presence of a strongly bound oxide layer (patina) [2]. Low corrosion rates can allow weathering steels to be used uncoated for structural applications such as bridges, with weathering steel being used extensively in North America [3], Europe [4] and Japan [2] for over 50 years.

The patina that gives weathering steel its corrosion resistance is a strongly bonded layer of iron oxyhydroxides, which evolve in structure over several years. Weathering steel alloys undergo wetting and drying cycles during atmospheric exposure, fostering the gradual development of the patina, whose development process has been described by Yamashita et al. [5].

As the patina forms, different iron oxyhydroxide phases are produced, and the relative amounts of these phases are indicative of corrosion protection provided by the patina. Hara et al. [2] analysed 17 – 18 years of corrosion data collected by the Japan Iron and Steel Federation (JISF) and Japan Association of Steel Bridge Construction (JASBC) from JIS G3144 type (SMA490W) weathering steel witness coupons. They identified two metrics that can be derived using XRD, which can classify patina condition, and they correlated these metrics to corrosion rate and visual appearance. The two metrics are:

1. The protective ability index (PAI), which is represented by the vertical axis on the ternary diagram in Figure 1a. PAI is the ratio of α-FeOOH (geothite) to the total amount of γ-FeOOH, β-FeOOH and spinel type iron oxides such as magnetite. PAI is represented as $\frac{\alpha}{\gamma^*}$, where α is the crystalline FeOOH phase and γ^* is the sum of γ-FeOOH, β-FeOOH and spinel type iron oxides.
2. The amount of β-FeOOH (β) and spinel-type oxide phases (s) can also be used to evaluate patina formation. These are represented on the horizontal axis of Figure 1a as $\frac{(\beta+s)}{\gamma^*}$.

The process of patina formation and the long-term corrosion resistance of weathering steels can be influenced by numerous factors. The inclusion of alloying elements such as chromium, copper, phosphorus and nickel in weathering steel can assist in the development of the protective patina. Variations in alloying elements used in weathering steels influence the effectiveness of protective mechanisms, as demonstrated by Townsend [6]. Alloys with nickel are particularly resistant to the effects of chloride deposition [7], with high phosphorus and chromium weathering steels such as ASTM A242 showing improved patina formation under acidic conditions [8], which are associated with elevated SO_2 deposition. Higher levels of carbon and phosphorus will generally improve corrosion resistance, but at the expense of weldability [3].

Correct surface preparation and handling conditions are also important for the formation and stability of the patina. Storage in a manner that prevents extended periods of wetting, and pretreatment involving removal of mill scale by blasting to SSPC-SP 6/ NACE No 3 / ISO Sa 2, followed by exposure to wetting and drying cycles using potable water will accelerate early patina formation [9].

In addition to the factors noted above, environmental conditions also strongly affect patina formation and need to be understood at both the macro and micro levels. The corrosivity of the macroclimate

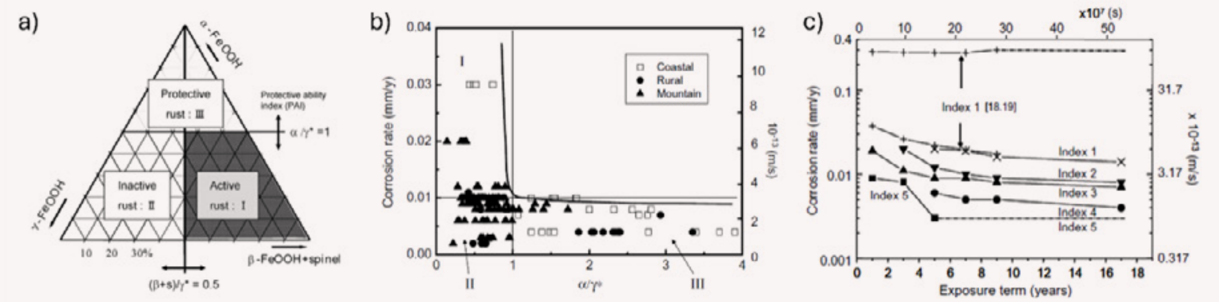


Figure 1: a) Ternary diagram showing three classes of patina composition. b) Relationship between corrosion rate of SMA490W and patina composition classes. c) Corrosion rate of SMA490W witness coupons over time, separated by appearance index. Appearance indices were determined using visual and XRD data [2].

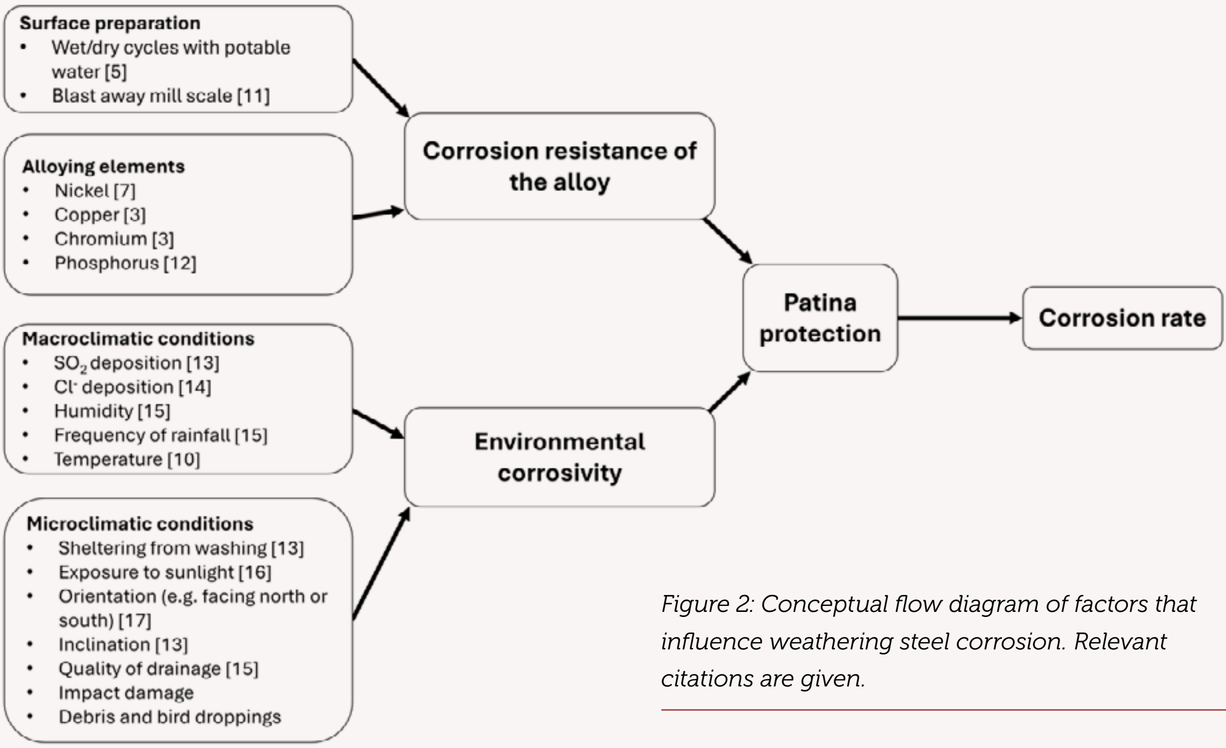


Figure 2: Conceptual flow diagram of factors that influence weathering steel corrosion. Relevant citations are given.

in the region can be investigated by assessing the critical environmental factors [10] that will influence corrosion rates and potentially disrupt patina formation (see Figure 2). Microclimatic effects such as sheltering, shading, orientation relative to prevailing winds, inclination, and detailing can all influence corrosion rate.

Weathering steel corrosion is best understood via a combination of factors relating to the alloy and its exposure environment, and their influence on patina protection. The prevalence of higher quality patina will influence the degree of protection provided. The diagram in Figure 2 maps out the relationship between factors that influence weathering steel corrosion rate.

The ASTM standard guide for estimating the atmospheric corrosion resistance of low-alloy weathering steels [1] derives methodologies for the modelling of uniform corrosion with the power law function (1), where A is the uniform corrosion loss after one year of exposure, t is the time in years, and B is the exponential factor describing the rate of patina formation and slowing corrosion rate. Data shown in Section 6.3 of the standard is derived from coupon trials on a range of weathering steel alloy types undertaken by Townsend [6]. While this is an invaluable resource, there are challenges to its application for the design of structures, particularly in coastal areas and for weathering steels that are not included in the standard.

$$C = At^B \tag{1}$$

ISO9224 provides a simplified version of the Townsend model for low alloy weathering steels, and adds a method for estimating the influence of chloride deposition (2) [18]. B is the exponential factor in the power law, b is the coefficient for the respective alloying element and w_i is the %wt concentration of the respective element in the alloy.

$$B = 0.569 + \sum b_i w_i + (0.0845\ S_d^{0.26}) \tag{2}$$

While this is a substantial step forward, it does not account for other relevant environmental factors and cannot be considered as representative as in-situ coupon assessments. These deficits can be partly overcome by undertaking witness coupon trials at the intended location for the structure. However, the typically short timeframes over which witness coupon studies are conducted can lead to uncertainty and reduced confidence in the accuracy of extrapolations.

To address this, and provide more confidence in predicting weathering steel performance, this paper presents strategies for corrosion assessment of weathering steel structures that consider the fundamental nature of weathering steel corrosion and how a range of witness coupon analysis techniques can aid in the prediction of future corrosion behaviour.

Methodology

A desktop estimate of uniform corrosion over the design life of a structure can be obtained from historical weathering steel coupon data, provided that elemental composition of historical coupons and the aggressivity of their exposure environment is carefully considered in the estimation.

Available historical coupon data may not directly reflect the composition and corrosion resistance index (CRI) [1] of the alloy under assessment. Application of this historical data to corrosion assessment, in the absence of a more representative alloy, even where the data were collected in a representative exposure environment, would result in an underestimation of corrosion where the CRI of the historical coupons is higher than the alloy under assessment and vice versa.

To account for composition and environment, an approach based on the method used by Townsend [6] and presented in ASTM G101-04 to determine corrosion extent accounting for composition has been modified to incorporate reference values from witness coupons that have been exposed in representative exposure environments for the alloys under assessment.

The method described in ASTM G101-04 (see (3) and (4)) includes reference values (a_0, b_0) that represent the first-year corrosion rate and the exponential factor values for cast iron in an industrial C2/C3 environment [6], to which adjustment parameters based on individual element concentrations in the alloy are applied ($a_i x_i$, $b_i x_i$) . A and B are the power law parameters from (1), a_i and b_i are the coefficients for the i^{th} alloying element, and x_i is the wt% concentration of the i^{th} alloying element.

$$A = a_0 + \sum a_i x_i \qquad (3)$$

$$B = b_0 + \sum b_i x_i \qquad (4)$$

Since the method from ASTM G101-04 is based on data only from C2/C3 industrial environments, there may be limits to its ability to accurately estimate corrosion in different environments as shown below. So, to more closely simulate corrosion of the alloy under investigation, the approach developed here takes historical witness coupon data from an exposure environment that better represents the environment to which the alloy will be exposed and applies reference first-year corrosion rate and exponential factor values from this historical data (a_{ref}, b_{ref}) , and elemental concentration differences between the alloy under investigation and the historical reference alloy (Δx_i) as per the equations below, rather than the total concentration.

$$A = a_{ref} + \sum a_i \Delta x_i \qquad (5)$$

$$B = b_{ref} + \sum b_i \Delta x_i \qquad (6)$$

To demonstrate this process and investigate its validity, desktop corrosion assessments were performed for an A588 weathering steel alloy at 20 locations for which coupon data has been made available in the appendices of ASTM G101-04. Reference data was taken from comparable A242 witness coupons also available in the appendices of ASTM G101-04. Reference first-year corrosion rate and exponential factor values from this historical data (a_{ref}, b_{ref}) were derived from Power Law parameters fit from the 8 – 19 years of available data. Coefficients for alloying elements in ASTM G101-04 Table 2 derived by Townsend at Pittsburgh, Philadelphia were used in this approach.

To assess how this approach compares to other commonly applied methods, the following three techniques for estimation of 100-year corrosion of an A588 alloy were evaluated:

1. Compositional approach detailed in ASTM G101-04, and described by (3) and (4).
2. Adoption of A242 historical coupon data
3. A242 historical coupon data (a_{ref}, b_{ref}) adjusted using (5) and (6).

There can be elemental compositional variation within alloy types, which gives rise to a range of corrosion resistance index (CRI) values (see Table 1) [1]. In some cases, this can lead to some formulations of A588 having a higher CRI and hence greater corrosion resistance than some A242 formulations, which can affect estimation of corrosion extent depending on the method used for analysis. Here, the assumed compositions for A242 and A588 alloys are based on the averages of compositional range and are shown in Table 2.

Results and Discussion

Figure 3 shows the differences between A588 coupon corrosion based on historical data available in the appendices of ASTM G101-04, and the predictions for corrosion using the three methods outlined above. The use of the composition-based model as described in ASTM G101-04 (Method 1) gives the greatest difference between historical data and predicted values, with underestimation of corrosion being dominant. Adoption of A242 historical witness coupon data without consideration of differences in corrosion resistance of the alloys (Method 2) resulted in a better estimation of A588 corrosion in most cases. However, underestimation of corrosion extent was generally evident, indicating the risks of adopting coupon data from a more corrosion resistant weathering steel to an alloy with reduced concentrations of alloying elements.

Differences between historical data and predicted values based on the methods used here may also arise from large uncertainties in elemental composition. Table 1 shows the range of corrosion resistance index (CRI) [1] values that can arise from variation in elemental composition from 72 heats of steel production. The concentration of alloying elements in some A588 formulations resulted in higher CRI than some A242 formulations. Therefore, it was not surprising that there were differences between predictions of corrosion extent for A588 alloys based on A242 historical data. Potential variation in elemental composition during production should always be considered when estimating lifetime corrosion and the suitability of a weathering steel for use in particular environments. Conservative assumptions that use the minimum concentration of alloying elements in the alloy being assessed should generally be made wherever necessary. However, the risk of corrosion overestimation can be minimised by obtaining more detailed information on alloying elements within a weathering steel.

The modified interpretation of the composition-based model from ASTM G101-04, which was developed here as Method 3 resulted in very close prediction for environments where the first-year corrosion rate was below 30μm/year (Figure 3), corresponding to rates observed in the upper end of C3 for weathering steels [19]. However, this approach substantially overestimated 100-year corrosion in more aggressive

Purpose	Alloy	Average CRI	CRI range
Historical reference coupon	A242/A242M Type 1	8.0	6.6 – 9.1
Alloy being assessed	A588/A588M	6.7	6.1 – 7.0

Table 1: Atmospheric corrosion resistance indices from 72 heats of A242 and A588 steels. Higher CRI signifies greater corrosion resistance, as presented by ASTM G101-04 [1].

Alloy Purpose	C	Mn	P	S	Si	Ni	Cr	Cu	Al	V	CRI
Reference: A242 Type 1 Historical reference coupon	0.11	0.31	0.092	0.02	0.42	0.31	0.82	0.30	0.08	0.01	8.26
Alloy being assessed: A588	0.13	1.03	0.006	0.019	0.25	0.015	0.56	0.33	0.043	0.038	6.12

Table 2: Assumed compositions for A242 and A588 coupons, adapted from ASTM G101-04 Table X1.4 [1]. Average composition of steels for coupon data in ASTM G101-04.

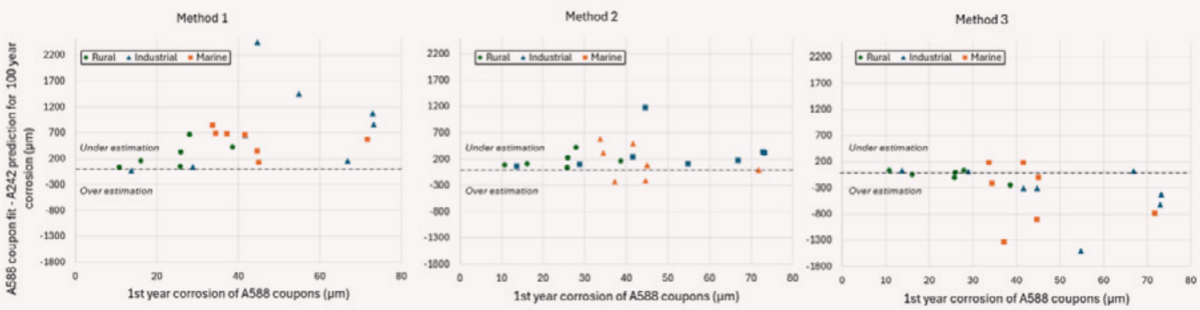


Figure 3: Validation of prediction for 100 year corrosion loss of A588 witness coupons based on: Method 1 - ASTM G101-04 using (2) and (3); Method 2 - A242 coupon data from ASTM G101-04; Method 3 - A242 coupon data modified using (4) and (5).

environments and is thus a conservative approach to corrosion prediction. Underestimation of corrosion was observed for some locations, but was not more than 200μm at 100 years exposure.

Method 3 can be applied without the need to evaluate or assume a chloride deposition rate, and implicitly captures the range of environmental factors that are experienced by historical reference coupons. In contrast, Method 1 estimates corrosion from weighted composition parameters that were calibrated by Townsend [6] in Pittsburgh PA, and therefore does not represent all environmental exposure conditions. Method 2 disregards the influence of alloying elements on corrosion and only considers the influence of the exposure location.

As shown above, there is typically a high degree of uncertainty in theoretical modelling for long-term corrosion prediction, but approaches that consider both the elemental composition and the exposure environment are less likely to result in underestimation of corrosion rate. Other methods that use this type of approach include that described in ISO9224 Annex C [18], where a simplified Townsend model that includes a term for chloride deposition rate for estimation of the exponential factor for the power law (2) is presented.

Chloride deposition can disrupt long term patina formation, and correction of the exponential factor as a function of chloride deposition rate is therefore sensible. However, environmental factors that may influence patina performance and corrosion rate are far more numerous (see Figure 2), so where possible it is better to rely on witness coupon data collected in a representative environment over a longer period, which will capture the sum of environmental factors.

Improving Confidence in Predictions Through Detailed Witness Coupon Analysis

Modelling approaches presented in standards and literature generally exploit mass loss data collected from witness coupons but do not consider information pertaining to patina composition. Considering that it is the presence of this strongly bound oxide layer that gives rise to weathering steel's corrosion resistance, it seems logical that patina composition analysis may provide more confidence in durability assessments and corrosion prediction.

Analysis of the patina formed during exposure can be obtained by X-ray Diffraction (XRD) measurements. A layer of corroded material is collected from a small area (0.01 m^2) of a witness coupon using a sharp cutter prior to coupon mass loss analysis (as per ASTM G1-03 [20]). The collected corrosion product for XRD analysis is dried and combined with an internal standard (e.g., ZnO) and then analysed [2]. Rietveld refinement of XRD diffractograms enables estimation of PAI and $\frac{(\beta + S)}{\gamma^*}$, which are key to determining patina stability (Figure 1) and whether active, inactive or protective rust is present. Where inactive or protective rust is indicated through XRD analysis, greater confidence in long-term corrosion performance with respect to reduced corrosion rates may be obtained.

Additionally, a combination of patina composition assessment via XRD, patina thickness analysis, and grain size measurement may be correlated with the corrosion rate, as per the work of Hara et al. [2]. This approach may be used to better gauge long-term performance from short-term witness coupon studies conducted at representative locations.

Conclusion

Prediction of 100-year corrosion of weathering steel from short-term coupon studies presents a significant challenge. While the pre-exponential factor for the power law prediction can be easily obtained through short-term testing, prediction of long-term trends in patina formation and stability is difficult without data collected over extended periods in representative exposure environments. Compositional approaches to the modelling of weathering steel corrosion may assist with prediction of long-term corrosion and have been assessed here using coupon data from two weathering steels. It was found that:

- Composition-based modelling that has not be calibrated in a representative environment can result in substantial prediction error. Models that rely on alloy composition are highly dependent on accurate alloy concentration data.
- Use of the ASTM G101-04 composition-based model can result in very large corrosion underestimation in environments with corrosivity of C3 and higher if environmental factors are not considered.
- Adoption of historical witness coupon data from a more corrosion resistant alloy results in underestimation of uniform corrosion, which may be up to 1.2 mm over 100 years.
- Modification of the ASTM G101-04 method with historical coupon data collected in a representative environment can reduce corrosion underestimation, to less than 0.2 mm over 100 years.

The work presented here highlights the need to consider alloy composition and environmental exposure for long-term corrosion prediction. There is potential to further improve predictions by applying interpretations of witness coupon data presented by Hara et al. [2], which can be used to further elucidate the relationship between patina appearance, XRD analysis and corrosion rate. Steps forward in this understanding hold the potential to improve durability assessment during design, as well as the assessment of existing weathering steel structures.

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Weathering Steel Durability in Australasia

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This paper was presented to Corrosion & Prevention 2024 in Cairns as Paper No. ACA2024-21565

Keywords:

weathering steel, durability, atmospheric testing.

Abstract:

The atmospheric corrosion rates for Australian-made weathering steels, as predicted by ISO 9224, are compared with historic 15-year weight loss results from Australian exposure sites, and current international design guides. Examples of weathering steel bridges in Australia and New Zealand are also presented.

INTRODUCTION

The purpose of the paper is to share unpublished historic data on the durability of weathering steel panels that were exposed in 1968 at different sites around Australia and monitored for fifteen years. The paper also compares these results with the durability predicted by ISO 9224 for these and a newly available Australian-made weathering steel in different atmospheric corrosivity environments in Australasia. Finally, it reviews the sacrificial thickness allowance recommended by various international bridge design guides for these environments.

It is hoped that this paper will give greater confidence to Australasian bridge designers to specify the use of weathering steel instead of conventional coated carbon steel in non-coastal environments.

Weathering Steel

Weathering steel (WS), or to use its technical title of “structural steel with improved atmospheric corrosion resistance”, is a high-strength low-alloy steel that, in suitable environments, may be left unpainted because it forms an adherent protective rust “patina” to prevent significant further corrosion. The added alloying elements comprise only 2% of the steel, with copper and chromium being the two most important, along with silicon and in some cases phosphorus. These do not diminish the structural capability of the steel which has strength, ductility, toughness and weldability suitable for bridge construction [1, 2].

All structural steel rusts at a rate which is governed by the access of the metallic iron to moisture and oxygen. As this process continues, the oxide (rust) layer becomes a barrier restricting further ingress of moisture and oxygen to the metal, and the rate of corrosion slows down.

The rust layer that forms on most conventional carbon-manganese structural steels is relatively porous and it regularly detaches from the metal surface after which the corrosion cycle commences again. Hence, rusting progresses as a series of incremental curves approximating to a straight line, the slope of which depends on the aggressiveness of the environment. This is illustrated schematically in Figure 1.

The weathering steel rust patina is initiated in the same way. However, due to the alloying elements in the steel, it produces a more stable rust layer that adheres to the base metal and is much less porous. This layer develops under conditions of alternate wetting and drying to produce a protective barrier, which impedes further access of oxygen and moisture. Eventually, if the rust layer remains sufficiently impervious and tightly adhering, the corrosion rate may diminish virtually to zero. The resulting reduction in corrosion rate is illustrated in Figure 1. In a suitable environment, this stable condition may be reached within 8 years or so, and the metal is then protected from significant future corrosion by the rust patina [2].

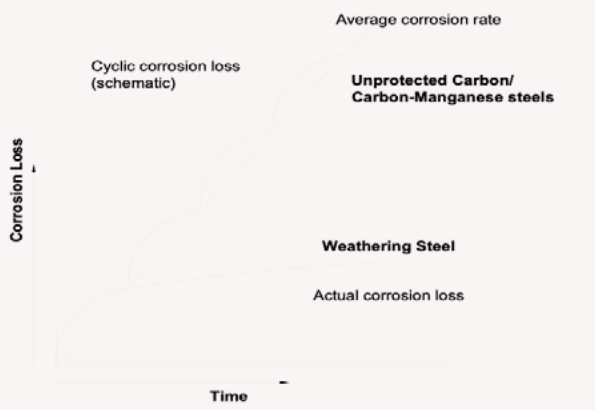

Figure 1. Schematic comparison between the corrosion loss of weathering steel and carbon steel [2]

Atmospheric testing

In 1968, the Corrosion Research Department of Australian Iron & Steel Pty Ltd (AI&S), at the time part of Australian steel making firm BHP Pty Ltd, commenced a comprehensive test program to compare the atmospheric corrosion performance of AusTen Type A, their proprietary low alloy weathering steel (WS), with a plain carbon steel (CS). Twenty-three exposure sites were located throughout Australia in a broad range of environments from heavy industrial/marine at Port Kembla to the very dry arid environment of Mt Newman in WA. Test panels were exposed, removed and analysed at regular intervals over 15 years and reported, but not published, by Badger and Wallace [3].

This current paper uses the AI&S data to estimate the expected WS metal loss after 100 years exposure within different ISO 9223 atmospheric corrosivity categories. These losses are then compared to the current allowances given in Table 3.2 of the Australian design guide [2] and Table 3.2 in the latest European design guide [4].

Estimate of 100-Year Metal Loss

The 100-year metal loss can be determined by analysing the long-term results in a number of steps.

Step 1:
WS Corrosion Rates for ISO Corrosivity Categories

The ISO 9223 Atmospheric Corrosivity Categories [5] are based on first year CS corrosion rates. WS in a given category will show a reduced corrosion rate, but there is no simple formula relating first year CS steel rates to first year WS rates. Figure 2 plots the first-year corrosion rates for the two steel types from the AI&S report.

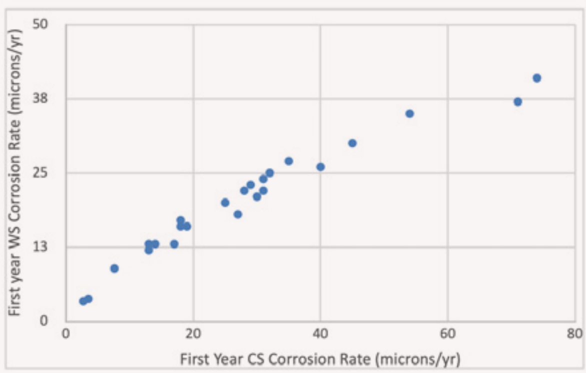

Figure 2: First year weathering steel corrosion rates compared to carbon steel rates from [3].

Figure 2 shows significant scatter, but there is clearly a relationship between the rate in CS and WS. Table 1 presents suggested first year WS corrosion rates for the standard ISO Corrosivity categories based on the relationship shown in Figure 2.

ISO 9223 Category	1st yr CS Corrosion Rate (microns/yr)	1st yr WS Corrosion Rate (microns/ yr)
C2	1-25	1-20
C3	25-50	20-35
C4	50-80	35-45

Table 1: First year corrosion rates for weathering and carbon steels for ISO categories

Step 2: Long Term Rates from Trends

Figure 3 shows the changes in corrosion rate with exposure time from six selected sites with 15 years exposure, which cover a wide range of results and show a relatively smooth transition. (Other results, and those from similar overseas investigations, show more varied behaviour, but do not seriously contradict these examples).

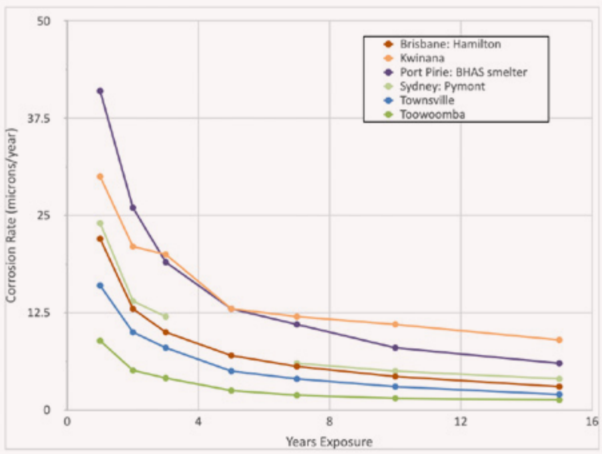

Figure 3: Decrease in weathering steel corrosion rate with time from six sites.

From these trends, a first year WS rate of 20 microns per year (C2/C3 border) shows a 15-year rate of between 2–3 microns per year. A first year WS rate of 35 microns per year (C3/C4 border) shows a 15-year rate of between 6–9 microns per year. The more conservative (greater) figure can be considered a long-term rate and has been used to calculate the 100-year corrosion allowance. These are given in columns 3 and 4 of Table 2.

Step 3: Check Mathematical Relationship

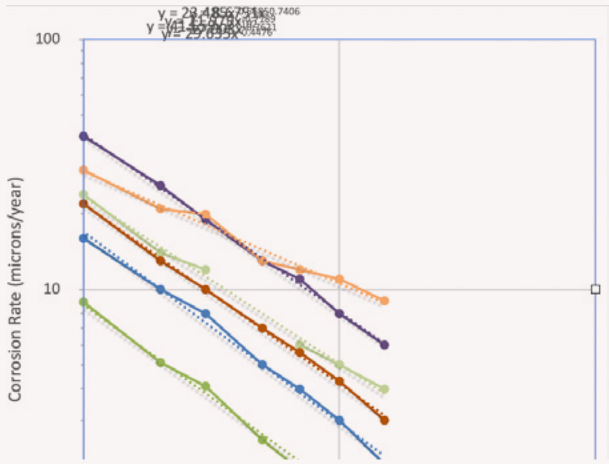

Figure 4: Figure 3 sites plotted using logarithmic co-ordinates, with trendlines and mathematical relationships.

Figure 4 shows that weathering steel, at least in these environments, does appear to follow a definite mathematical relationship, as per Section 4 of ISO 9224 [6], of the form:

[Rate in year t] = [First year rate] x [t] x [e(– b)]

where the constant *b* depends on the environment for a given metal. As the value of *b* becomes more positive, the difference between the short and long-term rate decreases. For the examples given, the value of *b* is approximately -0.75 for C2 environment, -0.7 for C3 and -0.5 for C4 (following the example of Kwinana). As the environment becomes more corrosive, it would appear that the value of *b* approaches zero and the long-term rate approaches the first-year rate, similar to the behaviour observed with carbon steel [7].

Using these exponents and the suggested boundaries noted in Step 1, we can calculate a 20-year corrosion rate using ISO 9224. Assuming the 20-year rate is a good approximation of the long-term constant rate,

1	2	3	4	5	6	7
	Calculated from AI&S data			Calculated using ISO 9224		
ISO Category	1st yr. WS rate (µm/yr)	15-year WS rate (µm/yr)	100yr WS loss (mm)	Exponent b	Long-term Rate (µm/yr)	100yr WS Loss (mm)
C2/C3	20	3	0.3	-0.7	2.5	0.25
C3/C4	35	9	0.9	-0.5	8	0.8

the loss over 100 years can also be calculated. These are given in columns 6 and 7 of Table 2 and give similar results to the extrapolated values.

Step 4:
Compare with Rates Predicted by ISO 9224

According to ISO 9224, total corrosion depth (D) for less than 20 years may be predicted using Equation 1:

$$D = r_{corr}\, t^b$$

For >20 years, Equation 3 of ISO 9224 is used:

$$D(t > 20) = r_{corr}[20^b + b\,(20^{b-1})\,(t - 20)]$$

Annex C of ISO 9224 is used to calculate (b) for an alloy. The specific value of (b) in a non-marine environment = ba

$$b_a = 0.569 + \sum b_i w_i$$

where:

b_a is the alloy-specific value of b in non-marine exposures;

b_i is the multiplier for the ith alloying element;

w_i is the mass fraction of the ith alloying element.

Table 3 presents the $b_i w_i$ calculated for *AusTen Type A* WS from the element multipliers given in ISO 9224 Table C.1

Table 3: Element multipliers

Element	AusTen Type A (%)	ISO 9224 Multiplier (b_i)	Calculated $b_i w_i$
C	0.11	-0.084	-0.00924
Mn	0.91	-	-
S	0.019	1.44	0.0274
Si	0.42	-0.163	-0.0684
Ni	0.25	-0.066	-0.0165
Cr	0.25	-0.124	-0.031
Cu	0.26	-0.069	-0.0179
P	0.09	-0.49	-0.0441

An estimate of the 100-year loss was made using Equation 3 of ISO 9224 and the steel chemistries for *AusTen Type A* and the recently Australian developed conventional weathering steel, *REDCOR*®, manufactured by BlueScope. The results are presented in Table 4, along with the estimated 100-year loss for WS presented in this paper.

Table 4 uses the data provided in ISO 9224 to predict the 15 year and 100-year losses for *AusTen Type A* WS, using a $\Sigma b_i w_i$ of -0.15988 and b_a of 0.40912. Also shown are the predicted 100-year losses for REDCOR W24W1 (High Phosphorus Type WR350A) with a b_a of 0.34258 and REDCOR W25W7 (Low Phosphorus Type WR350B) with a ba of 0.41514.

Table 4: Iso 9224 predicted 15 and 100-year losses for ws

Atmospheric Corrosivity Category	C2/C3	C3/C4
r_{corr} (for Carbon Steel)	25 µm/yr	50 µm/yr
D(15) for REDCOR®	63 to 77 µm	126 to 154 µm
15yr rate for AusTen Type A using AI&S data	*4 µm/yr*	*7 µm/yr*
D(100) for AusTen Type A	**0.23mm**	**0.45mm**
D(100) for REDCOR®	**0.17 to 0.23mm**	**0.33 to 0.46mm**
D(100) for AusTen Type A using AI&S data	**0.25mm**	**0.8mm**

Step 5: Comparison with the Recommended Corrosion Allowances

Table 5 compares the calculated 100-year loss for WS in this work to the corrosion allowances in the two published guides. The allowance given in the guides would be expected to include the 100-year loss plus a margin of error, so the figures from the ECCS Guide for C2 and C3 could probably be adopted. However, there are insufficient exposure test figures that would justify adoption of an allowance for the C4 environment.

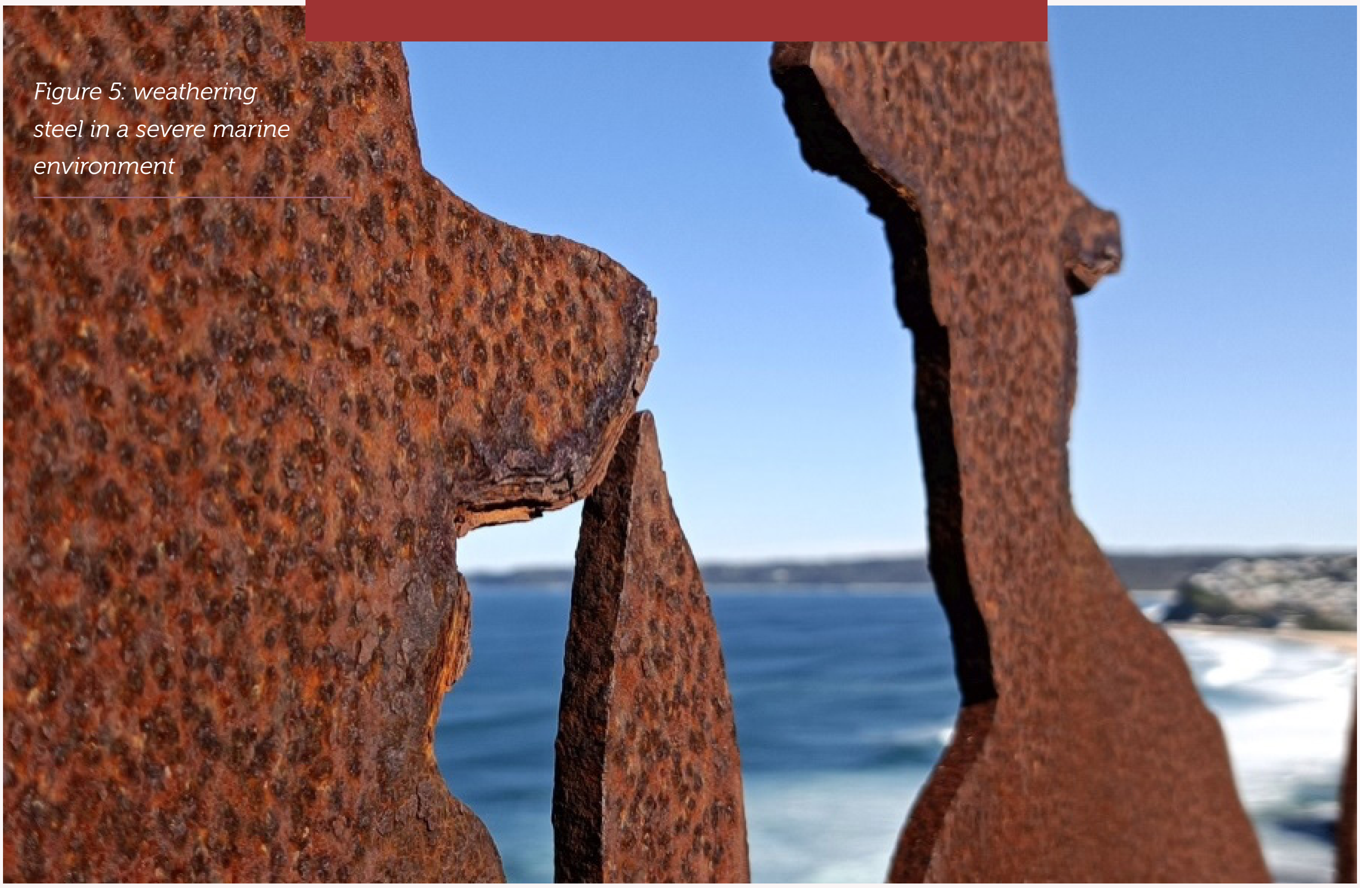

Figure 5: weathering steel in a severe marine environment

Table 5: Allowances compared to WS guides [2] [4]

ISO 9223 Category	100 yr Loss (mm)	Allowance (mm)	
	This work	Aust. Guide	ECCS Guide
C2	0.25 – 0.3	1	0.8
C3	0.8 – 0.9	1.5	1
C4	NA	NA	1.5

Coastal Environments

Exposure to high concentrations of chloride ions, deposited from airborne marine salts in aerosol originating from breaking waves at sea or on the shoreline, or from salt fogs, will negatively affect the patina formation on WS. The hygroscopic nature of salt can prevent surfaces from fully drying when relative humidity is elevated and thus stop the formation of the rust patina, thereby resulting in the weathering steel continuing to corrode at a rate similar to carbon steel. Figure 5 shows weathering steel exposed to a severe marine environment, showing formation of rust delamination at the edges.

Evidence of a higher corrosion rate (similar to carbon steel) and a delayed, or even absent, formation of the protective patina has been identified by Morcillo [8] for unwashed and sheltered surfaces (i.e. microclimate effects), as well as in crevices, on weathering steel structures in coastal locations. McKenzie [9] reported that severe pitting developed on weathering steel bridge members in sheltered marine environments.

Therefore, when determining the suitability of using weathering steel in a given location, the atmospheric corrosivity assessment needs to take into account not just the macroclimate, in accordance with AS 4312 [10] or SNZ TS 3404 [11] and/or the CSIRO Corrosion Mapping App [12]; but also the microclimate effects, as discussed by Francis [13] and described in the Australian Steelwork Corrosion and Coatings Guide [14].

Details regarding humidity levels, wind strengths and wind directions, which assist in determining the macroclimate and microclimate for a specific location, can be obtained from the Australian Bureau of Meteorology website [15].

Based on the findings of the Morcillo review of weathering steel performance data [8], it is recommended that conventional weathering steel should only be used where its steady state corrosion rate is less than 6 microns/year, or in areas where the maximum first year corrosion rate (taking into account both the macroclimate and microclimate effects on sheltered surfaces) of mild steel is less than 50 μm/yr. This is equivalent to a rain-washed surface in atmospheric corrosivity category C3 (Medium) to ISO 9223 or AS 4312. Therefore, if the determined surface-specific atmospheric corrosivity is C4 (High) or C5 (Very High), weathering steel should not be used. Higher nickel grades of weathering steel have been developed in Japan which are claimed to resist these more corrosive environments [16] but long-term experience is lacking.

AS 4312 suggests the C4 corrosivity boundary commences about 1km inland at exposed surf beaches, and 0.1km inland on calm shores, but a conservative approach to these distances is advisable to allow for microclimate effects on sheltered surfaces. Generally, weathering steel can be used in locations that are more than 2km from the ocean seacoast, where the maximum first year corrosion rate (taking into account both the macroclimate and microclimate effects) of mild steel is less than 50 μm/yr. On sheltered bays without breaking surf, WS that is freely exposed to rain washing may be acceptable up to 500m from the shoreline.

In the case that conventional weathering steel is being considered for sites where the microclimate corrosivity is borderline high C3 (Medium)/low C4 (High), or less than 2km from the open seacoast; then determination of the actual site-specific corrosivity environment (including those of unwashed and sheltered surfaces), with a minimum of 1-year record, is required. This assessment should be undertaken by an experienced and qualified corrosion engineer or materials scientist. It is recommended that the 'coupon weight loss' technique, to ASTM G1 [17], be used to determine the site-specific corrosivity, rather than testing for salt and sulphur dioxide levels in the atmosphere. Guidance for conducting the coupon weight loss test is given in the Australian WS bridge guide [2]. Alternatively, use of the 3 monthly qualitative 'wire-on-bolt' test method, to ASTM G116 [17], could be considered.

In summary, when assessing the site atmospheric corrosivity category in Australia (as per Figures A1 to A6 and Table 4.1 of AS 4312) to determine the suitability for the use of weathering steel, the following assessment guidelines should be used [2]:

- Any location in a C4, C5 or CX category or within 500 metres of the shoreline, whether the seas are temperate semi-sheltered, quiet (calm) or tropic quiet (calm), weathering steel should not be used.
- Any location within 5km of temperate surf (C4, C5 or CX), weathering steel should not be used.
- Weathering steel should be acceptable for all other locations (C2, C3) in Australia if at least 500m inland.
- However, if actual measurements or local features show high corrosivity, then this evidence should override these guidelines that apply to both boldly exposed macroclimates and sheltered micro-climates.

Conclusions

The historic exposure trials have confirmed that weathering steel can be specified with confidence for steel structures exposed to the atmosphere in C2 and C3 corrosivity zones, provided they are detailed and located in accordance with the relevant guide for Australia [2] or New Zealand [19]. The recommended corrosion allowance given in these guides at 1mm for C2 and 1.5mm for C3 has been shown to be conservative and allows for more severe environments due to microclimatic effects that may exist. These include underdeck bridge girders being sheltered from the removal of wind-deposited contaminants by rain washing, and being sheltered from sunlight which would otherwise aid evaporation of condensed moisture if steel temperatures drop to below dewpoint overnight.

Acknowledgments

The authors acknowledge the support of the NZ Heavy Engineering Association and BlueScope in preparing their guides for the use of weathering steel in Australian and New Zealand bridges. We also thank BlueScope for their permission to use the historic BHP test data [3].

EXAMPLES OF WS Bridges in Australasia

Figure 6: Examples of weathering steel bridges

BERWICK ROAD BRIDGE, INLAND NEAR DUNEDIN, NZ (1985)

MERCER RAIL OVERBRIDGE, SOUTH OF AUCKLAND, NZ (2006)

NZ RAIL REPLACEMENT BRIDGE (2012)

NZ RAIL REPLACEMENT BRIDGE (2012)

REPLACEMENT KUROW BRIDGE, NZ (2014)

KARAPIRO VIADUCT, NZ (2015)

PICTON RIVER BRIDGE, TASMANIA (1981)

JAMES RUSE DRIVE LIGHT RAIL BRIDGE, PARRAMATTA, NSW (2021)

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Breaking the hang up trade off in bulk handling

Hang up, the build up of fine, wet or clay rich ore on chutes, bins and hoppers, has long driven downtime, safety exposure and high water use for wash downs. The operational cost is real, from lost throughput to unplanned maintenance and manual clean outs.

Historically, sites have been forced to choose between hard, wear resistant liners that survive abrasion but allow sticky ore to adhere, or very slippery liners that shed material but wear quickly. The result is a costly compromise that shifts the problem rather than solving it.

A materials led approach changes the equation. Ultra low friction elastomeric polyurea can lower surface energy to reduce adhesion and carry back while its toughness and elastic recovery absorb impact and resist abrasion. Because these systems are spray applied, they form a seamless membrane that encapsulates welds and fasteners, removing common catch points and corrosion traps. Rapid cure enables application during short shutdowns.

Global Coating Systems' Anti-Hangup is the solution that resolves this trade off in practice. Applied at modest thickness to chutes, hoppers and high carry back zones, sites report up to 90 percent less build up, 70 to 85 percent lower wash down water, faster restarts and longer liner life. Optional wear indicator pigments support proactive inspections and planned change outs, delivering reliable flow without sacrificing durability.

Taber Abrasion

Sample ID	Wear Cycles	Weight (g)		Total Loss for 1,000 cycles (mg)	Conditioned		Wear Index (mg loss/1,000 cycles)
		Before	After		Temp °F	RH (%)	
Anti Hang-Up	1,000	32.4344	32.4096	24.8	73	50	24.8
PP1195	1,000	34.2194	34.1289	90.5	73	50	90.5

These results are based on the tests performed and are subject to change upon the receipt of new or additional information.

2025 Training Calendar

AMPP Coating Inspector Program Level 1	
WA - Perth	FULLY BOOKED! 13-18 Oct 2025
QLD - Brisbane	FULLY BOOKED! 13-18 Oct 2025
VIC - Melbourne	FILLING FAST! 17-22 Nov 2025
SA - Adelaide	24-29 Nov 2025
WA - Perth	24-29 Nov 2025

AMPP Corrosion Under Insulation	
Online/AEST	20-23 Oct 2025

AMPP Coating Inspector Program Level 2	
QLD - Brisbane	FILLING FAST! 20-24 Oct 2025
VIC - Melbourne	24-28 Nov 2025
SA - Adelaide	01-05 Dec 2025
WA - Perth	01-05 Dec 2025

AMPP Concrete Coating Inspector	
VIC - Melbourne	08-12 Dec 2025

2026 Training Calendar

AMPP Coating Inspector Program Level 1	
NSW - Sydney	12-17 Jan 2026
WA - Perth	09-14 Feb 2026
QLD - Brisbane	23-28 Feb 2026
SA - Adelaide	13-18 Apr 2026
WA - Perth	04-09 May 2026
VIC - Melbourne	03-09 May 2026
NSW - Sydney	06-11 Jul 2026
SA - Adelaide	17-22 Jul 2026
WA - Perth	03-08 Aug 2026
VIC - Melbourne	31 Aug - 05 Sep 2026
QLD - Brisbane	12-17 Oct 2026
WA - Perth	12-17 Oct 2026
NZ - Aukland	19-24 Oct 2026
NZ - Christchurch	02-07 Nov 2026
SA - Adelaide	23-28 Nov 2026
WA - Perth	23-28 Nov 2026
VIC - Melbourne	30 Nov - 06 Dec 2026

AMPP Coating Inspector Program Level 2	
NSW - Sydney	19-23 Jan 2026
WA - Perth	16-20 Feb 2026
QLD - Brisbane	02-06 Mar 2026
SA - Adelaide	20-24 Apr 2026
WA - Perth	11-15 May 2026
VIC - Melbourne	11-15 May 2026
NSW - Sydney	13-17 Jul 2026
WA - Perth	10-14 Aug 2026
SA - Adelaide	24-24 Aug 2026
VIC - Melbourne	07-11 Sep 2026
QLD - Brisbane	19-23 Oct 2026
NZ - Aukland	26-30 Oct 2026
SA - Adelaide	30 Nov - 04 Dec 2026
WA - Perth	30 Nov - 04 Dec 2026

2026 Training Calendar (cont.)

AMPP Cathodic Protection Level 1 Tester	
VIC - Melbourne	02-06 Feb 2026
SA - Adelaide	03-07 Aug 2026

AMPP Cathodic Protection Level 2 Technician	
VIC - Melbourne	09-13 Feb 2026

AMPP Cathodic Protection Level 3 Technologist	
Online/AEST	15-19 Jun 2026

AMPP Cathodic Protection Level 4 Specialist	
Online/AEST	22-26 Jun 2026

ACA GAA Hot Dip Galvanizing Inspector Program	
VIC - Melbourne	17-18 Feb 2026
NSW - Sydney	17-18 Mar 2026
QLD - Brisbane	14-15 Apr 2026
WA - Perth	21-22 Jul 2026
NSW - Sydney	15-16 Sep 2026

ACA ACRA Concrete Structures & Buildings	
Online/AEST	16-17 Mar 2026
VIC - Melbourne	30-31 Jul 2026
Online/AEST	14-15 Sep 2026

ACA Coating Selection & Specification	
Online/AEST	04-06 May 2026
NSW - Sydney	27-29 Jul 2026
Online/AEST	19-21 Oct 2026

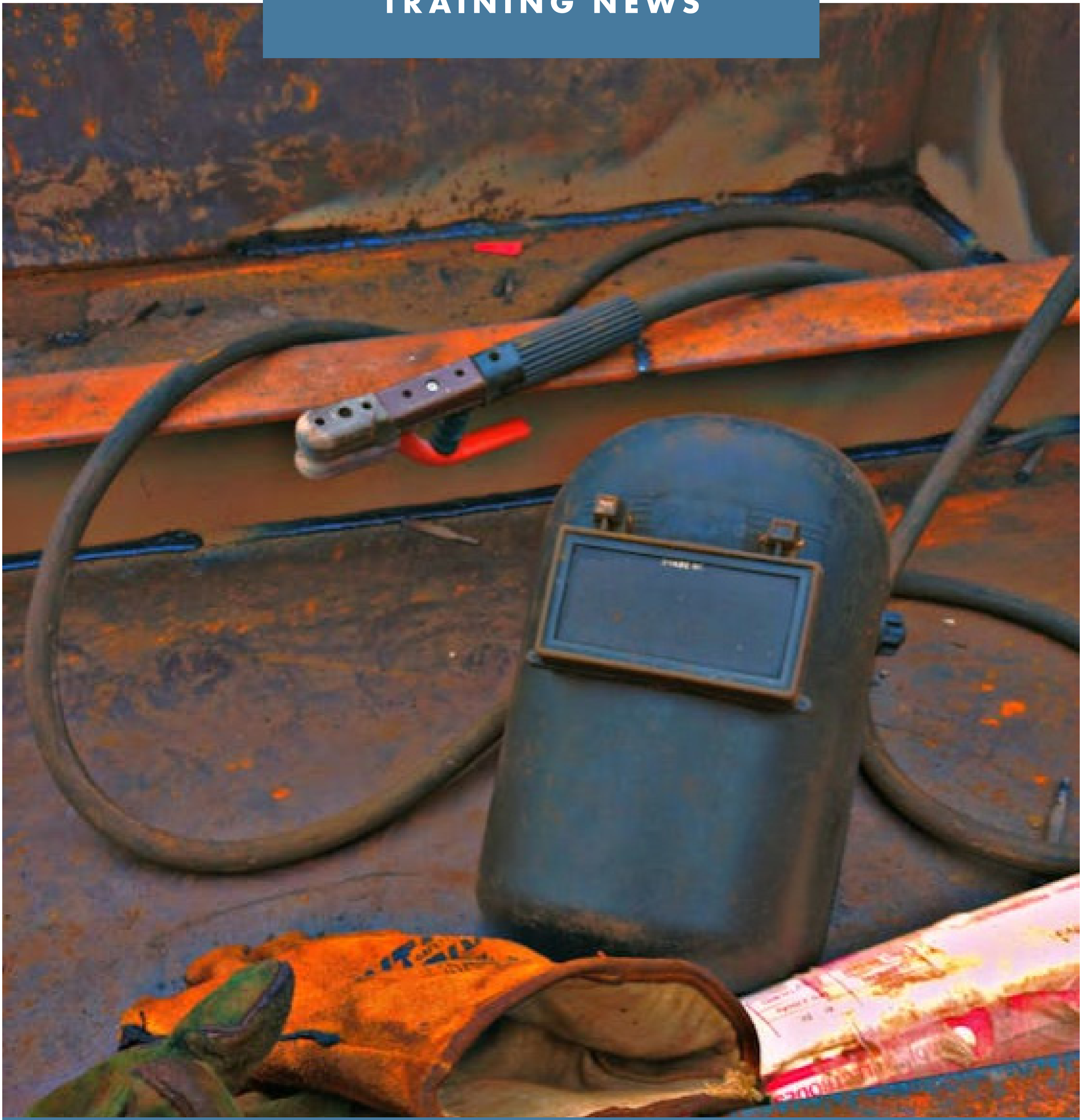
ACA Corrosion Technology Course	
VIC - Melbourne	01-05 Jun 2026
SA - Adelaide	07-11 Dec 2026

AMPP Craftworker Series	
SA - Adelaide	14-19 Sep 2026

AMPP Corrosion Under Insulation	
Online/AWST	20-23 Oct 2026

AMPP Concrete Coating Inspector	
VIC - Melbourne	07-11 Dec 2026

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



Course Spotlight: AMPP Corrosion Under Insulation (CUI)

Overview:

Corrosion Under Insulation (CUI) is a severe form of localized, external corrosion that most commonly occurs on insulated carbon and low alloy steel and stainless steel equipment that operate at high temperatures at or below 175°F.

CUI is most prevalent in the chemical/petrochemical, refining, offshore, and marine/maritime industries. If left undetected, CUI can result in catastrophic leaks or explosions, equipment failure, prolonged downtime due to repair or replacement, and safety and environmental concerns.

This course introduces the theoretical and practical aspects of preventing, managing and inspecting CUI.

Who should attend

The course was designed to be applicable for anyone working within an industry affected by CUI. Job titles may include but are not limited to:

- Specifiers and Designers
- Metals, Coatings and Risk Based Inspectors
- Coating Contractors
- Maintenance personnel and project engineers
- Manufacturers of insulation materials and equipment
- Unit managers involved in CUI

More information & registration:

Learning objectives

- Explain what CUI is, including the components of a typical CUI system and why it is required in a range of industrial settings
- Explain the importance of lab testing on the selection of CUI system components
- Define the role protective coatings play in the prevention of CUI and outline the factors that need to be considered when selecting a coating for application under insulation
- Identify the common types of coatings applied under insulation and describe their advantages and disadvantages
- Outline the factors that need to be considered when selecting insulation
- Describe the types of insulation and jacketing commonly used within CUI Protective Systems
- Describe the different types of spray-on insulation and their advantages and disadvantages
- Identify when passive fire protection is required and outline the steps to minimize the likelihood of corrosion under fireproofing occurring
- Summarize the differences between intumescent coatings, high density concrete coatings and cementitious coatings
- Explain common design practices used to minimize CUI
- Outline the common steps involved in installing a CUI Protective System
- Recognize common mistakes made during the application of insulation, jacketing, banding, vapor barriers and when sealing entry/exit points
- Identify the key components of risk-based inspection programs and describe their benefits within a CUI context
- Discuss the inspection methods that can be utilized with and without the removal of the CUI Protective System

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

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	✓	✗	✗	✗	✗	✗