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Corrosion Exclusively

INSIDE:

60 YEARS OF EXISTENCE Est. 1960

Corrosion Institute Southern Africa

Corrosion Exclusively

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President's Comment

The impact of corrosion on our economy, safety, and environment cannot be overstated, and it is our duty to continue advancing the frontiers of knowledge and practice in corrosion mitigation and prevention. To remain at the forefront, we must adapt, innovate, and collaborate like never before.

Two years ago at the start of my tenure I listed a few things I was hoping to achieve during my term. I am pleased to say that a number of items have been achieved. I am hoping that the steps that are being taken will allow us to reinforce what has been achieved and to continue on our path to making the Corrosion Institute more relevant and an important cog in the whole industry.

Here is the list:

- Transparency & Inclusivity
  - We have been far better at involving all stakeholders
- Improved Communication
  - We have introduced Quarterly updates – from Executive Director and President
- Spreading the course offering into the rest of Africa
  - We are ready to run courses
- Accredited Courses
  - Petra has engaged with ECSA for lower tier courses
  - CPD for higher level courses
- An up-to-date growing database
- Making membership benefits so appealing that the rewards far outweigh the costs
- Surveys have resulted in well attended recent site visits & planned site visits
- New user friendly interactive searchable website which now allows payments for membership & courses
- New branding and the use of our slogan on all the branding. Champions of Corrosion Control is a very apt tag line and promise.
- One membership anniversary date has eased the administration burden
- The draft business plan is now available
- We have managed to negotiate new terms with AMMP
- Our media partnerships have improved Corrosion Awareness generally
- Collaboration with asset owners – we have had very fruitful discussions to collaborate with Asset Owners regarding their Corrosion related strategies

For me there are 3 key aspects for the continued success of Corrosion Institute. Our executive director, Petra has now been in her role for three years and she is continuing to make a visible difference. She is learning all the time and listening to the stakeholders in terms of the requirements. She has made my role as President a relatively seamless exercise and a big thank you to Petra for her role in moving the Corrosion Institute to where it is currently and for laying the building blocks and foundation to take the Corrosion Institute to the next level.

Petra's team is the second aspect and the mixture of youth and experience has worked well and we hope to see the continued improvement in the teamwork and proactiveness of the staff. Stefani, our auditor should be acknowledged as part of the team in making a difference.

The third aspect is our active council and we are very pleased to see how many of our members put their names forward to participate in the future of the Corrosion Institute. Thanks also to our many non council members who go above and beyond the request for assistance with various aspects of the Corrosion Institute.

All of our efforts are also showing dividends with regards to the increase in company and individual memberships and the conversion of complementary members into individual members.

In conclusion I have previously referred to our school motto Spectumer Agendo *"Let us be judged by our deeds"* and to borrow the Springbok tagline *Lets be Stronger Together*. By carrying on putting our plans into action and pulling in the same direction we can be Champions of Corrosion Control.

Yours Sincerely,
Graham Duk, President
Corrosion Institute of Southern Africa

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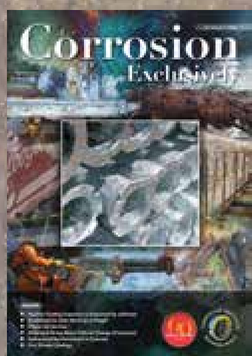

***Cover:** General hot dip galvanizing doesn't always have to be dull grey. This is surrounded by a plethora of corrosion related and work at height examples, seen at and along our coastline.*

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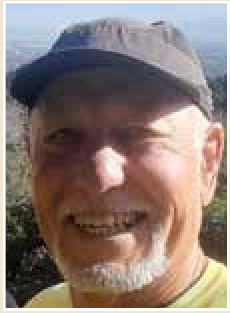
Editorial Comment



How time flies. What can I say?

I must apologize to all our readers that since our last edition of Corrosion Exclusively which was October 2021, we have had some notable challenges in producing a viable publication. These relate to anything from insufficient advertising support, the lack of an accurate and up to date database, coupled with a general laid back lethargy on my behalf.

My friend and colleague Bruce Trembling, who motivated during his presidency in 2015 that I should undertake to produce this magazine, would say it's a Cape Town thing, including the weather!

In spite of this so-called bad weather, I must say I feel tremendously blessed to daily be able to walk our two extremely energetic dogs along the many nearby trails close to our home.

Based on the generous support by a number of our usual and a few (but very welcome) new advertisers, we are extremely pleased to be able to provide you with 44 pages of sound corrosion related articles, plus highlights of the past two years of "face to face" (not Zoom or Teams) technical events, exhibitions, plant tours and fun gatherings of our members and invited guests to our HQ and branches in Cape Town and Durban.

I wish to especially thank our incumbent hard working President, Graham Duk for the support given to me during his two year tenure and welcome Dave Raath as his successor.

We feature the following in this edition:

- How modern data management software improves the efficiency of the pipeline coating inspection process – Part 2.
- Guidelines for safe working at height.
- Fitness For Service – A quest for Asset Integrity plus case study.
- Helping to Bring About Cultural Change (Corrosion) in Canada and throughout the World.
- Galvanized Reinforcement for Corrosion Control in Concrete – Part 1 of 4.
- Zinc Silicate coatings – Part 1 of 3.
- From the KETTLE – F38 (white rust) and F39 (wet storage staining).
- Institute news and feedback.
- Graham Duk the current President of CorrISA gives an account of the activities and achievements of CorrISA during his term of office.
- The Cape Region Chairman Flippie van Dyk reports back on these activities.
- We include a comment from Executive Director Petra Mitchell, on the achievements of CorrISA over the last two years.
- Under Education we include a bunch of recent AMPP educational course's including CIP 1 and CIP 2 as well as CIP Tester that took place over the last two years.

We again wish to sincerely thank all our advertisers who have made this edition possible. It is again through the support of people and companies like yourselves that this publication will eventually be amongst specifiers who require assistance when drawing up corrosion control specifications on behalf of their clients. Due to the unreliability of our Post Office, we have decided not to post the publication but have copies available for all who attend future CorrISA activities.

Terry Smith

OBJECTIVE OF THE MAGAZINE

"The objective of ***'Corrosion Exclusively'*** is to highlight CORRISA activities, raise and debate corrosion related issues, including circumstances where inappropriate material and/or coatings have been incorrectly specified, or have degraded due to excessive service life. Furthermore, it shall ensure that appropriate materials or coatings, be they metallic or otherwise, get equal exposure opportunity to the selected readers, provided these are appropriate for the specified exposure conditions on hand."

How Modern Data Management Software and State-of-the-Art Inspection Gauges Improve the Efficiency of the Pipeline Coating Inspection Process

PART 2

By David Barnes, Elcometer Ltd, Manchester M43 6BU, UK

Adhesion Measurement

The Type V Adhesion tester is operated by hydraulic pressure.

The Automated Type V Adhesion Tester controls the rate at which the stress is applied to the dolly, which is a requirement of the standards.

The motor powered hydraulic system ensures a smooth increase in the force and this adhesion tester can be used with 10, 14.2, 20 and 50mm diameter dollies offering full range pull-off force options of:

10mm dolly:	100MPa (14,400 psi)
14.2mm dolly:	50MPa (7,200 psi)
20mm dolly:	25 MPa (3,600 psi)
50mm dolly:	4MPa (580 psi)

The Automated Adhesion Tester also has a memory capacity for up to 60 000 readings stored in up to 2 500 batches; the batches can have alpha numeric names, individual pull graphs and a record of the type of failure (attribute) information recorded for each stored pull-off test.

USB cable and Bluetooth® wireless data output allows the recorded information to be transferred to data management software such as ElcoMaster™ for PC and Apps for iPhone, iPod, iPad and Android mobile devices

All pull-off adhesion test standards recognise that it is not only the value of the strength of the coating that needs to be recorded but also the mode of failure is significant and should be recorded/reported. This failure mode is treated as attribute information and can be added to each individual pull test stored in the batch.

First and foremost, a glue failure is not a valid reading unless the force applied to achieve the failure shows a value that is above the value specified for the coating, in which case the coating can be said to have exceeded the specification for the adhesive strength of the coating.

Typically a glue failure with be an invalid test (glue fails below the required strength of the coating) and the test will have to be repeated. Allowance for possible glue failures can be included in the number of dollies applied to an inspection area.

When the force applied to a dolly exceeds the specified value for the coating it is not always necessary to continue until the coating fails, as this will require a repair to the coating and such a test will not provide any additional information. There is a feature in the gauge where the dolly can be pulled to a limit – the limit being the expected/ required strength of the coating.

If the dolly is pulled to the set limit and the coating does not fail the gauge will release the force from the dolly leaving the coating in tact and the dolly can be removed using heated tongs to melt the adhesive.

If the fracture strength is less than the specified value the validity of the test is determined by visually inspecting the face of the dolly and determining the surface area and mode of the coating failure.

If no more than 20% of the area of the face of the dolly shows a coating failure of the adhesive and or cohesive property of the coating or the glue or adhesive failure at the glue/topcoat interface the test is not valid.

For a fracture to be identified as adhesive or cohesive the area of the relevant fracture must be 80% or more of the dolly face.

The following panel describes how the attribute data is coded and how the Elcometer 510 Automatic Adhesion Tester can be used to manage this information.

Assessing The Results – Failure Attributes

Many National and International Standards, including ISO 4624 & ASTM D4541, require the user to record not only the pull-off force but also the nature of the failure. This is done by examining the bottom of the dolly and assessing the failure. In 'Advanced' mode on the Elcometer 510 it is possible to select the 'Attributes' feature (Menu/Setup/Gauge Mode/Advanced) allowing the nature of the fracture to be recorded against each reading and stored within the batch.

Examining The Dolly

a) Cohesive Failure: The coating fails within the body of a coating layer leaving the same coating on the surface and on the dolly face.

b) Adhesive Failure: Failure occurs at the interface between layers (inter-coat) where one pulls away from the other. The

Figure 1: Manual Type V adhesion tester.

Figure 2: The automated type V tester.

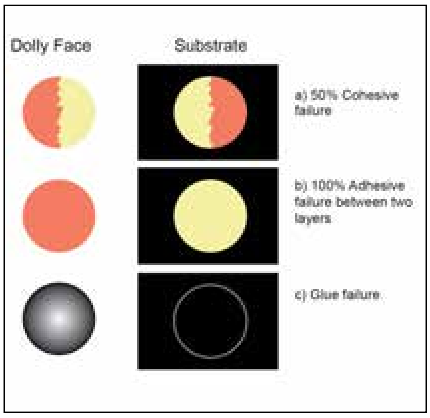


Figure 3: Dolly face appearance – attributes.

Cohesive Failure Layers		Adhesive Failure Layers	
Code	**Description**	**Code**	**Description**
A	Substrate	A/B	Substrate & Layer 1
B	Layer 1	B/C	Layer 1 & Layer 2
C	Layer 2	C/D	Layer 2 & Layer 3
D	Layer 3	D/E	Layer 3 & Layer 4
E	Layer 4	E/F	Layer 4 & Layer 5
F	Layer 5	F/Y	Layer 5 & Glue
Y	Glue	Y/Z	Glue & Dolly

Table 1.

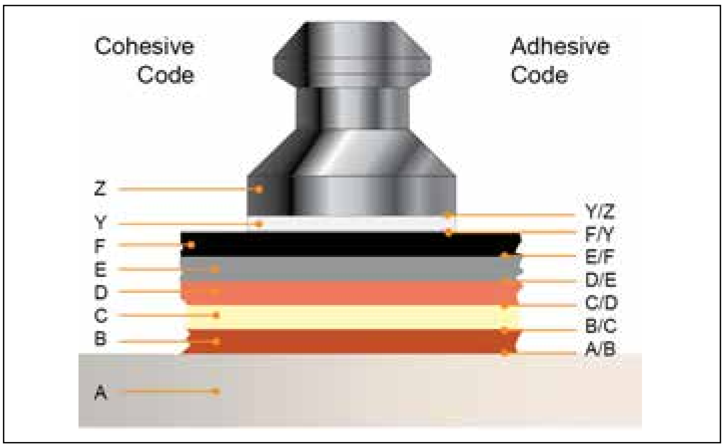


Figure 4: Coating layers and failure codes.

Figure 5: The pulsed DC high voltage holiday detector showing a rolling spring electrode ready to wrap round a pipe.

Figure 7: An array of high voltage test electrodes including band brushes, rolling spring, straight and curved wire brushes, conductive rubber and internal brush types. These can be used with either continuous DC or pulsed DC high voltage porosity detectors.

Figure 6: A pulsed DC system showing the trailing lead, the battery pack, the extension piece, the shoulder strap and the operating instruction.

"coating" on the dolly face will not be the same as that on the test area.

c) Glue Failure: When no coating is present on the dolly it must be recorded as a failure of the glue. This may be due to incorrect or insufficient mixing of the component parts of the adhesive, incompatibility between the adhesive/coating/dolly/test surfaces.

Porosity Assessment

The new design of Pulsed DC High Voltage Holiday Detector allows coatings to be tested using a training signal return cable that lies on the surface of the coating and provides a capacitive signal path if a flaw is located by the high voltage electrode.

The trailing signal return cable is able to operate because the Pulsed DC test voltage is changing, rising from zero volts to the pre-set test voltage, several kV, 30 times per second. This changing voltage means that a capacitor in the circuit will charge and discharge allowing current to flow. This is not the case with the Continuous DC power supply. A training lead on top of the coating will create a capacitor between the conductive substrate and the un-insulated cable conductor with the insulating coating acting and the dielectric in the capacitor.

It is also the case that the energy in the Pulsed DC system is contained within the short duration pulses and therefore the test voltage can be maintained on a slightly conductive coating. The system is monitoring for a significant release of energy through a flaw and can ignore the lower energy released by dirt or moisture on the coating. The alarm circuit is set to ignore these stray currents and only react to the significant pulses of energy in the signal return cable.

It should be noted that the capacitive effect that provides the connection through the trailing lead also has an influence on the choice of test electrodes. The capacitive loading of a particular electrode design is affected by the size of the electrode and the thickness of the coating to be tested. In some cases, a large electrode on a thin coating can provide a significant capacitive loading to the pulsed high-voltage power supply making it appear that the electrode is constantly finding flaws. A smaller electrode will normally solve this problem.

Good quality control procedures will provide for the monitoring of the surface preparation processes, the climatic conditions at the time of the application and the process outcomes, such as wet film and dry film thickness, porosity, adhesion and where appropriate appearance, colour, gloss, etc. The issue for the client is the provision of evidence that these monitoring or inspection processes have been carried out correctly and ensure the best quality outcomes consistently.

Figure 8: The gauge selection screen showing the major gauge options.

Figure 9: A single page data report showing a run chart.

This is leading to increased demand for detailed reports on the individual stages of the coating process rather than the simple pass/fail statements of the inspector that has prevailed in the past. Often the "evidence" has been a list of hand-written values recorded in the inspector's logbook for the day that the work was carried out.

Some of the coating process inspections can be carried out using digital gauges and therefore inspection areas can be associated with batches of readings and these provide good evidence of the work and the outcome. Other inspection processes are only possible using manual gauges where the Inspector has to note the result. For example, the Bresle Salt Contamination Test according to ISO 8502-6 and ISO 8502-9 produces a result on a gauge without data output capabilities. There are also a group of inspection tasks that rely on the expertise and experience of the Inspector and these are assessed against visual standards or guides, such as the Swedish Rust Standard (ISO 8501-2) or the SSPC VIS 1 guide and reference photographs. The results of these inspections will be a simple pass/fail statement against the specification, for example does the surface preparation meet the Sa 2½ rating as defined by ISO 8501-2 or alternatively the commercial blast grade described in SSPC VIS 1.

The problem is therefore, how can good evidence of the inspection results for coating processes be provided without adding considerable cost to the process?

The Data Management Solution

The answer to the need for a cost effective evidence trail for coating inspection processes is in the planning of the inspection tasks and the recording and presentation of the inspection results. This is commonly called "Paperless QA" and relies on computer software solutions.

There is a new development in the software available for managing and reporting inspection data in the industrial environment. Software has now been developed to operate in either standard mode to facilitate data transfer, data viewing and simple data reports, or in the extended mode, which also provides further analysis with combination of batches of data and inspection templates and customised report creation.

The software has several language sets for the messages, instructions and menus so operation in the international environment is simplified. For example, the software can be set up for Spanish, French or German operatives with similar menus in Spanish, French or German on the digital gauges that link to the software.

The software opens with the data download screen, which allows the selection of a range of inspection gauge types. These include dry film thickness gauges, a coating hardness tester, an appearance gauge (Glossmeter), material thickness gauges (Ultrasonic Gauges), surface profile gauges and a climatic monitoring gauge.

The data transfer can be achieved using Bluetooth® wireless data transmission, USB data cable or the RS 232 serial data cable depending on the capability of the

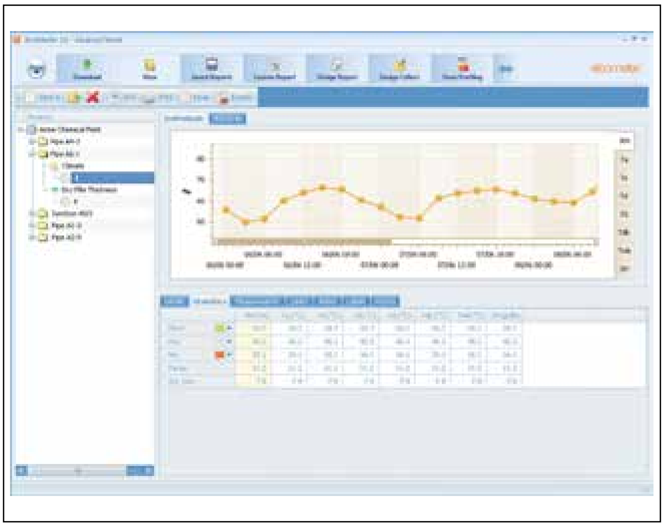


Figure 10: An example of the statistics page for climatic data.

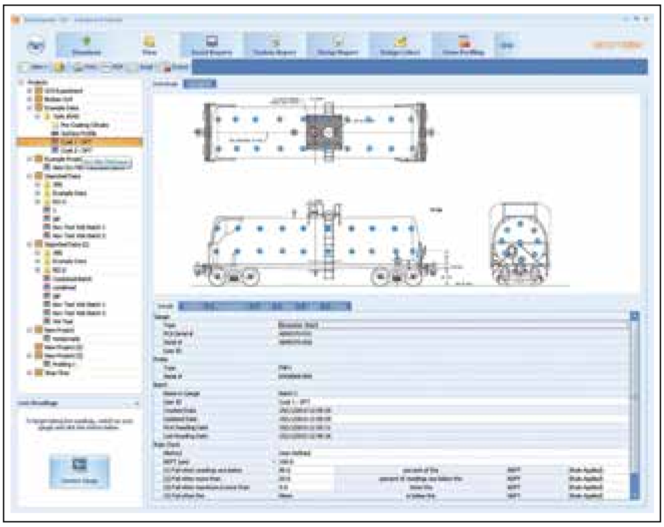


Figure 11: A single page coating thickness report form with inspection template.

gauge and the computer being used. The data transfer and other software features are supported by a "Wizard" to simplify and speed the process, with on screen instructions for clarity.

The software has a top-level folder in the directory, which is called "Project". This can be used to identify the work item for which the inspection data is being collected. In this way data from different gauges and different inspection stages can be linked together to eventually produce a single report on multiple inspection stages. Each project can have three project labels and five batch tags to facilitate grouping of data for further analysis, e.g. all the coating thickness readings on the night shift, etc.

Once data has been transferred from the gauge to the software, the view page offers the capability to see various charts compiled from the batched values, details of the batch (gauge information and statistics), reading limits, notes, labels and photographs.

Data from the different styles of gauges can be combined into a single report so that the surface profile data for a component can be seen alongside the climatic conditions at the time the paint was applied, with the climatic conditions during the cure process and the final film thickness data.

The SSPC Average takes groups of dry film thickness readings, normally three, and averages them in to a single reading, known as a spot reading. These averages readings are then grouped and averaged. This analysis is not valid for climatic reading sets.

Batches can be combined to form a larger batch for further analysis. For example, if a structure has been divided up into significant areas for inspection and each area given an individual batch number, a group of batches can be combined to determine the overall average value or the highest and lowest values, etc.

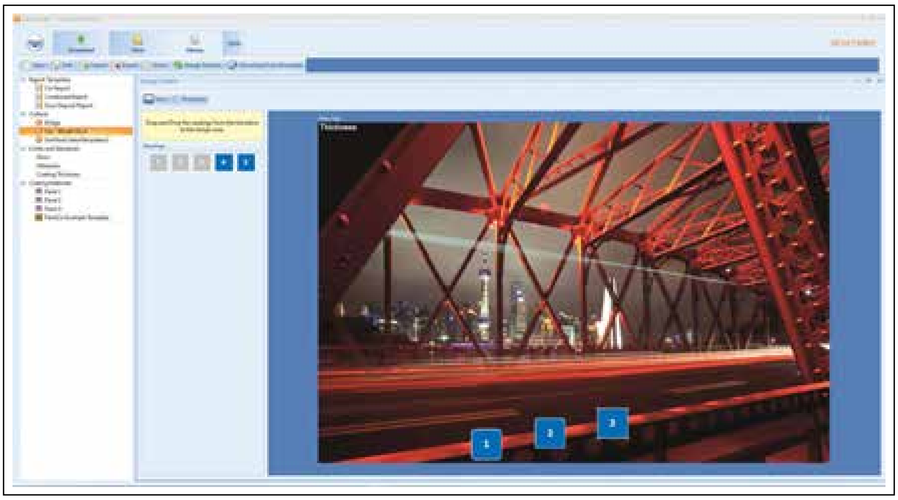


Figure 12: The template set-up showing the positioning of the reading sequence.

It is also possible to create templates so that with structured data collection the relevant readings can be shown against their location on the component for more detailed analysis. The positioning of the reading sequence can be set so that the operator can take batches of data with reading 1 in the same position for each component or part of the structure. This could be peak-to-valley profile readings on a plate or coating thickness readings on a beam.

Information can be printed, e-mailed or compiled as a .pdf file for reporting and it is possible to export the readings that have been downloaded to the software either directly into a Microsoft® Excel spreadsheet or into other spreadsheet formats using CSV (coma-separated values). The print command uses the computer's default printer. The e-mail command opens an e-mail message and appends the data report and the PDF command converts the report to the Portable Document Format (PDF) that allows two-dimensional documents to be represented in a manner, which is independent of the application software, hardware and operating system.

A recent innovation is the addition of "Cloud" computing to make it possible to share data files and reports by transferring them to the Internet via a cloud drive. The Cloud allows data to be transferred, stored and accessed through an Internet provider's hardware, without the need for a local computer. There are a number of Cloud providers such as

Dropbox, Amazon Cloud Drive, Google Drive, SkyDrive, etc. and these services can be accessed via the data management software using both personal computers and mobile Internet capable devices.

Imagine an Inspector working at a remote site with no access to a computer network, or a number of inspectors working at different places on a large site or even on different sites, all needing to communicate data to a central point quickly. It would even be practical for several inspectors at several sites in different countries with a client in yet another country to communicate quickly and simply using the cloud drive as a commonly accessed database resource.

The inspection measurements are taken on the structure and stored in the memory of the gauge. These readings are then transferred from the gauge to any Smart phone or tablet using Android via the Bluetooth™ communications and using the Android-based ElcoMaster™ Mobile software. This data can then be e-mailed to the Cloud. The specific Cloud drive is then accessed by any authorised device in any country on any continent to share the information, quickly, accurately and at a low cost.

Using these techniques inspection information to be shared instantly and therefore reporting time and costs are greatly reduced. Decision-making, based on good quality information, can be timely and accurate, particularly when re-working is indicated. At the end of a coating process, approval for the next stage can be quickly given, even when the client is at the other side of the world.

Bluetooth™ has been preferred to Wi-Fi for the ElcoMaster 2.0 application because it does not suffer from the requirement to dedicate the communication link to a single task such as data transfer from a gauge to a suitable device. For example, if Wi-Fi is used to transfer data to a Smartphone with the intention of sending it to the Internet, all other Wi-Fi connections on the Smartphone, such as to a Wi-Fi hub or to a Wi-Fi headset or to a Wi-Fi hands-free system, must be completely disconnected until the transfer is complete. The link to the Internet from the Smartphone then has to be re-established before the Cloud can be accessed. Bluetooth can be used for multiple communications simultaneously and is password protected for security. It is also the case that the current consumption of a Wi-Fi connection in a battery powered hand held gauge is very significantly higher than that of a Bluetooth connection.

The Cloud database offers a significant expansion in the way coating inspection data is transferred and viewed utilising equipment such as a Smartphone, which is already part of the travelling Coating Inspector's normal kit.

The Report Designer software feature is also available in the Extended Mode of the software and allows the User to create a customised report format specific to the client or the work in hand. The report can reference a single batch of data or multiple batches. The software uses a wizard to aid the setting up of a Report Design and each report has a unique name and description. The wizard will then request what type of data is to be included and how many batch of each type. Finally, the design page is displayed.

The report designer comprises of a design area, a list of pages, and a list of report items from which the design area is populated. The report item list contains a basic set of report items, such as a text box, an image, etc. These are dragged from the item list onto the design area, once dragged these can then be positioned and resized to suit.

In addition to the general report items, are items specific to the batch types, previously specified in the Wizard. Therefore, if the user specification for this report was for a single coating thickness batch, only the coating thickness readings, statistics & charts are dragged to the design area.

It is also possible for the user to click and drag the project, folder and batch labels onto the design area, alongside the batch & general report items.

Any relevant information modification appears above the selected item in the form of a toolbar. So with regards to text, the font & style can be changed, whereas with an image, the method used to re-size the image can be changed. Pages can be added and deleted from the report via the toolbar.

Institute for Work at Height (IWH) Guidelines

People falling from height, or being struck by objects that fall from height, result in more death and disabling injuries than any other occupational hazard. This is not only in South Africa but across the world in both developing and developed nations.

Documenting the fundamental responsibilities of employers will work to reduce the number of fatalities and disabilities caused in this way. These responsibilities can be broken down as follows:

- Developing, implementing, and continuously improving safe systems of work
- Providing safe access and egress to work locations
- Conducting continuous hazard and identification and risk assessment to confirm environments are safe and remain that way throughout every task
- Ensuring safe and compliant equipment is provided, maintained, and used correctly
- Confirming employees are competent to do the work expected of them and receive continual professional development

The purpose of the IWH guidelines is to provide people with the necessary basic knowledge to understand and make safe any task that is to be carried out at height. It was developed with input from several industry experts, in their individual fields, looking at ways of improving current practices and making work at height safer for everyone.

The scope did not focus on any one particular industry, such as construction or mining, but rather at anybody who, through the course of their work, is required to be in an elevated position and at a risk of falling. An elevated position is considered to be a position from where a person could fall a distance liable to cause personal injury, into, off of or on to.

The guidelines aim to provide suitable and sufficient content to allow informed decisions to be made whilst applying duties of care. Take a step back, before work commences to ask, 'have we done enough to safeguard ourselves and others?' is paramount to successfully working safely at height as well as carrying out any activity in a safe and controlled manner.

Accidents, near-miss events, and dangerous occurrences must be part of the overall planning of safe Work at Height. All companies should have policies and procedure in place for reporting accidents and should always follow the stated protocols and reporting methods, ensuring the employer is notified immediately. In addition, the accident scene should never be tampered with until so authorised by the employer, unless to save life or prevent further harm.

Rescue guidelines must also be an integral part of the plans and procedures. Looking at the probability of how harm will occur will provide the best insight into necessary equipment and methods required for potential rescue. Carrying out training and drills, with the people involved with rescue teams, will further assist in achieving the ultimate goals.

What is Covered in the Guidelines?

- **Competency of Work at Height Personnel**
  - What is Competence?
  - Training Provider Selection
  - Misrepresentation of Qualifications
  - Registration with the Professional Body
  - Continual Professional Development

- **Fall Protection Plan**
  - The Construction Regulations 2014, CR10 (a) – (e), states that 'any work where there is a fall risk will need to have a Fall Protection Plan in place'. Section 18 (2) (b) goes on to state that 'should rope access be performed then a site-specific Fall Protection Plan will be needed'.

- **Steel Scaffolding**
  - Steel Scaffolding is a temporary structure constructed from approved and tested components, that are erected and used to support a crew of workers and/or material to aid in the construction, maintenance and repair of buildings, bridges and other man-made structures.

- **Falsework**
  - Falsework consists of temporary structures used in construction to support a permanent structure until its construction is sufficiently advanced to support itself. Falsework combines the use of Support Work and Formwork

to achieve this goal. For a better understanding, the explanations of these terms are provided below.

- **Access Towers**
  - An access tower is an effective and efficient method of working and is one way to prevent a fall when working at height. The type of access tower selected must be suitable for the work and comply with SANS 51004. This covers freestanding mobile access and working towers, made of prefabricated elements, to a height of 8m when used outdoors and 12m when used indoors. This is due mainly to potential wind factors that could be exerted onto the tower.
- **Ladders**
  - Ladders are the most common found access method when working at heights but the risks are often not considered, due to their ease of use and unregulated supervision. Ladders are generally used for light work, done over a short period of time and are used in all industries, not just construction.
- **Mobile Elevating Work Platforms (MEWP)**
  - MEWPS, sometimes referred to as "aerial platforms" are mechanical devices used to provide temporary access for people, tools and equipment at elevated work positions.
- **Suspended Access Equipment**
  - Suspended access equipment (SAE) refers to equipment, machinery, platforms, or other devices (including all rigged components) that are suspended by support lines and are used by workers to gain access to the sides or high-angle surfaces of buildings or structures.
- **Rope Access**
  - Rope access is a method of working at height, typically using synthetic fibre kernmantel ropes and associated equipment, used to gain access to, be supported at and as a means of egress from a place of work. Hauling and lowering systems cannot be the same set of working ropes that the worker is suspended on but must be its own set of separate ropes anchored on its own points.
- **Fall Protection**
  - Fall protection is the use of controls designed to protect people from falling or in the event they do fall, to stop them without causing severe injury.
- **Prevention of Falling Material(s)**
  - Handling materials on the ground is physically strenuous with some items are unwieldy and difficult to handle, unless people are trained correctly.
  - Operatives have to be able to adopt manual handling skills, when handling materials at height, sometimes from temporary platforms, to reduce the fatigue and possible dropping of materials.
- **Steel Erection**
  - Structural steel erection requires that a person work in a fall risk position. All the steps required for any safe working at heights exercise, as covered elsewhere in this document, should equally apply to steelwork erection.
- **Roof Work and Fragile Roofing**
  - According to Construction Regulation 2014 Regulation 10 (5) all contractors must ensure that when roof work is undertaken all openings or fragile covers are protected in a material that is strong enough to withstand the loads that it will be expected to carry and that suitable and enough guard- rails, barriers and toe- boards or other means

are installed or used to prevent the fall of any person, material or equipment (Reg. 10 (5) (d, e, f)).

- **Lift Shafts and Floor Openings**
  - A building shaft is a continuous vertical space substantially enclosed on all sides that extends for two or more floors, and includes elevator shafts, ventilation shafts, stairwells and service shafts.
  - A floor opening can also be an opening or hole in a platform, pavement or yard that measures 300mm or more in its smallest dimension.
  - Unprotected openings in floors and shafts are serious hazards and put employees at risk of injury from falls. Covers and guardrails are used as common forms of protection.
- **Penetrations & Risers**
  - Penetrations, risers, shafts, and voids or whenever openings exist, which could result in a fall of workers or materials and must be protected by robust physical barriers and warning signs.
  - Penetrations and risers fall within the scope of Construction Regulation 10(4) (a) and similar legal requirements apply as covered in the Section "Lift Shafts and Floor Openings".
- **Use of Stilts in an Occupational Task**
  - Basic steps to ensure the correct use of stilts are followed and by trained personnel.
- **Confined Space**
  - The Occupational Health and Safety Administration defines a confined space as being made up of three parts:
    - Being large enough for an employee to enter and perform work;
    - Has limited or restricted means for entry or exit; and
    - Is not designed for continuous occupancy.
  - These are areas not designed or intended to be occupied by people but may need to be for maintenance or cleaning work. It is always recommended in the design of a confined space structure that there is an entry and exit point, separate to each other, however this is not always the case and must be factored in when assessing the risks.

- **Wind Energy**
  - The wind energy sector is currently one of the fastest growing sectors. Although general methods of fall arrest and rope access are applied to accessing a wind turbine to work at height, there are specialised standards established by the Global Wind Organization (GWO) to ensure the work on, and in wind turbines, are regulated and remain same for all.
  - In order for a person to work legally in the Wind Turbine/Wind Energy Sector training against the GWO standard is required. This DOES NOT replace the already accredited training that is offered for work at height access, but rather needs to be seen as an additional component, which is specific to the wind industry and forms part of standard practice.
- **Maritime/Ports**
  - Maritime has historically not been included in legal aspects of the Occupational Health and Safety Act, as they are governed by their own special set of laws and regulations. However, there are work at height activities that occur in the maritime environment, that the Working at Height Guidelines sections would apply to.
- **Stage and Theatre**
  - The nature of theatre involves some special hazards, including safety hazards, fire hazards, working at height, and chemical hazards. Backstage crew, performers, and sometimes even the audience can be at risk.

The ultimate goal is to prevent accidents, save lives and reduce the number of working at height events that cause death, disabling injuries and suffering damage.

Fitness for Service – A Quest for Asset Integrity

Structural integrity of the pressurized components in operating, process, or petrochemical plants are of great importance in ensuring continued safe operation and at the same time ensuring the safety of the personnel. Numerous service induced deteriorations and failures happened due to the existence of corrosive & aggressive chemical components (e.g., CO2, H2S, and etc.) in various industrial sectors, e.g., oil and gas, nuclear and petrochemicals. Commonly existing defects in pressure containing components and associated structures are crack-like flaws and mechanical or material damages. Damage mechanisms being found in processing or operating plants are categorized into following categories[1]:

(i) Mechanical and metallurgical failures (e.g., graphitization, softening, etc.)

(ii) Uniform and localized reduction in thickness (e.g., general corrosion and pitting)

(iii) High temperature corrosion (e.g., oxidation, sulfidation, metal dusting, etc.)

(iv) Environmental assisted cracking (e.g., sulfide stress corrosion cracking, hydrogen induced cracking, etc.)

In order to guarantee operational safety along with structural integrity, all of these defects need to be identified and assessed properly. FFS assessment itself is a quantitative engineering calculation of operational components. In practice, FFS assessments are piloted periodically in order to govern the suitability of in-service components and structures for continuous service. Comprehensive evaluations are generally carried out in an effort to schedule periodic inspections, and at the same time estimating the remaining life of the component. There are various FFS assessment approached which uses various parameters to assess the condition of the assets. In case if the outcome of the assessment stipulates that the equipment is suitable and safe for the current service operation, then the asset is supposed to operate in service by assuring that the that appropriate inspection and monitoring plans are well in place. Otherwise, the equipment should be either considered for rerating, repair, and/or replaced depending upon the calculations provided in API 579/ASME FFS-1[2,3].

FFS assessments are conducted in three levels[4]. Level 1 having the most conservative approach, whereas level 3 having the most sophisticated assessment approach that yields more accurate results compared to the results taken than those from level 1 and 2 assessments. In conclusion, each level of FFS assessment provides a degree of equilibrium between the degree of conservatism, the skill level of the practitioner, and the complexity of the investigation. The acceptance criteria irrespective of the level of FFS assessment is one or more of the following[5]:

- **Allowable stress:** using linear elastic stress analysis and it is based on the calculation of the stress (loading condition and so on) and comparing the calculated stress in an assigned category or class to an allowable stress value.
- **Remaining strength factor:** using non-linear stress analysis.
- **Failure Assessment Diagram (FAD):** which is used for crack-like flaws in pressurized components.

Case Study

During annual shut down, the surface of the Turbine Condenser was assessed for Residual Life Assessment (RLA). Since the unit was already of production, it was quite easy to perform the various tests at the surface of the condenser, and it gave an opportunity to also inspect the inside surfaces of the condenser shell. The condenser carried steam condensate.

The planned scope of work consisted of covering the following areas systematically:

- Collection and review of engineering, design and operating data
- Collection and review of inspection history data
- Review, validate and update existing potential damage mechanisms and corrosion loop drawings
- Calculation of corrosion rates and remaining life
- Fitness for Service (FFS) study of selected equipment and piping systems.
- Review, validate and update existing RBI Assessment
- Recommendations to improve condition of equipment for future operation

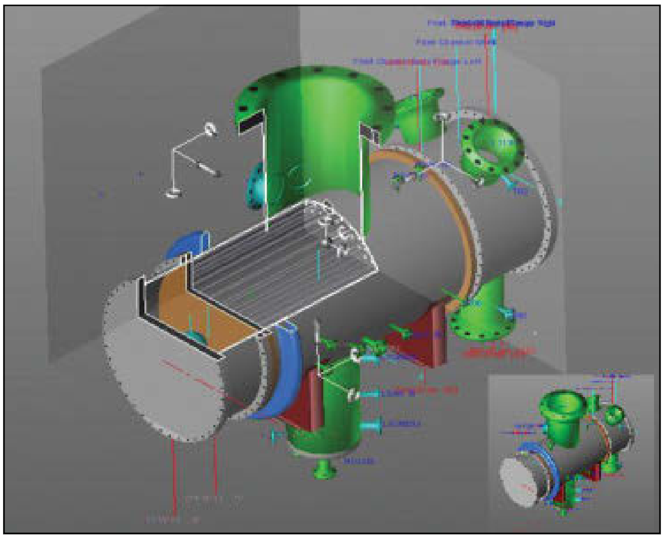
Various engineering data were collected from the plant site for RLA assessment which included piping and instrumentation diagrams (P&ID's), process and flow diagrams (PFD's), general arrangement

Design Verification as per ASME SEC VIII, Div. 1 (PV Elite Software)			
Description	**Design Code**	**Evaluation**	**Conclusion**
Case-1 (Design Verification)	ASME Sec VIII Div.1	Design Analysis 0.1259" CA as per ASME Sec. VIII Div.1 (PV Elite software)	Results found acceptable

Design Verification as per ASME SEC VIII, Div. 1

General Metal Loss Assessment as per API 579-1 / ASME FFS-1			
Description	**Design Code**	**Evaluation**	**Conclusion**
Case-2 (General Metal Loss)	API 579-1 / ASME FFS-1	API 579-1/ASME FFS-1 2007 Part 4- General Metal Loss, Level-I Analysis	Results found acceptable

General Metal Loss Assessment as per API 579-1 / ASME FFS-1



Design verification (PV Elite software).

(GA) drawings, data sheets, operating manuals and procedures and engineering design documents.

Numerous inspection data elements, for example, visual inspection reports, ultrasonic testing, magnetic particles inspection, dye penetrating testing, radiography testing, failure analysis reports and metallographic reports of equipment and piping systems, were received and reviewed. Remaining life was calculated based on the corrosion allowance and latest thickness measurements reports. Measured corrosion rates (MCR) were calculated based on the available inspection thickness results of the condenser.

The remaining life assessment concluded there was a metal loss defect. Therefore, the equipment was further assessed for Fitness for Service (FFS) per criteria given in API 579. This assessment was performed to make re-rate / repair / retire decisions.

It was observed that metal loss in shell side of the turbine condenser has already failed the criteria given in API 510[6]; because of this the shell side was further assessed with API 579. As per the inspection history provided by the client and API 579 *Table 2.1* & *Figure 2.1*, metal loss was identified as the flaw type for which the associated Part-4 (General Metal Loss) assessment was performed.

The approach adopted for evaluation of these assets followed the eight-step methodology defined in API Recommended Practice 579-1/ ASME FFS-1 2007:

- **Step 1** - Flaw and damage mechanism identification.
- **Step 2** - Applicability and limitations of the fitness for service assessment procedure.
- **Step 3** - Data requirements.
- **Step 4** - Assessment techniques, acceptance criteria and Results.
- **Step 5** - Remaining life evaluation.
- **Step 6** - Remediation.
- **Step 7** - In-service monitoring.
- **Step 8** - Documentations.

According to API 571 (Damage Mechanism Effecting Fixed Equipment in Process Industries), Turbine Condenser with steam at shell side, service is susceptible to the following damage mechanisms:

- Erosion/erosion-corrosion
- Boiler water / condensate corrosion

The remaining life assessment of the Turbine Condenser was performed in accordance with following codes by using PV Elite 2015 software and spread sheets:

ABOUT THE AUTHOR

Syed Umair Niaz Bukhari is a corrosion researcher and asset integrity professional with more than 9 years of diversified experience focused on asset integrity management, coatings, corrosion, and risk-based inspections. He currently serves as senior engineer for corrosion and asset integrity related projects in Bureau Veritas, UAE. He has published numerous articles and papers in various internationally recognized journals and magazines. Along with his bachelor's degree in Mechanical Engineering, Syed is a Chartered Engineer from Engineering Council, UK. He also holds API certifications in Pressure equipment inspections (API 510), Process piping systems inspections (API 570), welding and metallurgy (API 577), and risk-based inspection (API 580). Syed has an active affiliation with various corrosion management related bodies such as NACE (National Association of Corrosion Engineers), API (American Petroleum Institute), IMechE (Institute of Mechanical Engineers), TWI (The Welding Institute), and ICORR (Institute of Corrosion UK). Syed is also a NACE certified Senior Corrosion Technologist. He can be contacted at: um_niaz@yahoo.com.

- ASME Sec VIII Div.1[7].
- API RP 579-1/ASME FFS-1 2007 Part 4 Level-I (Fitness for Service).

The fitness for service assessments that have been completed using the most recent inspection results showed that the equipment was fit for service in its current condition. Although this study has focused on defect analysis, it is acknowledged that there are other failure mechanisms that can influence overall equipment integrity including, but not limited to, abnormal operating conditions (upset), third party damage and any other defects (non-assessed) in the equipment. It should also be noted that this result is only valid for the assessed defects (as per the inspection report) when the equipment is operated within the specified design operating and service conditions. It is important to remember that the results of this FFS assessment are valid only if:

- It is considered that the fabrication, welding and commissioning of the component were as per design and appropriate procedures/ qualifications were complied.
- The vessel was operated within operating range without any variation
- The region of metal loss has relatively smooth contours without notches (i.e. negligible local stress concentrations).
- The component is not in cyclic service: component subjected to less than 150 cycles (i.e. pressure and/or temperature variations including operational changes and start-ups and shutdowns) throughout its previous operating history and future planned operation
- The component is not in creep regime.

Conclusion

- Extensive regular monitoring by visual inspection and UT scanning techniques should be in-place, to check for defects (metal loss, crack etc.) in the component.
- Regular inspection of the supports should be carried out and the values to be documented accordingly.
- Implementing RBI for these types of scenarios doesn't necessarily demand costly tools and outsourcing; rather it can be a simple, qualitative effort done by in-house reliability and corrosion personnel.
- Finally, using an RBI approach (even qualitative) at all levels of an inspection and testing plan's development and implementation is an important step toward the organisational goal of a facility's operation.

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The 2021 IMPACT Canada Study

Helping to Bring About Cultural Change in Canada and Throughout the World

By Rebecca A. Bickham

After having seen the NACE International (now AMPP) 2016 International Measures of Prevention, Application, and Economics of Corrosion Technologies (IMPACT) Study, the International Union of Painters and Allied Trades (IUPAT) reached out to AMPP in regard to conducting a similar country-specific study in Canada. IUPAT partnered with NACE Northern Area to become the two major sponsors on the project. The study was conducted over six months and was completed in April 2021. The key purpose was to foster coordination between government and industry to change the mindset about corrosion mitigation being the sole concern of materials and corrosion engineers and those that maintain corrodible assets.

"After the global study, there was a huge amount of interest on particular regions," explains Monica Hernandez, Country Manager for the IMPACT Canada Study and CEO of Infinity Growth Corporation, Vancouver. "Canada has its own climate, and different industries, so there was an interest from industry in knowing how we were represented as a country. I think that was the first steppingstone and what motivated the subsequent steps."

This initiative will help industry understand the financial and societal impacts of corrosion on various industry sectors across Canada. Four sectors were examined – energy, transportation, manufacturing, and mining. These sectors were chosen because of their large size based on gross domestic product (GDP), and the mining sector in particular was chosen, not only based on its size, but the fact that they were far behind in terms of their corrosion practices.

Information found from these industry sectors will aid in identifying opportunities for the public and private sectors to improve corrosion management across the lifecycle of their assets. The cost of corrosion on Canada's bridges, buildings, pipelines, and all major infrastructure is enormous. These costs may seem invisible, but governments, private industry, and all Canadians are all paying the price of industrial deterioration. In fact, the cost of corrosion in Canada is estimated to be $63.26 CAD ($51.9 billion U.S. dollars) annually, which represents nearly 3% of Canada's GDP. It is estimated that 15 to 35% of this cost could be saved if all available corrosion mitigation techniques were utilized and applied. For Canada, this would equate to $7.8 billion to $18 billion.

"Technology helps us invent coatings, and nanotechnology, and new things – but if we don't invent anything new, if we don't learn anything, if we only use the resources we have right now, the learning we have right now, the people we have right now – we can reduce that cost 15 to 35%," says Hernandez. "So why are we not doing it?"

The 2021 IMPACT Canada study also provides a means for government and industry to coordinate on best practices for corrosion management and planning in diverse industry and municipal sectors. For several decades, business leaders and asset-owner organizations have considered the practice of corrosion prevention and control as the sole responsibility of materials and corrosion engineering experts, practitioners, and maintainers within their organizations. However, the risks associated with aging infrastructure are prevalent and costly, so now it is incumbent upon corporations to assess a broader array of financial risks by placing value on potential corrosion-related consequences and failures. Business decisions should be optimized so that those who develop budgets consider financial gains that inevitably result from investing in corrosion control.

Although the study took place in Canada, it can be helpful for other countries as well. "Other countries will be able to take information from the study and say, 'I wonder how we compare?'" says Elaine Bowman, past president of NACE International. "It's already generated discussions with other countries to do very similar studies as well." Another country can take the data from the report and get an idea about how they compare as far as spending, how different industries are performing, and how much work needs to be done and in what areas.

Corrosion Management Systems

A corrosion management system (CMS) is the documented set of processes and procedures required for planning, executing, and continually improving the ability of an organization to manage the threat of corrosion for existing and future assets and asset systems. To lower the cost of corrosion and increase safety, corporations in Canada must adopt robust CMSs. This process will require them to fundamentally change their corporate cultures to the extent that asset integrity becomes a core value as critical as safety management. Such a significant cultural change must flow from the top to the bottom levels of each business organization. Asset owners in Canada should also recognize that a strong CMS guarantees a greater return on investment.

"A big motivator was to increase the knowledge for regulators," says Bowman. "Perhaps they would put into place that when you design a highway, or bridge, or the assets that the government is helping to pay for – that you were including corrosion management aspects of that in the planning."

The study revealed the importance of changing cultural mindset to include corrosion management as part of an organization's strategic planning. Doing so would increase return on investment (ROI) related to industrial assets, while also increasing protection of the public and environment. Adopting more robust corrosion management practices, including plans for addressing corrosion across the entire lifecycle of an asset, would help reduce the staggering cost of corrosion. Advancing corrosion knowledge and training to create a skilled workforce via Canada's educational network and corrosion-focused training bodies, such as technical societies, is another way to strengthen efforts by companies seeking to implement a successful CMS framework. A comparison of CMS to other organizational management systems can be seen in *Figure 1*.

Key IMPACT Canada Study Findings

The AMPP study team examined nine management system domains to determine how Canada's energy, manufacturing, mining, and transportation sectors implemented corrosion management practices across the asset lifecycle, during the phases of design, manufacturing and construction, operations and maintenance, and abandonment. The team also explored benchmarks on sustainability.

The energy, manufacturing, mining, and transportation participants excelled at integrating certain corrosion management processes, while showing the need to improve upon the policies, resources, organization, accountability, and communication components that can impact asset preservation and return on investment. Businesses in Canada that simply excel at managing corrosion at the design or manufacturing stages have significant room to improve compared to global participants from the 2016 NACE IMPACT Study.

The following sections will include details and additional key findings from each sector plus sustainability.

Canada's Energy Sector

Within the continuous improvement domain, energy companies signal, by a large margin, that formal organizational management of change processes do exist. In the CMP integration area, numerous energy businesses attest to the fact that their corrosion management processes include risk management. In the domain of resources, however, Canada's energy sector is challenged across the entire lifecycle of asset preservation. At the policy level, corrosion management is not emphasized across the lifecycle, but it is seriously considered during the asset design strategy phase and the operations and maintenance stages of asset preservation. This result stems from the fact that leadership does not view corrosion management as an enterprise-wide pursuit.

Canada's Manufacturing Sector

This sector exhibited three areas of strength related to the commitment to corrosion management: accountability, continuous improvement, and stakeholder integration. But in the domain of policy, Canadian manufacturers must improve by developing a corrosion management strategy across the entire lifecycle of asset preservation, including at the design, manufacturing and construction, operations and maintenance, and abandonment phases. Manufacturers would benefit from better communication of their corrosion management processes and better alignment of their corrosion management processes and tools with their health, safety, and risk management disciplines.

Canada's Mining Sector

In the realm of CMP integration, mining sector participants included risk management as one of their corrosion management processes, a significant strength. Participants also reported that corrosion control practices are designed into their systems and solutions, another strength. Whereas the domain of organization posed a significant challenge across the entire lifecycle of asset preservation among mining industry participants, the study team found that corrosion professionals did interact with colleagues in the design organization, within operations and maintenance groups, and among asset abandonment experts. Two other challenge areas for mining sector participants fell within the domains of accountability and resources across the entire lifecycle of asset preservation.

Canada's Transportation Sector

Throughout the lifecycle of asset preservation, researchers noted that within the domain of CMP integration, survey participants feel that their corrosion management processes are well-communicated. Participants also included risk management as one of their corrosion management processes, a notable

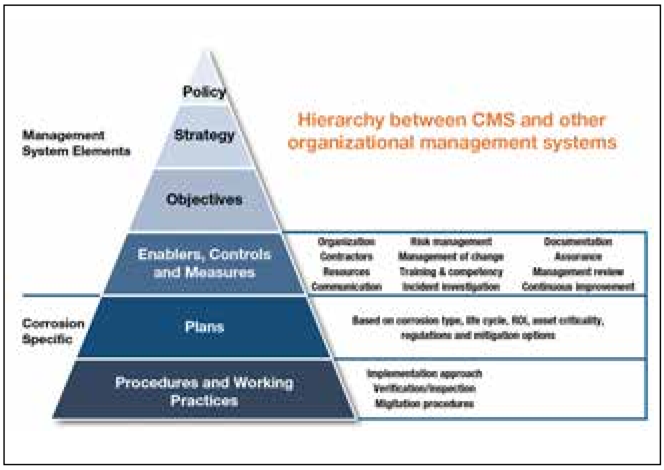

Figure 1: Corrosion management pyramid comparing CMS to other organizational management systems.

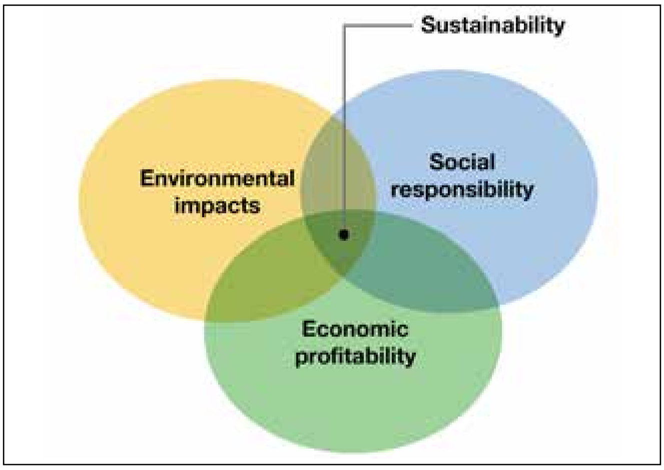

Figure 2: Extending the lifecycle of a corrodible asset through better corrosion management practices ensures organizations are operating in the most sustainable manner possible.

strength. As regards performance measures, participants excelled in that their corrosion management systems resulted in the lowest corrosion cost over the intended life of the asset. These companies excelled at monitoring and reporting corrosion management performance.

Sustainability

Material sustainability refers to the way materials are sourced, processed, and manufactured into products, and then maintained through the product lifecycle and redirected at their end of life.

Canada's business culture reflects a commitment to sustainable business practices at the design and manufacturing and construction stages of the asset lifecycle. However, compared to countries who participated in the 2016 NACE IMPACT Study, Canada falls behind in its ability to integrate corrosion management planning across all four stages of an asset's lifecycle.

Close to 70% of study participants considered material sustainability during the operations and maintenance phase of asset preservation, a noteworthy strength. More than 60% of those surveyed reported that they promoted sustainability during the design phase of an asset's lifecycle. However, fewer than 48% of Canadian companies cite sustainability as a corrosion management priority. Canadian asset owners suggested that their corrosion management processes would greatly benefit from more robust sustainability policies and strategies at all organizational levels and throughout an asset's lifecycle.

Extending the lifecycle of a corrodible asset through best practices in corrosion management ensures organizations are operating at optimum sustainability *(Figure 2).*

Embracing Enterprise-Wide Corrosion Management – Cultural Mindset

Those who worked on the study say they hope there is a cultural change within companies and industries. Recognizing that Canada's government, industry, and academic realms have strong corrosion prevention regulations, standards, and training in place, the IMPACT Canada report reviews the merits of Canada's pipeline regulations, the strength of current standards and where they can be improved, and the rich array of education and training programs supported by academia, government, and industry.

To improve upon its current strengths in these areas, all asset-owner companies must shift their corporate cultures toward successful corrosion management from top to bottom, establishing it as a norm analogous to today's safety management culture. Such a shift necessitates a cultural change that must flow from top to bottom. To bring about change, businesses must translate their corrosion practices into the language of their broader organizations. The report also explores useful management and financial tools such as IMPACT PLUS, which can help companies build a corrosion management system and integrate it within their existing systems.

"[The IMPACT Canada report] validated that there needs to be a cultural mindset – a change within companies," says Bowman. "Perhaps you have to spend more upfront, but over the lifecycle of the asset, your ROI is going to be better. There needs to be a change in the mindset that, even though it might cost more upfront, you're going to recoup that."

Corrosion mitigation is not relegated to just the concern of corrosion engineers and those who maintain corrodible assets but is the responsibility for all within an organization who design, build, operate, or maintain an asset. There must be a change in the existing cultural mindset, so corrosion management is included as part of an organization's strategic planning as a method to increase ROI related to industrial assets while also increasing protection of the public and environment.

Bowman says the IMPACT Canada report has already spurred interest from other countries in conducting their own similar country-specific report. In fact, AMPP is currently in discussions with Australia and some of the Latin American countries.

The 2021 IMPACT Canada study is fully accessible online. It can be found on the AMPP web site (ampp.org) and the IUPAT web site (iupat.org).

For questions pertaining to the IMPACT Canada Study, contact Monica Hernandez, email: monica@infinitygrowth.can.
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a.b.e. Has Wide Range of Product Solutions for Concrete Repair and Protection

a.b.e. Construction Chemicals, a major supplier of specialised construction products, has for many decades supplied a wide range of products for the construction and maintenance of essential civil engineering infrastructural facilities throughout South Africa.

a.b.e. – established 91 years ago – is part of Saint-Gobain Africa.

a.b.e. supplies a wide range of products – as well as professional advice – on many aspects of infrastructural maintenance and construction, covering aspects such as concrete crack injection, fairing, reprofiling, priming, mortar repair, and the rehabilitation of spalled concrete surfaces all of which could save the owners and municipalities millions of rands.

Among a.b.e. products widely used include:

- epidermix 389 and 395 for concrete crack repairs;
- durarep ZR for the treatment of steel reinforcement bars;
- epidermix 344 as an epoxy primer;
- durabond GP and duralatex for acrylic priming/bonding;
- durarep FMC, durarep FR, and durarep FC for cementitious repairs; and
- duracote WB and durasil SH protective coatings.

epidermix 389 is a solvent-free, low-viscosity modified epoxy injection compound to fill cracks, while **epidermix 395** is the ideal product for fixing starter bars, or bolts, vertically down into concrete or rock. The fast-setting product is also suitable as a flowable grout or bedding for areas with awkward access.

durarep ZR (zinc-rich) is a single-component liquid epoxy resin, enriched with metallic zinc, that offers excellent corrosion protection properties, particularly for the rebar in concrete infrastructure.

epidermix 344 is a solvent-free, polysulphide-modified epoxy adhesive, particularly suitable for bonding fresh (plastic) concrete to existing concrete, and cementitious repairs to concrete structures where structural integrity is critical.

Fishwater Flats

Olifants river bridge

durabond GP (general purpose) is used as a primer/bonding medium for repairs to concrete elements while **duralatex** is a synthetic resin polymer designed to improve the qualities of site-batched cementitious mortars and slurries.

a.b.e. durarep high strength mortar range is widely used for structural cementitious repairs. **durarep FMC** (fluid micro concrete) is a non-shrink concrete reinstatement grout with a migrating corrosion inhibitor; and **durarep FR** (fibre reinforced) is used for vertical, overhead and honeycomb repairs. **durarep FC** (fairing compound) is a thin film coating to aesthetically enhance and smooth concrete and masonry surface imperfections and blowholes which are not trafficked.

a.b.e. also supplies protective coatings such as **duracote WB**, a flexible aliphatic acrylic polymer coating with high crack bridging properties and acts as a contaminants barrier; and **durasil SH**, a highly effective water repellent with hydrophobic properties to protect concrete against chlorides and carbon dioxide ingress.

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World Corrosion Awareness Day

Galvanized Reinforcement for Corrosion Protection in Concrete PART 1

By: Professor Steven R Yeomans

Recent Developments and Future Opportunities

In February 2010 Prof Stephen Yeomans was invited to South Africa as a guest of the IZA in support of the HDGASA and conducted countrywide presentations on the merits of using hot dip galvanized steel reinforcement in concrete structures.

Following the tour, *Hot Dip Galvanizing Today*, the HDGASA's official voice piece published a series of articles extracted from Stephen Yeomans book *"Galvanized Reinforcement in Concrete"* published by Elsevier in 2004.

Stephen has kindly provided *Corrosion Exclusively* with an update on these articles, which we have serialized and will publish over the next four editions of *Corrosion Exclusively.*

Abstract

This chapter updates the 1st Edition chapter of *"Galvanized Reinforcement in Concrete"* published by Elsevier in 2004, by including further information on recent developments and new opportunities for galvanized steel reinforcement. The chapter covers the general characteristics, performance and use of galvanized steel reinforcement in concrete construction. Both traditional galvanizing by hot dipping, so-called batch galvanizing, and the recent development of continuous coating of reinforcement will be discussed and differences in the morphology of the zinc coating will be explained. The following sections discuss the behavior of zinc in concrete including the reaction of the zinc coating in alkaline environments and the passivation of zinc, as well as carbonation resistance and chloride tolerance of galvanized steel in concrete. There is also discussion of design considerations for galvanized reinforced concrete including bond-slip considerations and typical applications of galvanized reinforcement, and brief coverage of the duplex coating of reinforcement.

Keywords: *Galvanizing, hot dipping, continuous coating, passivation, carbonation, chlorides, design, bond strength, applications.*

Introduction

The corrosion of steel reinforcement in concrete is a worldwide problem that impacts the long-term durability and serviceability of concrete construction. Should the reinforcement corrode, this may have serious consequences on the longevity of the component or structure that in turn affects both the environmental sustainability of a project as well as its economic viability.

While the provision of good-quality concrete is fundamental to ensuring adequate durability of concrete and primary protection of the reinforcement, the galvanizing of reinforcement (i.e. coating with zinc) provides additional corrosion protection to embedded steel in the event of a lack of durability of the concrete due to inappropriate materials choices and/or poor workmanship and site practices, and also where long maintenance-free life is required. From its first reported use in the United States in the 1930s, galvanized reinforcement has been widely used since the mid-1960s in many types of concrete construction in a variety of exposure conditions.

Galvanizing provides multi-faceted protection to reinforcement and other embedded steel in concrete (Yeomans, 1994). In addition to providing both barrier and sacrificial protection to steel, the zinc-rich coating is essentially immune to the effects of carbonation of concrete and has a higher tolerance to chlorides than black steel. The result is a delay in the initiation of corrosion of the zinc should aggressive species migrate to the depth of the reinforcement, after which continued corrosion of the zinc layers is required over an extended period before the underlying steel is exposed. The combined effect is a significant extension of service life over black steel reinforced concrete; a key factor in the sustainability of concrete infrastructure where 50 - 100 year design lives are now commonly required.

In this updated chapter, a review is presented of the nature, characteristics and performance of galvanized coatings for concrete reinforcement. This will focus on the hot dip galvanizing (HDG) of steel reinforcement, sometimes called 'batch' galvanizing, for which there is an extensive published record of laboratory-based research and field studies of existing structures, some more than 40 years old. Detailed reviews of this topic have been published by ILZRO (1981), CEB (1992), Yeomans (2004a) and FIB (2009). Reference will be made to these reviews where appropriate, along with recent research.

Also discussed is the newer technology of the continuous galvanizing of reinforcement (CGR). As a convenient in-line processes, continuous coating can process straight bar or coil-to-coil product directly into galvanized bar and offers not only an ease, speed and economy of production compared to traditional hot dip galvanizing, but is more energy efficient and has less environmental impact.

Some brief comment is also made on the duplex coating of reinforcement in which a galvanized layer is over-coated with an epoxy. This combination of coatings affords a synergy of corrosion protection by which the total life of the duplex coating is more than the sum total of the two individual coatings.

Galvanized Reinforcement

A number of technologies are available to coat steel with zinc – that is to galvanize – and each method results in a characteristic thickness and morphology of the zinc coating produced (Porter, 1994). For steel products greater than 5 - 6mm thick, such as structural sections and reinforcement, for which a durable, robust and long-life coating is required, hot dipping is the preferred and most commonly used method. Another technology widely used in the automotive sheet and pipe

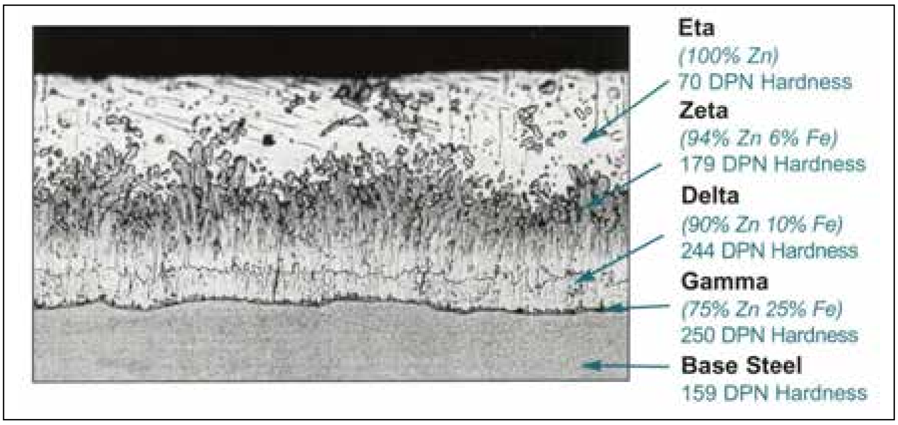

Figure 1.

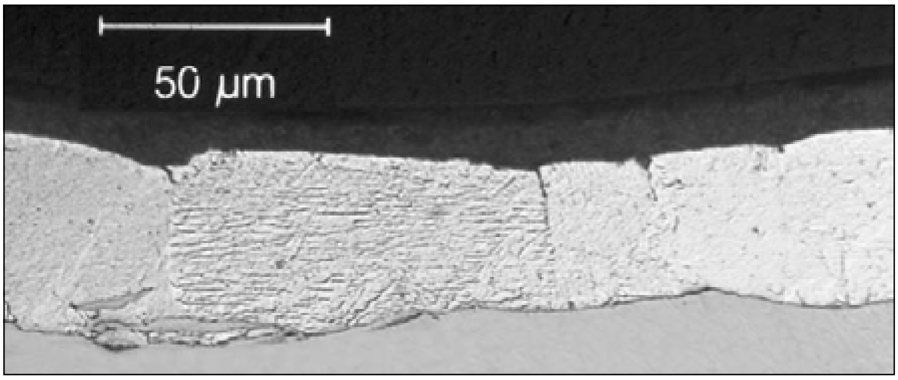

Figure 2.

products markets, and recently adapted for reinforcement, is continuous coating.

Hot Dip Galvanizing

Hot dip galvanizing (HDG) involves immersing clean and pre-fluxed steel in a kettle of molten zinc at about 450°C. During the immersion time while the steel is heating to the temperature of the molten zinc, a metallurgical reaction occurs between the steel and the zinc.

Depending on the mass of the steel being galvanized, the immersion time varies from a few minutes for light sections to 20 - 30 minutes for heavier structural sections. As a consequence, the thickness of the HDG coating varies with the mass (primarily thickness) of the steel being coated. This is accounted for in all national and international galvanizing standards, including those specifically for reinforcing steel, [Bureau of Indian Standards] IS 12594 (1988), [International Standards Organization] ISO 14657 (2005), BS ISO14657 (2005), [American Society for Testing and Materials] ASTM A767 (2019), [European Committee for Standardization] EN 10348-2 (2018), which variously nominate a minimum specified coating thickness of galvanized coatings of 85 - 87µm, equating to a coating mass of approximately 600 - 610g/m^2 for ISO14657 Class A coatings and ASTM A767 Class II coatings. It is to be noted that the typical coating thickness for HDG reinforcing steel is usually 110 - 120µm, though may be as much as 150 - 180µm, depending on the size of the bar.

The reaction between steel and molten zinc produces a coating on the steel made up of a series of iron-zinc alloy layers (gamma, delta and zeta) that grow from the steel/ zinc interface, with a layer of essentially pure zinc (eta) at the outer surface. The alloy layer structure of a typical (so-called 'bright') galvanized coating is shown in *Figure1*. What distinguishes galvanizing from other types of coatings is that the galvanized layer is metallurgically bonded to the steel due to inter-alloying between the steel and the molten zinc.

As shown in *Figure 1,* the alloy layers in the coating are harder than the base steel, resulting in a coating that is not only firmly adhered to the steel, but also tough and abrasion resistant. This allows the galvanized article to be handled, transported and fabricated in much the same way as ordinary steel. Further, as is the case with the galvanizing of general engineering products, the zinc coating on reinforcement provides both barrier protection to the underlying steel as well as sacrificial cathodic protection of exposed steel in the event the coating is damaged.

A key feature of hot dip coatings is that the outer eta layer, which is effectively pure zinc that remains on the surface of the product as it is withdrawn from the galvanizing kettle, is generally about 40 - 50µm thick. As will be discussed in the following, it is the presence of this eta layer that controls much of the behaviour of zinc when in contact with wet cement. It is to be noted, however, that not all galvanized coatings necessarily contain all of the alloy layers evident in a 'bright' coating.

Depending on the steel chemistry and the processing conditions, the coating may contain only one or two of the alloy layers. For example, the microstructure of the coating on so-called 'reactive' steels, with silicon content around a peak at 0.065% or above 0.3%, consists almost entirely of enlarged zeta crystals that grow in an uncontrolled manner and consume the outer pure zinc eta layer. Such coatings can be quite thick and have a dull grey surface appearance.

It is to be noted that when galvanized steels are heated (i.e. annealed) above about 450°C, the growth of the zeta phase is promoted at the expense of the pure zinc outer layer, which can result in partial or even complete disappearance of the eta layer at the surface. Similarly, larger size reinforcement can retain significant heat in the core of the bar after withdrawal from the kettle if the bar is not sufficiently cooled by water quenching. This residual heat can cause a continuation of iron and zinc diffusion in the coating layers and part of the eta layer may be consumed.

Continuous Galvanizing

A recent development has been the continuous galvanizing of reinforcement (CGR). Continuous coating is an in-line (thus not batch dipping) process similar to the coating of sheet and pipe products, where (generally) blast cleaned and preheated bar is fed through a molten zinc bath, alloyed with 0.2 - 0.3% aluminium, at speeds higher than 10 m/min such that the bar remains in the bath for no more than 1 - 2 s (Dallin, 2013), and the total time at temperature including the preheating stage is not more than 4 - 5 s. A key feature of this process is that it produces a coating that is almost entirely pure zinc without the underlying alloy layers typical of hot dip processing. While affording an ease and economy of production, the nature of the coating significantly improves the adhesion and formability of the galvanized bar.

Continuously galvanized reinforcement has previously been specified to ISO 14657, where a Class B coating with a minimum 300g/m^2 of deposited zinc (i.e. 42µm minimum thickness) is appropriate for continuously galvanized product. More recently, the ASTM published a standard specification for continuous hot-dip galvanized steel bars for concrete reinforcement (ASTM A1094). This standard specifies Coating Grade 50 as a minimum coating thickness of 50µm and minimum coating mass of 360 g/m^2. It also gives guidance for the transportation, storage and construction site practices for continuously galvanized bars. In China, standard GB/T 32968 (2016) is the product standard for continuously galvanized reinforcement. In India, a new standard for continuously galvanized reinforcement has been submitted for review to the Bureau of Indian Standards (BIS).

In order to control alloy formation and promote adhesion of the zinc or zinc-alloy to the steel base, a small amount of aluminium (0.05 - 0.25%) is added to the molten bath. The coating process is identified as passing individual bars through a trough or tube of molten zinc and then immediately through an air or steam wiping device to remove excess coating from the bars. It notes that the zinc coating shall be chromate treated unless waived by the purchaser. The specification also sets requirements for the finish and adhesion of the coating.

With the addition of the small amount of aluminum to the zinc bath, a coating typically 50 - 60µm thick is produced that is almost entirely pure zinc, with only a very thin layer (approximately 0.1µm) of a ternary (Fe2Al5-xZnx) alloy at the zinc/steel interface. The typical microstructure of continuously coated bar is shown in *Figure 2*. Apart from the economy and speed of production with CGR, a key feature of this type of coating is the improved formability of the coated product. The high speed of coating and the very short time the bar is at temperature also allows silicon-containing reactive steels (as earlier noted) to be coated without detrimental effect.

CGR lines can be run as a low-volume operation coating a couple of bars at a time or 6 to 8 bars simultaneously for higher volumes. Even at a lower production rate, a CGR line can run continuously for longer times (with minimal manpower) to increase thru-put and the line can easily be started on demand and shut down very quickly – the zinc reservoir is relatively small, easily heated and temperature controlled.

Continuous coating also can be adapted to convert coiled black rebar into coiled CGR. Continuously galvanized reinforcement is readily available in the United States and China, and from a new facility in India. A pilot facility has also been trialed in Dubai (Yeomans, 2018).

Patnaik (2019) has recently undertaken an extensive investigation of the performance of structural concrete reinforced with CGR compared with other reinforcement including MMFX, black steel and epoxy-coated bars (ECB). The test program included pullout and bond strength testing, crack widths, flexural and shear strength of slabs, and corrosion performance. The broad conclusions from this work were that CGR reinforced structural concrete showed both better structural and corrosion performance than ECB, black bars and stainless steel bars, and also MMFX. Further detail of the results of the structural testing undertaken is in Section 6.5.2 following.

Laboratory Studies

Several extensive reviews of laboratory studies of galvanized steel in concrete have previously been compiled (ILZRO, 1981; Yeomans, 2004b). In much of the work undertaken, especially over the last 20 - 30 years, studies of galvanized steel have variously used alkali aqueous solutions, simulated pore water solutions, cement pastes, and cement mortars and concretes as corrosion media. Comparison with black (i.e. uncoated) steel has commonly been used as a control. In some, other types of reinforcement have been included, primarily epoxy coated bar, solid stainless steel bar and/or stainless clad bar. Being laboratory based, and in order to produce some corrosion reaction in a short period of time, most of the investigations have used a chloride-contaminated medium and accelerated testing protocols.

While the results from such a wide range and variety of laboratory investigations are sometimes difficult to compare, the results have clearly demonstrated a number of key features of galvanized steel in concrete. These include important issues such as the nature of the passivation reaction, the importance of the presence of a layer of pure zinc on the coating surface, the higher chloride tolerance of galvanized steel compared with black steel, and the resistance of galvanized steel to the carbonation of concrete. The effects of the differing morphology of the galvanized coating on its corrosion behaviour, the processes at work when the galvanized coating is actively corroding, and the migration of zinc corrosion products into the adjacent matrix interfacial zone have also been widely studied.

Though some contradictory results have been published, as well may be expected over such a long period, the vast majority of this extensive body of work has demonstrated the benefits of galvanizing as a long-term and robust corrosion-protection system for steel reinforcement (and other fittings) in concrete compared with black steel (Yeomans 2004b). Some key aspects of this research follow.

Zinc in Concrete

As is well known, when bare steel comes in contact with fresh concrete, it is passivated and thus protected from corrosion due to the high alkalinity of the concrete pore-water, initially a saturated $Ca(OH)_2$ solution at a minimum pH of about 12.2. As hydration proceeds, and depending on the alkali content of the cement, the pH rises to about 14 as other alkali hydroxides form (e.g. NaOH and KOH). The steel largely remains passivated through this transition.

A key feature of this change in pH relevant to the passivation of zinc in concrete is that as the pH rises, the concentration of Ca^{2+} ions in the pore solution steadily decreases. These and other effects impacting on the behavior of zinc in concrete have been thoroughly reviewed by Andrade and Alonso (2004). Some detail of this follows.

Passivation of Zinc

Zinc, as an amphoteric metal, reacts in both strong acids and strong bases but is relatively stable over the pH range from about 6 to 12.5. With relevance to the alkaline environment of wet cement and concrete, Macais and Andrade (1987a) indicated that while different zinc products form on the surface as corrosion proceeds, above pH 12.9 the main product is the soluble zincate ion (ZnO_2^{2-}). Over the pH range 12 to 13.2 ± 0.1, the galvanized coating corrodes at a relatively low rate and will passivate, while above this pH dissolution of the coating occurs with no diminished passivation effect.

The corrosion product that leads to the passivation of zinc in calcium-rich alkaline solutions is calcium hydroxyzincate (CaHZn), the morphology of which varies with the pH of the contact solution. For example, at a pH around 12.6, the zinc surface is totally covered with a dense and compact layer of CaHZn crystals. However, as the pH increases, the individual size and distribution of the CaHZn crystals also increase to a point where they cannot completely cover the surface.

Above pH 13.5, the crystals become quite coarse and isolated and, under these conditions, complete passivation of the surface is not possible and dissolution of the coating continues at a high corrosion rate (Macais and Andrade 1987b). The reason for this change is that as the pH increases above 13.2, the reduced availability of calcium ions impedes the formation of CaHZn. As a consequence of this change, the dissolution of zinc as passivation proceeds is not retarded, and so the galvanized coating may continue to dissolve.

What is generally observed with a typical hot-dipped galvanized coating in contact with wet cement is that up to about 10 µm of zinc from the outer layer of the coating is consumed by the passivation reaction. This process occurs through the initial set of the concrete (about 1 - 2 h), and while the initial reaction between zinc and the pore solution is quite vigorous, once the concrete has started to harden and mobility within

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the mix is restricted, the reaction at the surface diminishes as the passive film forms and blankets the zinc surface. Once the passive film has formed it will remain intact even if the pH increases to about 13.6.

More recently, Maeda et al (2020) studied the different passivation behavior of HDG rebar and black steel rebar in fresh concrete. They found that while black rebar was quickly passivated by the formation of a very thin oxide film (several nanometers thick), HDG rebar was passivated by the formation of a thick CHZ film (several µm thick) after being kept active for about 30 h. The corrosion loss of the zinc coating during the initial active period was less than about 1µm, which is negligibly small compared with the initial coating thickness of 70µm. They also noted that a concentrate of dissolved zincate ions on the surface is very important for the passivation of zinc.

The effect of the surface condition of hot dip galvanized rebar in ordinary Portland cement concrete has been studied by Tan and Hansson (2008). This work showed that slight weathering of the bar resulting in the formation of zinc oxide and zinc carbonate on the surface increased the initial corrosion rate and passivation time compared with non-weathered bar. Further to this, galvanized coatings with exposed iron-zinc intermetallic phases required longer to passivate than those with a pure zinc surface layer, thereby confirming the importance of the presence of pure zinc in the passivation reaction. It is to be noted here that the presence of a pre-existing passivation layer on galvanized rebar, such as that produced by quench passivation after galvanizing, can reduce the initial reaction between zinc and the alkaline concrete mixture.

With regard to continuously coated reinforcement, and noting that the passivation of zinc requires the presence of pure zinc on the coating surface, and that up to 10µm of zinc is consumed during passivation, it would be expected that CGR would afford equivalent corrosion protection in concrete due to the amount of pure zinc in the coating, and also over coatings with a thin or non-existent pure zinc top layer.

Darwin et al (2019) investigated, inter alia, the corrosion performance of hot dip galvanized reinforcement to ASTM A767 and continuously galvanized reinforcement to ASTM A1094. After 15 weeks of macrocell testing, the results indicated that there was no significant difference in the corrosion rate when comparing A767 (hot dipped) and A1094 (continuously coated) galvanized reinforcement. It was also reported that galvanized reinforcement tends to exhibit a high corrosion rate early in the testing period that rapidly decreases as a passive layer forms on the zinc.

Data of this type points to the importance of the presence of the outer pure zinc layer in the passivation of zinc in concrete, whether this be applied by traditional hot dipping or the continuous coating processes.

We wish to thank Professor Stephen Yeomans for his contribution and this update on the use of galvanized reinforcement for concrete.

Part 2 to follow in next issue.

Zinc Coating Review PART 1

By Nick Karakasch, Total Corrosion Consultants, Melbourne, Australia

KEYWORDS: Inorganic Zinc Silicate Coatings (formulation classification and sequence, use by dates); Dimetcote; Carbozinc11; Galvanic Coatings; Cathodic Protection; Zinc Coatings – application principles/performance/ surface preparation/metallic zinc content/ abrasion resistance/ assessment; Organic Zinc Rich Primers; Micaceous Iron Oxide; Price Comparison vs Coverage.

Abstract

Breakthroughs take different forms. It is almost 90 years since a breakthrough in the science of corrosion prevention gave us the extraordinary benefits of long-life steel protection that we now take for granted. This article discusses a range of issues, together with a general overview related to the protection of steel with metallic zinc coatings. The content is not new to those with industry experience nevertheless the matter is worth a revisit for those who have over recent times entered the Protective Coating Industry. This review is based on personal and practical experience and is not all inclusive. The intent is to provide a general insight into the historical background, performance, and a basic understanding of the principals associated with the use of metallic zinc coatings.

Introduction

An early reference to zinc-based coatings was back to May 1837 *(reference 1)* when Frenchman Stanislaus Sorel filed a patent for Hot Dip Galvanizing with the use of molten zinc. A further addition was added in June of that year specifically referring to Galvanic Paint. In 1839, Professor Standin, Inspector General French Military Academy wrote:

"A patent was recently taken out by S. Sorel 'for galvanic protection of iron, by either coating it in a bath of molten zinc or by covering it with a so-called galvanic paint."

"Zinc reduced to very small powder is mixed with oils and other substances used in ordinary paints and varnish, all substances which are used to make different colours can also be put into galvanic paint".

By today's standards early zinc coatings were disappointing, they had limited success in providing long term protection because binders such as linseed oil and resins derived from trees were generally used. The other problem was the high zinc oxide content which coated and electrically insulated the metallic zinc particles.
With time and improved technology, a breakthrough occurred in 1937 with the advent of the first Inorganic Zinc Silicate Coating(IOZ) Other developments introduction were Organic Zinc Rich Primers Coatings(OZRP).The term Inorganic Zinc Silicate was not used till the early 1960s previously it was known as "Silicated Composition Containing Finely Divided Zinc."

Zinc coatings are classified into two broad categories, Inorganic Zinc Silicate (IOZ), incorporating binders that are inorganic based, meaning they are inert to UV and atmospheric deterioration. They come in two forms water or solvent based materials available as single or two pack products. Organic Zinc Rich Primers(OZRP) are either single or two pack materials using a variety of binders all based of organic matter, meaning they are not inert and will degrade in atmospheric exposure. Present day binders incorporate materials such as, Epoxy, Urethane Alkyds, Polyurethane, Polyester/Polystyrene, and Chlorinated rubber etc.

Inorganic Zinc Silicate (Historical Development Background)

The world's first Inorganic Zinc Silicate (IOZ) was "Galvanite" later renamed 'Dimetcote 2' *(reference 2)* invented by Victor Nightingall (Melbourne, Australia 1937) the founding director of the Dimet Coating company. The Australian patent was issued in 1939 *(reference 2)*, other countries covered in later years were USA 1949 *(reference 3)*, Canada, UK, NZ, Belgium, Singapore, and Ireland. Dimetcote was licenced to the US Ameron Corporation in 1949, who were world leaders in Vinyl Paint Technology. This arrangement resulted through close collaboration(1954) into the first IOZ that did not require heat treatment for curing purposes. The 1954 version meant for the first-time IOZ offered flexibility, large steel objects such ships, offshore oil platforms, bridges, tanks etc, together with site projects could be accommodated, and existing structures refurbished to provide long term protection. In those days long term meant four years.

Nightingall's invention was the 'holy grail' of the old age corrosion problem, the protection of iron and steel in a sea water environment. It revolutionized the protective coating industry throughout the world. For the first time structural steel components too large for a galvanizing bath, could be given long term protection. Nightingall is not well-known, few people realise this important principle of steel protection had its origins in Melbourne Australia. His contribution to the Corrosion Industry was like what Microsoft bestowed to the computing industry.

The first IOZ coating (1937) was water based and heat cured. Over the years numerous upgrades and variations throughout Australia and the USA were developed. The first in Australia 1945, Zincilate 100 another heat cured version with the addition of sodium sulphide to stop gassing and included red lead. In 1954 Dimetcote 3 the first Chemically cured coating appeared(USA/Australia). This was followed by two variations of Self-Curing Solvent Borne Ethyl Silicate, Acid hydrolysed by Carboline Corporation USA 1959 *(reference 4)*, and Alkali hydrolysed (Australia/ USA1965). Also 1965 a Water Borne (potassium silicate) appeared, Colloidal and Lithium silicate followed (late 1960s) coming onto the market.

The latest variation in general use is High ratio (water based) patented 1980 in the US by NASA. High ratio relates to the liquid component "silica-alkali ratio". The zinc component remained largely unchanged, any liquid component with a ratio over 1.4

is considered high ratio. IOZ are unique their films closely resemble Silica Sand in chemical composition and are sometime referred to as "liquid Glass".

Dimet had numerous high ratio materials well before the 1980 patent, the first in 1965 "Dimetcote 5" (1.47 ratio). These at the time were viewed as only slight raw material variations to their original patent. In their view there was no need to upgrade their patent. One formula, was based on potassium silicate, the next a combination of Potassium / lithium, and the third based on straight lithium. These variations were developed to emulate curing properties similar to that of Solvent Borne Inorganic Zinc Silicates. Tidal zone testing at the RAAF Air Base Victoria testing facility showed the lithium material to outperform the other two by a factor of 3. However, it was expensive at the time and only ever used in the early days by the shipping industry where the cost could be justified.

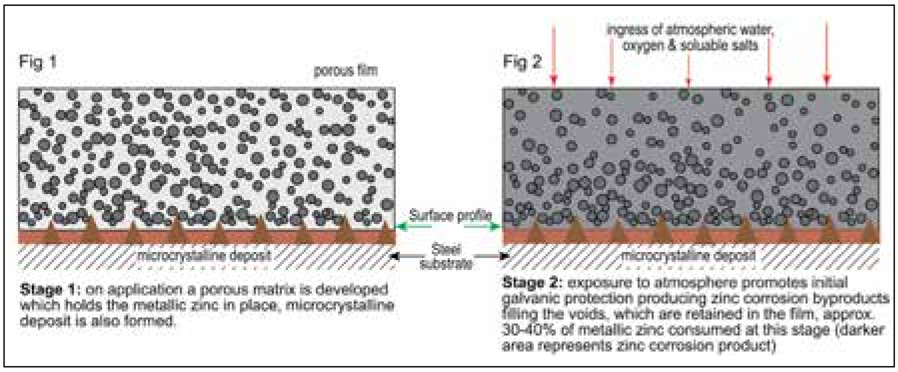
Performance

On performance, the original heat cured IOZ (Galvanite/ Renamed Dimetcote 2) is still ongoing exceeding 80 years on the 359km Morgan Whyalla Pipeline. The chemically cured 60 years, water-based materials 55 years on many steel bridge and offshore structures are also ongoing. The performance figures outlined have average Metallic Zinc content of 500 - 600 grams/ M^2. The protection of offshore platforms presents one of the most difficult corrosion problems unlike a ship, fixed Platforms are extremely difficult to maintain as the they remain at sea for life of the well. It is likely that there is no other system that has been able to provide the same level of performance under these very harsh marine conditions. Hundreds off Offshore Platforms worldwide were successfully coated some of which I believe are still in operation.

Solvent Borne IOZ are excluded from offshore environments unless top coated. However, the offshore industry over recent times now allows their use on the basis the platforms are near their use by dates and don't require the same level of durability as water HR Zinc provides.

Metalizing processes such as Hot Zinc Flame Spray or Hot Dip Galvanizing have outstanding "Onshore Marine" performance. However, performance Offshore and in Shipping is limited, usually confined to fasteners, stair treads, and gratings due to their geometrical configuration making them impactable to paint. The success of IOZ cannot be denied, putting this into prospective known performance in the Shipping Industry and Offshore Marine Environment, an average of 500/600 grams/ M^2 of metallic zinc held in a matrix has exceeded 40 years of service. Whereas, galvanizing with 700 grams under the same harsh conditions provides 3 - 5 years maximum.

What this demonstrates is, pure metallic zinc system's go into solution considerably



Figures 1 and 2.

faster in harsh marine environments than zinc held in an inert silica matrix. Another outstanding area is structural steel within containment shells of nuclear power plants IOZ is immune to UV attack and unaffected by radiation or radioactivity. It is important to understand IOZ is not a metalizing process it's a Coating, a layer of paint incorporating metallic zinc particles as a pigment held in a matrix. The performance and consumption of pure Zinc in Metallic materials (Galvanizing, Hot Zinc Flame Spray, Zinc Plating, Sherardizing), is linear purely related to Zinc Volume. There is no matrix barrier similar to IOZ coatings to regulate consumption, therefore performance for these materials can be predicted to a known corrosion environment.

Zinc Coating Principles

The function of a zinc coating is primarily to provide corrosion protection to the underlining steel surface, for this to occur an electrolyte needs to be present (water, oxygen, and soluble salts). In electrochemical terms steel surfaces are divided into anodic and cathodic areas. There must be a release of electrons at the anodic surface where oxidation of the metal occurs. Cathodic areas accept the electrons, this reaction occurs at the same time and at equivalent rates. However, deterioration only occurs at the anodic areas, these sites change from time to time and can give the appearance of uniform corrosion.

Figure 3: Corrosion being contained by IOZ at the point of failure. NOTE: no under film corrosion creep.

Galvanic action or Cathodic protection is when an electric current is generated between differing metals in contact with one another in an active electrolyte solution or corrosive environment. Relatively speaking electrons will flow from metals that have high electrical potential to metals with low electrical potential. Compared to steel, zinc has a higher electrical potential therefore it is sacrificed going into solution. If the current can be blocked, broken, or reversed corrosion will not occur. The anodic reaction is sometimes referred to as deterioration, oxidation, or sacrificial action of the zinc.

The term Galvanic was named after the Italian Physician/Physicist Luigi Galvani (1737 - 1798). Professor (Count) Alessandro Volta another Italian who invented the first electric battery (1800) coined the term Galvanism meaning a current produced by chemical action when two different metals in an electrolyte are in contact with one another. This was later reinforced by the research conducted at Cambridge University(1932 - 1943) by Messer's Evans & Mayne that clearly showed conductivity and cathodic protection occurs with materials that have high metallic zinc content.

The current flow or amperage which determines performance is less when metallic zinc is held in a matrix binder, compared to other forms of protection where pure zinc is exposed in its own right. The matrix interrupts and regulates the current flow. The consumption of zinc under these circumstances slows considerably, meaning less metallic zinc is required for protection to a given environment. Apart from the zinc component the importance of the matrix cannot be overstated, it is the main element that has contributed to IOZ success.

The simplest way to describe IOZ coatings is a zinc anode in the form of fine particles of metallic zinc held in a matrix of silica. When the two components combine chemical changes take place during the curing process creating the matrix which in turn holds the zinc in place. After the initial curing process, the coating is somewhat porous, porosity decreases on atmospheric exposure when initial galvanic process takes place protecting underling steel. The corrosion by-products produced are essentially inert insoluble compounds i.e., zinc carbonate, hydroxide, and zinc oxide, all retained within the film filling the voids which then blocks and regulates the current demand on the zinc.

Up to 3 - 40% of the metallic zinc at this stage is consumed, the remaining zinc needs to be dislodged or exposed for the galvanic action to continue the protection process. At the same time if either Zinc, Calcium or Magnesium ions are present in the electrolyte, a Microcrystalline deposit is formed at the steel surface which has a stifling effect on the cathodic area. Thereby minimizing the current demand on the zinc and consequently extending the protective period, by holding unreacted zinc which only becomes operative if the coating is damaged or the zinc is exposed at some later stage *(Refer Figures 1 and 2).*

The other action that occurs is the exposure to carbon dioxide, this results in the formation of Insoluble Zinc Carbonate. This basic carbonate held in the film is initially a semi permeable barrier which protects the zinc from corroding too rapidly while at the same time providing sufficient permeability to allow the necessary electrical current to flow keeping the steel from corroding.

Formation of zinc carbonate is not unique to IOZ, it also applies to Galvanizing and Hot Zinc Flame spray. With Galvanizing it's a 2 - 3-micron layer on the surface, with Hot Flame spray it is retained on the surface and in the film. When these layers are depleted generally through atmospheric erosion it activates the galvanic action.

In some exposers the consumption of metallic zinc is so rapid IOZ coatings are impactable, exposure to strong acidic, or alkali environments are not recommended, neither is under buried conditions nor fire proofing compounds unless appropriately top coated. Zinc being an amphoteric metal means it will react with both acidic and alkali environments.

The ideal pH range is between 5 - 10 for sacrificial action to be kept at a minimum. If used outside this range top coating is always necessary to protect the zinc primer. Top coating may also be required to improve the aesthetic appeal of the installation. In the early years enamel (alkyd) paints were often used, these products should never be applied directly to any zinc surface as it produces a soapy substance at the interface leading to loss of adhesion. Scientifically it is called Saponification.

If enamel paint is to be used, then an application of non-reactive barrier intermediate coat such as an epoxy/primer is necessary, chlorinated rubber coatings in the past had been widely used for this purpose however their use has been superseded.

Over coating IOZ provides another important feature, a Synergistic Effect meaning, working together or a combined action to increase performance.

IOZ have a unique ability to contain corrosion at the point of damage *(Figure 3)*, there is no under film corrosion creep. In simple terms where the corrosion is visible its contained, this progresses slowly as the surrounding zinc is gradually consumed and spreads. This benefit has implications to repair costs as it can be accurately costed.

Porosity has a significant influence on both selection and application where topcoats are required. The quality of application must be controlled to minimize the risk of pin holing, or dry over spray. These aspects also need consideration when estimating material and labour requirements. In many cases to overcome these problems when top coating a mist coat/full coat technique is used. The acceptability to the end client or inspector will vary, and the appearance can be subject for questioning or rejection, in some cases the final appearance can be less than expected. Following are some procedures that can minimize this dilemma.

A. Apply IOZ to achieve the smoothest possible finish.
B. Remove any dry or over spray.
C. In the case of SB-IOZ use slow evaporating thinners.
D. Use the mist coat-full coat technique.
E. Correct visible pinhole areas with an additional spray pass of the topcoat material.

Surface Preparation, Adhesion and Dry Film Thickness (DFT)

The degree of surface preparation is the most important factor controlling the performance. For IOZ complete removal of mill scale, rust and all foreign matter is mandatory. Abrasive blast cleaning is always necessary, although with the original IOZ Acid Descaling was also acceptable. The blasting process should impart a rough angular surface profile. The origins of this technique can be traced back to the USA patented by B.C. Tilghman in 1869, the concept came to him during the US civil war when he witnessed the effects of windblown sand on glass windows, Tilghman formed his own company now called the Wheelabrater Group a world leader and major supplier of abrasive blasting equipment.

Minimum standard for surface preparation is SA2.5 (near white metal), although SA3 (white metal) is the preferred standard, particularly for severe environments. The importance the of surface profile is that if IOZ was applied to a smooth surface there would be poor adhesion, no film strength, and be brittle. The silicate component in the material reacts with the steel in a similar way it does with metallic zinc. A microcryline layer *(figures 1and 2)* is formed at the interface which greatly assists with adhesion. When fully cured the film becomes extremely hard and is highly abrasion resistant.

Prior to abrasive blast cleaning all surface contaminates need to be removed either by appropriate decreasing or high-pressure water washing, otherwise long-term adhesion is compromised which in turn effects the overall coating performance. If contaminants remain, particularly if IOZ is top coated, osmoses will occur resulting in osmotic blisters within the topcoat materials.

Surface roughness is important for attaining good adhesion, the surface profile is generally subject to an agreement between the contracting parties, the general rule, this should not exceed one third of the specified total dry film thickness (DFT). The same principal applies to all coating systems. Allowance must be made to eliminate the surface profile effect which can range between 15 - 20 microns depending on the size of the abrasive medium used. Abrasive medium size is important for two reasons 1) if the profile height is too high there may be insufficient coating cover in relation to coating thickness, 2) contractor's coating usage will increase due to the increased surface area which can be as high as 10%. The following guidelines should be used when specifying profile height.

Coating DFT	Average Profile Height
0 – 75um	25um
150um	50um
300um	75um
400um	100um

Adhesion can be divided into Mechanical or Chemical. Mechanical involves the anchoring of the film to the substrate, this is determined and influenced by the degree of surface cleanliness and roughness obtained. (Surface profile). This aspect is critical as it provides an anchor Pattern for the IOZ to adhere to and increases the surface area for adhesion. Chemical Adhesion generally depends on the chemical affinity with the substrate to form a relatively strong bond.

Adhesion strength has a direct bearing on long term coating performance and durability. Paint cohesive properties play a role in performance, which is derived from the strength of the molecular forces within the paint film. Paint coatings require good wetting properties with good flow characteristics they needed to be able to fill crevasses, micro voids etc to displace any trapped air at the interface. Molecules within the coating need to flow freely sharing electrons attached by negative and positive regions.Scientifcally the process is called Absorption. Pin holes and dry spray can occur after application via solvent entrapment and release. Application in hot and low humidity conditions can increase the tendency for these defects.

When using IOZ in multi-coat systems there are several points of potential failure of which the most important is failure of the coating to adhere to the metal surface, or a clean separation of one coat from the other. Cohesive failures within a paint layer are of less importance and are preferable to adhesion failures to the metal substrate. Delamination between coats can in broad terms be related to over thickness, solvent entrapment, overcoating time limits ,incompatibility between coats or where they have been applied before the IOZ cure is complete.

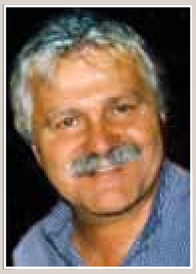
Cohesion film strength is not to be confused with adhesion to the substrate. If for example topcoat systems are applied before IOZ is cured well above the required thickness and structural movement takes place, the system overall will tend to crack in most cases delamination from the substrate occurs. The weakest point in the system in the early stage's is somewhere in the IOZ film. The reason is that topcoat materials such as epoxy have a much higher initial cohesive strength.

Another major concern has been the radius of steel edges, whilst clearly outlined in the abrasive blast standard and necessary it is rarely performed by the steel fabricator. The contracting parties need to be made aware of this requirement during the design and tendering stage and reinforced in a pre-start meeting attended by fabricator, painting contractor, coating supplier, inspector, and owner's representative. Unfortunately, when failures occur usually starting on edges. Invariably the painting contractor and or the paint suppler are blamed. In my view the steel fabricator is primarily responsible to ensure steel edges are properly radiused. If this facet is absent, it could be argued successfully that this is a cojoined responsibility by all those associated with the project if this aspect of the specification is not performed during fabrication of the steel components.

Assessment

Assessing IOZ can be confusing, it's worth noting conventional enamel paint systems can be assessed by accelerated testing which have previously been associated with practical performance. These systems which may last for three to four years can be made to fail in a few hundred hours in a Salt Spray Cabinet test. The best IOZ coatings usually require approximately 20000 hours plus, or over a two-year period to fail for the best of these coatings. Proven case history performance in the relevant environment is the most practical way for selection.

ABOUT THE AUTHOR



Nick Karakasch is the retired principle of Total Corrosion Consultants Melbourne Australia, his experience spans over 50 years, specializing in services to the Protective Coating, Galvanizing, and Structural Fire Protection Industries. Nick spent over half of his working career with the Dimet Coating Company, the inventors of Inorganic Zinc Silicate Coatings by their founding director Victor Nightingall, Nick has also been the Executive Marketing Manager to the Galvanizers Association of Australia. Whilst living in South Africa in the mid-1970s he was employed as a Site Contracts Manager for R.J. Southey P/Ltd. Africa's largest Corrosion Prevention Contractors.

There are four aspects that are measurable, Friction Grip Bolting, Dry Film Thickness, Metallic Zinc content, and Abrasion Resistance.

IOZ is unique, being Inorganic they will not burn and have outstanding friction grip resistance to bolted steel connections, Painted Surfaces and Galvanizing are generally prohibited. IOZ has a coefficient of friction 0.599 well above the minimum for design purposes of 0.45 this aspect cannot be overstated considering the importance of bolted connections to the steel construction industry.

For technical reasons it is not possible to incorporate the same high zinc loading in solvent borne materials as with water-borne coatings, nevertheless they provide considerable better application properties under adverse weather conditions due to their greater tolerance to high humidity and lower temperatures during application particularly under site conditions.

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From the KETTLE

The role specifiers and end-users have in selecting a corrosion control coating, suggests that all aspects of a hot dip galvanized coating be highlighted and if necessarily de-mystified. The intension of this series of surface conditions is to ensure that the customer or specifier has a greater understanding of the coating so that it is not necessarily rejected or accepted for the wrong reasons, resulting in wasted time for all personnel. See F38 and F39

Legend

A Accept **R** Reject **REP** Repair

F38

DESCRIPTION:

Wet storage stain.

CAUSE:

Wet storage stain, a white voluminous deposit of zinc hydroxide, can form as a result of the stacking or storage of hot dip galvanized steel with moisture trapped between closely packed components.

Consumption of the protective zinc coating will continue as long as such conditions remain in place.

EFFECT / REMEDY:

Wet storage stain ceases when the cause is eliminated. If the coating thickness at the affected area is equal to, or greater than the minimum required in the specification, it is not a cause for rejection, other than for aesthetic reasons. The latter is subject to discussion with the end user. Customer is to exercise caution during transport and storage. Avoid storage of hot dip galvanized components in such conditions. #9

ACCEPTABLE TO SANS 121:

A – And remove cause.

Ascertain coating thickness and accept or reject accordingly.

ACCEPTABLE FOR DUPLEX AND ARCHITECTURAL FINISH:

R

F39

DESCRIPTION:

White rust is a white surface stain on a freshly hot dip galvanized surface that is subjected to moist or wet and/or humid conditions.

CAUSE:

Similarly to wet storage stain white rust is also zinc hydroxide but is not as serious as wet storage stains, but rather a superficial surface stain that is formed on freshly galvanized surfaces in the presence of moisture, wet or

F39 continued

humid conditions.

Usually all items that are hot dip galvanized are quenched in water containing a passivation solution to prevent white rust in the short term.

Freshly galvanized coatings react with the environment until such time as a stable zinc carbonate film is formed on the coating surface.

EFFECT / REMEDY:

The occurrence of white rust ceases when the cause is eliminated. Superficial white rust will very rarely affect the life of a general hot dip galvanized coating.

For aesthetic purposes it can be excluded by prior arrangement with the galvanizer. Similarly it can be appropriately removed. #10.

Where components are exposed to continuous rain for a number of days, most of the passivation would have been removed and white rust may develop.

Customer is to exercise caution during transport and storage.

ACCEPTABLE TO SANS 121:

A

ACCEPTABLE FOR DUPLEX AND ARCHITECTURAL FINISH:

A – (D) remove prior to painting.

A if mild (A) but remove if excessive or negotiate with customer.

Fireside Chat – Cape Region

Comment – Executive Director

I hope this message finds you all in good health and high spirits. I am pleased to provide you with an update on the remarkable progress the Corrosion Institute of Southern Africa (CorrISA) has made over the past year. Your dedication and commitment to our industry have played a pivotal role in our achievements, and I am excited to share the latest developments with you.

1. **ECSA Specified Category**

   I am thrilled to announce that CorrISA is in the process of achieving recognition from the Engineering Council of South Africa (ECSA) for the ECSA Specified Category. This recognition will mark a significant milestone in our journey to promote excellence in corrosion management within the engineering community. Our members' expertise and dedication to advancing the field of corrosion will be instrumental in securing this designation. We will communicate more information in due course.

2. **Kusile Plant Visit**

   Our recent visit to the Kusile Power Station has been an invaluable experience for CorrISA. It gave us a unique opportunity to witness firsthand the challenges and solutions related to corrosion in the power generation industry. We gained valuable insights that will inform our future research and educational initiatives. This visit has sparked collaborations with other State-Owned Entities. I extend my gratitude to those who participated and made this visit a resounding success.

3. **Site Visits**

   CorrISA has been actively engaged in organising and participating in various site visits across the region. These visits have allowed our members to witness corrosion mitigation firsts hand and collaborate on finding innovative solutions. We will continue to organise such events to facilitate knowledge exchange and networking opportunities among our members. Thank you to Ferro SA, Jondec and Transvaal Galvanisers for opening your doors to us.

4. **Collaboration with CESA (Consulting Engineers South Africa)**

   Our collaboration with Consulting Engineers South Africa (CESA) continues to strengthen. We have been working closely on joint initiatives aimed at advancing corrosion management practices in engineering projects. This collaboration enhances our ability to influence industry standards and promote corrosion awareness within the engineering community.

5. **Corrosion Institute of Ghana**

   In our pursuit of international collaboration, we are excited to announce that we have re-established our partnership with the Corrosion Institute of Ghana. This collaboration aims to facilitate knowledge exchange, research collaboration, and joint initiatives that will benefit both organisations and enhance the corrosion control community in Africa.

We are dedicated to furthering the mission of CorrISA, which is to advance the understanding and management of corrosion-related challenges in Southern Africa. None of these achievements would have been possible without your continued support and active participation.

As we move forward, I encourage you to stay engaged, attend our upcoming events, and actively contribute to our initiatives. Together, we can make significant strides in the field of corrosion control. If you have any questions, suggestions, or would like to get involved in any specific project or initiative, please do not hesitate to reach out.

In conclusion, our progress over the past year demonstrates the positive impact we can make when we work together towards a common goal. I want to express my gratitude to each member for your support and dedication to CorrISA. Let us remain committed to advancing corrosion knowledge, promoting best practices, and fostering collaboration within our industry.

Warm Regards, Petra Mitchell, Executive Director
Corrosion Institute of Southern Africa

THE INSTITUTE AND EDITOR WOULD LIKE TO ACKNOWLEDGE THE ADVERTISERS AND THANK THEM FOR THEIR SUPPORT

2023 AGM & Tenpin Bowling Evening – Cape Region




2022 Year End Function – Cape Region




2021 Year End Function – Cape Region





Comment – Chairman of the Cape Region

The start of 2023 was well planned, with events for just about every month, with technical presentations and site visits.

Nobody kept in mind that we need to take into consideration the weather as well as this had an impact on site visits.

Our technical presentations and site visits during the year, were once again the high light for the Cape Region CorriSA.

February:

Visit at Inducote where Schalk Pretorius, MD Inducote welcomed us had a turnout of 27 members and visitors to make up the group.

March:

Topic for meeting was "Will you build a House of Steel in Cape Town?". Terry Smith met up with Hennie de Clercq.

April:

We did not have any talks due to the many public holidays.

May:

BAMR had visitors, doing Corrosion Inspections with Ultrasonic Test Equipment, presented by Ben Andrew Elcometer UK.

June:

The highlight of our year for the last 4 years. "The Fireside Chat". A Technical presentation was followed by a social get together.

The Fireside Chat which was held at Emplast and the evening was sponsored by John Houston and Gilbert Theron.

July:

The Muizenberg Pavilion visit was planned and setup by Simon Norton and Terry Smith. This year was our 2nd visit to the Pavilion with all new ideas. This was more than just a site visit or to look at the rate of corrosion and poor maintenance by the City.

This was an educational trip with discussions and everyone's opinion during the walkaround and then the feedback section afterwards.

Following the success of the Muizenberg Pavilion site visit which has many corrosion examples leading to interesting discussions, I would like to suggest we arrange this visit at least twice a year, to benefit all attendees.

August:

At the Ten Pin Bowling Stadium, Claremont where we held our AGM, all the committee members present agreed to stand again.

We want to welcome the new members Bernard Lembeck, Verna Olifant, Gys van Schoor and Masego Mosupye and Janet Cotton.

After the meeting formalities closed, everyone enjoyed the evening playing bowls.

Yours in Corrosion, Flippie van Dyk
On behalf of Graham Duk, Dan Duler, John Houston, Indrin Naidoo, Simon Norton, Norman Otto, Fulufhelo Sithole, Terry Smith, Johann Snyders, Gilbert Theron, Pieter van Riet and our new members.

NDT Training and Presentation by Elcometer – Cape Region

Stadium Visit and Presentation – Cape Region






Tour of Inducote Powder Coaters – Cape Region



Muizenburg Pavilion Corrosion Control Tour and Discussion – Cape Region





The President and His Men – Cape Region

Presentation by Sithole Fulufhelo of Armscor Chemicals Materials Laboratory – Cape Region

2022 Awards Evening – Johannesburg

Technical Evenings – Johannesburg




Kusile Plant Visit – Johannesburg

Plant Tour: Transvaal Galvanisers – Nigel, Johannesburg



IFAT: Africa's Leading Trade Fair for Water, Sewage, Refuse and Recycling – Johannesburg


Nelson Mandela Fun Day at The People's Pantry – Johannesburg



CorrISA Courses

CIP 1 Midrand: 4 - 9 July 2022

A CIP 1 was held in Midrand with 11 students attending. Thank you Bruce and Neil for Instructing. A big thank to STORM MACHINERY for hosting the Practical Day and to PPG for supplying the paint required.

CIP 3 Peer Review: 22 - 23 August 2022

Due to COVID / insufficient numbers and Peer now being run virtually, we have not run a CIP 3 Peer course for a couple of years. We scheduled one 22 - 23 August 2023 with six students. CorrISA was the first AMPP licensee to run a virtual Peer.

A BIG thank you to the reviewers, who had to be up at crack of dawn to accommodate the time differences.

- John McEwan (Lead) S Africa
- Laurie MacKay (NL) Scotland
- Mark Weston (NL) Australia
- William Reid (Trainee) UK
- Nelson Kuriakose (AMPP Staff) Manager Dubai Training Centre

CIP 1 Midrand: 19 - 24 September 2022

Thank you to instructors Mark Terblanche and Armin Schwab for lecturing the 18 students. Appreciation goes out to CORROCOAT BENONI for hosting the Practical Day and STONCOR MIDRAND for the paint supplies.

CIP 1 Midrand: 21 - 24 November 2022

Bruce Trembling and Gert Conradie were the instructors for the above course. We had 17 students who attended. Thank you to JOTUN PAINTS for supplying the paint and TURNKEY AFRICA for hosting the practical day.

CIP 1 Midrand: 23 - 28 January 2023

Small class of 7 students attended the CIP 1. Thank you to Gert Conradie and Bruce Trembling for lecturing. Thank you to STORM MACHINERY for hosting the practical day and SIGMA for supplying the paint required.

CIP 1 SAPPI KZN: 20 - 25 February 2023

Mark Terblanche presented the 1st in-house CIP Lite (now named Basics of Coatings Inspection) 3 day course to SAPPI in KZN. The week after the SAPPI staff attended a CIP 1 course. Thank you to Mark Terblanche and Neil Webb for lecturing.

CIP 1 Midrand: 13 - 18 March 2023

We had 17 students attend the course in Midrand. Thanks to Bruce Trembling and Neil Webb for lecturing. Thank you to TURNKEY AFRICA for hosting the Practical Day and JOTUN PAINTS for supplying the paint required.

CIP 1 Midrand: 22 - 27 May 2023

15 Students attended the CIP 1 in May. Thank you Bruce Trembling and Armin Schwab for lecturing. Thank you INTERNATIONAL PAINTS for supplying the paint required and STORM MACHINERY for hosting the practical day.

CIP 1 Midrand: 4 - 9 July 2022.

CIP 1 Midrand: 19 - 24 September 2022.

CIP 1 Midrand: 21 - 24 November 2022.

CIP 1 Midrand: 23 - 28 January 2023.

CIP 1 Midrand: 13 - 18 March 2023.

CIP 1 Midrand: 22 - 27 May 2023.

CIP 2 Midrand: 5 - 9 December 2022.

CIP 2 Midrand: 17 - 21 April 2023.

CP 1 Tester Midrand: 5 - 9 September 2022

A CP 1 Tester was held 5 - 9 September 2022. We had 9 students attending the course. Thank you to Neil Webb and Craig Botha for lecturing.

ECDA: 30 November – 1 December 2022

ECDA course was held at Rand Water premises with 16 Rand Water students and 1 outside student. Thank you Chris Ringas for lecturing.

CIP 2 Midrand: 5 - 9 December 2022

A CIP 2 was held with 11 students. Thank you to Neil Webb and Armin Schwab for lecturing.

CP 1 Tester Midrand: 6 - 10 February 2023

A CP 1 Tester was held with 20 students attending. Thank you to Neil Webb, Daniel Hovy and Vanessa Sealy-Fisher for lecturing.

CIP 2 Midrand: 17 - 21 April 2023

CIP 2 course was held in Midrand 17 - 21 April 2023 attended by 11 students. Thank you to the Instructors Gert Conradie and Bruce Trembling.

CP 1 Tester Midrand: 5 - 9 September 2022.

CP 1 Tester Midrand: 6 - 10 February 2023.

CIP 1 Midrand: 3 - 8 July 2023.

CIP 1 Cape Town: 14 - 19 August 2023.

CIP 1 Midrand: 3 - 8 July 2023

A CIP 1 was held in Midrand with 9 students attending. Thank you Gert Conradie for Instructing. A big thank to TURNKEY AFRICA for hosting the Practical Day and to PPG for supplying the paint required.

CIP 1 Cape Town: 14 - 19 August 2023

CIP 1 was held at the Belmont Conference Centre, Rondebosch, CPT. We had 12 students that attended. Thank you Gert Conradie and Bruce Trembling for Instructing. A big thank to CORROCOAT CAPE TOWN for hosting the Practical Day and to STONCOR CAPE TOWN for supplying the paint required.