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FEATURE: COATINGS & APPLICATIONS

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Hello Members,

It has been a great last quarter since the addition of the inaugural Corrosion magazine. We have had many well-attended branch events, and it is great to see some of the technical groups also being active.

I have attended quite a few branch committee meetings, and there has been great energy at these meetings with members being engaged and sharing their passion through our community. I'm excited that conference tickets are now on sale, so please feel free to promote this through your networks and attend what will be a fantastic conference in Cairns. The technical program is looking strong, and we have locked down many of our plenary speakers, which is fantastic. As always, we have great support from our sponsors.

I've had some meetings with the AMPP CEO and Operations Manager, discussing how we can work together and assist in growing and engaging our asset owners. We plan to have a dedicated stream for them to participate in.

I recently attended a council meeting and the AGM, where the board informed the council, and members present that we are currently in the process of updating the association's constitution. I look forward to working with the council and members to come to an agreement on what this should look like for the future of the association. I hope that at the next AGM next year, we can have a constitution ready to be accepted by the membership.

I feel a strong positive vibe from the people I have had conversations with throughout my meetings and interactions over the last few months, and I look forward to building on this. While there are always hiccups and hurdles, I believe all of these have been sorted out in a timely fashion. We have listened and acted on the comments or concerns brought to us. I would love to hear more from members, especially positive feedback and further improvements that we can make in the drive to provide member engagement and value. To that end, I would like to invite all members to reach out to me and see how we can contribute together with good ideas and initiatives.

Lastly, it's an exciting time with all our major awards nominations open for submission and review. This year and next year, each one of the board positions is open for nominations. To this end, I will be setting up the nominations committee with the President, Vice President, and Governance Committee Chair in accordance with our new bylaws to vet candidates before nomination. I encourage all those interested in a leadership position to apply. For those who are unsuccessful, this committee will hopefully find alternative substantial roles for our volunteers.

Kingsley Brown

ACA Board Chair

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Embracing the Power of Coatings

Dear ACA Members,

As we move through another busy year with the Australasian Corrosion Association, I'm reminded of how important our combined knowledge and experience are in keeping our infrastructure and assets in good shape. In this edition of the Corrosion and Materials Magazine, we're focusing on Coatings—such a vital part of preventing corrosion.

Coatings are more than just a protective layer; they represent the hard work and teamwork within our industry. We've seen amazing advancements in coating technologies that have changed the way we tackle corrosion, making these solutions more sustainable and effective. These breakthroughs wouldn't be possible without the dedication of the coating suppliers and applicators. Your hard work and expertise help us protect valuable assets, ensure public safety, and build a more sustainable future.

I also want to say a big thank you to our sponsors, so far this year all the technical and networking events organised by our branches and technical groups have been a great success. Your support and contributions allow us to offer great activities and resources for our members. Every initiative we take on is made better because of your involvement, and for that, we're incredibly grateful.

Our Association is strong because of our community and the active participation of every member. I encourage all of you to join our upcoming national and regional events, organised by our branches and technical groups. These events are fantastic opportunities to learn, network, and share best practices. Your presence and engagement are key to making these gatherings a success.

I'm very enthusiastic about our Corrosion and Prevention Conference in Cairns from the 10th to the 14th of November. This conference is set to be a highlight of the year, with a range of presentations, workshops, and networking opportunities. It's a great chance for us to come together, exchange ideas, and advance our knowledge in corrosion prevention even further.

Lastly, I want to emphasise the significance of our work and its impact on society. The support from our coating suppliers and applicators isn't just helpful; it's essential. Your contributions are a big part of the success of our Association and the well-being of our communities.

Thank you all for your continued dedication and support. Let's make this year exceptional by working together and pushing the boundaries of what we can achieve.

Warm regards,

Isaac Isakovich Castillo

ACA President.

Dear ACA Members

We have been busy planning for the next six months for the conference and other activities.

Implementing a new Member Portal has been intense for the ACA team over the past two months. If you don't have access to your member portal please let us know and we will send you your login credentials.

There is a new program being developed for Asset Owners at the 2024 Corrosion & Prevention Conference in Cairns (10-14 November registrations and draft program here) . This will include a Confidential Asset Owners forum where asset owners can hear some case studies from colleagues about challenges they are experiencing, and it will provide a safe confidential environment for sharing and considering solutions. The conference will also include an Asset Owners Welcome Cocktails on Monday night in the Exhibition Hall.

In regard to advocacy, the ACA has been active in following up the replies from our correspondence to Ministers regarding our petition for more Certificate 3 TAFE courses for early stage applicator training with Tim Billing, Applicator Technical Group Chair. One of the key findings that has become evident is that Australia needs to acknowledge Industrial Painters as a recognized trade. This is not currently happening. This means the quality of the applicators can vary enormously, there is no formal links to increase pay with productivity and quality, and this vocation is not a real consideration for people considering a trade.

An interesting point is that the USA recognized Industrial Painters as a trade about five years ago. With all the future defence work in the pipeline, we are hoping that we make some headway in gaining this recognition in Australia, so that our critical assets are protected by qualified and competent personnel.

I am hoping to commence similar discussion with our members in New Zealand. I have plans to travel to New Zealand and meet with members and stakeholders in the third week of August. The exact itinerary is to be finalised but will include major NZ cities. I would value any New Zealand members' input into key personal to visit or meet.

In fact I welcome feedback from any members. We are on a journey of continuous improvement, so please contact me at maree.tetlow@corrosion.com.au

Bye for now!

Maree Tetlow

ACA CEO

Sustainability of Structures Through Advanced Coatings: Driving Towards Net Zero Carbon

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Keywords:

Coating, sustainability, corrosion protection, durability, built environment

Abstract:

To achieve sustainability, most governments and corporations have identified three parallel pathways and have each developed their environmental policy, social policy, and governance policy, also known as ESG. This paper will focus on the environmental aspects of sustainability. Embodied carbon emissions are hard to eliminate.

Some of our most common building materials – like concrete and steel – require process heat and chemical reactions that can't be achieved with electricity alone. Without taking a targeted and collaborative action, embodied carbon emissions will be responsible for 85% of the built environment's carbon emissions by 2050. This study will focus on two ways in which the coatings industry aims to contribute towards a sustainable future:

1. *By better protecting built assets, and thus keeping embodied carbon embodied for as long as possible.*
2. *Limiting emissions of greenhouse gas; improving air quality; and reducing the use of harmful materials.*

Project specifiers have a responsibility to select the most appropriate protective systems that provide optimum durability to our infrastructure. Particularly now the carbon footprint of maintenance interventions needs to be considered in a life cycle assessment, the advantages of durable protective systems and the consequent reduced number of maintenance painting interventions will reduce the overall environmental impact.

INTRODUCTION

This study will focus on two ways in which the coatings industry aims to contribute towards a sustainable future:

1. By better protecting built assets, and thus keeping embodied carbon, embodied for as long as possible.
2. Limiting emissions of greenhouse gas; improving air quality; and reducing the use of harmful materials.

In this discussion the term 'coatings' will be used for protective coatings that are used to prevent corrosion. The term 'paint' will only be used for decorative paints. Where the word "carbon" has been used, reference is made to carbon dioxide.

BACKGROUND

Sustainability is a catchphrase that means something different to each person and a person's association with that word probably changes depending on the context in which "sustainability" is used in the media. The Oxford Dictionary describes sustainability as "*avoidance of the depletion of natural resources in order to maintain an ecological balance*". To achieve sustainability, most governments and corporations have identified three parallel pathways and have each developed their environmental policy, social policy, and governance policy, also known as ESG. This paper will focus on the environmental aspects of sustainability.

Climate Change

To tackle climate change and its negative impacts, world leaders at the UN Climate Change Conference (COP21) in Paris reached a breakthrough on 12 December 2015: the historic Paris Agreement (1). Under the Paris Agreement, to which Australia is a Party, countries are required to communicate their Nationally Determined Contribution.

The Intergovernmental Panel on Climate Change (IPCC) 2022 report Impacts, Adaptation and Vulnerability (2) found that global warming, reaching 1.5°C in the near-term, would cause unavoidable increases in multiple climate hazards and present multiple risks to ecosystems and humans. In their Mitigation of Climate Change 2022 report (3), the IPCC concluded that the world is not on track to limit global warming to 1.5 or 2°C on the basis of current policies.

The breakdown of climate associated with the difference between these two scenarios is likely to result in more demand for heating and cooling. The negative economic impact globally of additional heating and cooling demand is expected to increase fourfold by the end of the century and apply further pressure on eco-systems. The consequences will be long lasting and, in some cases, irreversible.

Society needs to radically transform current unsustainable models of consumption. The Australian Government has introduced the Climate Change Bill 2022 (4). The Bill legislates the nation's commitment to reduce greenhouse gas emissions by 43% below 2005 levels by 2030, and net zero by 2050. Australia is the world's 14th highest emitter, contributing just over 1 per cent of global emissions. Globally, the 1.5°C goal requires net zero emissions by 2050. To achieve this the Paris Agreement requires a balance between emissions and removals of greenhouse gases to be at net zero.

Greenhouse Gas

Greenhouse gas is any gas that has the property of absorbing infrared radiation (net heat energy), thus contributing to the greenhouse effect. Greenhouse gasses emitted by industry in general include carbon dioxide, methane, ozone, and chlorofluorocarbons (CFCs).

Harmful emissions to which the coating industry more specifically contributes are;

- Carbon embodied through production of their raw materials, and the energy used in manufacturing, transport and warehousing.
- Volatile organic compounds (VOC's) from solvents and coatings which contribute to harmful ozone formation.

Carbon

Carbon is not only emitted during operational life but also during the manufacturing, transport, construction and end of life phases of all built assets.

Operational Carbon

Operational carbon is generated during the normal operation of an asset for lighting, cooling, heating, ventilation and other processes that require electricity.

Basics like improving building insulation, installing LED lighting and automatic controls have long been used to reduce operational carbon, and new buildings are now designed to be highly energy-efficient, with the use of innovative materials and smart technology.

Coatings do not generally contribute to operational carbon of built assets.

Upfront Embodied Carbon

Upfront embodied carbon refers to the greenhouse gas emissions generated during the manufacturing and transportation of materials and throughout the construction phase.

Until this past decade, these emissions have largely been overlooked however since the easy gains have already been made in reducing operational carbon, upfront embodied carbon has attracted an increased focus to help drive further toward net-zero.

Upfront embodied carbon contributes approximately 11% to the total global carbon emissions (5) and will be responsible for half of the entire carbon footprint of new construction between now and 2050, threatening to consume a large part of our remaining carbon budget.

Embodied carbon emissions are hard to eliminate. Some of our most common building materials – like concrete and steel – require process heat and chemical reactions that can't be achieved with electricity alone. Without taking a targeted and collaborative action, embodied

Sustainability Through Reducing Carbon Emissions

The built environment sector has a vital role to play in responding to the various agreed commitments to reduce greenhouse gas emissions. With buildings currently responsible for 39% of global carbon emissions (5), decarbonising the sector is one of the most cost-effective ways to mitigate the worst effects of climate change (7).

As operational carbon is reduced, embodied carbon will continue to grow in importance as a proportion of total emissions and increased efforts are being made to tackle embodied carbon emissions.

CARBON EMISSIONS IN INFRASTRUCTURE

Many government agencies do not have a formal framework to measure and manage carbon throughout a project lifecycle and most of the published data references studies from the built environment.

Lifecycle Assessment

The LCA approach was first defined by the International Organization for Standardization, who developed the ISO 14040 series of standards that provide a systematic tool for the quantitative analysis of environmental loads of a product in its entire life cycle and assessment of their potential impacts on the environment. The LCA can be seen as the "cradle-to-grave" or "whole of life" approach and consists of four main steps:

- Goal and scope - to determine the life cycle of the project.
- Life Cycle Inventory (LCI) – provides possible resources, material and waste list or discharge material during the life cycle of a product.
- Life Cycle Impact Assessment (LCIA) - where the inventory data collected for the various phases of the life cycle are classified into their categories of impact.
- Interpretation – the point at which decisions are taken based on the outcome of the inventory and impact evaluation.

An LCA can also be used for evaluation of the environmental impact of buildings and other large pieces of infrastructure, where the extraction of raw materials and disposal or recycling of materials are also considered.

For the built environment, the life cycle assessment largely needs to consider the use of concrete and steel.

Emissions from Steel Production

At around 1.9 billion tonnes of production per year, steel is the third most abundant man-made bulk material on earth, after cement and timber.

The People's Republic of China accounts for more than half of global steel production today and – despite high domestic demand – it is also the largest exporter, followed by Korea, Japan and the Russian Federation.

The blast furnace is a major piece of equipment used for primary steelmaking, with this route accounting for 90% of production from iron ore. Secondary (or scrap-based) production is carried out in electric furnaces and is around one-eighth as energy-intensive as production from iron ore, using electricity – as opposed to coal – as the main energy input.

Among heavy industries, the iron and steel sector ranks first when it comes to CO2 emissions, and second when it comes energy consumption. The iron and steel sector directly accounts for 2.6 gigatonnes of carbon dioxide (Gt CO2) emissions annually, 7% of the global total from the energy system and more than the emissions from all road freight. The steel sector is currently the largest industrial consumer of coal, which provides around 75% of its energy demand. Coal is used to generate heat and to make coke, which is instrumental in the chemical reactions necessary to produce steel from iron ore. CO2 emissions are projected to continue rising, despite a higher share of less energy intensive secondary production, to 2.7 Gt CO_2 per year by 2050 – 7% higher than today. Each tonne of steel produced today still results in 1.4 t CO_2 of direct emissions on average (8).

Emissions from Cement Production

Approximately 4.3 billion tonnes of cement was produced in 2021. China was the largest contributor to global production, accounting for about 55% of the total, followed by India at 8%.

The direct CO_2 intensity of cement production increased about 1.5% per year during 2015-2021. In contrast, 3% annual declines to 2030 are necessary to get on track with the Net Zero Emissions by 2050 Scenario. Two key areas need to address carbon reductions by: reducing the clinker-to-cement ratio (including through greater uptake of blended cements) and deploying innovative technologies, such as carbon capture and storage, and clinker made from alternative raw materials. (9).

Steel and concrete are indispensable materials in modern construction and buildings and infrastructure remain a key source of demand. General estimates for upfront embodied carbon from different construction elements for a typical building project are:

- Substructure: 10% to 30% (depending on the extent of basements)
- Superstructure: 40% to 70%
  - Upper floors and columns: 30% to 50%
  - External walls, windows, and external doors: 8% to 25%
- Finishes (including coatings): 4% to 8%
- Building services: 5% to 8%

For other infrastructure like tanks, bunds, roads and bridges, the embodied carbon distribution is somewhat different but it is more difficult to define since they are more variable in design and construction complexity than an average building. However, given the extensive use of concrete and steel in both sectors, useful parallels can be drawn to identify building materials and their proportionate contribution toward carbon emissions.

Carbon Emissions from Coatings

As seen in the example above, the current focus for embodied carbon is on the substructure, upper floors, columns, external walls and windows that represent approximately 70 to 80% of the project's upfront embodied carbon. Even though coatings only represent a relatively small proportion of overall upfront embodied carbon the coatings industry is subject to a disproportionate share of regulations due to relatively high emissions of volatile organic compounds (VOC) that not only impact air quality but also contribute to greenhouse gasses in the atmosphere.

Unlike steel, and concrete to a lesser extent, it is impractical to reuse or recycle used coatings. The paint and coating industry, typically uses solvents such as toluene, m/p-xylene, butene, butadiene, and acetone in their product formulations.

When coatings go through the curing or drying phase, these VOCs are released from the coating film. VOCs have high vapor pressures (0.01 kPa or more at 20°C (10)), which means they evaporate easily or off-gas in the open air as soon as the coating is applied and, depending on its formulation, may continue to off-gas for months as the coating completes the curing process.

VOC's are problematic for five main reasons;

- They require synthetic raw materials that come from other production processes that depend on the burning of fossil fuels (11).
- VOCs in paints are usually hydro-carbons so they contribute to the overall carbon footprint.
- They oxidise in the atmosphere to form ozone, also a greenhouse gas.
- VOCs indirectly contribute to the formation of smog and particulate matter (12).

Solvents are often considered environmentally toxic products and affect people, animals, and plants in different ways and VOCs are recognized as causative agents of the sick-building syndrome (13). In short, VOC's pose a threat to human health and affect the environment and climate change.

Concerns of governments over ground-level ozone formation and regional air quality has promulgated directives in many jurisdictions with some of the most advanced being from Europe and California with respect to solvent emissions. In China, several government initiatives have been introduced to reduce VOC emissions under the 13th Five-Year Plan. Consequently, industry is required to reduce its emissions of volatile organic compounds (VOCs) in general, and solvents in particular.

Table 1 provides an example of typical volume solids for generic coating groups.

For 2018, the total global paint and coatings market for solvent borne paint was approximately 2.4 mega tonnes (14). From that volume, we can extrapolate that this includes approximately 590 kilo tonnes of VOC's.

Table 1: Typical Densities and Solids Contents of Coatings based on ASNZS2312 PUR5 System.

Type of Coating	Density (kg/L)	Solids (Volume %)	VOC (w/w%)
Primer ZRE	2.52	59	15.2
Intermediate, epoxy	1.51	70	19.8
Polyurethane	1.33	60	34.1
Average	1.78	63	23.0

VOC's are not the only issue that make coatings problematic with respect to sustainability. Coatings are however an important tool that help to make infrastructure in general more durable and therefore more sustainable. In the sections below, a deeper focus is placed on additional issues that are normally considered problematic with coatings and what the industry is doing to make coatings more sustainable.

COATINGS

Paint has been integral with human history starting from early rock paintings through to modern surface coatings.

History of Coatings

In early rock paintings humans have expressed themselves starting over 40,000 years ago using mineral-based pigments. Nawarla Gabarnmang has the oldest radiocarbon dated painting, in Australia. It is a large rockshelter located in remote Jawoyn Aboriginal country in southwestern Arnhem Land, Australia. On the roof and pillars are hundreds of vivid interwoven shapes of humans, animals, fish and mythical figures, all painted in radiant red, white, orange and black pigments representing generations of artworks spanning thousands of years with mineral ochres, calcite, charcoal, hematite, and manganese oxide.

As societies advanced around the world, the transportation of materials became increasingly common. This was apparent in Ancient Greece and Egypt, where people imported paints from all over Europe and Asia to paint their temples and tombs (15).

Over 6000 years ago pigments included, sand, lime, and copper ore. These could be mixed together and heated to make a greenish blue pigment called Egyptian blue; a vibrant red was produced by mixing and roasting together hazardous mercury with sulfur; and white was made by sealing strips of lead in earthenware pots with vinegar and covering with manure. A vibrant blue pigment called ultramarine was created from the semi-precious gemstone, lapis lazuli (meaning blue stone in Latin).

The earliest paints used animal fat and saliva as a binding agent, and later, during the Middle Ages, artists used eggs to combine their pigments. However, by the 15th century, artists began using vegetable oils and dramatically transformed the art of painting.

Painting as described by Encyclopedia Britannica as, *the expression of ideas and emotions, with the creation of certain aesthetic qualities, in a two-dimensional visual language. The elements of this language, its shapes, lines, colours, tones, and textures are used in various ways to produce sensations of volume, space, movement, and light on a flat surface.*

The first recorded coating mill in America was reportedly established in Boston in 1700 by Thomas Child. A century and a half later, in 1867, D.R. Averill of Ohio patented the first prepared or "ready mixed" coatings in the United States and Sherwin-Williams sold the first pre-mixed wall coatings. Before that, people had to mix their own wall coating from powdered pigment.

These early coatings were primarily alkyd coatings with first variants being of the glycerol-diacid reaction, finding modification with oils derived from vegetable and fish oils providing the resins with solubility and flexibility (16). These oil-modified polyester resins were well suited for use as binders in coatings.

Synthetic pigments then were being discovered in the 19th Century. From the early 1900's the Industrial Revolution provided vast new markets for paints and coatings. Virtually every product created on an assembly line, from the Model T Ford to the latest-model television had extensive use of paints and coatings to beautify, protect and extend the life of the manufactured goods.

Many of today's paints and coatings may go unnoticed by the consumer, but play immeasurably valuable roles in delivering high-quality foodstuffs, durable goods, housing, furniture and thousands of other products to market. Coatings are integral to the myriad of larger manufacturing and end-use industries.

The importance of coatings in this respect can be seen by research showing an average compound annual growth rate for the global coatings industry of 4.8% in revenue through to 2030 (14).

Harmful Materials

Various materials used in coatings throughout history have later been discovered as being harmful to either people or the environment.

Organic Solvents

The early alkyd coatings provide one of the earliest examples where environmental concerns were raised about organic solvents in the product formulations.

Heavy Metals

The second concern with these same oil-based coatings involved the pigments. The early versions of alkyd coatings used lead-base pigments and additives. White lead from Lead Carbonate ($PbCO_3$) or lead hydroxide ($Pb(OH)_2$), was an ideal masking pigment with high opacity (17). Lead also enhanced other performance characteristics such as adhesion, water resistance, and weather-related flexibility. Lead has been shown to react with certain resin systems, linseed oils, or other oils to form metal soaps that are active corrosion inhibitors. Unfortunately, the toxic effects of lead presented a significant health risk for coating industry workers, professional painters and the general public, particularly children who could ingest the coating material after contact with weathered, flaking surfaces.

Although the U.S. Consumer Product Safety Commission has banned the manufacture of coatings containing lead since 1978, some countries still produce lead containing coatings and pigments. The health risk associated with lead-pigmented coatings still exists in structures that were painted up until the late 1980's in Australia.

Chromium was also used in the form of zinc chromate in many primers for steel structures. Arsenic and cadmium have been used in coloured pigment manufacture mainly in greens and yellows. Each has its own toxicity to humans and presents environmental risks.

Biocides in Anti-fouling Coatings

In the early days of sailing ships, lime and later arsenic were used to coat ships hulls, until the modern chemical industry developed effective anti-fouling coatings that contained metallic compounds. These anti-foulings allow the controlled release of toxic compounds from the surface of the coating, making it very unattractive for barnacles, algae and other marine life to attach themselves to the hull of the ship. But various studies have shown that these compounds accumulate in the environment, killing sea life, harming the environment and possibly entering the food chain. One of the most effective anti-fouling coatings, developed in the 1960s, contain tributyltin (TBT) or similar organotin compounds, which have been proven to cause deformities in oysters and sex changes in whelks (18).

MORE SUSTAINABLE COATINGS

The coatings industry has a history of working toward sustainability over the past century by manipulating the chemistry of its products to better manage risks. Coating manufacturers started replacing lead pigments in some coatings, for example, before World War II, when safer alternatives became available.

Industry consensus standards limiting the use of lead pigments date back to the 1950s in the USA, when manufacturers led a voluntary effort to remove lead from house paints. Since then, other pigments such as the much safer titanium dioxide are mostly used.

Since the 1940s the coating industry has been working to reduce the VOCs and responded with innovative formulations that aimed to produce environmentally friendly, low-VOC, alkyd-based coating with the same or better performance than the traditional formulations.

In 2009, Proctor & Gamble Co. (Cincinnati, Ohio) and Cook Composites & Polymers (Sandusky, Ohio) were jointly awarded the Presidential Award for Green Chemistry by the U.S. EPA for their Chempol MPS product, an innovative alkyd resin technology that enables paint formulations with less than half the VOCs of traditional alkyds.

The harmful environmental effects of Tributyltin (TBT) compounds used in anti-fouling coatings on ships were recognized by the International Maritime Organisation (IMO) in 1989 and by 1999, IMO adopted a resolution calling for a global prohibition by 2008 (19).

Replacements for tributyltin (TBT) have been based on metals such as cuprous oxide and co-biocides like zinc pyrithione. These have also proved to accumulate in the environment so coating manufacturers are developing new technologies to include low surface tension fouling release coatings, hydrophilic coatings and bio-based non-accumulating alternatives to cuprous oxide.

In 2011, the Sherwin-Williams Company (Cleveland, Ohio) was awarded the Presidential Green Chemistry Award for water-based acrylic alkyd coatings with low VOCs that can be made from recycled soda bottle plastic (polyethylene terephthalate or PET), acrylics, and soybean oil.

The coatings market continues to focus on new sources to develop environmentally friendly materials, introducing manufacturing processes and technologies that combine sustainability and performance.

Some examples of advancements that are innovating the present market are outlined below.

Green Chemistry and Alternative Formulations

Green chemistry refers to those items that involve the synthesis of raw materials or coatings from environmentally friendly processes rather than from more conventional sources such as crude oil. These processes may be using biodegradable raw materials, recycled materials, or have significantly decreased or zero VOCs due to an alternative manufacturing process.

One example is obtaining diluents for coil coatings from epoxidized fatty acids using renewable resources such as linseed oil and rapeseed oil (20). Another example is the development of sustainable polyurethane polymers from soybean oil that, when modified with silica, have low molecular weight and are free of VOC's. Coatings formulated with this resin exhibit good performance and studies indicate that vegetable oil coatings based on soy monoglyceride-modified polyurethane and tetraethyl orthosilicate (SMG-PU-TEOS) have commercial application potential (21).

Further sustainability gains in coating manufacturing are being researched to develop coating formulations with lower VOC content, systems with lower film builds whilst still achieving suitable protection, protecting steel from hydrogen absorption, linings for bio-oils and new fuels. Smart coatings for absorbing hydrogen from steel, improving conductivity between metallic pigments, self-healing photo oxidation and inhibitor releasing nanotubes.

The manufacturing process is being optimised through specific reactions and VOC reduction to balance specific performance requirements of the coating such as adhesion-promoting additives with lower VOC content (22). Another example is the continued development of water-based protective and marine coatings, including anti-foulings, to reduce VOCs emissions (23).

In concrete protection, water borne epoxies and polyurethanes are now quite common, but they are still somewhat slow in gaining popularity in the steel protective coatings market, even though most manufacturers do make them. It is likely that further environmental regulation will continue to drive further development in this field, and it is almost certain that we will see more of these coatings in the not too distant future.

Also, powder coating technology has further developed, and powder coatings are starting to replace liquid applied coatings in many fabrication industries such as pipeline, windows, fencing and facades. Powder coatings provide all the components of a liquid applied coating except for the VOC's and largely eliminate the need for solvent clean-up of application equipment and containers.

Nanotechnology

The introduction of nanotechnology has a significant role in the industry but is probably still in its infancy. Various manufacturers have used this technology to introduce ceramics or metals in the form of granules, free powder, or particles in various types of formulations. Some of the recent innovations that nanotechnology has enabled the formulators to develop include products that can better conduct electricity or exhibit UV protective or self-healing properties. Apart from these characteristics, they are also highly resistant to scratch, marring, wear, and corrosion. These advancements in technology look promising and the introduction of new products is expected to augment future advances in the coatings industry (24). For example, the use of graphene has been touted for use in coatings for over 15 years but only recently, after economically viable production methods and safe handling processes were discovered, the industry has started to develop formulations that will soon be widely available.

Another example where improving performance of environmentally friendly corrosion protection coatings is achieved, is by using polymeric micro and nano-containers loaded with 8-hydroxyquinoline and 2-methylbenzothiazole corrosion inhibitors via emulsion (from oil-in-water emulsions) by interfacial polyaddition (25).

SUSTAINABILITY GAINS IN REDUCING COATINGS WASTE

Generally, change is brought about either by a company's desire to innovate, new government regulations and/or changes in consumer demand.

The coatings industry has a history of adapting to all three drivers but a gap remains between the two stages of delivery of the finished product. Even though the manufacturer has tried their best to reduce embodied carbon and eliminate toxic compounds in the first stage, intended sustainability aims can be lost during the second stage being, coating application.

Sustainability gains can be achieved not only through chemistry and technological advances but also through field-based techniques to reduce waste, including;

- Use of application techniques that reduce overspray.
- Mixing of excessive quantities resulting in left over coating or waste.
- Applicators like to add thinners to their coating to make it easier to apply and there is a pattern of using 5% to 10% thus adding to the total VOC content.
- Coating application requires clean-up of equipment. This means using a solvent to wash the coating off brushes and rollers or flushing of spray equipment. This uses copious amounts of solvent and increases the release of VOC to the environment.

'Paint back' schemes are available in many jurisdictions and allow for reuse of waste coating as an alternative fuel source within manufacturing industries

The application industry should learn to understand and acknowledge the progress that manufacturers have made in reducing VOC and get involved to implement strategies that are initiated by sustainable formulation and manufacture and carry them through by adopting sustainable application methods.

WHY COATINGS MATTER

Coatings matter since they provide many of the desirable properties people require for protection, decoration or identification of surfaces. However, in relation to sustainability, modern coatings provide;

- Heat reduction in urban heat islands - The urban heat island (UHI) effect is a common environmental problem occurring in metropolitan areas in which the air temperature is significantly higher than in suburban areas. The UHI effect also leads to a smoggy climate. Coating of concrete, steel and asphalt substrates with sunlight reflecting coatings can provide cool surfaces.

- Scavenger and photo catalyst products - nanoparticle engineered visible light responsive photocatalysts can be used in coatings to cause a photo catalytic reaction to either;
    i. Suppress viruses such as COVID-19 which contact the painted surface with their ability to destroy pathogens using visible light (26); or,
    ii. Degrade pollutants which contact the painted surface such as Formaldehyde (HCHO).
- Lasting infrastructure – Notwithstanding the benefits a well-functioning infrastructure has to quality of life, coatings are used to extend the service life of the structure to which they are applied. Given suitable maintenance cycles, coatings can provide preservation of the structure enabling recycling or adaptive reuse at the end of service life of the protected structure. This leads to a reduced demand for raw materials.
- Fireproofing – protects structures for a period of time, from collapse during a fire event enabling safe egress of persons.
- Colour and mood - Colour is a powerful communication tool and can be used to signal action, influence mood, and even influence physiological reactions.
- Lasting transport – Coatings are used to preserve fuels in storage and reduce friction on ships hulls therefore making transport more fuel efficient.
- Anti bacterial for healthcare - antimicrobial coating additives provide lasting and effective protection against harmful bacteria, mould and fungi.
- Preserve foods - food can coatings are used to maintain the flavour, texture and appearance of canned foods by performing the dual role of protecting the filling from the metal and the metal from the filling.
- Road marking - The increased visibility provided by highly reflective coatings is used for road markings and indoor parking lots. Thus, coatings contribute to the safety of people and functioning of our transport infrastructure.

LASTING INFRASTRUCTURE

Steel and concrete make up the most abundant manmade materials on earth and coatings have a large role to play in making infrastructure durable.

As governments and industry make gains on embodied carbon and operational carbon, a growing focus will be keeping the carbon, embodied. This is part of the net zero strategy. Once carbon is embodied, we must aim to keep it embodied to prevent future release of carbon from that structure otherwise we must find another way to balance the release through capture of atmospheric carbon to gain a net zero balance. Examples would be sequestration and reforesting.

Project specifiers have a responsibility to select the most appropriate protective systems that provide optimum durability to our infrastructure. Particularly now the carbon footprint of maintenance interventions needs to be taken into account in an LCA, the advantages of durable protective systems and the consequent reduced number of maintenance panting interventions will lessen the overall environmental impact.

Reducing use of resources by painting less can be achieved through better selection and specification of coating systems. Asset owners are looking to adopt a whole of life approach to carbon reduction in building and infrastructure design, applying principles to identify cost effective low and, ultimately, net zero carbon designs (27). This is done through development of a lifecycle assessment (LCA). Additionally robust quality control programs during applicator works will provide the longest coating service life.

Effective Protection of Structures

A typical steel distribution pipeline at 610-mm API 5l Pipe Schedule 40 weighs about 254.9 kg/m. A 9-m run of this pipe would weigh close to 2.294 metric ton. If this steel pipe had to be replaced due to corrosion, the environmental cost is high. For every tonne of steel that is produced in a steel mill, approximately 1.4 tonnes of CO_2 is released into the atmosphere. Thus this 9 m pipe section has 3211 kg of embodied carbon (kg CO_2e).

To protect that same 9-m run of steel pipe with a standard three-coat, high-performance coating system would generate 65.38 kg of CO_2 emissions. Though 3211 kg CO_2e to replace the pipe versus 65.38 kg CO_2e to protect the pipe, is a dramatic difference, it is common for asset owners to allow degradation until replacement is required, rather than allocate resources to the maintenance that is required to extend the service life of the asset.

The same calculations can be provided to structural steel for example: A typical 610 Universal Beam contains 1273 kg CO_2e and coatings to protect the beam from corrosion contain only 70.49 kg CO_2e.

In addition to the CO_2 produced from steel, the VOCs generated by the transportation of steel from the mill to the jobsite exceed those produced by high-performance industrial coatings that could be used to prevent asset replacement in the first place (28).

Example of Adaptive Reuse of Structures

A 2016 report titled Assessing the Carbon-Saving Value of Retrofitting versus Demolition and New Construction at the United Nations Headquarters describes the sustainability values achieved by choosing to renovate rather than demolish in favour of new construction.

If the UN complex had been demolished and replaced with new construction of similar size, it would have taken between 35 to 70 years before the improved operating efficiencies of the new complex would have offset the initial outlays of carbon emissions associated with the demolition and new construction process (29)

These results indicate that the practice of demolishing existing structures and replacing them with new construction creates a significant initial carbon burden that is typically recovered over a very long carbon payback period. It is even possible, if one uses typical industry assumptions of a 50 to 60 year useful building life, that new construction will never recoup its initial carbon outlays when compared to a quality renovation (29).

Structural Steel 610 UB		API 5l Pipe Schedule 40	
Length (m)	9.00	Length (m)	9.00
Weight (kg)	909.00	Weight (kg)	2294.10
Steel Embodied carbon (kg CO_2e)	1272.60	Steel Embodied carbon (kg CO_2e)	3211.74
Paint Embodied carbon (kg CO_2e)	70.49	Paint Embodied carbon (kg CO_2e)	65.38
	5.5%		2.0%
Paint Durability (years)	20	Paint Durability (years)	20
External Surface Area (m2)	18.63	External Surface Area (m2)	17.28
Depth of Section (mm)	W 602	Outside diameter (mm)	610.00
Flange Width (mm)	D 228	Inside diameter (mm)	574.64
Web Thickness (mm)	10.60	Wall Thickness (mm)	17.47
Depth between Flanges (mm)	572.00		
Depth between Flanges (mm)	572		

Table 2: Characteristics of common steel building elements

In this context, building renovation can be considered a fundamental strategy to reduce near-term carbon emissions as part of the national and global response to climate change (29).

CONCLUSION

Technological advances and innovations are not new to the coatings industry. Although traditionally perhaps forced by regulation, materials suppliers have acknowledged the need to be proactive and demonstrated that they understand the need to keep up with changes in the market, including the drive to better sustainability and net zero. This does not only include the development of coating materials that are more sustainable in terms of their chemical formulation and method of production, but also coating systems that offer improved durability to reduce the number of maintenance interventions over the service life of our infrastructure.

Once the coating manufacturers have delivered their part of the puzzle, it is the responsibility of specifiers to select solutions that provide optimum durability and up to applicators to deliver the end product in the least harmful manner. On the path to 2050, embodied carbon can remain embodied by effectively preserving built assets with modern coating systems, enabling optimum durability and adaptive reuse in favour of demolition and new construction.

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AUTHOR DETAILS

Justin Rigby is the Principal at Remedy Asset Protection (RemedyAP). He has extensive experience in the corrosion protection industry developed over 28 years and is a board member for the Australasian Concrete Repair and Remedial Building Association Limited (ACRA). Justin is an AMPP CIP and AMPP CUI lecturer, AMPP Certified Corrosion Technologist, Certified Protective Coatings Specialist, Icorr Level 3 inspector, DoT Level 2 Bridge Inspector and serves as Chairperson of the Australasian Corrosion Associations (ACA) Coatings Technical Groups. Justin also serves on various Standards committees in Australia and internationally. Justin has authored many papers for publication in prestigious journals and has presented at international and Australian conferences with regard to protection of concrete and steel using coatings technologies. He has a passion for project delivery and his focus is on introducing efficiencies and building team-based strategies with enhanced performance and cost benefits for Clients and their suppliers.

Protective Coating Standards Update

Since the last report in Corrosion & Materials (November 2019 by Arthur Austin) on new protective coating Standards there have been revisions and updates to the following:

Compiled by Willie Mandeno and Peter Golding for ACA CTG.

AS 3862:2020 External fusion-bonded epoxy coating for steel pipes

AS 4848.1:2019 Application specifications for coating systems Single coat inorganic (ethyl) zinc silicate - Solvent-borne

BS EN 13144:2018 Metallic and other inorganic coatings. Method for quantitative measurement of adhesion by tensile test

BS EN 15773:2018 Industrial application of powder organic coatings to hot dip galvanized or sherardized steel articles [duplex systems]. Specifications, recommendations and guidelines

Recent new or revised SSPC Standards include:

AMPP SP21494:2022 Technical Specification for Ship Coating Repair

SSPC-Guide 12:2023 Guide for Illumination of Industrial Coating Projects

SSPC-PA 2:2022 Procedure for Determining Conformance to Dry Coating Thickness Requirements

SSPC-SP 16 Brush-Off Blast Cleaning of Coated and Uncoated Galvanized Steel, Stainless Steels, and Non-Ferrous Metals (2020)

SSPC-SP 17 Thorough Abrasive Blast Cleaning of Non-Ferrous Metals (2019)

SSPC-SP 18 Thorough Spot and Sweep Blast Cleaning for Industrial Coating Maintenance (2020)

Recent new or updated ISO Standards include:

ISO 2409:2020 Paints and varnishes: - Cross-cut test

ISO 2810:2020 Paints and varnishes: - Natural weathering of coatings: - Exposure and assessment

ISO 2812:2018 Paints and varnishes: - Determination of resistance to liquids (several parts)

ISO 3233:2019 Paints and varnishes: - Determination of the percentage volume of non-volatile matter (several parts)

ISO 4524:2023 Paints and varnishes: - Pull-off test for adhesion

ISO 4618:2023 Paints and varnishes: - Vocabulary

ISO 4623:2018 Paints and varnishes: - Determination of resistance to filiform corrosion (several parts)

ISO 6923:2023 Paints and varnishes: - Determination of monomeric diisocyanate content in coating materials and similar products using high performance liquid chromatography with ultraviolet detection (HPLC-UV)

ISO 7784:2023 Paints and varnishes: - Determination of resistance to abrasion

ISO 9514:2019 Paints and varnishes - Determination of the pot life of multicomponent coating systems - Preparation and conditioning of samples and guidelines for testing

ISO 11890:2024 Paints and varnishes - Determination of volatile organic compounds (VOC) and/or semi volatile organic compounds (SVOC) content (several parts)

ISO 11997:2022 Paints and varnishes - Determination of resistance to cyclic corrosion conditions (several parts)

ISO 12944-5:2019 Paints and varnishes - Corrosion protection of steel structures by protective paint systems – Part 5: Protective paint systems. This fourth edition cancelled and replaced the third edition (2018) with some minor revisions and corrections. Note: Rob Francis recently represented SA in London at the TC35/SC14 committee meetings to incorporate Part 9 on offshore coatings (previously ISO 20340) into this and Part 6 (Test methods and requirements)

ISO 15091:2019 Paints and varnishes -Determination of electrical conductivity and resistance

ISO 15184:2020 Paints and varnishes: - Determination of film hardness by pencil test

ISO 16053:2022 Paints and varnishes - Coating materials and coating systems for exterior wood (several parts)

ISO 20566:2020 Paints and varnishes: - Determination of the scratch resistance of a coating system using a laboratory-scale car-wash

ISO 21545:2018 Paints and varnishes: - Determination of settling

ISO 22553:2019 Paints and varnishes: - Electro-deposition coatings (several parts)

ISO 22696:2019 Paints and varnishes: - Determination of solar reflectance

ISO 23169:2020 Paints and varnishes: - On-site test methods on quality assessment for interior wall coatings

ISO 23322:2021 Paints and varnishes: - Determination of solvents in coating materials containing organic solvents only Gas-chromatographic method

ISO 28199:2021 Paints and varnishes: - Evaluation of properties of coating systems related to the spray application process (several parts)

ISO 1463:2021 Metallic and oxide coatings: Measurement of coating thickness: Microscopical method

ISO 4042:2022 Fasteners Electroplated coating systems

ISO 4518:2021 Metallic coatings: Measurement of coating thickness: Profilometric method

ISO 7989-2:2021 Steel wire and wire products: Non-ferrous metallic coatings Part 2: Zinc or zinc-alloy coating

ISO 8080:2021 Aerospace: Anodic treatment of titanium and titanium alloys: Sulfuric acid process

ISO 8081:2021 Chemical conversion coating for aluminium alloys: General purpose

ISO 10111:2019 Metallic and other inorganic coatings – measurement of mass per unit area – Review of gravimetric and chemical analysis methods

ISO 21809:2019 Petroleum and natural gas industries - External coatings for buried or submerged pipelines used in pipeline transportation systems (several parts)

ISO 24449:2021 Metallic and other inorganic coatings: Determination of thermal conductivity of thermal barrier coatings at elevated temperature

Standards under revision or preparation:

AS/NZS 2312.3 Guide to the protection of structural steel against atmospheric corrosion by the use of protective coatings Part3: Thermal spray coatings.

This guide will replace references to thermal metal spray (TMS) coatings in AS/NZS 2312:2002 Section 5 and a draft for public comment is expected from Standards Australia (SA) within the next few months. It has been developed for SA Committee MT-014, Corrosion of Metals by an industry Working Group with the following ACA members;

Chris Berndt
Bob Cordewener*
Oscar Duyvestyn
Rob Francis
Peter Golding
Kevin Healey**
Philip La Trobe*
Willie Mandeno (Chair)
Craig Ross*
Christiane Schulz
Ann Sheehan
Narendra Tripathi
Matt Vercoe**
Aude Wenzinger (SA Proj. Mgr.)
**TMS Applicator*
***TMS Supplier*

The guide focusses on the thermal spraying of zinc and aluminium and their alloys onto structural steel to give it long life protection against corrosion. It also discusses duplex systems where the thermal spray is top coated with an organic coating system to provide a decorative finish, or to preserve the integrity of the underlying thermal spray coating.

AS/NZS 4680 Hot dip galvanized coatings on fabricated iron and steel articles — Specifications and test methods. This Standard was last revised in 2006, is being developed by SA Committee MT-009 and will largely follow the technical aspects of ISO 1461, itself revised in 2022. A draft for public comment is likely to be available in 2024.

SNZ TS 3404: 2018 Durability requirements for steel structures and components. The ACA has proposed amendments to this Standard, which have been published in the SESOC Journal Vo.34 No.1 April 2021 pgs.36 -40. It is recommended that users of this Standard make themselves aware of the proposed additions and corrections.

ISO Standards relating to Corrosion (ISO TC156, Corrosion of metals and alloys)

This ISO committee has a broad remit, and SA committee MT-014 has representation. In recent times, many new or revised Standards have been published. A selection is included here

ISO 8044:2020 Corrosion of metals and alloys — Vocabulary

ISO 8407:2021 Corrosion of metals and alloys — Removal of corrosion products from corrosion test specimens.

ISO 9227:2022 Corrosion tests in artificial atmospheres — Salt spray tests (plus minor amendment in 2024)

ISO 11844-1:2020 Corrosion of metals and alloys — Classification of low corrosivity of indoor atmospheres — Part 1: Determination and estimation of indoor corrosivity

ISO 11844-2:2020 Corrosion of metals and alloys — Classification of low corrosivity of indoor atmospheres — Part 2: Determination of corrosion attack in indoor atmospheres

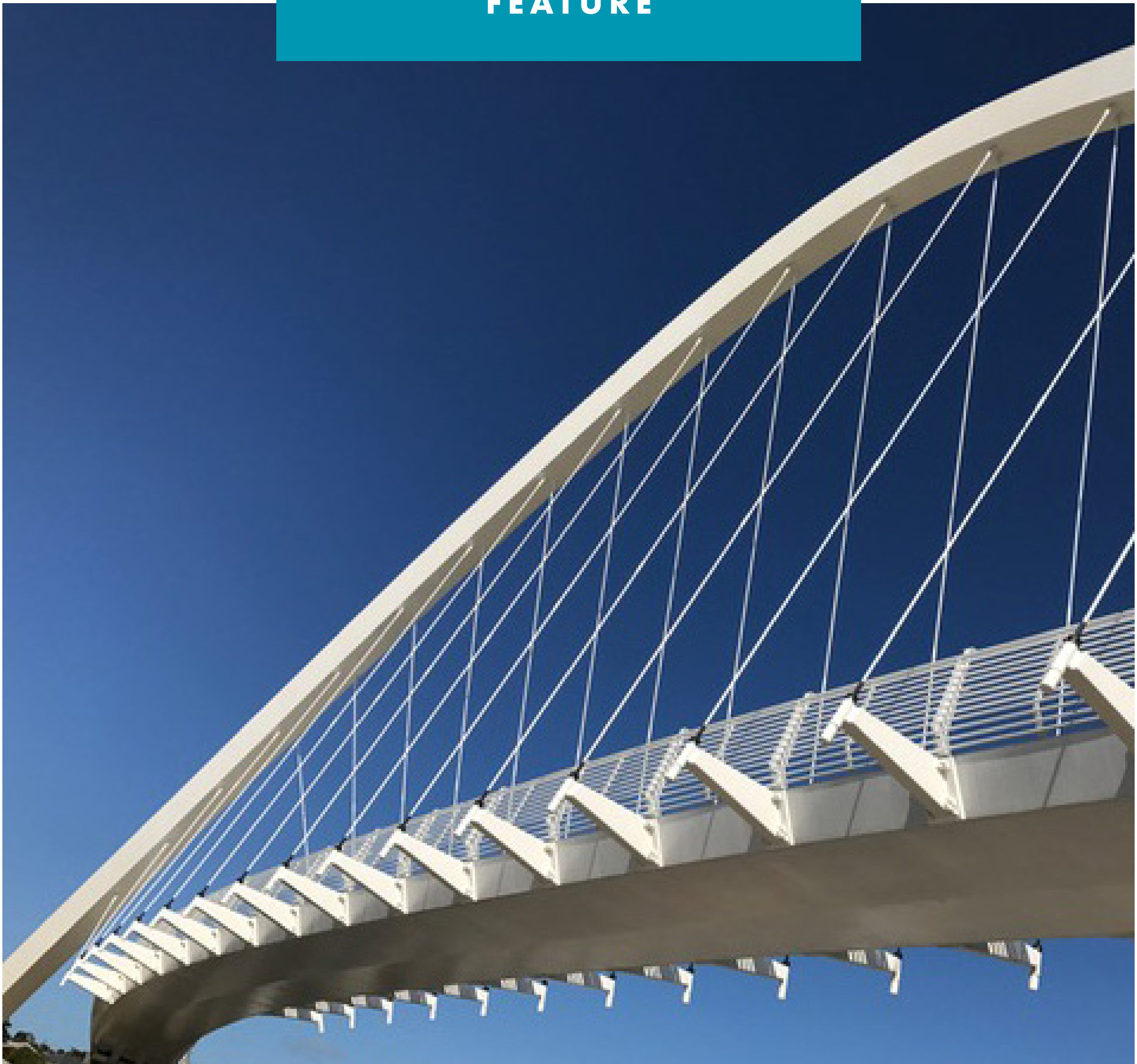
ISO 11844-3:2020 Corrosion of metals and alloys — Classification of low corrosivity of indoor atmospheres — Part 3: Measurement of environmental parameters affecting indoor corrosivity

ISO 11845:2020 Corrosion of metals and alloys — General principles for corrosion testing

ISO 23721:2022 Corrosion of metals and alloys — Rating method by appearance of rust and stains of atmospheric corrosion for stainless steels

ISO 24656:2022, Cathodic protection of offshore wind structures

FEATURE



The Silent Threat: Why Corrosion Management is Crucial for Infrastructure Longevity

By Mike Dehghan

Corrosion, the relentless degradation of materials by chemical reactions with their environment, is a hidden enemy that silently eats away at our infrastructure. Bridges, pipelines, storage tanks, and countless other structures are constantly under attack, their integrity slowly compromised.

For industries that rely on long-lasting, reliable assets, corrosion management becomes an essential practice. It's not about reacting to emergencies, but about proactively safeguarding your infrastructure investment.

The High Cost of Corrosion

The National Association of Corrosion Engineers (NACE) International has conducted influential studies on the economic impact of corrosion. Here's a summary of their findings:

- **Global Cost:** A 2016 NACE study titled "International Measures of Prevention, Application, and Economics of Corrosion Technology (IMPACT)" estimated the global annual cost of corrosion at a staggering US$2.5 trillion, which is roughly equivalent to 3.4 percent of the global GDP at the time of the study (2013) [IMPACT Report]. This has been estimated to cost 3.5% - 5.2% of the global gross domestic product in recent years.
- **US Cost:** An earlier 2002 US-focused study, "Corrosion Costs and Preventive Strategies in the United States," estimated the annual direct cost of corrosion in the US to be $276 billion, representing approximately 3.1% of the US GDP [Cost of Corrosion Study - AMPP].
- In Australia and New Zealand, the cost of corrosion is estimated to be approximately AUD $100 billion.

These studies highlight the significant economic burden caused by corrosion. They also emphasize the potential for substantial cost savings through effective corrosion management practices. The IMPACT report estimates that applying existing corrosion control practices could save between 15% and 35% of the global corrosion cost, translating to savings of US$375 to $875 billion annually.

It's important to note that these figures typically focus on the direct financial costs and don't usually take into account the indirect costs associated with corrosion, such as safety hazards and environmental damage. These indirect effects can be substantial and should be considered when making economic decisions about corrosion management.

The High Cost of Corrosion

The consequences of neglecting corrosion management can be severe. Here's a glimpse of the dangers it poses:

- **Safety Hazards:** Corroded structures can weaken and fail, leading to catastrophic events. A burst pipe or a collapsing bridge can cause injuries, fatalities, and environmental damage.
- **Financial Losses:** Unexpected repairs, replacements, and production stoppages due to corrosion failures translate into significant financial losses.
- **Environmental Damage:** Leaking pipelines can contaminate soil and water, posing a serious threat to ecosystems.

Proactive Strategies for Corrosion Control

Fortunately, we're not powerless against corrosion. Here are some key strategies for effective corrosion management:

- **Embrace a Holistic Approach:** Develop a comprehensive program that incorporates risk assessment, material selection, corrosion control methods (coatings, cathodic protection, inhibitors), and continuous monitoring.
- **Invest in Early Detection:** Regular inspections and non-destructive testing techniques like ultrasound or radiography can identify corrosion problems at their early stages, allowing for timely intervention.

- **Embrace New Technologies:** Advanced data analytics and machine learning can be used to analyze inspection data, predict corrosion rates, and optimize maintenance activities.
- Prioritize Training: Equipping your workforce with the knowledge and skills to identify, assess, and mitigate corrosion threats is vital.

Building a Culture of Corrosion Awareness

Corrosion management is not a one-time fix; it's an ongoing commitment. By fostering a culture of corrosion awareness within your organization, you can ensure that everyone involved understands the importance of proactive measures. Integrating corrosion management into your overall asset integrity strategy will lead to:

- **Extended Infrastructure Life:** By preventing corrosion-related damage, you can significantly extend the lifespan of your assets.
- **Reduced Maintenance Costs:** Early detection and intervention are far more cost-effective than dealing with extensive repairs or replacements.
- **Enhanced Safety and Environmental Protection:** A proactive approach to corrosion management minimizes the risk of accidents and environmental damage.

Elements of Robust Corrosion Management Program

A robust corrosion management program is a crucial component for any industry that deals with assets that are susceptible to corrosion. Corrosion can lead to expensive repairs, downtime, and even safety hazards. A well-designed program can help to minimize these risks and ensure the long-term integrity of your assets.

Here are the key elements of a robust corrosion management program:

- **Policy and Leadership:** A clearly defined corporate policy endorsed by senior management demonstrates a commitment to corrosion management. The policy should outline the goals, objectives and responsibilities for corrosion control.
- **Planning and Procedures:** Develop a comprehensive plan that identifies the assets most susceptible to corrosion, defines the inspection and monitoring techniques to be used, and outlines the mitigation strategies for identified risks.
- **Data Gathering and Analysis:** Collect and analyze data on corrosion rates, material properties, operating conditions, and inspection results. This data is vital for understanding the mechanisms of corrosion and predicting future problems.
- **Inspection and Monitoring:** Regularly inspect assets using appropriate techniques to identify and track the extent of corrosion. Common methods include visual inspection, ultrasonic testing, and radiography.
- **Risk Assessment:** Systematically evaluating the likelihood and severity of corrosion threats across different assets. Risk assessments help prioritize resources and determine the most effective mitigation strategies.
- **Mitigation and Repair:** Implement strategies to slow or prevent corrosion, such as coatings, corrosion-resistant materials, and cathodic protection. Repairs should be conducted promptly to prevent further damage.
- **Training and Competency:** Ensure personnel

responsible for corrosion management have the necessary knowledge and skills through training and certification programs.

- **Communication and Reporting:** Establish clear communication channels to ensure all stakeholders are aware of corrosion risks and mitigation efforts. Regularly report on the performance of the corrosion management program to senior management.
- **Continuous Improvement:** A corrosion management program is a living document that should be continuously reviewed and updated. This includes incorporating new technologies and best practices, as well as lessons learned from experience.

By incorporating these elements, organizations can establish a proactive and effective corrosion management program that protects their assets, reduces costs, and ensures operational safety.

Corrosion may be a silent threat, but its consequences are loud and clear. By implementing a robust corrosion management program, you can safeguard your infrastructure investment, ensure the safety of your workers and the public, and contribute to a more sustainable future.

In the following series of articles, I will discuss more about the elements of robust corrosion management programs.

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1. International Measures of Prevention, Application and Economics of Corrosion Technology (IMPACT), NACE International IMPACT Study, 2016
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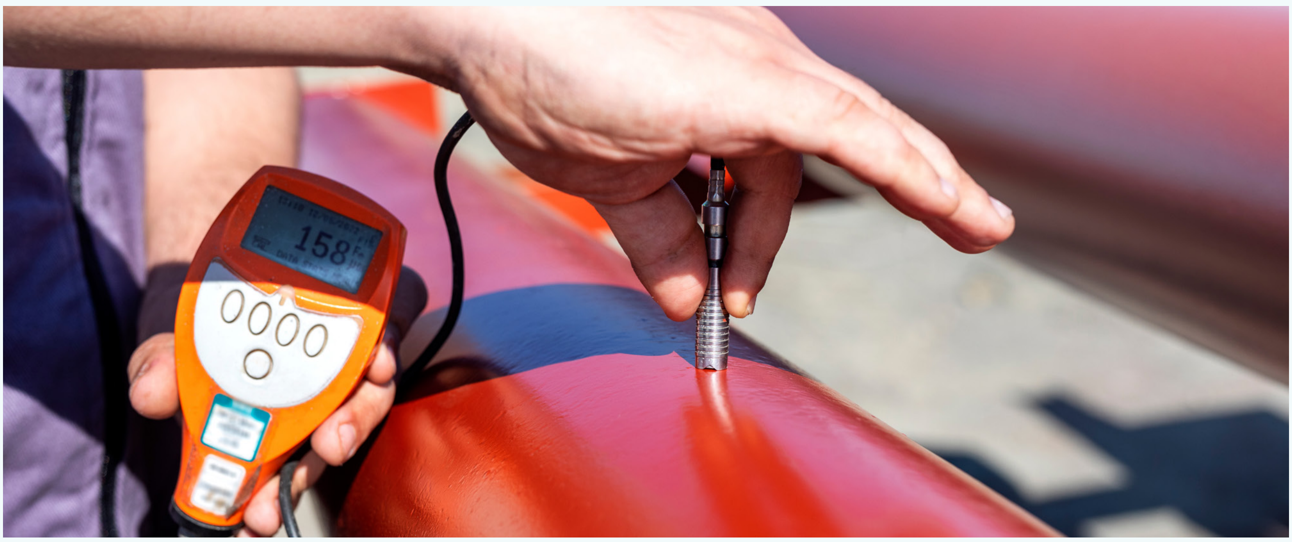
Mr. Dehghan is the registered charted engineer. He is an Accomplished Mechanical Integrity Specialist with over 17 years of expertise in on/offshore oil & gas and petrochemical sectors. Proven in establishing corrosion management frameworks, risk-based inspection programs, and comprehensive mechanical integrity plans aligned with regulatory standards. Expertise spans damage mechanisms, materials selection, welding, and asset integrity management.



Good things come in threes!

On the 5th of June 2024, the Newcastle Branch of the Australasian Corrosion Association held a great breakfast event with three insightful speakers at Noahs on the Beach, Newcastle focused on the design, construction and management of cathodic protection systems.

With 35+ people attended to hear Troy Palmer of Marine & Civil present on the Impressed current cathodic protection (ICCP) Fremantle Bridge & Brotherston Dock Case Studies. Then Ian Godson from Infracorr presented on ICCP in a black rust environment, and Huber Madrio of Transport NSW, presented on Improvements of Practice on Corrosion Protection of Steel in Concrete – The TFNSW experience. We can definitely chalk this one up to a success for the branch! Thank you to our Event Sponsor **Watt Asset Advisory**.

First Corrosion Event in Tasmania for 2024

The ACA partnered with the Tasmanian Minerals, Manufacturing and Energy Council (TMEC) to deliver the first corrosion event in Tasmania on 13 June 2024.

The event was held in Burnie, in the Northwest of Tasmania, and attracted 19 people. The attendees included representatives from the mines on the North West Coast as well as contractors and supplier from the North of the State. Thanks also to some of our members that travelled from Hobart to attend!

The CEO, Maree Tetlow, co-hosted the event on behalf of the ACA, and Vanessa Skipworth, General Manager of TMEC, co-hosted the event at their TMEC contemporary facilities in Burnie.

Jim Galanos and Jim Barraza (CCE/Eptec Group) presented the Cost of Corrosion and Mitigation Strategies, which considered both the coatings and cathodic protection elements of corrosion management.

An interesting story came from Copper Mines of Tasmania, whereby corrosion suppliers are encouraged to test their products as the mine (in care and maintenance) is located on the rugged wet, cold and coastal area of Queenstown with highly levels of sulphuric acid leaching out of the soil. One supplier was testing a coated product, and three months later asked how his coated metal was going? He was surprised to hear it was 'gone' and assumed it was stolen. But no, it had totally corroded away in the environment!

Thank you to our Tasmanian based members. Discussions are underway with TMEC to offer another event in Launceston later in the year. Thank you to Corrosion Control Engineering and Eptec Group for your sponsorship of this event!

Breakfast Seminar

On May 22, 2024, the Western Australia Branch of the Australasian Corrosion Association (ACA) organized a breakfast seminar titled "Decision-Making Based on Corrosion & Material Failure Analysis." The sold-out event was attended by 23 industry professionals from various companies across WA, featured Dr. Margarita Vargas from Anti Corrosion Technology. With over 20 years of experience in material failure investigations, Dr. Vargas delivered an insightful presentation on failure analysis and its application in decision-making at different levels.

Dr. Vargas emphasized the importance of a balanced approach that integrates technical accuracy with effective communication. She discussed recent literature and broad strategies for conducting failure investigations. Highlighting the significance of considering multiple factors—environmental, mechanical, and chemical—she explained the benefits of assigning weights to these factors to make data more meaningful, especially in complex processes like microbiologically influenced corrosion (MIC).

Additionally, Dr. Vargas addressed the legal aspects of serving as an expert witness in court for failure investigations. She underscored the importance of implementing the latest technical developments to enhance the accuracy of analyses and strengthen technical reports. She also discussed the challenges of communicating complex results to non-technical audiences.

The seminar was a resounding success, providing a valuable opportunity for attendees to deepen their understanding of corrosion and material failure analysis, equipping them with the knowledge to conduct thorough investigations and make informed decisions in their respective fields.

YCG Strike Bowling

I'm excited to share highlights from our YCG WA branch social bowling event on 31 May 2024 at Strike Bowling Bar, Perth. It was fantastic to see everything run smoothly, thanks to our dedicated team.

We started with a warm welcome and enjoyed delicious pizzas before diving into a fun two-hour bowling session. The atmosphere was buzzing with friendly competition, laughter, and cheers.

Seeing both new and long-standing members connect and share experiences underscored the strong sense of community within ACA YCG. The positive feedback highlights the value of these gatherings for networking and camaraderie.

Thank you to everyone who participated and made the event memorable. We look forward to more events like this to continue strengthening our community bonds.

The ACA Queensland Branch & Young Corrosion Group held their first event of the year. A fantastic YCG technical session on AI in Corrosion featuring guest speaker Geoffrey Will (University of the Sunshine Coast) at the South Bank Tafe – 66 on Ernest sponsored by Scape Consulting.

The event was a great success, bringing together young corrosion professionals from academia and industry to share their experiences. Several of the YCG members commented how interesting Geoff's talk was. It was the perfect balance of old and new approaches to corrosion coming together, something that everyone appreciated. He highlighted how important it is to leverage new AI tools intelligently and understand that a trained corrosion expert is still very much needed. Ultimately, AI tools for corrosion analysis help us remove the tedious repetitive process from our work and allow us to focus on the more interesting aspects. Everyone had a great time and were glad to have the opportunity to forge closer relationships with experienced ACA members.

Upcoming Queensland Event

International
An AkzoNobel brand

YCG Burgers and Bowls

Date: 13th September 2024
Time: 5pm – 8pm AEST
Venue: The Boo, 126 Breakfast Creek Road Newstead QLD
What: YCG Burgers and Lawn Bowls
Sponsor: AkzoNobel

CLICK HERE TO REGISTER

NSW branch have focused developing relationships regarding corrosion protection with the engineering and academic communities in 2024.

Technical lunch and learn session have been presented by branch president Adam Hockey to Mott Macdonald , ACOR Consultants Pty Ltd, Apex Diagnostics and there are more planned before the end of the year.

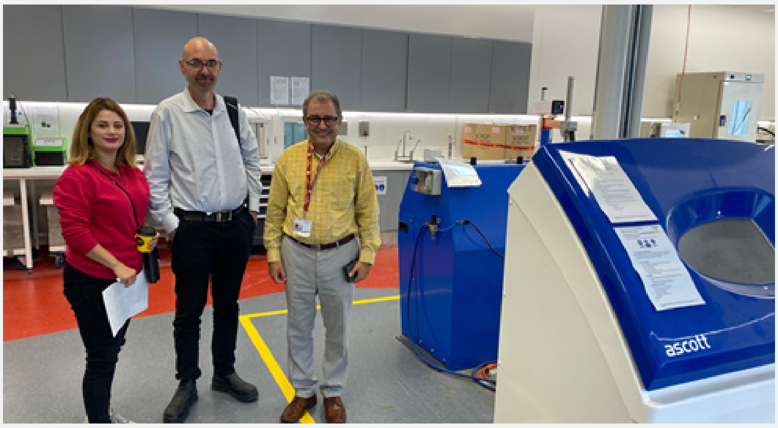
This initiative has been developed by NSW committee to help promote awareness of the resource that can be provided by the ACA on corrosion protection to engineering firms.

NSW branch has also been engaged with the Universities in Sydney to develop a program called Industry to Academics. Feedback from both the Industry and the Universities in Sydney is that there has been a gap between the two and both are welcoming the initiative.

So far introduction meetings have been held with the University of Technology Sydney , Sydney University and University of Western Sydney and a future meeting is scheduled with Wollonogng University. The NSW branch has also provided a guest lecture on corrosion protection at University of Technology Sydney in April.

This program will continue to develop and plans to have the ACA utilised as vehicle to share knowledge between Academics and Industry into the future.

NSW branch are also in early discussions with the CIA about providing joint technical /introduction events at major regional cities in NSW and Canberra in 2025.



SAVE the DATE

UPCOMING EVENT: In Person Technical Event

National Construction Code (NCC) Compliance

August or September 2024

Sponsored by:

REMEDY ASSET PROTECTION
CORROSION CONSULTANTS FOR CONCRETE REPAIR AND STEEL PROTECTION

Student Case Study Night

The South Australian branch hosted a student case study night (21st May, 2024) at the Original Coopers Ale House, an iconic pub that serves as a true staple of the Adelaide CBD, showcasing the rich history of SA's own Coopers Brewery. With over 40 registrations for the night from both industry and students, this demonstrates a strengthening interest in ACA events within South Australia - matching pre-COVID levels.

The case studies presented on the night gave the audience a unique look at the types of issues corrosion specialists encounter in the field, as well as the learnings and experience that have been taken on board. For the visual learners – a corrosion cell was also demonstrated which was a welcome change of pace.

It was a pleasure to see both regular and new faces at the event, with 3 new YCG delegate nominations and memberships. The South Australian branch are looking forward to hosting the upcoming events and seeing you again soon.

A huge thank you to our speakers and event sponsors: Alex Shepherd (Remedy Asset Protection), David Towns (Denso Australia) and Roman Dankiw (Asset Inspection Consultants).

Case Studies and Failures

The Victoria Branch hosted a technical event on Case Studies and Failures on the 8th May 2024. With presentations from 3 esteemed speakers:

John Everton (SRG Global, Asset Care) on Corrosion Failure – Nickel Alloy Pump Housing. Nathan Way (InfraCorr) on Remediating Swimming Pools – Aggressive Corrosion Conditions, Poor Maintenance and Construction Surprises and Sarah Furman (AECOM). It was an evening filled with a mind-expanding presentation and insightful conversations.

Thank you to our event sponsor Denso CORROSION PREVENTION

Upcoming Victoria Event

Victoria Round Table Conference

Date: 22nd August 2024

Time: 6pm – 8:30pm AEST

Venue: Duke of Wellington, Arthur's Bar & Deck, Flinders Street Melbourne CBD

Keynote: Tracey Gramlick - Chair of the board of Standards Australia, chair of the Industry Advisory Board for Macquarie University's Faculty of Science and Engineering, and remains the liaison between the National Building Products Coalition and CSIRO.

CLICK HERE TO REGISTER

An Update and Catch-up

On the 17th July the ACA NZ Branch held a meeting at the Mt Richmond Hotel, Mt Wellington, in conjunction with two CIP Level 1 courses and a CIP Level 2 course held at the same venue over three weeks. The two speakers were Kingsley Brown, ACA Board Chair, and Justin Rigby, ACA Coatings Technical Group Chair. The purpose of the meeting was to inform ACA members and visitors on a number of updates within the ACA. The meeting was also an opportunity for networking.

For the benefit of the visitors Kingsley gave an outline on the ACA's background and the developments since the Covid era. He described the current staffing situation at the ACA Centre, the welcome revival of the ACA journal Corrosion & Materials and the updating of the by-laws and Constitution of the Association.

Justin then provided an overview of the role of the Coatings Technical Group within the ACA. He discussed recent developments in applicator trade training, training of painters and blast cleaners, and the important role being played by new Standards.

The presentations were followed by a general discussion on different aspects of applicator training and how the CTG fitted into the ACANZ Branch structure. Refreshments and networking concluded the face-to-face meeting which was a welcome change from recent ACA zoom meetings. Matt Vercoe then thanked the two speakers for their interesting talks.

◀ *Kingsley Brown talking about recent ACA News and Updates*

▼ *Justin Rigby discussing the ACA Coatings Technical Group*

Over 40 members attended online the AGM on Thursday 20 June.

The key item of business was to provide an overview of the 2023 year, and also an update for members on the 2024 year to date. A copy of the Annual Report can be viewed here.

The ACA delivered a much better result in 2023 compared to 2022. Although it was still a deficit, it was also a better result than what was planned. The CEO also reported that the 2024 budget is planned to deliver a small surplus, and all indications to date are that this surplus will be achieved.

The ACA Board Chair, Kingsley Brown, provided an update on the options for changes to the constitution over the next 12 months. This was presented for feedback during general business. The ACA is considering moving from an incorporated association to a company limited by guarantee. This would allow the association to a simpler model to operate throughout Australia and provide more options for operating in New Zealand. A key consideration will be the future role of the Council, and the methods of voting in the of Board Directors to the ACA Board. More details will be available soon, via a Discussion Paper, for all members to make comment.

Upcoming Concrete Technical Group Event

Online Webinar

Date: 4th September 2024

Time: 2pm – 3pm AEST

Venue: Online

Troy Palmer

Andrew Dickinson

The Concrete and Structures Technical Group on behalf of the Australasian Corrosion Association (ACA) invites all members and those interested to join us for an online Zoom webinar on Corrosion protection case studies at different stages of an assets life.

CLICK HERE TO REGISTER

Water Industry Technical Group

The Water Technical Group hosted a successful seminar on 29 April 2024 at the Royal Society of Victoria, at a beautiful historical venue in the heart of Melbourne.

The theme was 'Accelerating Durability' and attracted 60 water-related delegates to hear 12 presentations covering all aspects of durability including concrete durability, cathodic protection, and the latest in coating technology. It also considered new and innovative products, and new methods of monitoring and assessment. The seminar was hosted the day before OzWater 2024, to maximise the water industry participants. Thanks to the Chair of the Water & Waster Water Technical Group, Paul Vince, for driving this successful event.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Promotion and Advancement of Science

History of the ACA Coatings Technical Group

Prepared by Willie Mandeno
Reviewed by Justin Rigby & Rob Francis

In 1996, the ACA formed the Protective Coatings Technical Group (PCTG), that was later renamed the Coatings Technical Group (CTG), for its members who were involved in all types of industrial coatings and linings used for the protection or restoration of corrosion affected structures through Australasia. Its mission is "to share ideas, project studies, technologies and market trends amongst asset owners, designers, manufacturers, suppliers and equipment providers to the protective coating industry".

Its inaugural meeting was held in Melbourne at the ACA Conference where the late Don Bartlett was elected Chairman and Fred Salome as Secretary. Subsequent PCTG Chairs have included Fred Salome, Rob Francis, Willie Mandeno, Mark Weston, Nick Subutch, Geoff White, David Hopkins, Stephen Wickham, and Peter Dove. The current CTG Chair, since 2016, is Justin Rigby from the Victorian Branch.

The year of its formation coincided with two landmark dates in the history of the development of inorganic zinc coatings. It was exactly 60 years since the patent for the first inorganic zinc coating was taken out by its inventor, Victor Nightingall of Melbourne. Furthermore, it was also 50 years since his passing in 1947. The coinciding of these events made the celebration of this important Australian contribution to corrosion prevention, an ideal inaugural activity of the PCTG.

A series of seminars on inorganic zinc coatings were run in Australia and New Zealand. The first was in Auckland in September 1997. Later seminars were held in Sydney, Melbourne, Adelaide and Launceston. The majority of the papers presented at these seminars were included in the ACA publication 'Sixty years of Inorganic Zinc Coatings: History, Chemistry, Properties, Applications and Alternatives' that was edited by Dr R.A. Francis.

The PCTG also agreed to make an annual award known as the 'Victor Nightingall Award' to honour him and to recognise distinguished achievement in the development, manufacture or application of protective coatings, or advancement of the protective coatings industry. The inaugural award was made at the 1997 ACA Conference in Brisbane to John Biddle and the second award to David Donald at the 1998 Conference in Hobart. Both these recipients had papers in the ACA publication. Other recipients have been:

1999 John Hartley, NSW	**2001** Ivan Baxter, NSW
2004 David Blackburn, TAS	**2005** Alex Szokolik, VIC
2007 Ern Hemmings, NSW	**2009** Don Bartlett, VIC
2014 Rob Francis, VIC	**2017** Fred Salome, NSW
2018 Mark Weston, SA	**2022** Ted Riding, VIC

Don Bartlett receiving his VN Award from Willie Mandeno

The ACA Coatings Technical Group have also organised many stand-alone events including;

Melbourne, 21 June 2000
'Coatings 2000: A Clean Start to the New Millennium' (with BCCA)

Melbourne & Brisbane, 20 February 2003
'New Standards for Protective Coatings'

New Zealand, April 2008
'Corrosion and Asset Management Seminars'

Auckland & Australia, 26 May 2011
'Protective Coatings for Corrosion Control'

Wellington, 26 May 2011
'Corrosion Mitigation & Monitoring'

Melbourne, 18 & 19 July 2013
'Improving the Longevity of Protective Coatings – Industry Updates and Lessons Learnt!'

Brisbane, 20 November 2014
'Protective Coatings Preventing Corrosion: How, Why & When to Act'

Auckland, 5 July 2018
'Designing for Durability in the Build Environment'

Melbourne, 4 April 2019
'Protective Coatings and Applications'

Wellington, 14 July 2021
'Design for Durability'
(with SESOC)

Aukland, 6 November 2023
'Protecting Structures from Fire'
(with SESOC)

The PCTG/CTG has been active in supporting the development and updating of Australian and New Zealand industry standards. These have included;

AS1580 Paints and related materials – Methods of test (series)

AS1627 Metal finishing – preparation and pretreatment of surfaces (series)

AS2312 Guide to the protection of structural steel against atmospheric corrosion by the use of protective coatings (Parts 1, 2 & 3)

AS2700 Colour standards for general purposes

AS3750 Paints for steel structures (series)

AS3894 Site testing of protective coatings (series)

AS4020 Testing of products for use in contact with drinking water

AS4361 Guide to lead paint management (Parts 1&2)

AS4506 Metal finishing – Powder coating

AS4680 Hot-dip galvanized (zinc) coatings on fabricated ferrous articles

AS4791 Hot-dip galvanized (zinc) coatings on ferrous open sections, applied by an in-line process

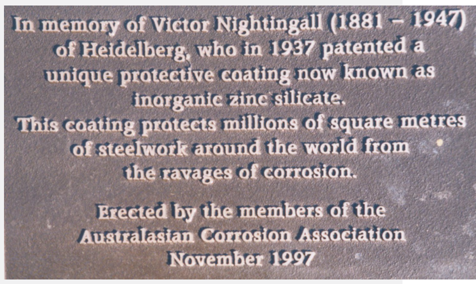
AS4792 Hot-dip galvanized (zinc) coatings on ferrous hollow sections applied by a continuous or a specialized process

AS4848 Application specifications for coating systems

The CTG also arranges a Forum at the annual ACA conferences where members present and discuss relevant and current topics of interest less formally, ie. without having to prepare a peer reviewed paper for the coatings' technical session in the conference. More recently, the CTG has combined with the ACA Applicators Group (AG) to organise a field day in conjunction with the conference where service providers could demonstrate inspection instruments and their equipment for surface preparation and application of protective coatings.

With the ATG, the CTG has also organised 'Roadshows' at regional centres that have combined a seminar with equipment demonstrations, most recently at Brisbane, Newcastle and Melbourne in August 2023, and planned again for Auckland, Christchurch, Sydney and Perth in 2025.

A memorial plaque was cast and placed on Nightingall's grave at Warringal cemetery to ensure that Nightingall's final resting place would have some record of his contribution.



CORROSION & PREVENTION
CAIRNS 2024

Cairns Convention Centre | 10 - 14 November 2024

Navigating Corrosion Challenges in Marine and Coastal Environments

2024 PLENARY SPEAKERS

PROF NICK BIRBILIS

CHRISTINE CRAWSHAW

WAYNE NEIL

KATE DYLEJKO

BLANE MCGUINESS

REGISTRATIONS NOW OPEN

WWW.CORROSION.COM.AU/CONFERENCE/TICKETS

PRELIMINARY PROGRAM

SUNDAY

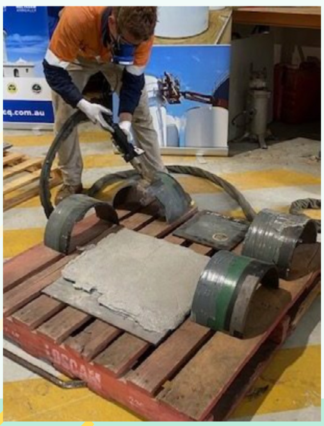
Our Sunday Festivities commence with a YCG Pool party (all delegates welcome, tickets must be purchased for this event) followed by the official Welcome to Cairns reception for all delegates.

9am	Board Meeting (Private)
2pm-5pm	YCG Pool Party (Venue TBC)
3pm	Council Meeting (Private)
6pm-9pm	Welcome Reception

MONDAY

Our Monday program is Jam Packed full of paper sessions and will be followed by our inaugural asset owners reception. All local Queensland Asset Owners are welcome to attend the cocktail function in the evening free of charge.

9am-5pm	Exhibition Hall Open
9am	Plenary Sessions & Conference Opening
	Major Sponsor Plenary Speaker
	Plenary 2
11am-5pm	Paper Presentations and Forum
6pm-9pm	Asset Owners Reception in the Exhibition Hall



TUESDAY

Tuesday is our biggest day of the program!

9am-5pm	Exhibition Hall Open
7am	Women in Corrosion Breakfast
9am	Plenary Speakers
	PF Thompson Lecture
	Plenary 4
11am-5pm	Paper Presentations and Forum
6pm-11pm	Awards Night
11pm	After Party

WEDNESDAY

Our Wednesday program closes out the official paper presentations and exhibition hall.

8:30am	NAVC Forum
9:30am-3pm	Exhibition Hall Open
9:30am	Plenary Sessions
	Plenary 5
	Plenary 6
11:30am-5pm	Paper Presentations and Forums
3pm	Exhibitor Bump Out Commences
5pm	Exhibition Hall Closing Drinks

THURSDAY

Our Thursday is all things Applicator Day. We are showcasing the latest and greatest in Applicator Technology.

9am-11am	Site Tour – Shipyard Facility
11:30am-5pm	Applicator Day Live Demo and Presentations.
5:30pm-8:30pm	Conference Wrap Party

THE ATG, CTG & ACA ANNOUNCED THE POSTPONEMENT OF THE 2024 ROADSHOW.

Although we had great support from sponsors, exhibitors and speaker, the group was conscious of running out of time to attract the best crowds in Auckland, Christchurch, Sydney and Perth. It was agreed to keep plans in place for 2025, and to have greater leadup time to build our target audiences, especially in New Zealand.

Justin Rigby, Chair of the Coatings Technical Group and Kingsley Brown, Chair of the ACA Board, travelled to Auckland in July for Coatings Inspector training, and took the opportunity to meet with the Auckland members for a networking and ACA update. The CEO of the ACA is also scheduled to travel to four locations in New Zealand from 11-17 August to meet with the NZ Branch and members. This will also be an opportunity to leverage the 2025 Roadshow activities.

PROPOSED ROADSHOW DATES FOR 2025

SYDNEY
Tuesday 6th May 2025

PERTH
Tuesday 13th May 2025

AUCKLAND
Monday 21st July 2025

CHRISTCHURCH
Thursday 24th July 2025

WE NEED SPONSORS, SPEAKERS & CONTRIBUTORS!

Interested in contributing to the 2025 Applicator & Coatings Roadshow?

Next meeting: 5th August 2024

Please contact frances.marshpaaki@corrosion.com.au for a meeting invite.

The **ACA Applicators Technical Group** aims to represent the needs of specialist contractors in industries that serve the protection or restoration of corrosion affected structures throughout Australasia. These include companies and individuals in concrete protection, applied concrete floor finishes, concrete repair, hazardous coating removal, surface preparation and coating application.

The **ACA Coatings Technical Group** shares ideas, project studies, technologies and market trends amongst asset owners, designers, manufacturers, suppliers and equipment providers to the protective coating industry that serve the protection or restoration of corrosion affected structures throughout Australasia.

Sam Chen
Concrete & Structures Technical Group Chair

Dr. Fangjie Chen has extensive knowledge on concrete sustainability and durability. He has 21 publications on academic journals and international conferences and own two patents on high-performance concrete admixtures. He has worked at Arup on multiple large scale infrastructure projects in Australasia, driving for better sustainability and durability in concrete.

His hands-on experience in concrete design, testing, characterization, and production allows him to utilise innovative recycled materials to improve concrete performance in service. His technical expertise in concrete structural deterioration helps to devise effective strategies for asset assessment and maintenance.

Q1.
Can you briefly describe your background and how you came to specialise in corrosion?

My journey into the world of corrosion started during my PhD at RMIT University and Wuhan University of Technology. With a strong background in materials and civil engineering, I focused on sustainability, durability, and structural deterioration. My research delved into the deterioration of corrosion-affected civil infrastructure, particularly in modelling the service life of concrete structures and assessing corrosion impacts. This academic path naturally led me to specialize in corrosion, combining theoretical knowledge with practical applications.

Q2.
Can you tell us about your current role?

As a Senior Materials Engineer at Arup, my role involves providing technical advice on the durability design of various infrastructure projects. This includes developing low-carbon concrete solutions, implementing sustainable materials, and conducting durability assessments of concrete structures. I also have the privilege of serving as the Chair of the Concrete & Structures Technical Group at the Australasian Corrosion Association, where I contribute to advancing our understanding and management of corrosion in concrete structures.

Q3.
In your opinion, what makes corrosion a critical issue for the oil and gas industry specifically?

Corrosion is a major concern for concrete and structures because it directly affects the longevity and safety of infrastructure. When steel reinforcement within concrete corrodes, it can cause cracking, spalling, and ultimately lead to structural failure. This not only escalates maintenance costs but also poses significant safety risks, making it crucial to address corrosion effectively.

Q4.
What are the most significant corrosion challenges facing the oil and gas sector today?

Some of the most significant challenges include managing chloride-induced corrosion in marine environments, addressing carbonation-induced corrosion in urban areas, and mitigating the effects of industrial pollutants on infrastructure. There is also a pressing need to develop cost-effective and durable materials that can withstand these harsh environments while maintaining sustainability and reducing carbon footprints.

Q5.
Could you discuss any new technologies or materials that have emerged recently to combat corrosion in the Concrete & Structures area?

We're seeing advancements in low-carbon concrete incorporating supplementary cementitious materials (SCMs) like slag and fly ash, which enhance durability and reduce environmental impact. The use of nano-materials, such as nano-TiO2, has also shown promise in improving concrete's durability and corrosion resistance. Innovations in corrosion inhibitors and coatings for steel reinforcement, along with advancements in predictive modelling and monitoring technologies, are playing a pivotal role in more effective corrosion management.

Q6.
What are the key strategies for corrosion prevention and management that companies in the oil and gas industry should implement?

Companies should implement comprehensive durability designs that consider environmental exposure, material selection, and protective measures, as well as regular monitoring and timely maintenance to address early signs of corrosion. New advancements can make a real difference so companies should be exploring SCMs, protective coatings and advanced materials like corrosion inhibitors and nano-materials to improve the performance and longevity of concrete structures.

Q8.
Where do you see the future of corrosion research and technology heading for Concrete & Structures sector you work in?

In the future, I believe we'll see more high-performance, low-carbon concrete mixes and recycled materials to enhance durability and reduce environmental impact.
Technology is likely to result in more advanced monitoring techniques such as sensors and data analytics to track corrosion in real-time, while predictive modelling could improve the way we anticipate corrosion behaviour under various environmental conditions, leading to more effective maintenance and management strategies.

Q9.
What advice would you give to companies in the oil and gas industry to better address corrosion challenges?

I strongly recommend prioritising the use of high-quality, durable materials suitable for the specific environmental conditions of their structures. It's best practice to have a thorough durability design approach that considers potential corrosion risks and incorporates protective measures from the outset. Additionally, collaborating with corrosion experts and engineers to develop tailored strategies for corrosion prevention and management is crucial for long-term success.

Q10.
Could you share a specific case where innovative corrosion management significantly improved an oil and gas operation's efficiency or safety?

We used advanced in-house models to assess the risks of corrosion induced by chloride or carbonation on the Bolte Bridge Remaining Service Life Assessment project in Melbourne. This allowed us to accurately gauge the remaining service life of the bridge components. Our innovative approach led to a targeted maintenance strategy that improved the safety and longevity of the bridge while optimising maintenance efforts and reducing costs. Identifying high-risk areas precisely enabled efficient resource allocation, ensuring the structural integrity and reliability of this critical infrastructure.

Q11.
How are data analytics and predictive maintenance being utilized to address corrosion-related issues in the industry?

Sensors and IoT devices that continuously monitor environmental conditions and corrosion indicators provide real-time data on the state of structures. Predictive data analytics can forecast potential corrosion issues, enabling proactive maintenance, and reducing unexpected failures. Integrating data analytics into lifecycle management practices can optimise maintenance schedules and resource allocation, extending the service life of structures, and reducing costs.
Developing decision support systems that combine data from various sources to provide actionable insights for asset managers can improve the effectiveness of corrosion prevention and maintenance strategies.

Adam Hockey, President, NSW Branch

Adam Hockey has worked for Dulux Group for 30+ Years. Adam is passionate about sharing learnings and providing technical support for corrosion protection and is the current NSW Branch President for the Australasian Corrosion Association.

Q1.
Where do you work? Describe your job.

I am a AMPP Certified Coatings Inspector Level 2 – Certified and Concrete Coating Inspector Level 2, and my current role is a Business Development Executive with Dulux Protective Coatings. I am a Business Development Executive with Dulux Protective Coatings. In this role I am responsible for providing specification, developing, and presenting technical presentations and consulting on technical matters related to corrosion and fire protection for new construction and asset management.

Q2.
Can you share your journey into the corrosion industry? What motivated you to become involved?

I had worked in the decorative coatings industry for 20 years before starting a role as representative in protective coatings. I then realised that there was this industry that involved historical and changing technology , knowledge from experience and academic knowledge, technical application techniques , and collaboration with multiple parties that I never knew existed. I now look at major structures with intrigue and look to understand their story , condition and if they are protected. I truly believe once you enter this industry you can never leave.

Q3.
Who or what has influenced you most professionally?

Moving from a long-term role of sales to providing technical advice has provided me with energy and inspiration. Continued learning and teaching is now my path, and I don't think I ever want to retire.

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

Unfortunately, I cannot be specific due to confidentiality clauses. I have had projects that had challenges that required finding solutions that meet

Government material sustainability requirements but also found a way to provide durability outcomes in high atmospheric corrosivity environments. I have also had to find solutions to manage coating fumes for in-situ work in very busy sites in the CBD. These challenges have multiple set objectives that do not usually meet but they are rewarding when practical solutions are found.

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

There are two challenges that I see.

1. *Delivering sustainable outcomes for the future utilising safe and sustainable materials that also provide long term durability outcomes. Both are required to provide a truly sustainable solution.*
2. *Education on corrosion protection. Corrosion protection is a niche profession , there is a wonderful opportunity to share knowledge in our construction ,asset management and universities to achieve better outcomes.*

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

There is a lot more concern from Builders, Specifiers and Asset Managers about providing assurances of performance. This is a good trend, but we could do better as an industry teaching the standards and in recording case studies and failure analysis for future professionals.

Q7.
Where do you see the future of corrosion mitigation and management heading in the next decade?

I hope that we can get Industry , Academics and our Government working together on regulating expectations and outcomes for long term corrosion prevention.

Q8.
What advice would you give to someone just starting their career in the corrosion industry?

Learn to take a holistic approach to corrosion protection . Understand the standards , listen to the technical information provided by our academics, and talk to the industry that makes it happen.

Q9.
What has been your greatest professional achievement?

Becoming a part of the ACA Sydney Branch has been a great achievement for me. The opportunity to work and collaborate with amazing people that are from different industries within the corrosion protection world and also working with our students and academics has been very rewarding.

Q10.
How has being a member of the ACA benefited you professionally or personally?

Developing a network both professionally and personally is vital in providing a sense of purpose in what you do. The ACA provides this.

Joseph Davies

Joe is an innovative materials scientist with four years of experience developing practical solutions to diverse problems. Including, cathodic protection and coating specification for buried pipelines, coating specification for structural steel, durability design for low-alloy steel structures, concrete mix design and materials selection for coal/gas facilities and green hydrogen projects. Among his specialties are corrosion prevention and asset management, with a particular interest in organic coatings. He continues to undertake industry relevant research towards improved inspection and maintenance of marine assets through electrochemical analysis, corrosion modelling and optimisation of inspection policies.

Q1.
What is your Company or University name?

Aurecon

Q2.
What is your job title/what are you currently studying?

Materials scientist at Aurecon

Q3.
What is the YCG?

The Young Corrosion Group is a network for young and early career professionals looking to make industry connections while having a good time. Some of our events are learning focused and others are more around networking, but we always make sure to have fun and enjoy ourselves. It's a great opportunity to step back from the daily grind and have a look at the bigger picture of what is going on in the wider world of corrosion. Our presentations are always forward looking, identifying new opportunities for innovation while drawing on experience of the past. Our presenters bring unique perspectives to corrosion challenges, from the fundamental science of corrosion all the way up to on the ground application.

Q4.
Why are you a member of the YCG?

I'm always keen to learn from the experience of others in the industry, particularly when they have a different technical background. It's also essential to take time to look at the bigger picture and think about where a career in corrosion can take you..

Q5.
What are some important corrosion related issues facing your industry today

There are many and they are varied. As infrastructure ages around the world, corrosion costs continue to increase rapidly. I think that the primary challenge is in communicating to asset managers and owners the consequences of deferred action to future costs. An ounce of prevention is better than a pound of cure, and this needs to be communicated from the design phase of an asset all the way through its life, which is especially challenging.
Secondly, there has been a great deal of interest in the use of alternative materials for the reduction in cost and carbon emissions for infrastructure projects. Along with the introduction of these new material solutions comes the technical challenge of demonstrating corrosion resistance over the design life of an asset. These are problems that I particularly enjoy because they require us to go back to the basic first principles of corrosion and check that our assumptions will hold true.

Q6.
How does the ACA and YCG support young people in the corrosion industry?

The biggest advantage is the opportunity to learn from experience of industry veterans from the ACA more broadly and make connections that last throughout your career. Joining the association also gives you access to our library of resources, papers and our material expertise. ACA is offering free corporate memberships for new members of the YCG, and we are also offering free event tickets to YCG members.

Q7.
What is your ACA membership level:?

I am part of a corporate membership

Zinc-Rich Paints: Exploring Protection Mechanisms

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

Keywords:

Zinc-rich paints, sacrificial protection, zinc content, inhibition.

Abstract:

Zinc-rich paints are the protective coating of choice as primers and single coat systems for many aggressive environments. They provide sacrificial protection to the steel substrate and it is this property that sets them apart from other coating types. There must be some sort of alternative protection to explain their performance for long-term protection when cathodic protection may be lost, but there have been many differing opinions and theories provided over the years. This paper reviews some of the field exposure, accelerated testing and electrochemical investigations that have been carried out on zinc-rich paints over the years to attempt to provide a clearer understanding of how they provide protection.

1. INTRODUCTION

Zinc-rich coatings, such as inorganic zinc silicates (IZS) or epoxy zincs (EZ), are the protective coating of choice as primers and single coat systems for many aggressive environments. For over 80 years they have been used in marine, construction, transport, petrochemical and other industries where optimum protection with good economics is required. The conventional wisdom is that they are effective because they provide cathodic protection (CP) to the steel substrate and it is this property that sets them apart from other coating types. On closer scrutiny, there will be acceptance that there must be some sort of barrier or other form of protection to explain their performance when no steel is exposed, or for long-term protection when cathodic protection may be lost. But there are a number of aspects of such coatings that cannot be explained by this simple protection explanation. This paper reviews some of the field exposure, accelerated testing and electrochemical investigations that have been carried out on zinc-rich paints (ZRP) over the years to attempt to provide a clearer understanding of how they provide protection. A complementary paper [] describes these testing techniques and their applicability to the study of zinc coatings. This should be reviewed for details of the methods described.

2. ELECTROCHEMICAL BEHAVIOUR OF ZINC-RICH COATINGS

Before looking at their actual behaviour in the atmosphere, it is worth reviewing the galvanic behaviour of zinc-rich coatings in general, as galvanic or cathodic protection is considered to be such a critical aspect of their protective ability. It must be stressed from the outset that this can only be studied in an aqueous solution, whereas real coatings are typically exposed to the atmosphere, so electrochemical behaviour cannot be directly related to actual atmospheric properties.

Upon initial immersion in sea water or similar chloride-containing solution, a steel panel coated with a ZRP will achieve a potential of approximately -1.05 volts vs Saturated Calomel Electrode (SCE), close to that expected for pure zinc metal exposed to the same environment. This potential will change, usually but not always gradually, to more positive values, eventually reaching the potential of iron corrosion in the electrolyte (approximately -0.5 to -0.6 volts vs SCE) when the zinc has been spent and iron (red) rust appears. However, this general behaviour can vary considerably depending on the nature of the coating and its properties.

The Evans diagram is one way of looking at the reactions on a metal surface, especially when two metals are involved. The Evans diagram for the zinc and iron systems, shown in Figure 1, gives anode and cathode potentials and current flows as the electrodes polarise. In a corrosion cell, there will be an anodic corrosion reaction and a cathodic reaction, typically the oxygen reduction reaction (ORR). Unprotected iron will corrode at a relatively high rate proportional to icorr (Fe) with an open circuit potential at Ecorr (Fe). Zinc alone will corrode similarly with an open circuit potential of Ecorr (Zn), but as oxygen reduction on zinc is more difficult than on iron, icorr (Zn) of zinc alone, and thus its corrosion rate, is somewhat lower than for iron even though its corrosion potential is much more negative. If zinc is electrically connected to iron in a common electrolyte, the zinc is the anode and will corrode and the cathodic reaction takes place on the iron surface. Zinc metal does not polarise significantly, so when joined to iron there is only a slight positive movement of the open circuit potential to Ecoupled. However, the corrosion rate of the zinc, acting now as a protective anode, is significantly increased to icoupled as the cathodic reaction takes place on the iron.

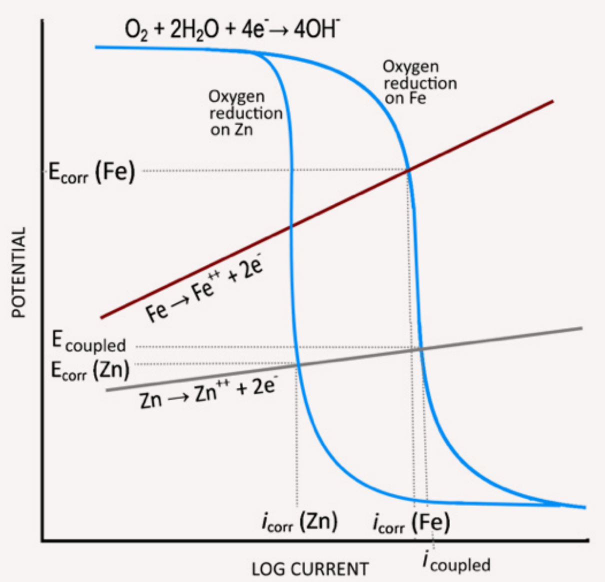


Figure 1: Evans diagram showing corrosion of iron and zinc in a neutral solution, and the effect of coupling the two metals.

Cathodic protection of the steel will last while there is plenty of zinc present, but as the zinc corrodes and cathodic area increases, the potential will increase (become more positive or anodic) and approach that of the steel. There is no hard and fast potential at which CP ceases, but the commonly used figure of 0.85 volts vs the copper sulphate electrode (0.8v vs silver chloride, 0.78v vs saturated calomel) has been found as a good approximation in practice. However, red rust has been noted to initiate at potentials some 50 to 100mV more negative than this figure, perhaps as result of local cells forming on the surface.

Properties such as coating thickness and, for zinc-rich paint, the percentage of zinc pigment in the paint will influence how long the CP lasts. An insulating topcoat will, as with painting sacrificial anodes, prevent the zinc providing protection. Proximity of the protective anode to cathode is also important, with protective potential and current dropping away the further the edge of the zinc coating is from the exposed steel. A zinc coating cannot be expected to protect steel distant from the edge of the zinc coating, but this protective distance or 'throwing power' varies with different zinc coatings as well as conductivity of the electrolyte/environment.

Many other factors influence the amount of protection given by a zinc coating. Ross and Wolstenholme [] measured the electrochemical potential of panels coated with organic zinc-rich paints with areas of bare steel of differing sizes. They found the potential became more positive quicker and red rusting occurred sooner as the size of the bare steel area increased. As the area of the steel cathode increases, there are more sites for oxygen reduction, increasing the zinc corrosion rate. Eventually, the potential will become so positive that cathodic protection will cease and steel corrosion will commence.

Some changes can slow down consumption of the zinc. On initial exposure, the corrosion current is relatively high, but the rate is controlled by the cathodic reaction so depends on access of oxygen and water to the steel surface. Therefore, current drops as oxygen access becomes more difficult. Build-up of corrosion products on the cathode will further restrict oxygen access, moving the oxygen reduction curve to the left, slowing down zinc corrosion.

3. A CLOSER LOOK AT POTENTIAL VARIATIONS

In practice, behaviour is more complex than described. Figure 2 shows the change in Open Circuit Potential (OCP) as a function of time for a number of ZRPs studied by Armas et al [] showing potential generally increasing with time. There is considerable variation in potential, especially with the epoxy zincs for shorter exposure times, while the potential of the thick IZS coating shows little change. Knudsen et al [] monitored the deterioration of a number of zinc-rich epoxies continuously, as shown in Figure 3, and found numerous potential transients as the coating degraded. This is clearly due to some electrochemical activity taking place, not just variations or fluctuations due to experimental variables. Rubbing or scraping the surface or disturbing corrosion products tends to restore the protective potential as reported by Pass and Meason [].

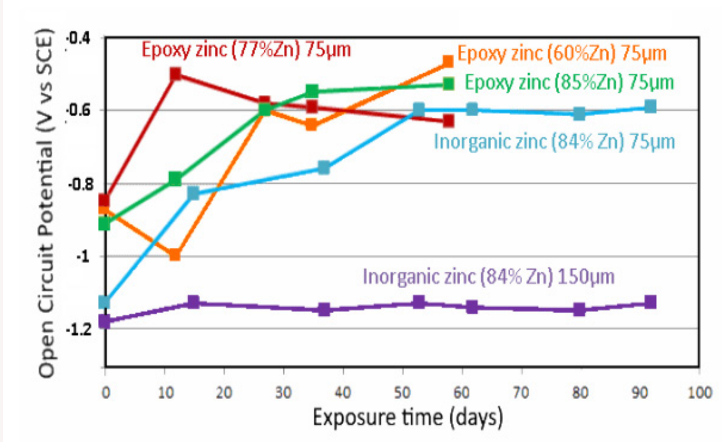


Figure 2: OCP versus exposure time for a number of ZRPs [3].

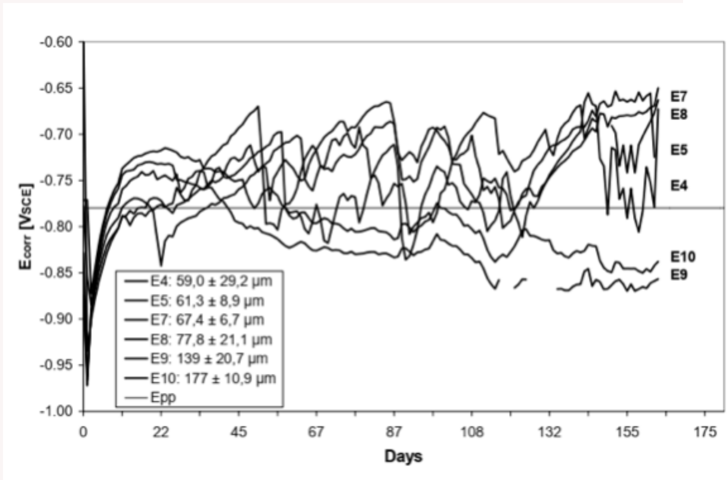


Figure 3: Continuously monitored OCP versus exposure time for some ZRPs from [4].

There are also differences in the manner initial potential varies, which are not observed unless behaviour over the first few hours of exposure is recorded. Typically, a zinc-rich coating will initially be at a potential some hundreds of millivolts more positive than the potential of zinc, before dropping to a value close to this, as shown in Figure 3. Abreu et al [] investigated this 'activation' region and believed behaviour was a result of the electrolyte soaking into the coating, penetrating any oxide film and eventually making contact with the zinc metal. For a porous inorganic zinc or zinc metal spray, or indeed a galvanized coating, the potential will stabilise quickly as the electrolyte can readily access the zinc metal. However, the initial potential of an organic binder is significantly more positive than zinc, far less conductive and less permeable, so it may take some hours or even days to reach a minimum potential.

Single-coat epoxy zinc ZRPs are known to have inferior performance to IZS of similar thickness in atmospheric exposure, even though they can show similar performance in accelerated testing or electrochemical testing in a solution. The slowness of this 'activation' stage could be a reason for this. In the atmosphere, with wetting by rain and dew and subsequent drying, there will often be insufficient time for the zinc to activate, and the coating may dry out before the zinc has a chance to react. However, porous IZS, thermal spray zinc or galvanizing will activate rapidly and provide protection almost immediately on exposure to moisture.

4. COATING RESISTANCE AND PERMEABILITY

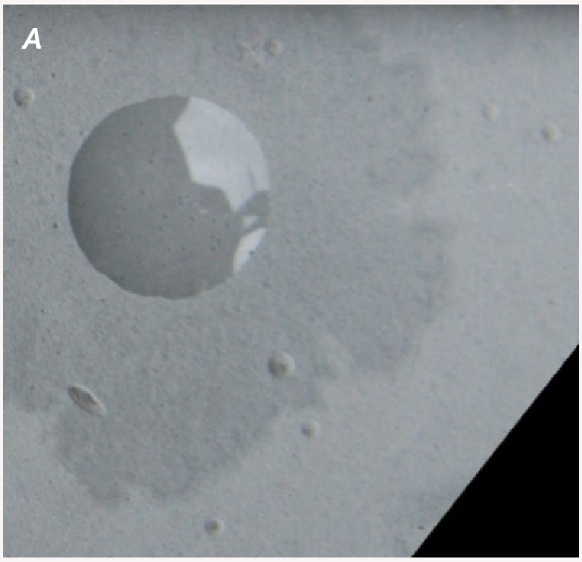
The electrical resistance of the coating is clearly an important property as it influences not only the electrochemical behaviour but also gives a measure of the permeability of the coating as a barrier against oxygen, water and ion diffusion. Most organic coatings are highly resistive, and the aim is to retain that resistance as long as possible as this will minimise the risk of corrosion of the substrate. However, a ZRP is different. To provide CP, the oxygen and water need to contact the cathode so a permeable coating is essential. However, a coating that is too permeable would allow the reactions to take place too quickly, using up the zinc. Ideally, the permeability should initially allow rapid activation of the zinc, then decrease to allow the reactions to occur at a slow enough rate to keep the coating within the CP potential. Once CP is lost, it would be beneficial if the permeability could decrease to provide a barrier effect.

IZS and most organic ZRPs are permeable as they are formulated with a pigment volume concentration (PVC) near or above the Critical Pigment Volume Concentration (CPVC), the volume of pigment (and other powder additives) where there is just enough binder to coat the particles. Above this figure there are gaps between the particles and porosity increases. As a result, the electrolyte will rapidly come into contact with the zinc (or conductive zinc oxide) resulting in the desired negative potential. However, for less permeable organic ZRPs formulated below the CPVC, the electrolyte will not contact the zinc until after a significant exposure time and electrochemical behaviour will be different. The potential initially developed on immersion will be much more positive, depending in the binder type, zinc content and other factors before it slowly becomes more negative.

Electrochemical Impedance Spectroscopy (EIS) enables determination of the coating resistance, although for ZRPs it requires skill to determine this parameter, and distinguish it from the polarization resistance of the zinc corrosion reactions that will be occurring within the coating film. Furthermore, as mentioned above, the OCP can fluctuate so care and caution are essential when interpreting EIS results.

As noted in the complementary paper [1], for an inorganic zinc exposed to the weather the resistance of the film is low initially, of the order of hundreds of ohms for the first month or so. After some time, insoluble salts build up in the porous matrix, increasing resistance somewhat with exposure time. Organic zinc-rich coatings will show far more variation in resistive behaviour. The initial resistance is quite high and the paint behaves more like a typical barrier coating, although the resistance is some orders of magnitude lower than a zinc-free epoxy because of the high zinc content. With exposure to salt water the resistance drops as the water fills the gaps within the coating. Zinc corrosion products form, but the increase in resistance due to their presence often does not overcome the resistance reduction caused by water penetration and coating breakdown.

It would be difficult to consider IZS, freshly-applied or weathered, or freshly-applied organic zinc a barrier coating. EIS of true barrier systems shows a resistance some million times or more greater than that measured for these systems. A simple experiment shows that ZRPs do not resist the passage of water or oxygen, even after weathering. Figure 4 shows inorganic zinc coatings easily soak up water, whether recently applied or weathered. This is not the behaviour of a barrier coating. The claim that zinc-rich coatings provide barrier protection, whether freshly applied or after weathering, cannot be sustained, although there is some minor barrier protection in a weathered organic ZRP.



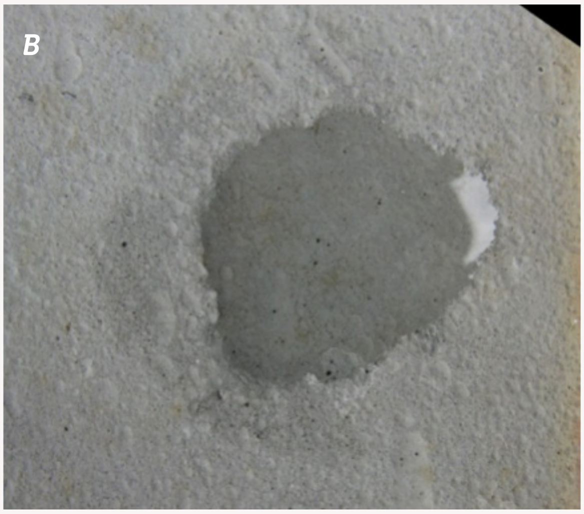


Figure 4: Rapid soak-in of a water droplet on (a) new IZS, (b) weathered IZS, showing their porosity.

However, a topcoat system over a ZRP will change its performance and properties. An intact, non-conductive topcoat over a ZRP will act as a barrier film with barrier film properties and protection. EIS will show a very high resistance for such a coating system that slowly decreases with time as moisture penetrates the film, similar to any other barrier coating system.

5. EFFECT OF ZINC CONTENT

The zinc content of a ZRP is usually considered its most important characteristic. A high minimum zinc level has been an essential requirement for a ZRP since the earliest investigations []. There are numerous standards which give the minimum content of zinc in ZRPs as shown in Table 1, with considerable variation depending on the standard adopted. It is worth looking at experimental and exposure testing results to see how these levels in fact relate to ZRP properties and performance.

Table 1: Minimum zinc content of zinc-rich coatings according to various standards

Standard	% Zinc dust (by weight)
AS/NZS 3750.15 Type 3,6 (IZS - Water-borne)	(>90.5%)
SSPC Paint 20 Level 1 (IZS and epoxy zinc)	>85%
AS/NZS 3750.9 Type 2 (Epoxy zinc)	>85%
AS/NZS 3750.15 Type 4 (IZS - Solvent-borne)	(>82%)
NORSOK M501 (IZS and epoxy zinc)	>80%
ISO 12944 (IZS and epoxy zinc)	>80%
SSPC Paint 20 Level 2 (IZS and epoxy zinc)	77 – 85%
SSPC Paint 20 Level 3 (IZS and epoxy zinc)	65 – 77%
SSPC Paint 29 (IZS and epoxy zinc)	>65%
SSPC Paint 30 Weld through primer (IZS)	>65%
AS/NZS 3750.15 Type 5 (IZS – pre-construction)	(>54%)

AS/NZS 3750.15 gives zinc metal rather than zinc dust content (the figures in brackets assume~95% of zinc dust is zinc metal)

[Note: Standards will usually have other requirements than just zinc content]

5.1 Electrochemical Behaviour

Electrochemical behaviour is an obvious approach to justify such figures. The work of Felieu et al [] covered a fairly broad range of zinc contents and testing was carried out for long enough to note when cathodic protection was no longer provided by the zinc. This has been taken as the time that the potential remained more negative than -780mV versus SCE. The results for inorganic and epoxy ZRPs are shown in Figure 5. Generally, there is an improvement in performance with increased zinc, but the relationship is not strong. The difference between inorganic and organic binders is significant, however. Some of the ZRPs contained di-iron phosphide (Fe2P) filler, but it does not appear to have had an effect on OCP. It is interesting that galvanic protection can be achieved with quite low levels of zinc, and there is little evidence of any sudden change in performance as suggested by the various standards. Other investigators have also measured changes in OCP with percentage zinc, but often little or no relationship could be found, especially with organic zincs. Often the range of zinc content was too narrow, or the time that protection was provided was not clearly defined. While zinc content is a factor determining how long the coating will provide cathodic protection in a solution, it is clear that other factors, especially binder type, will be just as important.

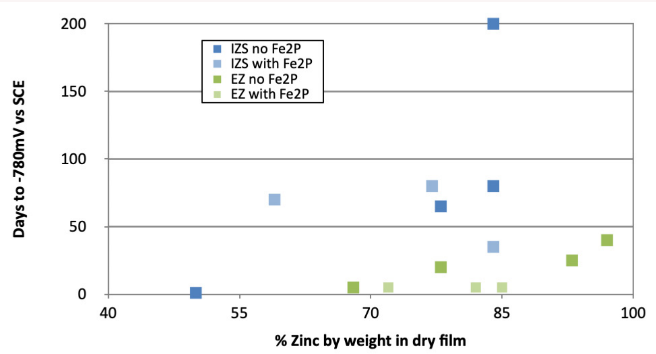


Figure 5: Time providing galvanic protection as a function of zinc content according to Felieu et al [8].

5.2 Accelerated Testing

Ulkem and Winter [] measured the amount of scribe creep on a number of single-coat and topcoated inorganic zinc coatings after 4200 hours of cyclic exposure testing according to ISO 20340. The lower the creep, the better the performance. Figure 6 shows there was no correlation between creep after testing and the percentage zinc in the dry film, whether topcoated or not. Indeed, the two lower zinc products show quite good performance. The single coat system shows far less rust creep, not surprising as there is far more zinc available to provide protection to the exposed steel.

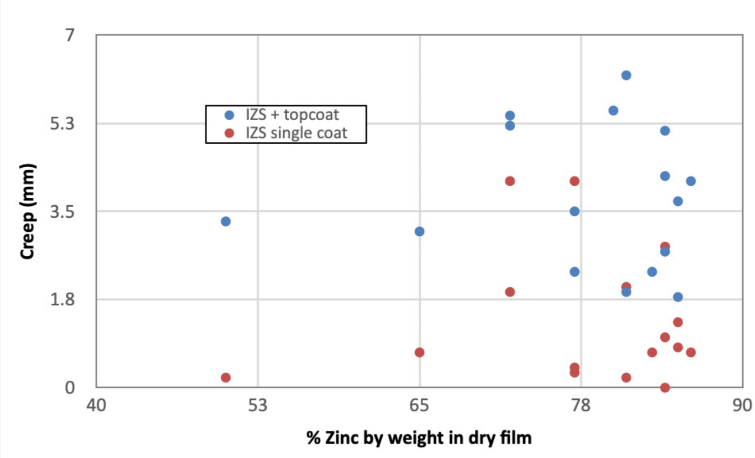


Figure 6: Effect of zinc content on amount of cyclic exposure creep in single and topcoated inorganic zinc systems [9].

5.3 Actual Performance

Investigations carried out relating zinc content to actual performance (as distinct from accelerated testing or some electrochemical property) have been few. Weaver et al [] carried out a number of exposure tests on ZRPs with a range of zinc contents. Amongst other tests, panels coated with water-borne and solvent-borne inorganic zinc and epoxy zinc coatings with a range of zinc contents were exposed for 123 months to a severe marine atmospheric environment at Kure Beach, North Carolina and rust ratings made according to ASTM D610 [], where 10 is no rust and 0 is 100% rust. The results are shown in Figure 7 along with some results for IZS coated panels exposed for 18 months at Kennedy Space Center at Cape Canaveral, Florida []. There is no relationship between percentage zinc and performance for either the IZS or the (admittedly few) epoxy zinc products. Interestingly, there is evidence of reasonable performance at levels well below any standard minimum. Almeida et al [] carried out similar work exposing coated panels to a marine atmosphere in Portugal for 33 months. Again, there was no relationship between the percentage zinc in the dry film and corrosion and blister rating for the eight epoxy zincs (60% to 81% zinc) or the ten ethyl silicate zinc-rich coatings (69% to 84% zinc).

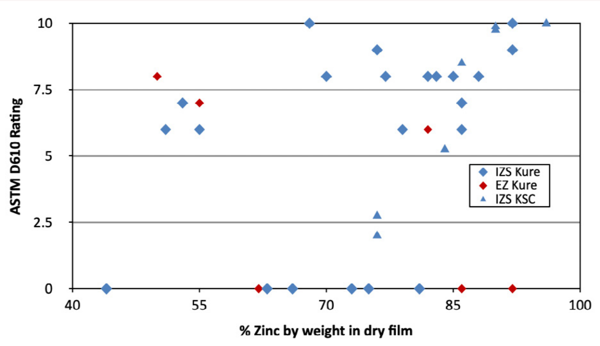


Figure 7: Rust ratings (ASTM D610) vs percentage zinc for ZRP coated panels exposed at Kure Beach and Cape Canaveral [10,12].

As protection of bare steel is an important requirement for ZRPs, not just general rusting, Figure 8 shows the number of days for rust to appear in a 10 cm scribe on the panels from the exposure tests carried out at Kure Beach [10]. Again, although performance is slightly better for higher zinc coatings in general, there is good performance for some low zinc content coatings.

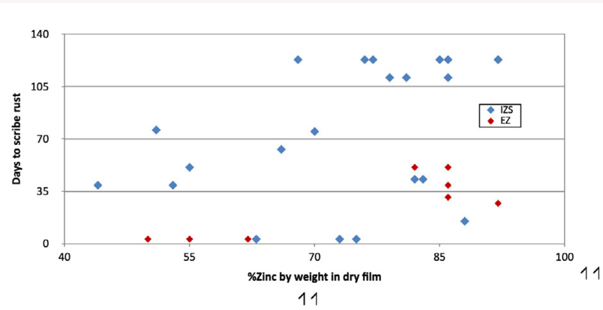


Figure 8: Time to rust in the scribe vs zinc content for ZRP coated panels exposed at Kure Beach [10]

Overall, there appears to be little evidence for any of the minimum zinc contents in Table 1. It should be noted that this view is not universally held. A highly respected coatings expert, Clive Hare, carried out an investigation into the effect of different zinc levels in organic zinc ZRPs [] and concluded that optimum performance is not achieved in such coatings until zinc content is near 94% in the dry film. With a zinc loading of approximately 70 to 90%, the "the films are of little use as either zinc-rich primers or barrier primers". Below this loading, "the films act as rather poor barrier primers". However, close inspection of the work shows an improvement in performance was noted at lower levels of zinc. Figure 9 shows general steel corrosion and scribe corrosion (10: Excellent, 0: Poor) after salt spray testing for the epoxy zinc coatings as a function of zinc content and suggests that a zinc content of greater than 90% zinc by weight is desirable, but that good performance can also be achieved with much lower zinc contents. Similar U-shaped performance was also noted with urethane and epoxy ester binders for corrosion, although not as significant as for the epoxy. The figure also shows the amount of white rust (0: None, 5: Heavy) increased with zinc content.

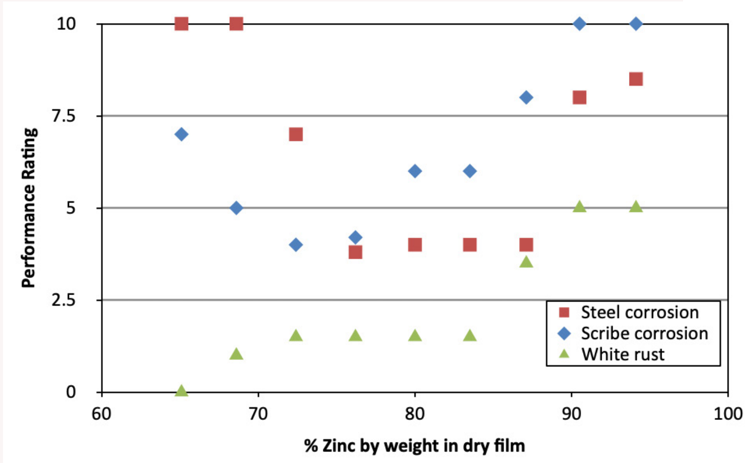


Figure 9: General and scribe corrosion ratings and amount of white rust after salt spray testing for epoxy zinc coatings [14].

It would appear that zinc content has an important influence on galvanic action, but is only one factor that influences coating durability, and others such as binder type, thickness and exposure atmosphere are likely to be as or more important. However, it is clear that the high levels given in standards or the widespread belief there will only be galvanic action if there is sufficient zinc to provide a continuous path between the zinc particles (a content approximately equal to or greater than the CPVC), are difficult to justify. From the work of Felieu et al [8] described above, a minimum of 50% zinc by weight for inorganic zincs and a somewhat higher figure for epoxy zinc would appear to be practical minimums to achieve galvanic action, but factors such as the presence of additives, shape and size of zinc pigment and environment will all influence this figure. However, good actual exposure performance can be achieved with lower levels than these.

6. ZINC-RICH PAINT PROTECTION PRINCIPLES

Electrochemical investigations clearly show that ZRPs provide protection to a steel surface by cathodic protection, that is reducing the potential of the steel to a level where is it thermodynamically immune from corrosion. The protection potential is usually taken as 0.85 volts vs the copper – copper sulphate electrode (0.78 volts vs SCE). However, there is more to CP than this. Recent discussions, such as those by Ackland and Dylejko [] and Gummow et al [], have shown that this change in potential is associated with a significant increase in pH on the cathodic surface and this change in surface chemistry is now considered to contribute a major part of the protective action.

In conventional CP, the cathode is remote from the anode and cations produced by the corroding anode are unlikely to influence reactions at the cathode, but this will not be the case with a zinc coating. The zinc ions formed as a result of the galvanic action are able to react with the hydroxyl ions formed at the cathode producing a film of zinc hydroxide. Zinc hydroxide is an effective cathodic inhibitor which will provide a cathodic surface even if the zinc metal has been consumed. Zinc metal is clearly needed to electrically contact the steel to lower its potential, but the bulk of the coating can provide zinc ions to form the zinc hydroxide inhibitive layer without electrical contact with the steel cathode.

There must be sufficient zinc in the coating to form a galvanic cell and provide inhibitive zinc ions but a large amount of zinc can be a disadvantage. If there is limited cathodic area such as an intact coating, then the very large anode to small cathode ratio will create a low current density at the steel surface so few hydroxyl ions are formed there and little protective inhibitive film is formed. However, the outer surface of the film will corrode in a uniform manner forming heavy, but non-protective zinc corrosion products, especially in a severe environment such as salt spray. Even relatively low levels of zinc will be able to create sufficient zinc ions at anodic sites and hydroxyl ions at cathodic sites to form a protective, cathodic inhibitive film, as long as corrosion products are not washed out as may occur in a solution. The self-corrosion rate of a sacrificial pigment may be reduced by lowering the pigment concentration (or using a more resistive binder or a topcoat) but as long as there is sufficient zinc to keep the steel potential negative, galvanic control may be achieved for a longer duration. A coating with a low zinc content must therefore have a reduced life, especially in an aggressive environment, even if it initially it shows a strongly cathodic potential. There simply will not be enough zinc to provide protection for a reasonable length of time with such a ZRP. This will be especially true if there are large areas of steel to protect, such as with a damaged coating.

So, the protection at the steel surface will mainly be a combination of the CP action of the zinc, which will decrease with time, along with the inhibitive action of the zinc hydroxide (plus other corrosion products depending on the environment). There will be a minor barrier effect. This mechanism can assist in explaining many observations regarding ZRP performance.

The above results have shown a large variation in individual ZRP performance will be observed in practice. The time that CP is available depends on amount of zinc available (percentage zinc and thickness, for example), porosity of the coating, aggressiveness of the environment, binder type and other factors. More porous coatings such as IZS will show higher initial zinc corrosion rates than less porous coatings and would be expected to show a more rapid loss of protection, but they confine the inhibitive oxides and hydroxide within the pores and remain at a sufficiently noble potential for a considerable period of time if sufficiently thick. Adding an inert filer can assist with creating porosity, so such coatings can show good performance even with a relatively low zinc content. As little zinc will be lost in self-corrosion, such coatings may provide similar durability to higher zinc content products. A less permeable coating such as a zinc epoxy may be a poorer source of zinc ions than a more permeable coating, but is still effective while it remains anodic to the steel and provides CP. Even if it eventually can no longer provide CP, it would still slowly provide zinc ions by self-corrosion to provide a sufficient and permanent inhibitive effect. Regardless of the zinc content, low film thickness or large areas of cathodic steel to protect or both will reduce durability. Zinc content alone is of little value in determining the performance of a ZRP.

7. MECHANISM OF PROTECTION

Although there is a difference between ZRPs with different binders, different contents of zinc and additives, the basic mechanism of protection most likely follows this process, as shown schematically in Figure 10.

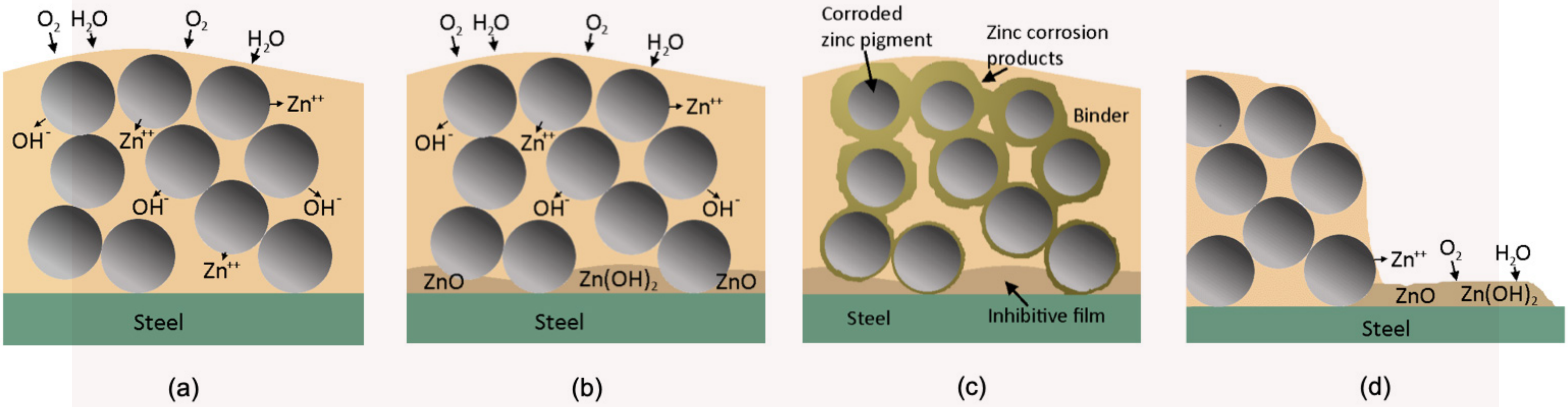
a) On exposure to an environment with water and oxygen, the zinc particles on the surface corrode in a uniform manner. That is, there are anodic sites where the zinc corrodes to zinc ions, and cathodic sites where oxygen and water take up electrons forming hydroxyl ions. If the coating dries out because of intermittent wetting, this process will stop, but restart on the subsequent wetting. In a mild environment or for short periods of time, only the outer layer of the ZRP may show significant corrosion of the zinc particles. In a more aggressive, chloride-containing environment heavy, voluminous zinc salt deposits will build up, especially with a high zinc content coating. The zinc oxide/hydroxide initially formed is rapidly converted to the bulky zinc hydroxy chloride/ carbonate. The life of the outer layer of the zinc coating will depend mainly on the zinc content and the aggressiveness of the atmosphere, but the zinc corrosion rate will largely independent of any galvanic protection provided to the steel.

b) If the coating remains continually wet or wetting is sufficient to keep the porous coating moist, the zinc ions and hydroxyl ions along with water and oxygen diffuse through the coating, reaching the substrate. A galvanic cell is set up with an initial potential independent of the zinc content. The steel surface will remain cathodic to the local zinc particles so the cathodic reduction reaction will take place on it. This reaction will be rate determining. The zinc ions produced will react with the hydroxyl ions and form an inhibitive layer of zinc oxide/hydroxide on the steel surface. With a low zinc content its corrosion rate will be high and the cathodic reaction can readily occur on the exposed steel producing a protective inhibitive zinc hydroxide film. If the zinc content is high, then the porosity will provide increased availability of oxygen and water, and protection increases again at higher zinc levels. At intermediate levels, the cathodic reactants may have trouble reaching the steel surface. This may explain why a U-shaped behaviour in protection as a function of zinc content is sometimes observed (Figure 9). This combination of CP and inhibitive layer will provide the bulk of the protection to the steel surface.

c) As the zinc particles corrode, there will be less zinc available for cathodic protection, but the zinc oxide/ hydroxide layer is cathodic to steel and continues to provide protection. Zinc corrosion products will form around the zinc particles [] and slow down corrosion, but the coating will remain porous and will not provide much of a barrier effect. Corrosion products are not strongly bonded within the coating and will regularly dislodge, creating fresh zinc which can provide inhibitive zinc ions. The anodic areas become smaller compared to the cathodic areas, especially if the coating is damaged. Eventually CP is lost, the exposed steel areas start to corrode and red iron rust forms. The amount of protection given by the coating depends on the binder type, zinc content, coating thickness, severity of the environment and amount of bare steel amongst other factors.

d) At a scratch or edge, similar reactions will take place but their location will be different. The bare steel will become the cathode and the adjacent zinc will become the anode and an inhibitive film forms in the scratch providing protection. The area of bare steel will control the reaction rate as well as the extent of protection. A less resistive coating such as an IZS or a more conductive electrolyte will protect a larger area, but zinc may be consumed faster. A more resistive coating in a milder environment may not be able to provide protection. A topcoat will greatly restrict the amount of zinc available, so topcoated zincs provide less protection to a scratch, but the presence of zinc keeps the scratch cathodic, largely preventing cathodic blistering that occurs under a zinc-free coating adjacent to a scratch.

Figure 10: Protection by an intact ZRP: (a) Uniform corrosion of zinc particles producing Zn++ and OH- ions, (b) Galvanic action and formation of an inhibitive film, (c) Corrosion of zinc particles, (d) Protection at a scratch.



8. CONCLUSIONS

- Zinc-rich paints contain a high percentage of zinc which enables them to provide cathodic protection to the steel substrate. Electrochemical studies have shown how the behaviour and protection ability can change with coating properties such as binder type, thickness, zinc content, etc.
- Contrary to popular belief and many standards, zinc content is not a major factor in determining the protective ability of a zinc-rich coating. Good protection can be achieved with zinc levels well below those commonly specified. It appears that protection depends on a myriad of coating and environmental factors, of which zinc content is only one.
- The formation of an inhibitive film of zinc oxide/ hydroxide is a major contributor to the protection offered by a zinc-rich paint, especially after exposure for some time. Barrier protection by zinc corrosion products is a minor contributor to protection.

9. AUTHOR DETAILS

Rob Francis has nearly 50 years' academic, industrial and consulting experience in corrosion and protective coatings. Dr Francis has a B.Sc. in metallurgy and a Ph.D. in corrosion science. He is an ACA Corrosion Technologist and was awarded the ACA Victor Nightingall award in 2014 and made an ACA Life Member in 2016. He chairs Standards Australia sub-committee MT14/2 which produced AS 2312.1 on protective coating systems. He has authored or co-authored over forty technical papers or presentations on corrosion and coatings. He edited the publication "Inorganic Zinc Coatings", for the ACA in 2013. He has been awarded the JPCL editor's award twice and was made a JPCL Top Thinker in 2012.

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When Colour Matters: Resisting Photodegradation of Coatings

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Keywords:

Colour, pigment, paint, coating, colour stability, photo-degradation

Abstract:

Many paint coating systems will provide good corrosion protection for years but achieving long lasting aesthetics is more challenging, especially for high profile structures exposed to harsh Australian UV conditions. Degradation of the appearance of a coating by chalking, loss of gloss or differential colour fading or some combination of these is caused by exposure to UV radiation and weathering. The CityLink Gateway is a high profile structure in Melbourne which was repainted twice in its first 15 years due to poor colour retention. When the structure was repaired and recoated in 2012, research and development was carried out into the pigmentation system with a focus on being able to deliver colour stability in the bright red colour the asset owner wanted. This paper focuses on the mechanisms of colour change and how such degradation can be measured. It looks at how the CityLink Gateway red colour degraded and how this has since been minimised. Monitoring colour change of the structure has shown only minor fade after seven year's exposure. Use of stable pigmentation and avoidance of titanium dioxide tinting were found to be the most important factors in achieving such performance.

1. INTRODUCTION

The primary purpose of a protective coating is to prevent corrosion of the substrate, but aesthetics are often important. Even when the protective ability remains intact, the coating can be considered as failed if the appearance is considered poor. There are a number of mechanisms that can result in poor appearance, and these are briefly described in this paper, along with how changes in colour as a result of such degradation can be quantified. The Melbourne CityLink Gateway repaint in 2012 provides a case study showing how such how such colour change can be monitored and how it can be reduced.

2. COLOUR AND COLOUR DEGRADATION

Colour pigments in paints work by absorbing certain wavelengths of light and reflecting the rest. When a pigment molecule absorbs a photon of light an electron is excited to a higher energy state. The pigment molecule will usually revert to its original state by giving off a small amount of heat and no damage will be done to the molecule. But sometimes a chemical reaction will occur in the excited high energy state, irreversibly breaking a covalent bond or reacting with another molecule, often oxygen or moisture. The molecule now has different optical properties and will absorb and reflect different wavelengths of light. Such breakdown is referred to as photodegradation or, less commonly, photolysis. The more energy in the photon, the more likely it is that such reactions will arise, so UV wavelengths tend to cause more damage as they have more energy than visible light.

The result of UV breakdown of the pigment usually causes it to lighten, and is generally called "fading". However, this term implies the colour becoming lighter whereas in some cases breakdown can cause a change in colour, although it is still termed fading. The greater the UV exposure, the more intense the fading, but fading also depends on the type of pigment, its colour and the effect of the UV on other constituents in the coating such as the resin.

UV light can cause other forms of degradation in paint coatings, which overlap with one another and cause confusion. Chalking is the loose, white material that remains on the surface after weathering. In this case, it is the remnants of the resin and pigment after break down of the binder by UV light and moisture. It will make the paint coating appear lighter in colour, but washing off may reveal little actual permanent fading of the paint. Chalking can be rated by a wiping method such as that described in later. Loss of gloss is another form of degradation that can arise from natural weathering which roughens the paint surface. Such degradation is permanent. However, build-up of chalk and dirt can also cause loss of gloss, but it can be restored by washing. These forms of coating degradation will cause a change in appearance of the coating, but need to be distinguished from fading. Table 1 summarises the differences between the types of failure which can change coating appearance. In true colour fade without chalking, there is no binder degradation so coating performance and gloss are not impacted.

Table 1: Coating failures causing change in colour

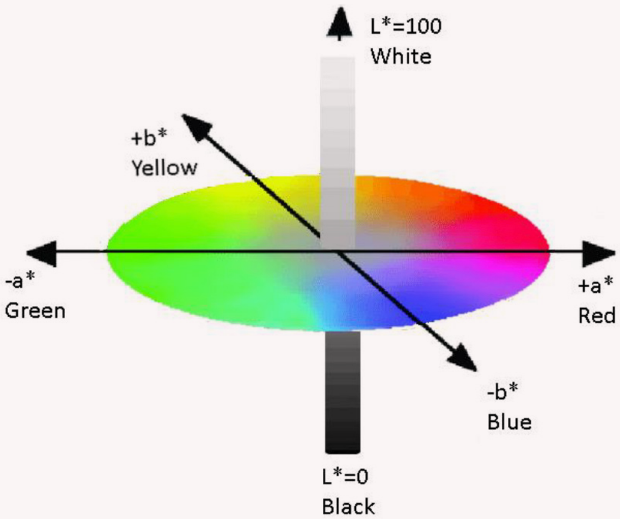
Failure	Effect	Usual cause
Fading	Colour loss from pigment degradation	Colour loss from pigment degradation
Chalking	White residue from resin breakdown	Weathering (UV moisture)
Loss of gloss	Reduced reflecitivity of the coating	Weathering of paint film (permanent), build-up of dirt or chalk (temporary)

3. MEASUREMENT OF COLOUR FADE

Fading is normally measured using a spectrophotometer. Spectrophotometers function by reflecting light off a surface and recording the wavelength distribution of the reflected light. A comparison of readings between the original coating and that after exposure will show the extent of fading.

The best known system of quantifying colour change in the coatings industry uses the CIELAB "uniform colour space". With this system, shown in Figure 1, a colour is quantified using three values (L*, a* and b*). "L*" indicates "Lightness" of a colour where 100 is white and 0 is black, "a*" indicates the degree of "red/green" for a colour (negative is green and positive is red) and "b*" indicates the degree of blue/yellow" (negative is blue and positive is yellow). Using this system, any colour can be described by its three dimensional L*, a* and b* co-ordinates. Measurements are standardised in ASTM D2244 [1] or ASTM E308 [2]. The system enables calculation of a numerical difference between two colours. The numeric colour difference between two sets of values is referred to as "Delta Error", "Delta E", "ΔE" or "dE", which is the square root of the sum of the squares of ΔL*, Δa* and Δb*. "Delta E" increases in proportion with the difference in colour. In practice, a visual colour difference is not noticed until Delta E values approach 3 and 3 is commonly used to define a perceptible colour difference. However, even a Delta E of 5 is considered quite subtle. Tighter tolerances may arise in some industries such as the automotive trade. It must be stressed that the differences are only apparent when the original colour is available for comparison.

Figure 1: CIELAB colour space diagram showing the three dimensions (L, A* and b*) used to define colours.*



Delta E provides a value indicating the overall difference between two colours. It does not provide any colour-related data such as which colour is lighter or darker, redder or greener, bluer or more yellow. The individual changes in L*, a*, and b* have to be analysed independently for such information. A positive shift in ΔL* means becoming lighter or fading, while a negative shift means darkening. A positive shift in Δa* is a shift from green to red while a negative figure is opposite. A positive shift in Δb* means a shift from blue to yellow while a negative figure is an opposite shift.

4. COLOUR FADE IN MELBOURNE GATEWAY

Transurban's CityLink Gateway, widely known as the 'Red Sticks', is a series of rectangular angled steel columns at the south exit of the Tullamarine Freeway, Melbourne. These were fabricated in 1999 and painted in a bright red colour, Cherry Red. They had been repainted with a polysiloxane system of the same colour in the mid 2000's but by 2012 a further recoat was necessary. There were only a few isolated rust spots, and the coating had retained its gloss quite well, but the red colour had faded to an unacceptable level, as shown in Figure 2.

Figure 2: CityLink Gateway "Red Sticks" in (a) 2007 and (b) 2012.

A formal investigation of the colour fading was not carried out at the time but there are a number of possible causes that were likely to be involved to some degree:

a) The required bright red colour can only be achieved by the use of organic pigments. Inorganic pigments,though fade resistant, do not provide the intense, vivid colours preferred by architects. Organic pigmentsare much more susceptible to breakdown by UV radiation.

Furthermore, red pigments tend to degradefaster than other colours because they absorb higher energy, shorter wavelength radiation.

b) Another issue is the "tint strength" of a pigment, or how much is required to achieve the required colourintensity. Coatings with a higher pigment concentration are usually more fade resistant than those with alower concentration simply because they have more pigment.

c) Strong colours are normally reduced to a softer colour by addition of an inorganic pigment such as titaniumdioxide (TiO_2). TiO_2 alone is a very stable, opaque white pigment but, under UV light, it creates free radicalswhich degrade organic pigments. So, although alone it can protect binders from chemical oxidation byabsorbing UV light, organic pigments can degrade when mixed with TiO_2 resulting in colour fading.

d) When colours are made in the factory, the pigments are added as a dry powder milled directly into the paint.Colours from in-store tinting use pigments dispersed in a liquid containing glycols and surfactants whichalter the formulation and can change the properties of the paint. So factory-produced paints tend to havesuperior performance and hiding power than paint coloured by a tinter. Factory tinting is carried out whenlarge quantities are ordered, usually at least 500 litres, so this factor is unlikely to have been an issue with ajob of this size.

To avoid these potential problems with the latest repaint, a new pigment was developed which would provide the desired colour without the need for inorganic reducer pigments such as TiO_2, and would be an integral part of the base paint, rather than require post-added tinter.

Colour was not the only issue when selecting the coating system. Good resistance to corrosion was essential so the paint formulation needed to be able to be applied in high film builds. Because of the location near a Freeway, spray application was not allowed due the risk of overspray. So the coating had to be formulated for brush and roller application. It was decided that a high build polyurethane topcoat would be used, pigmented with a specially produced batch of the desired colour, CityLink Cherry Red.

5. REPAINTING

Maintenance painting of the red sticks was carried out in August 2012 using the following system:

a) Low pressure water cleaning to a minimum of 20 MPa (3,000 psi) to remove surface contaminationsuch as oily deposits, bird droppings and loosely adherent coating. All surfaces were abraded with asander and solvent wiped.

b) Isolated rusted regions were power tool cleaned to remove rust to SSPC SP 11 [3].

c) Bare metal regions were spot primed with zinc-rich epoxy primer to 75 microns dry film thickness

d) Two spot coats at 80 microns per coat of surface tolerant epoxy were applied over the epoxy zincprimer.

e) The entire prepared surface was coated with 80 microns light grey surface tolerant epoxy primer

f) A top coat of 75 microns (minimum) of high build polyurethane in "CityLink Cherry Red" was finallyapplied.

Figure 3 shows application of the topcoat by roller.

Figure 3: Application of the polyurethane topcoat to the epoxy midcoat

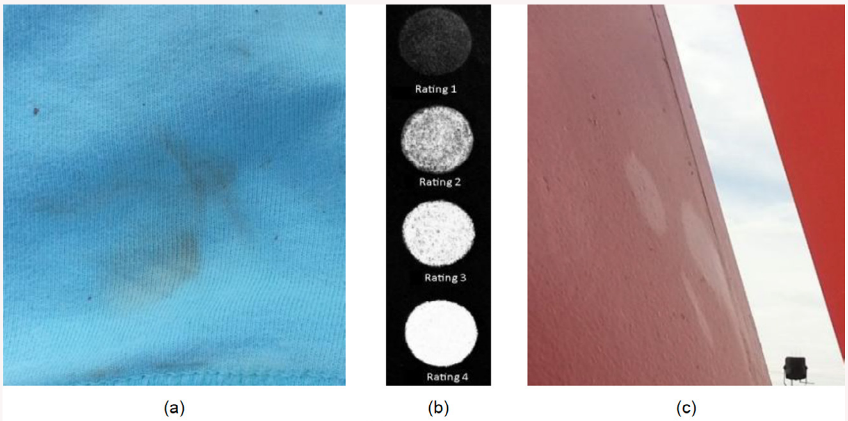
6. EVALUATION OF COLOUR CHANGE

Evaluation of colour change was determined by visual inspection and colour difference measurements using a spectrophotometer. The first evaluation was carried out 2015, a detailed evaluation on 2017 with a further more limited evaluation in 2019.

6.1 Chalking

Although there was no obvious evidence of chalking, its possible presence was evaluated in 2019. Chalking can be assessed by wrapping a cloth around the index finger and rubbing it over the surface, a method standardised in AS 1580.481.1.11 method A [4] or ISO 4628-7 [5]. The rating schemes are the same in both. Figure 4(a) shows discolouration on the rag after wiping a small area. Comparing to the chalking rating shown in Figure 4(b), the residue shows a rating of less than 1, a very low level. However, the orange colour suggests that discolouration is probably due to dust, most likely fine sand from the Mallee region which can appear in Melbourne during droughts. Figure 4(c) shows the region tested, again indicating very little chalking. It is clear that any discolouration measured will be largely due to pigment degradation.

Figure 4: (a) Discolouration on rag, (b) Chalking rating from AS 1580. 481.1.11, (c) Wiped region on red stick.



6.2 Colour change

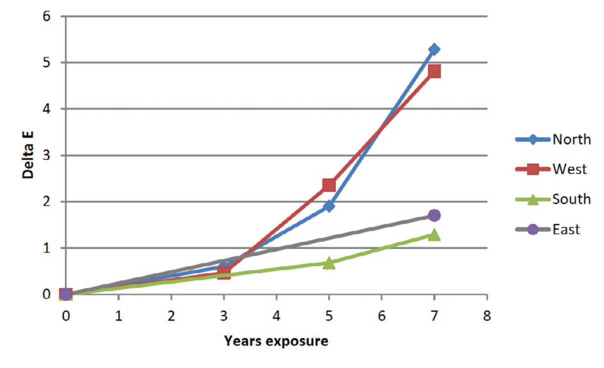
Colour change measurement was carried out using a reference standard of the original colour which had been stored indoors, away from light in a controlled environment. Colour difference measurements were carried out using a Konica Minolta Spectrophotometer CM-2600D. In 2017, measurements were taken at the lower levels on all four faces on a number of the red sticks. Using the results for the north face, the variance of the results was of the order of 10-15%, giving an indication of the uncertainty in results. For the 2015 and 2019 inspections, readings were taken on one stick only. The results are listed in Table 2.

Table 2: Colour change parameters on a selected number of sticks in 2015, 2017 and 2019.

Year	Stick No.	Elevation	ΔL*	Δa*	Δb*	ΔE
2015	22	West	-0.44	0.12	0.04	**0.46**
	22	North	-0.41	0.23	0.37	**0.60**
2017	22	North	-0.28	-1.19	-0.25	**1.25**
	22	North	-0.32	-1.26	-0.31	**1.33**
	30	West	-0.48	-2.30	-0.14	**2.35**
	30	North	0.37	-2.00	-0.85	**2.21**
	30	North	0.12	-2.24	-0.81	**2.30**
	30	North	0.30	-1.83	-0.03	**1.85**
	20	North	-0.38	-2.26	-0.73	**2.41**
	20	North	-0.36	-2.00	-0.45	**2.08**
	20	South	-0.33	-0.57	0.20	**0.68**
	15	North	0.09	-1.65	-0.70	**1.79**
2019	22	North	0.65	-4.69	-2.32	**5.28**
	22	West	0.20	-4.39	-1.95	**4.81**
	22	South	-0.30	-1.09	0.63	**1.29**
	22	East	-0.74	-1.50	0.29	**1.70**

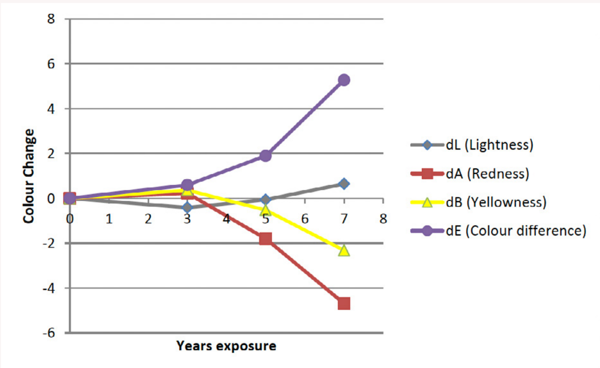
Figure 5 shows the overall changes in colour on the four faces from the results given in Table 2. The changes were more significant on the north and west faces, not surprising as these are subject to the most intense sunlight. In fact, changes on the south and east faces would be considered as minor colour changes in decorative coatings. However, colour change on the highly exposed north and west faces has reached a Delta E of approximately 5, a figure generally considered as significant for decorative coatings.

Figure 5: Overall colour change on the four faces of the gateway sticks.



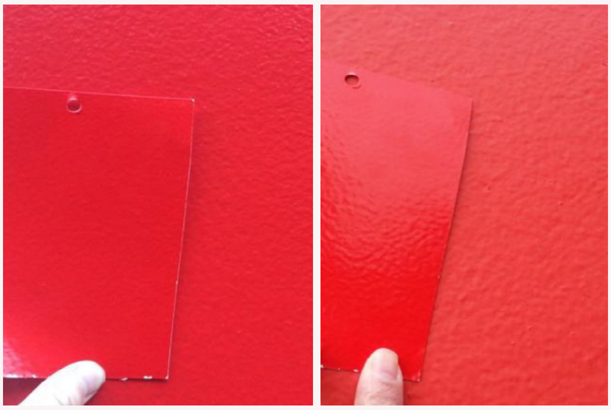
However, these results need to be looked at more closely to see how the individual colours have changed. Figure 6 shows the changes in the values that make up the overall colour variations on the north face according to the CIELAB system. As shown above, the overall colour change (Delta E) is significant, but this is largely a result of the colour becoming less red (or more green). There is also a smaller loss in yellowness (becoming more blue), but no discernible change in lightness or darkness. This last property is important, as it indicates that the colour is shifting rather than becoming lighter, unlike the previous coating.

Figure 6: Individual colour changes on the north face.



This change can be seen in actual photographs, although it must be recognised that printed colours or those shown on a computer screen will only approximate the true colour. Figure 7 shows the north face colour after exposure of five and seven years, with the latter showing a distinct change from the original colour swatch. However, it is still clearly red, with little evidence or lightening or turning pink. Furthermore, without the original to compare to, the sticks would still look bright. Only if a less-affected south or east faces was visible at the same time, would the colour change be considered noticeable.

Figure 7: North face colour compared to standard after (a) 5 years, (b) 7 years exposure.



7. CONCLUSIONS

a) Colour change in a coating system can arise due to pigment degradation from exposure to UV radiation.

b) Such changes can be successfully monitored using the CIELAB "uniform colour space" colour co-ordinatesystem following changes over time.

c) For the most recent repaint of the Melbourne CityLink Gateway, a coating system has been developedusing a more stable red pigment, and avoids the use of titanium dioxide tinter.

d) Colour change over the past seven years has only just reached a Delta E of 5 units, which is considered anoticeable change. However, this is largely confined to a red/green colour change rather than a lightening ofthe colour, and is unlikely to be considered as an unacceptable colour change.

8.AUTHOR DETAILS

Rob Francis has over 40 years' academic, industrial and consulting experience in corrosion and protective coatings. Dr Francis has a B.Sc. in metallurgy and a Ph.D. in corrosion science. He chairs Standards Australia sub-committee MT14/2 which produced AS 2312.1. He has authored or co-authored over forty technical papers or presentations on corrosion and coatings. He was awarded the Victor Nightingall award for outstanding contributions to the protective coating industry by the ACA in 2014.

Daniel McKeown completed a Bachelor of Applied Science in Swinburne University from 1992 to 1995, majoring in chemistry. Since graduating, he has worked for 22 years at Dulux in a variety of roles including Research and Development positions. Recent years have been spent in commercial roles within the Protective Coatings business of Dulux. These roles have included account management/ sales roles and he is currently Specification & Project Consultant.

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Sustainable Solutions to Reduce the Burden of Fabric Maintenance

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Keywords:

Fabric maintenance, sustainable solution, surface protection, visco-elastic coatings

Abstract:

Fabric Maintenance (FM) refers to any type of asset structural maintenance that does not involve mechanical and electrical works, therefore it typically includes coatings, passive fire protection, welding, insulation, and other material and surface protection disciplines. Over the years, FM as a discipline has been purposedly segregated from other maintenance categories to reinforce its importance in the safekeeping of aging oil & gas, petrochemical, marine and energy sector infrastructures, with an ultimate goal of not repeating catastrophic failures from the past. Still, the implementation of effective and efficient FM campaigns proves to be a challenge, often compounded by management neglect, misunderstanding of failure mechanisms, limited human and physical resources, and the lack of sustainable solutions with easy implementation.

This overview focuses on discussing sustainable corrosion and surface protection solutions to facilitate the delivery of FM campaigns, including a non-exhaustive summary of current FM solutions. The document concludes with an illustration of a sustainable solution consisting of the easy and cost effective implementation of visco-elastic coatings for mitigation of localised corrosion in widely used stainless steels.

INTRODUCTION

Fabric maintenance (FM) intends to restore materials to their intended purpose, whether it is protecting against corrosion and metal loss, or maintaining other materials properties (e.g., mechanical, heat transfer) to avoid failure.

With many of the large scale plants and assets in Oil & Gas, petrochemical, and energy sector infrastructures coming to the end of their originally intended service life, one of the main focuses to FM is to, first and foremost, protect assets that are already in place, but to do it in a sustainable way to ensure a gradual energy transition into new and cleaner technologies.

Over the last few decades, there has been a significant advancement of corrosion and materials knowledge with an important input from global major players mostly from the Oil & Gas sectors. Nonetheless, FM is still considered a burden with the widespread occurrence of corrosion and materials failures. Industry experts may attribute these to the following factors[1, 2]:

- Current drive by corporations to reduce operational expenditure (OPEX) as low as possible, with production outcomes prioritised over FM campaigns, leading to inadequate FM planning. There is a definitive disregard for ISO 4628-3 [3] and ISO 12944-5 [4] which mandate partial repair of assets at rust grade Ri3 (rust in 1% of the surface).
- OPEX cuts also impose extreme restrictions of resources which limit frequency and extent of inspection, and accurate condition assessments and repairs. Inspections are likely conducted beyond the material corrosion allowance. This aspect may also be linked to underestimation of corrosion rates, particularly in severely corrosive environments. As a result, the need for urgent repairs when material reaches its critical metal loss thickness significantly increases FM and operation costs. Ultimately, assets can reach a potential state of disrepair where replacement is the only viable solution.
- Incorrect material and coating specifications can lead to early and extensive fabric damage, requiring quick attention and reallocation of resources for repair.
- There is maintenance priority of pipelines and vessels due to the higher consequence in the case of failure (Figure 1). Structural repairs usually become secondary and even neglected in FM campaigns. For instance, damage of concrete and passive fire protection (PFP) structures can lead to catastrophic failures due to concrete cancer, and the continuous exposure and subsequent loss of reinforcing steel.

Figure 1: pipeline corrosion in a natural gas liquids plant. Pipe and vessels repair prioritised over structural repairs.

- Even though there is an increasing scrutiny on training and qualifications of applicators and related FM trades, improvement of quality assurance practices and increased effort in supervision in compliance with standards, it only takes ONE deviation from correct application for the early onset of coating failures and corrosion. Application errors are often compounded by limited safe access to site (e.g., the use of scaffolding, rope access, suspended platform, or boat/diving access for offshore installations) and contractual pressures.
- Extensive focus on general and atmospheric corrosion damage with a lot less attention to other corrosion mechanisms such as chloride localised corrosion and pitting affecting austenitic and duplex stainless steels used extensively in processing and seawater systems. Likewise, failures due to corrosion under insulation (CUI) or microbiologically influenced corrosion (MIC) are only becoming more acknowledged and better documented over the last decade.

The list goes on, but these facts exemplify some of the burdens and complexities faced by FM in most plants, with different degrees of criticality. Meaningful opportunities to improve FM delivery must start with decision making based on smart, cost effective, factual, and sustainable solutions offered by corrosion, materials, and asset integrity specialists. These are discussed in subsequent sections.

SUSTAINABLE SOLUTIONS TO FABRIC MAINTENANCE

In 1987, the United Nations defined sustainability as "meeting the need of the present without the ability of future generations to meet their own needs" [5], concept supported by 3 basic sustainability pillars: Environmental protection, social development, and economic development [6]. A brief analysis of what these pillars could mean for FM is presented in Table 1.

table 1: sustainability pillars applied to fabric maintenance

Sustainability Pillar	Definition	What it means for FM?
Environmental Protection	Reduction of carbon footprints and water usage, wasteful processes as part of a supply chain. These processes can be cost-effective and financially useful.	• Better understanding of fabric failures and effective protection mechanisms based on accurate analysis of failure, • Investment in R&D for increased technical and applied knowledge. • Improved coating and protection systems free of contaminants and non-toxic to nature, • Design for durability and deconstruction as well as for Reuse and Recycle. • Reduce landfill and waste. • If viable, transition to cleaner technologies.
Social Development	Ensuring responsible, ethical, and sustainable treatment of employees, stakeholders, and the community in which the business operates. Use of sustainable labour who can operate in a safe environment.	• Incorporate flexible scheduling and fatigue management, • Use of technology to facilitate decision making, execution and labour, • Better training and development opportunities, • Remove people from harm's way by consistent HSE practices.
Economic Development	To be economically sustainable, business to be profitable to maintain production into the future, while upholding the other elements of sustainability.	• Implementation of cost efficient and frequent maintenance routines, • Early identification of defects before they become large scale failures, • Use of cost efficient and high quality protection products and systems with extensive service life, • Fabric repair or refurbishment with no need for shutdowns or process interruptions, • Maximise the value of existing assets and raw material by keeping infrastructure, resources, and materials in use for as long as possible, • Circular economy: Minimise, reuse recycle economic benefits.

CURRENT DEVELOPMENTS ON SUSTAINABLE SOLUTIONS

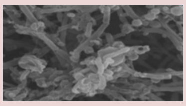
Over the last decades, there have been very encouraging developments on corrosion control and mitigation that have or potentially can be implemented for improved and sustainable FM campaigns. Some of these solutions are summarised in Table 2:

Table 2: examples of existing sustainable solutions applicable to FM

Self-healing pure polyisobutene visco-elastic (VE) coatings

- *Non-crystalline non-curing fully amorphous pure homopolymer polyisobutene.*
- *Molecular adhesion instead of mechanical interlocking, therefore surface preparation is not critical for bonding. Cold flowing and self-healing.*
- *Extensive service life, resulting on cost efficiencies on initial application and service lifecycle.*

Prevention and Mitigation of Microbiologically Influenced Corrosion (MIC)

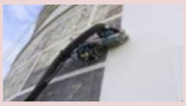


- *Increased microbial mechanistic knowledge and identification for better targeting of corrosive microorganisms and/or bioconsortia.*
- *Improved surface barriers and cleaning methods (e.g., pigging).*
- *Use of targeted biocontrol and corrosion inhibitors with significantly reduced impact on the environment.*

Prevention and Mitigation of Corrosion Under Insulation (CUI)

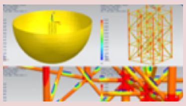
- *Use of hydrophobic insulation materials, including visco-elastic coatings and thermal insulation material*
- *Increased monitoring and deployment of remote wireless sensors for accurate collection of inservice data.*
- *Improved use of non-destructive testing (NDT) that facilitates inspection.*

Application of Conventional Coating Systems



- *Improved surface preparation and application methods.*
- *Deployment of robots to increase coating perfomance by more consistent surface preparation and coating application.*

Corrosion Modelling

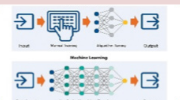


- *Predictive Digital Twins - Modelling of assets for risk prediction of corrosion and material related failures.*
- *Cathodic protection (CP) computer-aided engineering.*
- *Mathematical modelling as risk management tool (RMT).*

Additive Manufacturing

- *Production of specific corrosion resistant parts such as valves and flanges, significantly reducing cost, production time and material wastage.*
- *Optimisation of printing parameters, including alloy microstructures, minimising the risk of corrosion failure.*

Machine Learning and Artificial Intelligence (AI) as inspection tools



- *Automatisation of surveying methods and asset condition assessments.*
- *"Visual intelligence" and early predictions.*
- *Faster, cheaper, safer and more accurate.*
- *Lowers probability of catastrophic events.*

Rethinking Concrete

- *Use of low carbon concrete which is 50% better for the environment (8%of Global emissions come from concrete use) [7].*
- *Focusing on highly resistant concrete that does not require reinforcing materials, therefore minimising incidence of corrosion [7].*

Example of a Sustainable Solution:

Use of pure polyisobutene visco-elastic coatings to arrest pit growth in stainless steels

BACKGROUND

Stainless steels (SS) are materials of choice to build the infrastructure for oil and gas(O&G)operations due to their high corrosion resistance compared to carbon steels. The addition of Chromium (Cr) induces the formation of passive oxide films in the form of $Cr2O3$ or CrO. Single phase austenitic alloys (e.g., 304, 316, 316L) are mainly used for utilities, structural and transport applications, whereas higher grades such as duplex and superduplex SS (>22%Cr, >4%Ni) are used for building processing and seawater systems.

Stainless steels, however, prone to localised corrosion and pitting due to the rupture of the passive film, particularly in the presence of acids and high chloride concentrations in offshore facilities, where humidity is usually above 80% RH and corrosive saline droplets (NaCl, MgCl2) are constantly deposited at the metal surface. Localised corrosion and pitting are also exacerbated at temperatures exceeding 55°C [8], which are typical service temperatures at O&G operational phases.

Given the consequence of any possible failure, the standard industrial practice in O&G plants is to replace any SS pressure equipment undergoing pitting or localised corrosion [9]. Besides this being an extremely expensive approach, it also represents significant down time and production loss. The mitigation of pitting growth has been a matter of significant investigation as this corrosion mechanism costs millions of dollars in production sites worldwide.

The materials and corrosion engineering team at Woodside Energy have been able to implement the use of oxygen and water impervious visco-elastic coatings to mitigate uniform corrosion in carbon and low-grade steels. Woodside embarked in a collaboration with Monash University to trial the effectiveness of the pure polyisobutene visco-elastic coatings in stifling pitting corrosion of austenitic steels. The hypothesis was that an oxygen impervious coating can restrict the electrochemical cathodic reactions at the steel surface, in turn stopping the anodic reactions leading to pit growth [9,10].

Methods and Materials

SS 316L coupons were exposed to 6% ferric chloride (FeCl3) droplets to get pitting initiated on the surface. The pits were then characterised using high resolution X-Ray computed tomography (CT) with the sample stage being rotated to generate 2D images. Then, the 2D images were processed using Aviso® software to generate 3D X-Ray CT maps of specimens and pits. Similar tests were conducted using lower grade 304L to observe more significant pit growth over short exposures [10]. Complete experimental details are provided elsewhere [9,10].

Once the active pits were characterised, the visco-elastic coating was applied onto some of the specimens while others remained uncoated for control. Coated and uncoated specimens were kept in a humidity chamber (>80% RH) for a prolonged exposure of up to 6 weeks, after which the samples were again characterised by X-Ray CT, both before and after exposure.

Results

The X-Ray CT maps of the uncoated and coated coupons are presented in Figures 2-3.

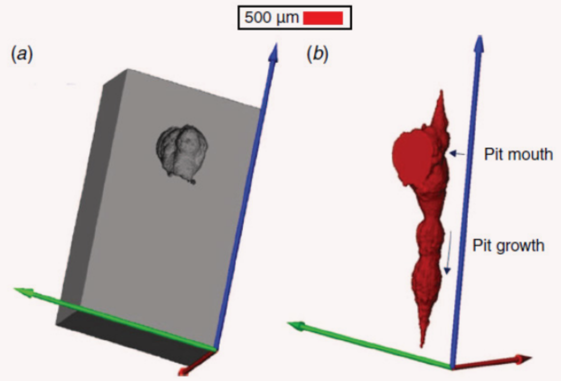


Figure 2: (a) X-Ray generated image of a pit in 316L formed after exposure to 6% FeCl3droplet after 2 weeks of exposure. (b) X-Ray CTmap of the pit, revealing the morphology of pit beneath the surface of material [9, Courtesy of M.Brameld]

The results presented in Figure3, clearly indicate that there is no pitting growth beneath the coating, whereas there is pit growth and propagation of the uncoated 316L samples. Replication of these tests in 304L samples provided repetitive results, with complete arrest of pit growth in the coated samples.

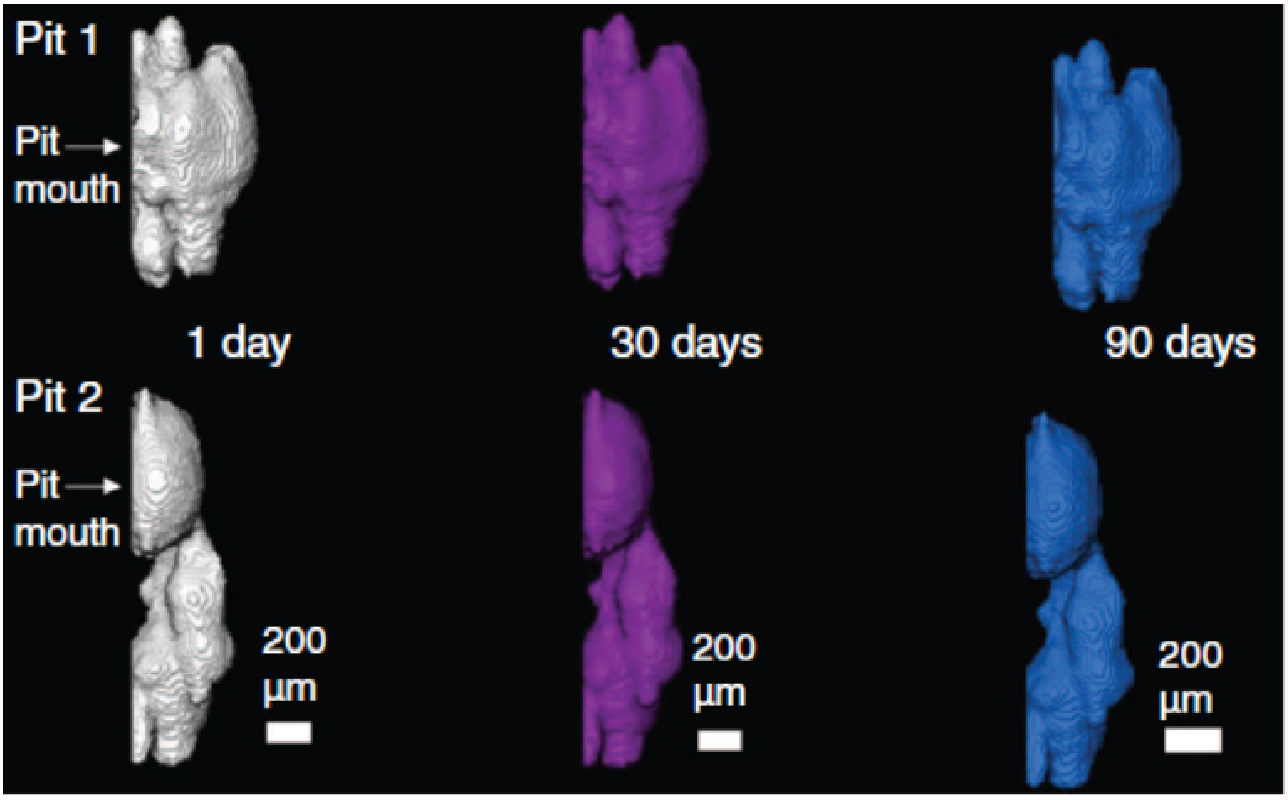


Figure 3: X-Ray CT images of two pits in 316L covered with visco-elastic coating after pit formation. the pits do not show any growth beneath the coating, after 1 day, 30 days and 90 days of ambient exposure. [9,Courtesy of M.Brameld]

The hypothesis was proven to be correct, with the visco-elastic coating being able to arrest pit growth by stifling the cathodic reaction at the metal surface. The success of this trial enabled the deployment of the visco-elastic coating on existing stainless steel assets, extending their service life, avoiding material replacement, and saving the business tens of millions of dollars in fabric maintenance.

CONCLUSIONS

There is no single solution to the many challenges affecting FM. Rather, the implementation of effective FM comes from a combination of practices appropriately defined under the sustainability pillars: Environmental Protection, Social Development and Economic Development.

The most viable starting point is the protection of the existing ageing infrastructure in a sustainable way, making use of existing technologies and expanding the knowledge by continuous collaboration between asset owners, research institutions, OEMs and stakeholders. In many cases, the problem lies on building confidence in the use of these newer materials and solutions, any technical attempts by research institutions, manufacturers and suppliers need to have full-scale trials and data around their durability. This approach will guarantee a safe and gradual transition into new technologies.

Figure 1 (referenced on page 71): pipeline corrosion in a natural gas liquids plant. Pipe and vessels repair prioritised over structural repairs.

ACKNOWLEDGMENTS

Special thanks to Mr Michael Brameld, Chief Technology Materials Engineer at Woodside Energy for his generosity sharing his knowledge and experience. Many thanks to the team at Anti Corrosion Technology and FITT Resources for their continuous support.

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AUTHOR DETAILS

Dr M.Vargas is the Engineering Services Manager at Anti Corrosion Technology, a position she has held since 2021. She has over 20 years research, industry, and consulting experience in the areas of corrosion, materials performance, integrity management and failure analysis. She is an SME in the topic of microbiologically influenced corrosion (MIC). As part of her current role, she leads the implementation of corrosion specifications in assets around Australia and is the main consultant in legal failure reports.

Wind turbines: The issue with coating repairs

Anti-corrosion factory applied coatings for wind turbines usually consist of multi-layer 2-component protective paint systems like epoxies or polyurethanes. Application of these coating systems require a high degree of surface preparation of steel, a roughness profile for achieving proper adhesion, low levels of salt contamination on the surface, and appropriate control of temperature and humidity during curing.

The factory-applied coating often gets damaged during transport and installation of the towers, but also during operation under highly corrosive environments. Locally repairing these coatings is almost impossible due to many factors like mobilization of equipment used for abrasive blast cleaning in an uncontrolled environment, the time needed for the coating to cure, and logistics round rope access application.

These challenges are compounded by the potential release of hazardous substances and waste such as blast-media and paint; and increase in C02 emissions.

1. Developing of an alternative coating repair coating

Pure homopolymer polyisobutene (PIB) has been providing reliable corrosion protection of assets for over 20 years, including pipes and piles under buried, atmospheric, and submerged conditions1.

Adhesion of coatings based on PIB is solely based on van der Waals intermolecular forces, therefore surface preparation is not as critical as with many other non-PIB-type coatings.

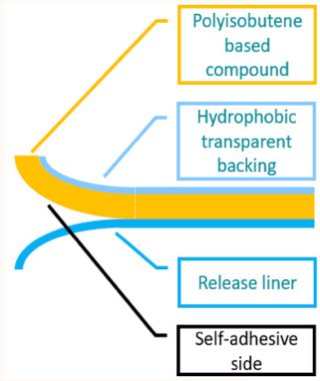
They have good adhesion to carbon steel, and existing epoxy- or polyurethane-based coatings. PIB-type coatings also have a low permeability for water vapor and oxygen, which makes them favorable for protection against corrosion.

PIB-based coatings meet the property requirements of ISO 21809-3 standard, for external coatings in the Oil & Gas industry, including glass transition temperature, drip resistance, and adhesion to various substrates before and after accelerated thermal aging and hot water immersion.

Moreover, PIB-based coatings are non-toxic (zero VOCs) and harmless to applicators and the environment. They do not cure and are inert to aging, offering an extended service life where less maintenance is required, adding to their unique value as sustainable and "green" repair systems.

2. Proof of concept: Testing of Easy-Qote® SC Patch System

Easy-Qote® is a self-adhesive compound based on PIB with a UV-resistant hydrophobic backing film.

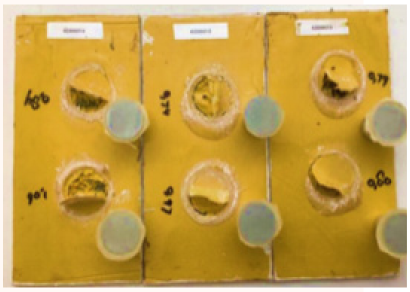


Easy-Qote® SC Patch repair system was tested under laboratory conditions for suitability as repair coating, following the methods in ISO 12944-9 for extreme corrosivity category CX (i.e., offshore tidal conditions).

Experimental details:

- Carbon steel panels (EN 10025-2 type S355JR)
  - Initial rust grade C (ISO 8501-1)
  - Wire brush cleaning to cleanliness grade St 3 (ISO 8501-1)
  - Surface roughness 62 µm (ISO 8503-5 replica tape)
  - Salt contamination approx 30 mg/m² (ISO 8502-9)
- Coated with a single layer of Easy-Qote® SC Patch system.

Unexposed coated panels were tested for adhesion (ISO 4624) and colour (ISO 11664-4). Three coated panels were exposed for 25 weeks to cyclic ageing test as specified in ISO 12944-9 Annex A:



- 72 hours of exposure to UV and condensation (ISO 16474-3 method A)
- 72 hours of exposure to neutral salt spray (ISO 9227)
- 24 hours of exposure to low temperature at -20 ± 2 °C

After termination of cyclic ageing, the panels were inspected for adhesion, colour, blistering, rusting, cracking and flaking.

Results unexposed panels

Property	Requirement	Results
Adhesion (ISO 4624) • Pull off value; Failure mode	≥ 5 MPa; 0% adhesive metal/coat	0.5 Mpa; 0% adhesive metal/coat

intrinsic properties of PIB

Results after cyclic ageing

Property	Requirement	Results
Adhesion (ISO 4624) • Pull off value; Failure mode; • Ratio to unexposed coat	≥ 5 MPa; 0% adhesive metal/coat ≥ 50% of original value	0.4 Mpa; 0% adhesive metal/coat 80%
Color difference (ISO 11664-4)	ΔE* = 3.5	ΔE* = 2.7 (no visual difference)
Blistering (ISO 4628-3)	0 (SO)	0 (SO)
Rusting (ISO 4628-3)	Ri 0	Ri 0
Cracking (ISO 4628-4)	0 (SO)	0 (SO)
Flaking (ISO 4628-5)	0 (SO)	0 (SO)

3. Field installation and inspection after 5 years in service

Although the tests conducted under ISO 12944-9 can provide useful information, the relationship with field performance is not always clear. ISO 12944-9 states that the results of artificial aging tests shall be used with caution, as artificial aging will not necessarily have the same effect as natural exposure. Some studies into various types of coating systems showed that there is a poor correlation between results from laboratory tests following ISO 12944-9 and performance in natural exposure2,3.

To test performance of Easy-Qote® SC Patches under natural exposure conditions, the product was trialed on a large-scale offshore wind farm in the Dutch North Sea. The product was installed on several wind towers, at locations where the factory-applied coating was damaged during transportation or installation.

Application was done partially by rope access, and included cleaning the surface with wire brushes, cleaning with isopropyl alcohol, cutting the repair coating to size with scissors, and application to the surface by patching and pressing it with a roller.

These installations took considerably less time when compared to traditional field repairs with the non-PIB-based coating systems. Materials to be taken care of after job completion consisted of wipes, release liner, and cardboard packing only.

The repair sections were visually inspected after a 5-year service for the condition of the repair Easy-Qote® coating. No anomalies were observed on any of the repair sections. The repair coating was still perfectly in place and no blistering, rusting, cracking, or flaking could be observed. The color of the Easy-Qote® coating repair material still matched with the original factory-applied coating.

4. Application Steps

Step 1- Surface preparation

- Application of Easy-Qote® SC Patches require minimum surface preparation, to a minimum cleanliness grade of St2/St3 (ISO 8501-1). This can be achieved by abrasive cleaning pads, wire brushing, etc.
- Surface must be cleaned with isopropyl alcohol (IPA)only, no need to apply thinners or harsh cleaning chemicals. The area to be coated must be clean, dry, and free from oil, grease, dust, rust scale.

Perform Surface cleanliness and adhesion test to confirm the surface has been sufficiently cleaned and is ready for EasyQote®SC Patch Application.

1. Apply a EasyQote®SC Patch adjacent the surface of the pipeline/structure where coating defect exists and press the material into the pores of the substrate.
2. Remove the EasyQote®SC Patch test piece after 5 min at an 135° angle with a pull off speed of 100mm/min.
3. Cohesive failure should occur and EasyQote®SC Patch material must cover ≥95% of the surfaces. If this is less, further cleaning is required. Repeat cleaning and cleanliness check until ≥95% adhesion is achieved.

Step 2- Coating Application

- Measure the area to be coated. If required, pre-cut strips of the EasyQote®SC Patch material with scissors or knife to the appropriate size.
- Remove the patch from the siliconised cardboard, just prior to application to the surface to avoid contamination of the adhesive surface and premature adhesion to the substrate.
- Apply the pre-cut material onto the clean substrate. For small defects, this firmly hand pressing the material onto the substrate. For large areas of coverage, the use of a roller is recommended. Avoid air inclusion.

Step 3- Inspection

- The EasyQote® SC Patch must be visually inspected for any defects. The appearance must be smooth and should be shaped tight around all details. If required, Pinhole/Holiday detection can be conducted in accordance with NACE SP0188 (for metallic substrates only).
- If the applied EasyQote® SC Patch material is mechanically damaged it can be easily repaired with the same type of EasyQote® SC Patch material. Sound existing coating edges shall be feathered by hand or via power sanding for minimum 50 mm towards the substrate prior to over coating and between each coat. Masking shall be soft taped so that sharp edges and step ups are not visually or physically evident.

5. Properties of Easy-Qote® SC Patch4

Properties of Easy-Qote© SC Patch		
Available colours	- Grey (approx. RAL 7035) - Yellow (approx. RAL 1023)	
Temperature range	Operational: -45 to +70°C [-49 to 158°F]	
Dry film thickness	1,7 ± 0,2mm [67 ± 8 mils] (as supplied)	
Mass per unit area	2,25 ± 0,3 kg/m2 [0.52 ± 0.06 lb/sq.ft]	
Adhesion	Peel test at 10mm/min [⅜"/min]: - Cohesive separation, no signs of adhesive separation	
Coating performance	Tested in accordance with ISO 12944-9 Annex B- cyclic ageing test:	
	- ISO 4628-2 Blistering: - ISO 4628-3 Russting: - ISO 4628-4 Cracking: - ISO 4628-5 Flaking:	0 (SO) Ri 0 0 (SO) 0 (SO)

General order information	
Product	Easy-Qote© SC Patch is available in patches for Australia
Art. Nr.: 30692-00030 30702-00030	Product dimensions and contents: Easy-Qote© SC Patch - Yellow, approx. RAL 1023 150mm x 300mm [6" x 12"], 70 patches/box Easy-Qote© SC Patch - Grey, approx. RAL 7035 t 150mm x 300mm [6" x 12"], 70 patches/box
Handling	Handle with care. Keep boxes upright.
Storage	Store indoor, clean and dry away from direct sunlight in a cool place below +45°C [113°F]. Unlimited shelf life.

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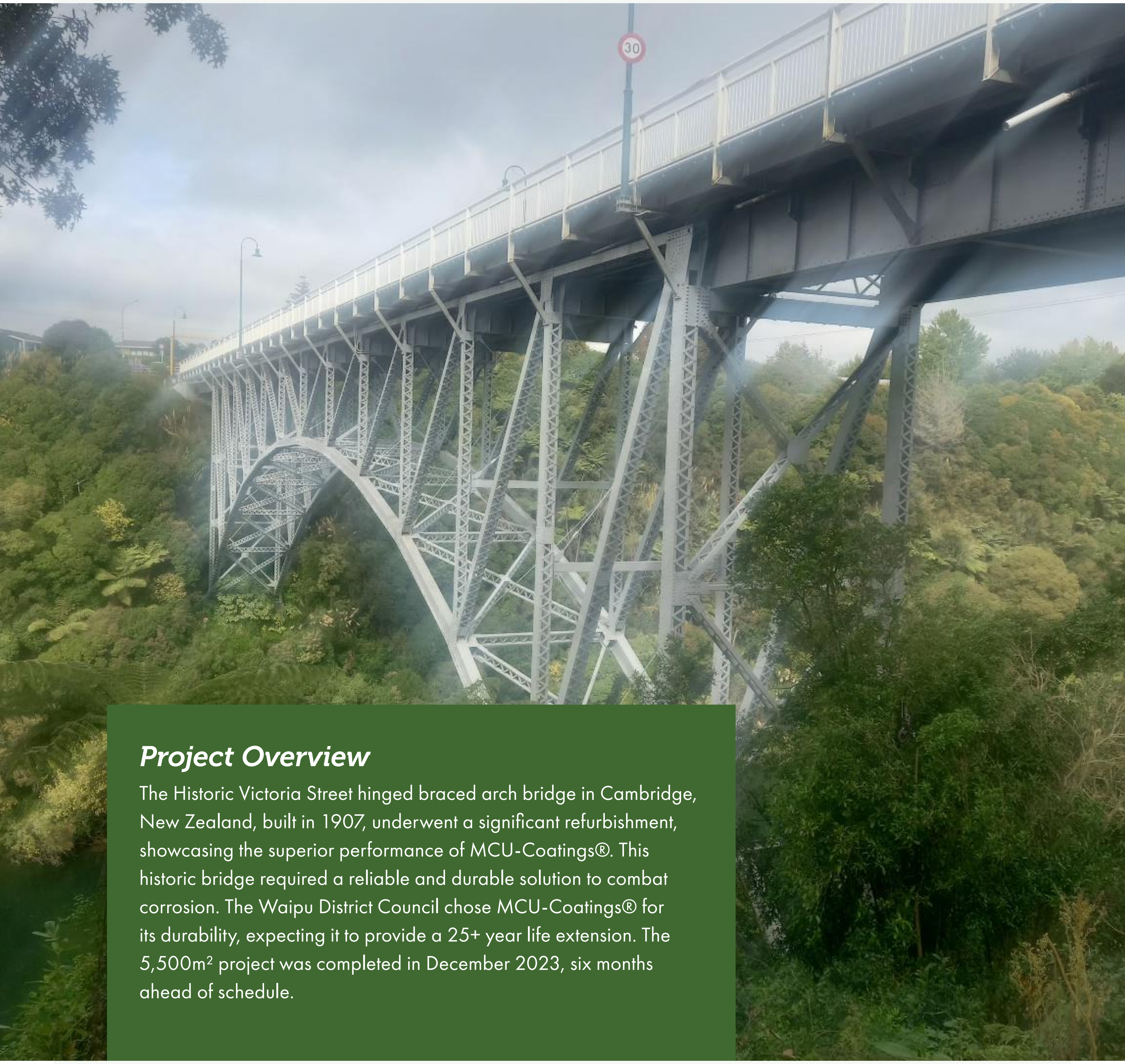
A new way of coating repair method designed with a few key factors in mind: turn-around time, health, safety, environment, and sustainability.

Easy-Qote® SC Patch repair system is based on pure polyisobutene (PIB) homopolymer, a proven **corrosion protection solution** for assets exposed to extreme atmospheric conditions.

ANTICORROSION TECHNOLOGY

Transforming the Victoria Street Bridge

By MCU Coatings



Project Overview

The Historic Victoria Street hinged braced arch bridge in Cambridge, New Zealand, built in 1907, underwent a significant refurbishment, showcasing the superior performance of MCU-Coatings®. This historic bridge required a reliable and durable solution to combat corrosion. The Waipu District Council chose MCU-Coatings® for its durability, expecting it to provide a 25+ year life extension. The 5,500m² project was completed in December 2023, six months ahead of schedule.

Key Achievements

Time and Cost Efficiency:
The technology was applied without atmospheric limitations, i.e. dewpoint, temperature, and RH, allowing the project to be completed in record time and within budget.

Minimal Waste and Rework:
The 2% product wastage and 0% rework highlight the efficiency of MCU-Coatings®.

Technical Highlights

Durability:
The MCU-Coatings® system for "Spot Repair" and "Full Overcoat" boasts over 25+ years of durability in a C5 environment and an expected lifespan of 40-50 years in a C4 environment. This is backed by independent testing to ISO 12944-6 C5 VH, NORSOK M-501 Edition 6, system 1, and SHELL DEP 30.48.00.32 F.1.3 and F.1.2.a standards.

Surface Preparation

The surface preparation followed AS/NZS 2312.1:2014 assessment process. significant corrosion with moss/algae overgrowth was noted. Different cleaning methods were employed:

Solvent Cleaning:
To SSPC-SP1 standards.

High-Pressure Water Jetting:
6000 psi to remove contaminants.

Abrasive Blasting:
Near-White Class Sa 2½ (NACE No. 2, SSPC-SP 10).

Coating Systems Applied

Spot Repairs:
This was a 225μm DFT three-coat system with MCU-Zinc® primer, MCU-Miomastic® intermediate coat, and MCU-Miotopcoat® topcoat. Two stripe coats were applied according to AS/NZS 2312.1:2014 guidelines.

Existing Paint Overcoat:
A 180μm DFT two-coat system for sound, well-adhered paint surfaces consisting of MCU-Miomastic® intermediate coat and MCU-Miotopcoat® topcoat.

Product Benefits

MCU-Zinc®:
Offers superior cathodic protection against corrosion.

MCU-Miomastic®:
Provides proven barrier performance.

MCU-Miotopcoat®:
Ensures long-term protection with excellent resistance to UV, weathering, and abrasion.

The MIO-filled coatings are primarily impermeable to water and gas ingress with an impressive WVT of <4 g/m²/24h.

Innovative Solutions

Crevice Sealing:
Utilised MCU-Aluprime NS® to penetrate and seal difficult-to-access areas between centre/foundation pins, overlapping steel and lattices.

Caulking:
MCU-Flex® was employed to seal gaps.

Bird Spike Adhesion: Utilised MCU-Flex®.

Anti-Graffiti:
Easy-to-reach areas were coated with MCU-Clearcoat®.

Lead encapsulation:
MCU-Miomastic® encapsulated lead coatings.

Handrails: Overcoated with MCU-Topcoat®.

Asbestos encapsulation:
MCU-Aluprime® encapsulated asbestos (Old form-work).

Testimonials

Jim McGovern, Intergroup's Project Manager, praised the ability to predict the project timeline accurately and deliver reliable financial forecasts, attributing this success to the absence of weather-related restrictions. Johann Myburgh, COO of MCU-Coatings®, highlighted the significant time savings and the innovative solutions for long-standing bridge maintenance.

Conclusion

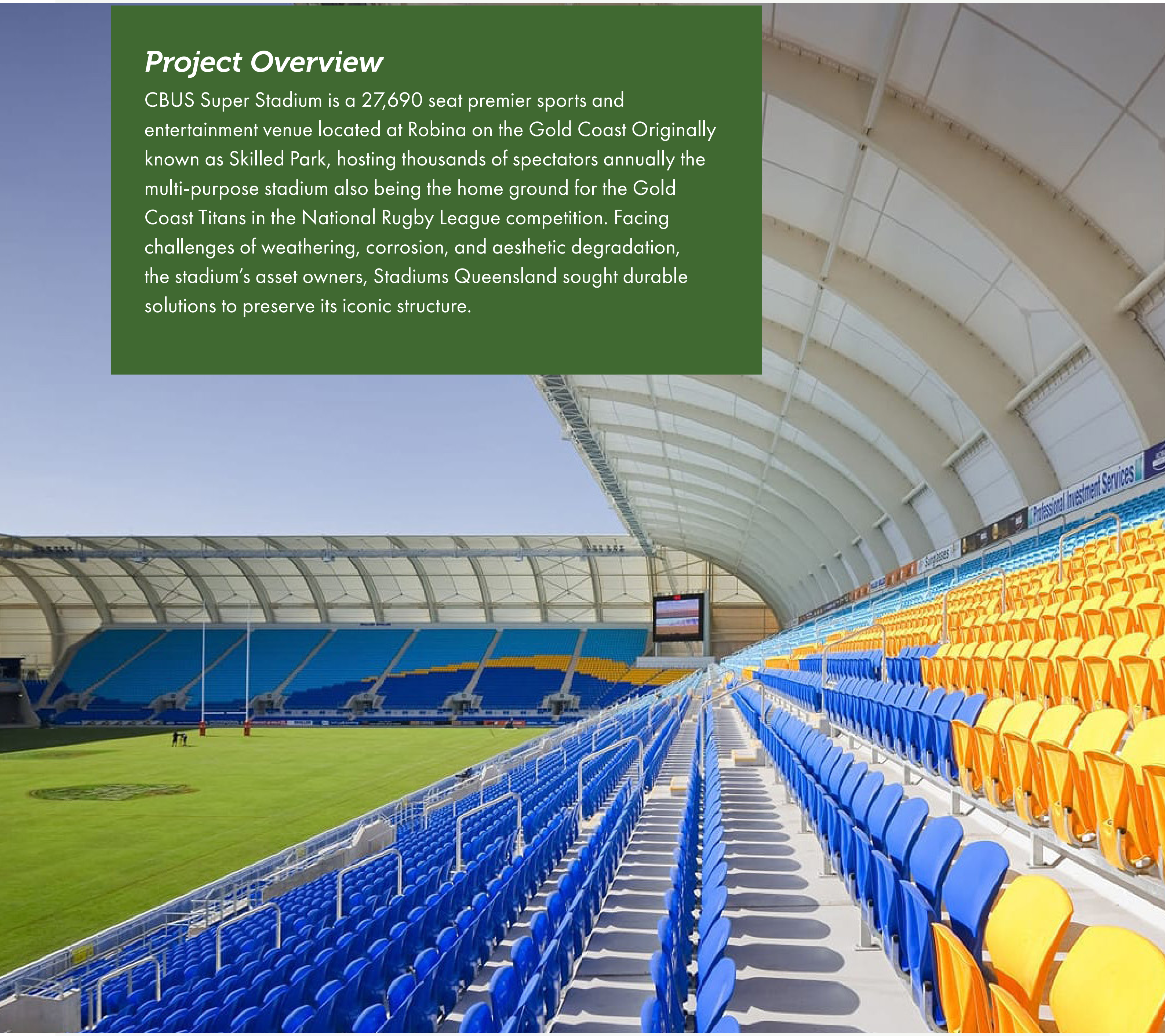
The Victoria Street Bridge project exemplifies the effectiveness of MCU-Coatings® in delivering comprehensive, durable, cost-effective, and timely solutions for infrastructure maintenance. This success story sets a new standard for industry bridge and infrastructure refurbishment projects.

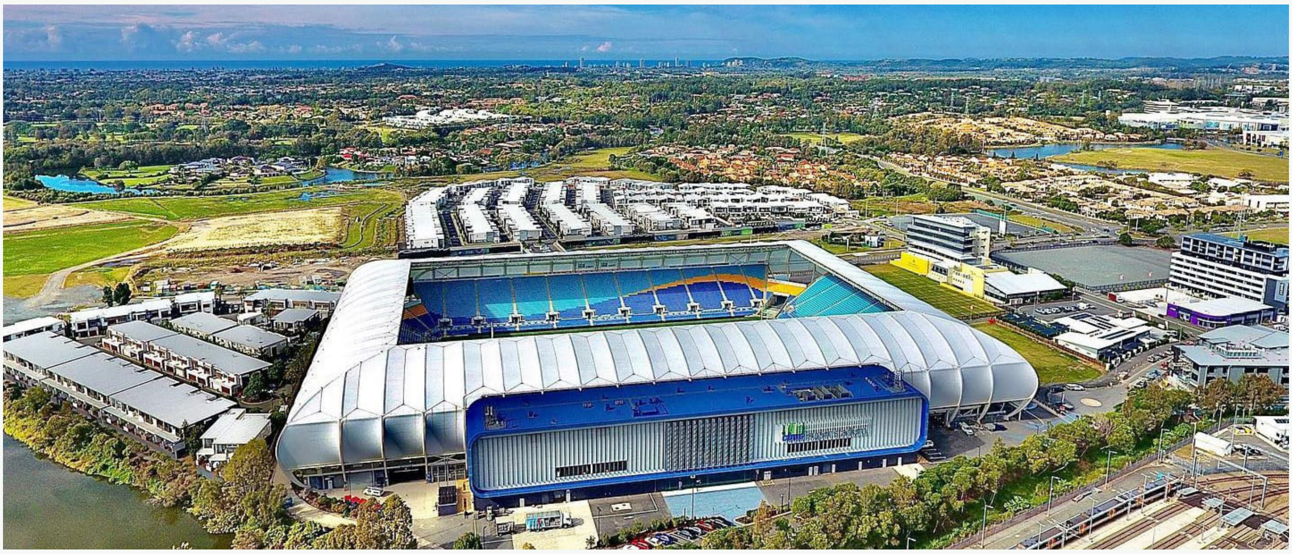
Enhancing Longevity and Sustainability at CBUS Super Stadium with Protective Coatings

By AkzoNobel

Project Overview

CBUS Super Stadium is a 27,690 seat premier sports and entertainment venue located at Robina on the Gold Coast Originally known as Skilled Park, hosting thousands of spectators annually the multi-purpose stadium also being the home ground for the Gold Coast Titans in the National Rugby League competition. Facing challenges of weathering, corrosion, and aesthetic degradation, the stadium's asset owners, Stadiums Queensland sought durable solutions to preserve its iconic structure.





Key Points:

1. Design Life:

AkzoNobel's journey with CBUS Super Stadium began in 2008 with a commitment to aligning our protective coatings with the stadium's ambitious design life goals. Through rigorous consultation throughout the architectural and structural design process the coatings system provided in specification were designed for longevity and durability, we aimed to exceed initial expectations and ensure prolonged structural integrity. We worked closely with Tranzblast Coating Services, the applicator, to ensure that the project ran smoothly.

2. Original Specification:

The initial specification called for coatings that could withstand rigorous environmental conditions and the typical stadia issues surrounding accessibility to conduct regular periodic cleaning and maintenance, whilst maintaining high aesthetic appeal. Coatings were carefully chosen to meet these stringent requirements, offering superior protection against UV exposure, weathering, and corrosion considering whilst considering its atmospheric exposure location. The high-performance coatings chosen were Interzinc 52, Intergard 475HS and Interthane 870.

3. Maintenance:

Continuing AkzoNobel's partnership with Stadiums Queensland, facility managers and contractors we have established a comprehensive maintenance regime tailored to CBUS Super Stadium's specific needs. Regular inspections and proactive maintenance schedules are integral to preserving coating effectiveness and minimizing operational disruptions.

4. Sustainability:

The applied coatings through correct specification and implementation have facilitated to prolong structural integrity, maximise durability reduce maintenance costs, and extend maintenance intervals, contributing to deliver overall operational efficiency and budgetary savings, minimizing its environmental footprint and demonstrate AkzoNobel's sustainability responsibility.

Conclusion:

In conclusion, the successful ongoing corrosion protection, aesthetic value and maintained structural integrity via application of our protective coatings delivered at CBUS Super Stadium exemplifies a successful synergy and the demonstrated value of early-stage consultation, correct specification, high performing products, meticulous planning and sustainable practices. No doubt delivered and assisted by AkzoNobel's strong track record with stadia in both Australia and the rest of the world.

Looking ahead, we are committed to further enhancing sustainability and operational efficiency, ensuring CBUS Super Stadium's specific needs remain a beacon of excellence in sports and entertainment and that make sure that this Gold Coast stadium remains in a league of its own.

Level 2 rating for Mooring Dolphin after 6 years

By Dulux

Project Overview

Sugar Terminals Limited owns six terminals in Queensland, which are operated by QSL. They play a vital role in Australia's sugar market, handling over 90% of the raw sugar produced in Australia each year.

The Lucinda Jetty and Wharf provides the offshore loading facility for the Lucinda Bulk Sugar Terminal, located in Lucinda, North Queensland.

Project partners

Asset owner:
Sugar Terminals Limited (STL)

Asset operator:
Queensland Sugar Limited (QSL)

Applicator:
Advanced Aquablasting (AAB)

Challenge

Stretching 5.76 kilometres into the Coral Sea, the Lucinda Jetty is the longest jetty in the Southern Hemisphere and conveys hundreds of thousands of tonnes of sugar out to shipping vessels each year. Wharf dolphin and berthing structures, including headstocks, are exposed to a severe marine environment and are also very difficult to access, making their maintenance both complex and costly.

Coatings solutions

Dulux® Duremax® GFX was selected as the coating for the remediation of the Southern Mooring Dolphin. Offering incredible corrosion-resistance, the dense lamellar pigmentation of Duremax GFX delivers long term durability in severe marine environments.

The specification delivered was a Class 2.5 blast with two coats of Duremax GFX at 500 microns (μm) dry film thickness each coat.

Duremax GFX delivers cost savings by significantly extending the periods between maintenance.

Coating rating after 6 years

Level 2*

Results

The assessment of Lucinda Jetty revealed headstock coatings to be in excellent condition:

- minor signs of breakdown: chalking due to high UV exposure
- no visible rust at welded sections
- excellent DFT values across all areas that could be inspected
- no coatings thickness measurements below original specification were recorded

*** Coating Inspection 5-Level Rating System**

Coatings are inspected to determine the degree of deterioration. Ratings indicate the following condition status:'

- No film damage other than dirt and minor staining
- Soiled, stained, ingrained dirt, chalking or loss of gloss
- Minor film damage (cracking, flaking or erosion of topcoats) in small areas
- Minor corrosion where up to 0.5% of the base metal is showing signs of rusting
- Widespread and excessive corrosion and damage

2024 Training Calendar

AMPP Coating Inspector Program Level 1	
Victoria	19-24 Aug 2024
Western Australia	2-7 Sep 2024
Newcastle	30 Sep-5 Oct 2024
Cairns	18-23 Nov 2024
South Australia	25-30 Nov 2024
Western Australia	25-30 Nov 2024
Victoria	2-7 Dec 2024

AMPP Coating Inspector Program Level 2	
Victoria	26-30 Aug 2024
New South Wales	23-27 Sep 2024
Cairns	25-29 Nov 2024
South Australia	2-6 Dec 2024
Western Australia	2-6 Dec 2024
Victoria	9-13 Dec 2024

AMPP Cathodic Protection Level 1 Tester	
New South Wales	26-30 Aug 2024
Western Australia	14-18 Oct 2024

AMPP Cathodic Protection Level 2 Technician	
Western Australia	21-25 Oct 2024

AMPP Concrete Coating Inspector Level 1 and 2	
Victoria	5-9 Aug 2024
Queensland	28 Oct-1 Nov 2024

AMPP Corrosion Under Insulation	
Online/AWST	16-19 Sept 2024
Queensland	18-21 Nov 2024

ACA/GAA Hot Dip Galvanizing Inspector Program	
New South Wales	17-18 September 2024

ACA Coating Selection & Specification	
Online/NZST	21-23 Oct 2024

ACA Corrosion Technology Course	
New Zealand	25-29 Nov 2024

Click here to review the Training Schedule:

www.corrosion.com.au/training/training-course-schedule/

Course Spotlight:
AMPP Coating Inspector Program Level 2

Overview:

The AMPP Coating Inspector Program – Level 2 (CIP2) course focuses on advanced inspection techniques and specialised applications for both steel and non-steel substrates, including specialised coatings and linings. This is the world's most recognised and specified coating inspection certification program.

Who should attend:

Coatings Inspectors seeking Certified Coatings Inspector knowledge or certification who will be responsible for performing and documenting destructive/non-destructive inspections under the supervision of a Senior Certified Coatings Inspector.

Course highlights:

- De-humidification
- Centrifugal Blast Cleaning
- Coating Types and Inspection Criteria
- Water Jetting
- Hot Dip Galvanizing
- Spray Metalizing
- Concrete and Cementitious Surfaces
- Pipeline Coatings
- Specialised Application Equipment
- Inspection Instruments Lab
- Laboratory Instruments and Test Methods Coating
- Survey Techniques
- Cathodic Protection
- Use of Inspection Procedures for both Destructive and Non-destructive Test Instrument

More information & Registration

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

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

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

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

Become a Member

MEMBER BENEFITS

KNOWLEDGE BUILDING

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

RESOURCES

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

COMMUNITY

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

RECOGNITION

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

MEMBER BENEFITS

Membership Benefit	Diamond	Platinum	Gold	Silver	Bronze	Individual
Number of Corporate Delegates accessing benefits (Delegates receive the same benefits as individual members)	30	12	8	5	3	1
Additional Young Corrosion Group (YCG) Delegates YCG Delegates receive the same benefits as individual members. YCG should be students or in early stage of their corrosion career (under 35 years)	Unlimited	10	5	3	2	✗
Join our Technical Groups Applicators Technical Group, Cathodic Protection Technical Group, Coatings Technical Group, Concrete Structures & Buildings Technical Group, Oil & Gas Technical Group, Young Corrosion Group, Water Industry Group.	✓	✓	✓	✓	✓	✓
Discounted prices for Training, Events and Conference attendance for Delegates Upskill with member prices on ACA and AMPP Training Courses, ACA events and our Annual Corrosion and Prevention Conference	✓	✓	✓	✓	✓	✓
Access to our online Corrosion & Materials Journal (Quarterly) Receive four (4) online issues of the Corrosion & Materials Journal for all members, featuring technical articles, latest news, new products, and industry events.	✓	✓	✓	✓	✓	✓
Access to Exclusive ACA Member resources Over 4,500 Technical Papers, Webinar Recordings, 2,000 past ACA conference papers, recorded presentations from ACA events, past issues of Corrosion & Materials, technical articles, case studies and more.	✓	✓	✓	✓	✓	✓
Access to past Conference papers from the European Federation of Corrosion (EFC) congress & access to be appointed on Membership of EFC Working Groups	✓	✓	✓	✓	✓	✓
Access to local, Australia wide & New Zealand networking Branch & Technical Group events	✓	✓	✓	✓	✓	✓
NEW **Exclusive Membership Portal** Renew and pay your membership dues, download invoices, access ACA events and training, update your details, review past training or events, access the technical library, read C&M Magazine, 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	✓	✗	✗	✗	✗	✗