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The Voice of SSPC: The Society for Protective Coatings

FEATURES

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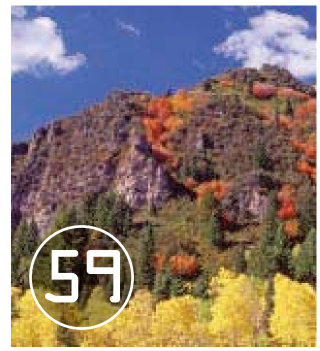

DEPARTMENTS

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The Society For Protective Coatings

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March Webinars Cover Achieving Efficiency in Blasting and Writing a Wastewater Spec

The *SSPC/JPCL Webinar Education Series* will include two webinars in March: "Achieving Efficiency in Abrasive Blasting" on March 14, and "Writing a Clear Coating Spec for Wastewater Facilities" on March 21. Both webinars are scheduled for 11:00 a.m. to Noon EST, and participation is free.

Making Air Abrasive Blast Cleaning Efficient

Bill Nelson of Axxiom will explain how to assure blast cleaning is carried out efficiently. He points out that abrasive blasting is a controlled erosion process where productivity is measured by how much area is blasted, the time required to do the work, and the amount of abrasive and energy consumed. The webinar will cover these metrics, together with a description of control system types, impediments to productivity, fine tuning a blast system, suggested system set-up, and safety considerations. The webinar is sponsored by Axxiom.

Specifying Coatings for Wastewater Plants

"Writing a Clear Coating Spec for Wastewater Facilities," will be presented by Jim Machen of KTA-Tator and will describe the complicated exposures encountered in these facilities, including various kinds of atmospheric, gaseous/vapor phase, and immersion conditions. Coating specifications must take these exposures into account, as well as surface preparation of differing substrate types and the testing and inspection needed to assure quality. The webinar will walk the participants through all the steps needed to produce an effective specification.

SSPC is an accredited training provider for the Florida Board of Professional Engineers (FBPE). PEs in Florida can now submit SSPC Webinar Exam CEUs to the FBPE. If interested in submitting Webinar Exam CEUs to the FBPE, you must download the FBPE CEU form and successfully pass the Webinar Exam.

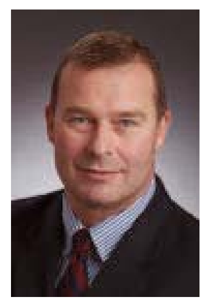
Jim Machen

Participation in the webinars is free, but for those who wish to receive continuing education credits from SSPC, a test is available after each webinar. Cost of the test service is $25. You can register through the SSPC Marketplace.

SSPC/JPCL Education Series Webinars provide continuing education for SSPC re-certifications as well as technology updates on important topics.

International Paint Has New GM for Americas

International Paint LLC, an AkzoNobel company, has named Neil Plowman as the company's new marine and protective coatings general manager, Americas. He will provide strategic leadership and oversight to all aspects of the company's financials and investments, supply chain sales, R&D, operations, and marketing efforts throughout the U.S., Canada, Mexico, and Central and South America. Plowman has 25 years of experience within the International Paint Worldwide business serving Western Europe, North America, Asia Pacific, and the UK, the company says.



Neil Plowman

He began his career at International Paint as a sales representative for the company's specialty coatings brand and moved to Yacht Coatings, where he held a number of sales, marketing, and product management positions.

International Paint is one of the world's leading providers of high-performance protective coatings, linings and fire-protection products.

Plowman has a bachelor's degree in politics from the

University of Bristol, UK, and a diploma in marketing from the UK's Institute of Marketing.

RPM Industrial Shows Strong Q2

Holding company RPM International Inc., the parent company of Carboline, Stonhard, and other well-known brands, reported a 10.1% increase in industrial segment sales, to $641.5 million, in the second quarter of 2012, compared to the same quarter of 2011. Industrial segment sales for the first half of the year increased by 10.4%, to $1.31 billion, from the same period a year ago.

According to the company, high-performance corrosion control coatings, commercial flooring, bridge deck products, and edible shellac products all posted double-digit sales increases, with most other industrial products having solid sales improvements.

During and after the second quarter, RPM announced acquisitions with sales totaling more than $130 million, all of which are expected to increase earnings within one year.

RPM's subsidiaries supply specialty coatings, sealants, building materials, and related services. Industrial brands include Stonhard, Tremco, illbruck, Carboline, Flowcrete, Universal Sealants, Fibergrate, and Euco.

Bayer MS Names Key Coating Sales Chief

Bayer MaterialScience LLC has appointed Marc Daniel Block as director of regional key account sales for its Coatings, Adhesives, and Specialties (CAS) business unit.

Block will lead the entire U.S. CAS regional key account sales team, and he will serve as head of the technical sales team and of the Single Point of Contact office in the NAFTA region.

A Bayer employee for 11 years, Block started as an industrial sales clerk for Bayer AG. Most recently, he served as director, global product management for CAS, where he managed Bayer's resin product line in the Asia Pacific region.

Marc Block

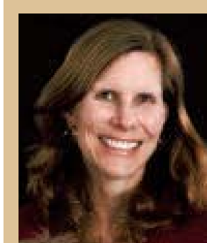
Block graduated from the University of Applied Sciences in Essen, Germany, with a business diploma in marketing and controlling. He earned his master's degree in business administration from the Nanyang Business School in Singapore in 2005.

Based in Pittsburgh, PA, Bayer MaterialScience LLC is a producer of polymers and high-performance plastics for the construction and other industries.

The CAS unit makes raw materials for a variety of products, including coatings for corrosion protection, primers, topcoats, direct-to-metal coatings, and polyurethane coatings. JPCL

Chollet Named PaintSquare Website Editor

Mary E. Chollet, the Editor-in-Chief of the daily enewsletter, *PaintSquare News*, has been given the additional title and role of PaintSquare Website Editor, Technology Publishing Company announced.



Mary Chollet

As PaintSquare Website Editor, Chollet will develop and edit content such as blogs, videos, news, white papers, events, and standards. She will also coordinate with website operations, sales and marketing, and traffic development.

"Mary Chollet has proven to be a masterful editor and developer of content in her work on *PaintSquare News*," said Harold Hower, Editorial Director of Technology Publishing, "and will bring the same talent and drive to her work on the website."

PaintSquare is the website home of the *Journal of Protective Coatings & Linings* (*JPCL*) and contains *JPCL*'s archives and buying guides. These materials will continue to be developed and posted by the *JPCL* editorial staff, headed by Karen Kapsanis, Editor-in-Chief.

Technology Publishing Company covers the protective, marine, and architectural coatings industries with its publications, *JPCL*, *PaintSquare News*, *Durability + Design* magazine (*D+D*), *D+D eNews*, and Paint BidTracker.

Most of the above stories and more news can be found on *PaintSquare News*, *JPCL*'s sister publication, a free daily e-newsletter. To sign up for the newsletter, go to paintsquare.com.

The BUZZ on PaintSquare.com

By Anita Socci, JPCL

Poll Results

When asked, "Which of the following research or development areas seems most likely to become a strong market for coatings?" the majority of respondents felt that, like smart technology for mobile phones, smart coatings technology likely will be a big influence for the coatings market.

- **45% said, "Self-healing and other smart coating types"**
- **23% said, "Painted-on solar panels"**
- **23% said, "Reflective coatings for cooling patios, walkways, driveways, etc."**
- **9% said, "Smog-destroying coatings"**

And speaking of smart technology, when asked, "How many apps do you use regularly on your smart phone?"

- **32%: More than 6**
- **28%: None; I don't have a smart phone**
- **23%: 1-3**
- **16%: 4-6**

Top 10 Stories

Bad Coating Spec Costs District $4M
2 Leaks in 4 Days at PPG Plant in UK
Heater Eyed in Blast at Pipe Coater
Tank Painting Taints NY Town's Water
Disclosures Urged on Abrasive Beryllium
OSHA Fines Navy Shipbuilder $166K
Sherwin's Revenues Jump in 2011
Ship Coating Inspection Goes Digital
Painters Roll Out a Parking Ticket
Probe of Bridge Collapse Continues

Quiz Results

(As of Jan. 11)

Chris McMillan 22 of 22
Brad Berkmeyer 22 of 22
Scott Lewis 22 of 22
Willem van Gent 22 of 22
John P. Psarianos 21 of 22

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On Overcoating an Existing Tank Lining

For maintenance painting of tank coatings, what are the pros and cons of overcoating an existing lining that appears to be in good condition?

From Simon Hope
BIS Salamis (M&I)

There are many thoughts regarding the timing for replacement of vessel linings and whether it should be a total or partial replacement.

Various mechanisms cause lining failures, the most common being the following.

- Coating thinning through abrasion
- Blister formation due to osmosis through the coating from surface contamination on the steel substrate during preparation
- Solvent entrapment in the coating
- Adhesive failure of the coating to the steel substrate caused by surface contamination, inadequate profile, material applied outside its pot life, or incorrect ambient conditions
- Adhesive failure between coats, often due to either surface contamination or material applied beyond the overcoating interval
- Cohesive failure of the coating where a particular coat has torn itself apart, which can be caused by solvents, excessive film thickness, or improper mixing
- Explosive decompression where molecules of a substance that are liquid at the operating pressure but gaseous at ambient migrate into the coating during operation but, in a rapid shut down situation, blow sections of the coating apart: It may take several cycles to effect this result.
- Thermal stress cycling, due to differences in the linear thermal expansion characteristics between the substrate and the coating: Thermal cycling sets up a series of stresses that compromise the cohesive and adhesive strengths of the coating system.
- Mechanical damage from either internal or external sources
- Material aging, accelerated by elevated temperatures, especially with epoxies, which tend to become embrittled
- Cathodic disbondment, where either an impressed current system or a local corrosion reaction causes the liberation of hydrogen from the substrate, leading to the adhesive failure of the coating
- Coatings inadequately cured before being returned to service will exhibit many of the above properties.
- Excessive heat exposure will break down chemical bonds in the polymer and ultimately the full coating system.
- Chemical attack of the lining from the introduction of liquids into the vessel that destroy the coating integrity in either small or high concentrations

The above list is not exhaustive but gives a feel for the problems associated with vessel lining performance. Because of the potential for the above failures to occur in a lining during service, it is a bit of a lottery estimating the life expectancy of a coating system. A vessel operating at ambient temperature and pressure with a non-aggressive liquid will have a greater lining life expectancy than a similar lining exposed to varying temperatures and pressures with an aggressive mixture if liquids are passing through. Coating manufacturers on the whole will quote life expectancies for what they expect an “average” exposure to involve. When inspecting a vessel lining that has been in service for a period of time, the inspector needs to carefully analyze any breakdown to check whether it is a local failure with a driving force that is not throughout the vessel or whether the breakdown is the first stage of a total lining failure.

This call can be a hard one for the inspector: The decision to either totally

Editor’s Note: Problem Solving Forum questions are posted on the free daily electronic newsletter, *PaintSquare News,* on behalf of *JPCL*. Responses are selected and edited to conform to *JPCL* style. Send questions and answers to kkapsanis@protective-coatings.com.

reline the vessel or to make spot repairs could lead to a premature/catastrophic lining failure when the vessel is returned to service. The risks are especially high when there is pressure to get a vessel back online as fast as possible.

From an inspection point of view, a lot depends on the inspector to visually identify the defects present. The visual inspection should be backed by non-destructive tests to determine that the coating still meets the specification; the most useful testing is to check the dry film thickness (DFT) to look for wastage and coating thinning. DFTs need to be taken over the entire vessel, concentrating on the areas such as nozzles and edges where thinning of the coating is likely to be prevalent. Spark testing at 4Kv per mm of coating will show any holidays along with other defects such as porosity and inclusions. Wet sponge holiday detection tends not to work on old coatings that have been immersed in an electrolytic medium or have a surface deposit of contamination; these conditions lead to false readings.

Destructive testing, such as dolly pull-off adhesion tests, will give a good indication of any potential reduction in adhesion/cohesion, but the test area will have to be repaired. Pull-off tests are also fairly lengthy to undertake because the adhesive for the dolly must be fully cured to achieve maximum strength; otherwise, the value of the tests is debatable. If possible, inspection should identify any problems that may occur during the repair procedure.

Spot repairing a vessel tends to be a short-term fix for a vessel lining because the repair itself can create a weak spot. Preparation is invariably of a lower standard than that used to prepare a full vessel. Regularly, clients ask for power tool preparation of the affected areas, which does not give a long-term life expectancy for the lining. If blasting is used, it is essential to remove all corrosion salts and contamination from the affected area; chase back to a firm feathered edge; but avoid damage to the surrounding area. It is essential to locate all breakdowns and repair them, although this practice never happens.

Many of the above failures are not readily visible and can be found only by destructive testing during the early phases of the failure. Holiday detection will only work if the coating is clean and dry with no contamination on the surface, which will allow the test to track to earth, giving bogus results. If done too often, spark holiday detection leads to failure of the coating and is not really recommended for regular inspection.

Spot repairs give large amounts of "free" edges where future breakdown may readily nucleate. When blasting in a vessel to undertake spot repairs, there will inevitably be collateral damage from the blasting operation in the form of overblast and ricochet plus damage due to personnel and equipment moving around in the vessel. All of these can lead to coating weakness and potential failure. If a coating is reaching the end of its expected life, it is not advisable to spot repair, except in extenuating circumstances. The failure rate will become unacceptable, and damage to the vessel shell will occur. A new coating system should be used that will give the optimum life expectancy, and consideration should also be given to the life of the vessel. Usually, it is preferable to completely renew a coating system.

Changes in the operating parameters need to be taken into account because there may have been changes since the original specification was drawn up. It is worth looking at failures and using these to learn from to improve the specification.

Stripping the old lining off with UHP water jetting techniques has multiple benefits, such as the removal of the old coating, corrosion scale, contamination, and corrosion salts. Water jetting leaves a substrate that can be rapidly dry blasted to the required standard, with minimum risk of surface contamination; thus, maximum life expectancy for the coating should be achieved.

Bearing the above comments in mind, applying this to the requirements for gas/oil/water separator vessels, the following procedures should be used.

- Initial vessel inspection: 100% visual inspection after clean-out to identify through coating failures
- DFT check on all nozzles, edges, and welds with at least three readings per m² to check for thinning/wear on the coating. Minimum acceptable thickness is 15% below specified thickness.
- 100% holiday detection to find any pinholing or porosity defects
- If deemed necessary, dolly pull-off adhesion tests to check for reduced adhesion or delamination
- Report findings to client

Under normal circumstances, a failure rate of 15 to 20% or greater would be deemed as uneconomical to spot repair because the effort needed would be as great as that to recoat fully. The percentage is based on the percentage area of the vessel shell that will receive the new coating, not the percentage area of visible failure or corrosion. What initially appears as a small defect of nominally 10 mm x 10 mm will probably end up as a repair on the order of 400 to 500 mm diameter if done correctly.

From Tom Selby
Rodda Paint Corporation

To overcoat, the pro, of course, is the savings in time and money from not having to remove and dispose of the existing coatings. The con is whether there is enough adhesion of the existing coatings to the substrate and the soundness of all existing coatings on the surface. Before making a decision, adhesion tests should be done. If a sweep blast is done per SSPC-SP 7, then adhesion tests should be done after the sweep blast to check to see if the adhesion of the old coating system has been compromised in any way.

From William Slama
International Paint/Ceilcote Products

This answer is in regard to internal tank linings and particularly thick, reinforced thermosetting systems. First, one must focus on the functional challenges to the lining system, simplified here as permeation, direct chemical attack, and mechanical damage. Next, the percentage of intact film area must make the “repair and overcoating” approach worthwhile, as opposed to removal and reapplication of the same or different lining system.

Basically, the existing lining system must be judged to have given and be able to provide good protection in the tank environment (primarily chemistry and temperature). In those cases, the existing lining damage could be due to application variables or localized challenges due to cold wall areas or abrasion. The intact lining areas should be assessed for remaining thickness and for through-adhesion with emphasis on evaluation of underfilm condition of the (steel) surface. If tensile adhesion strength through the film is acceptable (generally more than ⅓ of a new film), and underfilm corrosion is slight or none, overcoating is a good prospect. We have seen this in many high-build, reinforced linings that can be expected to have a protective life of 10–25 years. In some cases, localized areas have been compromised and/or the surface layer (topcoat) has been severely degraded over many years, but the underlying lining is still strong and well bonded. The result has been that localized repair and reapplication of the topcoat after abrasive blasting 20 or more years of service without the much higher cost and down time of removal and relining.

SSPC Protective Coatings Specialist

Q&A with Daniel Zarate, By Jodi Temyer, JPCL

This month's SSPC-certified Protective Coatings Specialist is Daniel Zarate, a research chemist in the Capital Improvements Waterfront Shore Materials Division at the Naval Facilities Engineering Service Center (NAVFAC ESC) in Port Hueneme, CA. He currently holds the position as the NAVFAC Paints and Coatings Technical Expert, making him the point of contact for coatings and corrosion prevention issues related to Navy facilities, as well as the senior coating consultant for Navy shore facilities worldwide.

Mr. Zarate has worked for the Navy for over 31 years, and his research efforts have spanned topics such as materials deterioration, environmental cleanup, and corrosion prevention and control. He holds a BS in biochemistry from the University of the Pacific and a MS in biochemistry from the University of Notre Dame.

JPCL: Explain what your role entails as the Paints and Coatings Technical Expert.

Daniel Zarate: NAVFAC set up a series of centers of expertise and subject matter experts. Those centers of expertise entail a number of people who are experts in that particular area. I cover Naval Facilities infrastructure. I don't deal with weapons platforms like ships and aircrafts. My main focus is facilities, including all buildings and industry structures like pipelines, runways—anything that has a coating on it.

JPCL: What are the most pressing issues in your areas of responsibility?

DZ: There are a lot of pressing issues. We are always dealing with environmental regulations, but we have a handle on those. There's always lead, which we have criteria in place for. Many of our structures date back to long before lead was regulated. VOC issues are at the forefront. We are moving more and more towards higher solids types of products. We don't have historical performance data on any of those products, so we don't know how they will hold up in the long term. Contracting is always an issue, and we address it by modifying our specifications.

Those are broad issues. You are constantly hearing about the latest cycle of people getting older; people with expertise leaving and retiring; and new, younger personnel coming on board without the same experience. How do you capture that corporate knowledge? We are working with the Office of the Secretary of

It's like when you have a Swiss watch and one little diamond is out of the position. The whole watch could stop working.

Defense Corrosion Policy Office and developing centers for training, especially with things dealing with corrosion prevention control.

JPCL: What kind of industry advances would you like to see?

DZ: Overall, the biggest problem that we see is training. That's across the board, not just in my position. The contractors are constantly dealing with personnel changes—they turn over very rapidly. Those are the ones that are most critical in terms of training requirements. They are ultimately responsible for generating the performance of that coatings system. We have a lot of good coatings systems today, but because of regulations, coatings today are more of an engineered material. You need an engineering type of education to properly handle these products. You have to know their limits and stay within those limits. The profile has to be just right. There is just so much that has to be monitored. You need someone who is very detail oriented.

JPCL: Has the cause of a coatings failure ever surprised you?

DZ: Over the years, we have worked our specs and documents to the point where, if you follow it, your chances of a failure are reduced to zero. Follow it, and you will have success every time. It's when you deviate from how we have written it that problems occur. It can be the minutest detail, and you can end up with a failure. It's like when you have a Swiss watch and one little diamond is out of the position. The whole watch could stop working.

JPCL: Your job has taken you all over the world. What city or country was the least like you expected it to be? Do you have a favorite place?

DZ: When I travel, I try not to have a preconceived notion about where I'm going. With the places I've been to, I've found that people are pretty much the same, and I've been welcomed wherever I've gone.

As for favorite places, I loved Japan. I had a chance to stay over in Hiroshima one time, and I could not believe how clean the city was. It looked like it was Disneyland property. And it was very accommodating in terms of language difficulty.

JPCL: When you started your undergrad biochemistry degree, what was your dream job?

DZ: Working for NAVFAC ESC! [laughs] I did not have a dream job. My thinking was always that if I got a degree in whatever I enjoyed, I would find something along that line and enjoy what I was doing. As long as I enjoyed what I was doing, I would enjoy life.

JPCL: Name at least one thing you would still like to accomplish in your career.

DZ: That's easy because I'm pursuing it now with the training and certification WIPTs (working integrated product teams). We are developing many training products for the next generation of people who are Internet-savvy. Some products developed recently include CorrSim, which is along the lines of the game Sim City, and corrosion videos narrated by LeVar Burton. Their intent is to train our personnel within the DoD, but we want to let the public have access to the same information at no charge. We get people who may not ever think about corrosion, and it might pique their interest.

JPCL: And what's one thing you would still like to accomplish in your life?

DZ: All my life I've wanted to pick up a surfboard and learn to surf.

JPCL

Fig. 1: High-tech coatings lab
Photos courtesy of the author.

Going by the Numbers:

Understanding Coating Manufacturers' Specification Sheets

By Ivan Ordaz
Belzona, Inc.

Choosing a coating for your project can be a challenging task. A good coating can extend the life cycle of an asset and significantly reduce cost and downtime. Alternatively, a poor coating can do quite the opposite; it could jeopardize the asset, thus contaminating a project and increasing downtime.

Information for comparison of the different coating options is generally limited to three possible sources: anecdotal evidence, a sales pitch, or a manufacturer's specification sheet. The first two can be judged by impression or level of trust and are somewhat subjective. The third is possibly the most misunderstood and difficult to judge.

This article is meant to provide some insight into the general makeup and applicability of the typical manufacturer's coating specification to help make your decision easier and increase the odds of choosing what is best for your asset.

Standards

Most reputable coating manufacturers carry out their performance testing according to industry-recognized testing standards (Figs. 1 and 2). Standards have one purpose—to put it simply, standards make a test as repeatable as possible. It does not guarantee that the results have any real world meaning, although many tests attempt to do so. This is important to understand when choosing a material based on a specification sheet. A common mistake is to compare values side-by-side and assume that the higher values are better. Without a basic understanding of the true meaning of the numbers, an objective comparison is impossible. One must resist the basic human instinct to compare the quick and obvious number to cast a swift judgment when, in reality, the not-so-obvious number is more meaningful and rarely represented by a single numerical value. Reading the standard itself offers much insight. Never take the number simply for what it is, and always understand that not all standards are created equal. Some are very specific and detailed, while others might be very broad and full of wiggle room. Some standards are also much more representative of desirable properties for a specific application. For example, compressive strength is a value that does not have much significance for a tank coating application, but could be more relevant for a machine shop floor coating with heavy machinery and traffic.

General Data

When analyzing a product specification sheet, keep in mind that there are thousands of possible tests that could be listed for a polymeric coating. Therefore, what is listed has been carefully chosen by the manufacturer for some specific reason. Perhaps the manufacturer thinks it is important data for a specific market the company is targeting. Maybe the data listed are limited by testing capabilities but could also be limited to the strong points of the product and intended to make the best impression possible.

Regardless of the reason or intent, what matters is that you identify the data that is most critical to the success of your application. For example, if you are dealing with coatings that will have contact with chemicals, then focus on chemical testing and identify how the products are tested and how rigorous the testing procedures are. But if you are dealing with roof coatings, for example, you should focus on data presented that proves their longevity in harsh natur-

Fig. 2: Performance testing equipment

al environments; strong resistance to UV, heat cycles, and rain; etc.

Some basic data that should be present on a specification sheet are physical properties such as density, appearance, consistency, viscosity, slump resistance, peak exotherm and time to peak exotherm, working life, percent solids, and shelf life information. Detailed physical properties allow for proper application planning.

Compressive strength, flexural strength, tensile strength, and hardness are values that could be considered performance data but, because they are so generic in nature, they seldom become a critical focus point during coating selection. Polymer materials could also be formulated in ways that amplify these basic mechanical characteristics but serve little purpose as far as performance in the intended environment or, in some cases, could be detrimental to the overall coating performance in the field.

Performance Data

At a minimum, the following general performance data should be present in a coating data sheet.

Adhesion–Cross hatch testing should be used for thin coatings, and direct tension and lap shear adhesion testing should be used for thick coatings. Adhesion is critical to the success of any coating. A coating that is unable to maintain a tight bond with the substrate stands little chance of successfully protecting that substrate.

Adhesion of coatings is highly dependent on methods of surface preparation. Some coatings are designed specifically to adhere to poorly prepared or contaminated surfaces. If your application has restrictions on surface preparations, these properties are important characteristics that could benefit your application. Such coatings should have appropriate data to prove the claims.

Dry Heat Resistance–The thermal stability of a coating is dependent on the formulation of the resin systems. Heat resistance is generally subdivided into dry heat resistance and wet (immersion) heat resistance. The temperature at which a coating will begin to break down is defined as the dry heat resistance of the material. Exposures to temperatures above this value will cause permanent, irreversible damage to the coating, eventually leading to its destruction.

Wet (Immersion) Heat Resistance–Immersion heat resistance is almost always lower than dry heat resistance. When immersed in a liquid, a polymeric coating will generally experience a lower heat resistance because permeation of the liquid increases as the temperature increases. The permeation can lead to blistering, chemical attack, undercoating corrosion, and other detrimental effects. Coatings chosen for immersion service should be tested by a rigorous method to determine the immersion heat resistance.

Atlas cell testing is among the most widely accepted and most scrupulous methods available. Atlas cell testing will not only expose the coating to the hot fluid but also incorporate the effects of a cold wall. A cold wall effect will make conditions much more aggressive to the coating by introducing a strong thermal gradient across the coating. The strength of the cold wall is dependent on the thickness of the coated metal panel. Thicker panels will dampen the cold wall effect because they contain a larger thermal mass.

Fig. 3: VICAT heat distortion temperature equipment

Fig. 4: Lab-based accelerated UV chamber

Heat Distortion Temperature–The heat distortion temperature of a material is the temperature at which the material begins to soften. When a material exceeds its heat distortion temperature, it will lose most of its physical strength and will soften. It is very important to note that this is not a permanent effect. Once the temperature has decreased below the heat distortion temperature, the material will regain its rigidity and return to normal.

The heat distortion temperature is

extremely important in some situations but meaningless in others. Any coating that will be subject to mechanical stress or chemical exposure should never be put in service above its heat distortion temperature (Fig. 3).

Abrasion Resistance–Abrasion is difficult to simulate and generalize in a test because of the nature of the effect. Abrasion of a coating can occur by different means, such as fluid impingement, impact abrasion, and erosion by entrained solids.

Sliding abrasion is often tested by the Taber method, in which abrasive wheels slide over a rotating sample for a given number of cycles. The mass loss is then determined. This method is very effective for comparing sliding abrasion of coatings. There are a several parameters that need to be established and quoted along with the results: mass of weights, wheel used, number of cycles, and abrasive condition (wet or dry). When Taber abrasion testing is used to compare coatings, all the parameters need to be the same. Only when all parameters are the same can two test results be compared side by side. Taber results are determined by measuring the mass of the sample before and after the test. The mass loss represents the degree of abrasion. It is very important to consider the density of the coating when comparing values; because coatings have very different densities, mass alone is a poor tool for comparison. Many coatings manufacturers will convert mass loss to volume loss, and comparison by volume is the only accurate way to compare two coatings' abrasion resistance. A gram of coating A doesn't necessarily equate to a gram of coating B if the coatings' densities are different. A cubic millimeter of coating A and a cubic millimeter of coating B will always be the same quantity. After all, we are interested in how fast the coating will wear down, not how much mass is being lost as it wears.

Cathodic Disbondment–Coatings that will work alongside cathodic protection systems should be tested for cathodic disbondment resistance. The presence of a polarizing potential on exposed sections of a cathode will produce a very aggressive environment for a coating, which could lead to disbondment and corrosion creep.

Corrosion Resistance–Accelerated corrosion testing is generally performed in a salt spray cabinet to demonstrate the coating's ability to provide protection in corrosive environments.

Accelerated Weathering–Testing should be done for discoloration, loss of gloss, blistering, flaking, rusting, or other breakdown when exposed to harsh environments. This test can be performed in a test chamber designed to simulate such environments or in outdoor exposures. Outdoor exposure should be in geographical areas of harsh weather conditions such as Florida or Arizona (Fig. 4, p. 20).

Conclusion

Choosing a coating is no easy feat. Coating selection consists of several steps, and the person deciding must possess extensive knowledge of the structure or equipment that will be coated as well as the coatings themselves. Unfortunately, this is not always the case and results in a significant number of coating failures. The first key step to choosing the right coating is to understand what key properties are required of the coating. Once this is accomplished, one can start looking at specifications sheets and determine if the standards quoted accurately simulate the expected real world conditions. This should lead to an educated and correct decision. In essence, a properly chosen coating will prolong equipment life, reduce downtime by protecting it, and possibly even improve its efficiency.

JPCL

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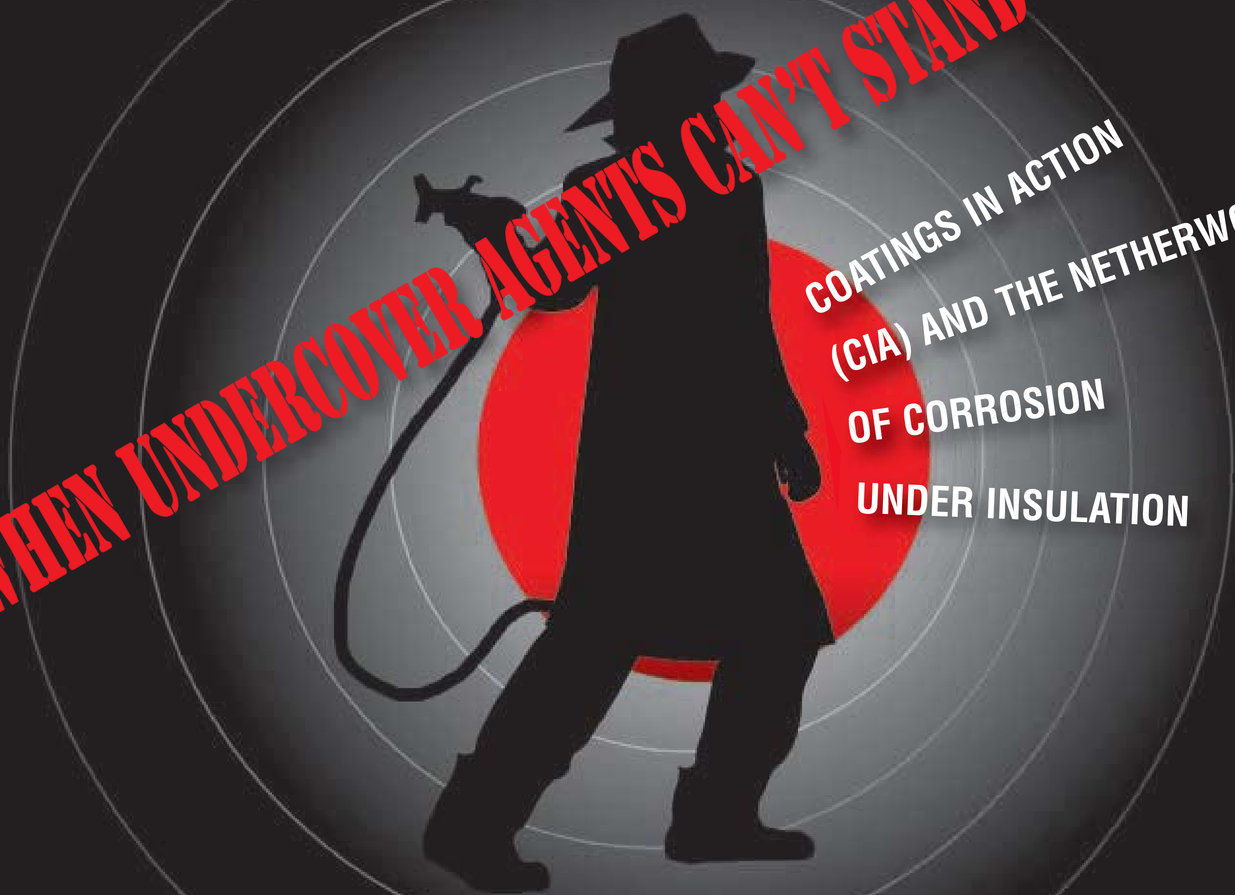
WHEN UNDERCOVER AGENTS CAN'T STAND THE HEAT:

COATINGS IN ACTION (CIA) AND THE NETHERWORLD OF CORROSION UNDER INSULATION



By Dr. Mike O'Donoghue,
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OPERATION HIGH HEAT

Mission Impossible gave us a thrilling movie where the daring hero, a master of disguise, belonged to an unofficial branch of the CIA. His prime directive was to prevent a secret list of covert eastern European CIA agents from falling into the wrong hands. Failure was not an option - countless lives were at stake; the balance of global power hung on a knife edge. Success depended on the courageous, quick thinking actions of our CIA agent and his team. Ominously, some CIA agents were not as they seemed. Who could be trusted? Who was friend? Who was foe?

With a focus on intelligence collection for the oil and gas industry, Mission Possible: "Operation High Heat," is our high-tech adventure into a mysterious corner of the coatings world where specialty high heat coatings work undercover on corrosion under insulation (CUI) assignments. Under close scrutiny, a task force of the CIA (Coatings in Action), was poised to expose potential fault lines, misinformation, and hyperbole with respect to coatings performance. What was trustworthy? What was friend? What was foe? Would a post-reconnaissance of the mission prove revealing? Would some new technology CIA agents be able to stand the heat? Could the same new technology CIA agents throw light on other CIA activities? And how would an older, well-respected CIA agent perform under the same adversarial conditions as the newer generation operatives?

This article will describe the importance of Coatings in Action (CIA) in the undercover realm of CUI. A suite of accelerated laboratory tests was undertaken in part to evaluate the claims made for engineered coatings touted to possess ultra-high-heat resistance to 400 C and simultaneous anticorrosion properties, and to evaluate the coatings' suitability for cyclic CUI use.

The inspiration for Operation High Heat stemmed in part from facility owners' requests to the authors to identify promising new pipe and process vessel coatings that could be used in cyclic (rather than continuous) temperature CUI environments that are more aggressive than those typical of CUI problems. The tests also continue earlier accelerated laboratory investigations of the CUI cyclic performance of new generation coatings.

COLLATERAL DAMAGE

Corrosion under insulation (CUI) and its high associated costs have been the subject of considerable attention by facility owners for several decades. CUI processes themselves are generally well understood.[1,2] For CUI to occur, the usual actors must be in play: oxygen (a strong corrodent), water, a contaminant salt (the corrosive), a metallic pathway, and a suitable temperature range. According to NACE SP0198, the critical corrosion temperature ranges that a high heat coating must withstand are -4 C to 175 C for carbon steel, and 50 C to 175 C for stainless steel.[3]

Typically, the most potentially menacing CUI environment for thermally insulated carbon steel piping spools will occur between 60 C and 120 C. Factors such as dissolved oxygen, corrosive salts in the water or insulation, the type of insulation, and isothermal conditions or thermal cycling will be important. Rain leaking through damaged cladding and porous insulation can lead to moisture at the carbon steel-insulation interface. So too can condensation at that interface after a rapid cooling stage in the process cycle. When the system cools and if an absorbent insulation like calcium silicate is used, moisture will be retained. Therefore, insulation materials like expanded perlite or aerogels tend to be favored.

A carefully designed facility and the use of high quality insulation materials and protective jacketing (e.g., aluminum cladding, multi-laminate tapes, and glass fiber lagging cloths) are important CUI deterrence strategies to prevent water reaching insulated carbon steel pipes.[4] But as noted, if mechanical damage occurs, water can reach hot pipes, where evaporation results in deposition of soluble salts. A continued water supply and repetitive thermal cycles will concentrate the salts, raising the boiling point of the water. In an open system, as water nears its boiling point, the solubility of dissolved oxygen will plummet. However, in a closed CUI environment, water entering the insulation is continually replenishing oxygen to the steel-insulation interface. The net result is that CUI rates of 1.5 to 3.0 mm per year can occur, some 20 times greater than rates due to atmospheric corrosion alone.[5]

A clandestine and unpredictable enemy, CUI normally goes undetected until the damage is significant. Without warning, perforation of carbon steel can bring operations to a grinding halt and may cause a catastrophe. Pipe maintenance repair costs from CUI alone have been reported to be 40-60% of a refinery's maintenance budget.[6] Ancillary costs can be significant from lost production, chemical spills, environmental cleanup, and health and safety implications.

Without the CUI countermeasures of judiciously selected materials, be they protective jacketing, thermal insulation, or specialty coatings, bare carbon steel pipe and vessels inevitably corrode undetected in water saturated-insulation. When the steel fails, the consequences can ultimately be dire.

COUNTERMEASURES TO CUI

Thermal Spray Aluminum (TSA)

For over 30 years, a single coat application of ~10 mils of TSA has had an excellent track record of protecting carbon steel against atmospheric corrosion in many environments.[7,8] Although TSA is somewhat expensive to apply, requiring a minimum SSPC-SP 5, White Metal abrasive blast with a profile of 3.5 to 5.5 mils, its life cycle costs are low and its performance is generally outstanding in the war on atmospheric corrosion.[9]

With respect to CUI mitigation, however, there appear to be relatively few case histo-

Editor's Note: This article, by Dr. Mike O'Donoghue and his strong team of co-authors, is part of the series of Top Thinker articles appearing in *JPCL* throughout 2012. Dr. O'Donoghue is one of 24 recipients of *JPCL*'s 2012 Top Thinkers: The Clive Hare Honors, given for significant contributions to the protective coatings industry over the past decade. The award is named for Clive Hare, a 20-year contributor to *JPCL* who shared his encyclopedic knowledge of coatings in many forums. Professional profiles of all of the award winners, as well as an article by Clive Hare, will appear in a special 13th issue of *JPCL*, to be published in August 2012.

ries using TSA and the jury appears to be out regarding its efficacy for CUI service. It has been reported that TSA can provide 25 to 30 years of maintenance-free and inspection-free service.[10] Indeed TSA has provided over 20 years of zero maintenance service life in some CUI pipe applications and its use in CUI environments continues to be the subject of investigation.[11,12] In atmospheric service, TSA provides both galvanic and barrier protection to carbon steel and austenitic stainless steel. While TSA is known to be tolerant of continuous temperatures as high as 500 C, and elevated cyclic temperatures in wet and dry conditions, what is not so well known is that TSA corrodes on steel in hot salt solutions at ~80 C.[13]

So while a facility owner's expectation is that TSA should provide markedly superior performance in CUI service compared to liquid-applied coatings, this expectation may not always be well founded. With wet insulation on steel pipe, TSA does have a temperature limitation in hot salt solutions. Although metallic aluminum is anodic to carbon steel, in a saline environment with the temperature close to 80 C, the efficiency of aluminum will be lowered. In contrast, barrier coatings, even if they contain aluminum pigments, do not behave as sacrificial anodes and thus can be more effective in hot brine.

Also, TSA, with high porosity (e.g., 5 to 30%), will form insoluble aluminum salts in the pores over time. Sealers have been used to address the porosity.[14] Typical sealers have been based on low viscosity coatings, although those based on vinyl coatings, and certain thin film inorganic copolymers have been shown to be more effective than those based on epoxy coatings.[15]

High-Performance Modified Silicone Polymer Coatings

In contrast to the use of TSA, a particularly interesting approach to mitigating CUI would be for the coating formulator to develop a high-heat and ultra-high-heat-resistant (up to 200 C and >200 C respectively) inorganic copolymer that contained leafing aluminum flake pigmentation. Distributed throughout an otherwise brittle coating matrix, an overlapping array of aluminum flake pigments could be theorized to afford internal stress reduction to the coating when applied to carbon steel. In essence, the aluminum platelets would be envisioned to provide mechanical toughening of the coating and enable it to withstand the expansion and contraction of carbon steel pipe in elevated and fluctuating temperature service. More obviously, aluminum flake pigmentation would function as a tortuous diffusion path against the intrusion of water, oxygen, and dissolved salts, and as an anticorrosive pigment. When used in epoxy formulations, aluminum pigments have been noted for their abilities to function as barrier pigments, and for their buffering reactions at the coating-steel interface.[16] In CUI environments, such a system could provide a much needed flexible and impermeable coating film on carbon steel or austenitic stainless steel.

These considerations formed the basis of the development of the titanium modified inorganic copolymer (TMIC), a relatively new technology that consists of cross-linked inorganic

Table 1: Distance along Pipe and Corresponding Temperature

Distance from Bottom (cm)	0-5	5-10	10-15	15-20	20-25	25-30	30-35	35-40	40-45	45-50	50-55	55-60
Approx. Temp Range (C)	445-390	390-335	335-285	285-245	245-210	210-190	190-160	160-145	145-135	135-115	115-110	110-95

Table 2: Adhesion Analysis of Coating After CUI Cyclic Testing

CUI Cyclic Test Temperature	**TSA**		**Coating #1 - Modified Silicone Copolymer**		**Coating #2 - Inorganic Polymer with MIO**		**TMIC**		**TMIC Patch**	
	Adhesion Rating	**Coating Chip Size**	**Adhesion Rating**	**Coating Chip Size**	**Adhesion Rating**	**Coating Chip Size**	**Adhesion Rating**	**Coating Chip Size**	**Adhesion Rating**	**Coating Chip Size**
400 C	10	0 mm	8	1-2 mm (cohesive)	0	~10 mm (adhesive)	10	0 mm	10	0 mm
300 C	10	0 mm	7	2-4 mm (adhesive)	0	~10 mm (adhesive)	10	0 mm	8	1-2 mm (cohesive)
200 C	10	0 mm	9	~1 mm (cohesive)	8	~3 mm (adhesive)	10	0 mm	10	0 mm
100 C	10	0 mm	10	0 mm	9	~10 mm (cohesive & adhesive)	8	1-2 mm (cohesive)	n/a	n/a
DFT (mils)	12.7		9.9		18.3		8.9		9.0	

film-formers with aluminum flake pigmentation. The TMIC network was designed to ensure that mechanical properties such as flexibility would accommodate the stresses generated within the coating during high temperature cycling in the typical CUI temperature range (and cycling anywhere between 100 C and 400 C), through improved network formation. TMIC technology has been described elsewhere for insulated and non-insulated pipe applications, deployed either in stand-alone mode or in conjunction with TSA.[15,17]

Two other commercial inorganic copolymers of interest were investigated in the present work. Derived from advanced silicone chemistry, they were expected to have thermal and thermo-oxidative stability through the resistance of their Si – O bonds to scission, and to be excellent potential CIA candidates.

It is important to point out that the evolution of coatings technology for high temperature resistance and anticorrosive properties in CUI service has been through inorganic zinc silicates (400 C), early thin film multi-coat aluminum silicones (500 C), and immersion-grade epoxy novolac systems (230 C).[18] The maximum service temperatures are in parentheses. First, the zinc silicates are no longer favored in CUI environments because of reactivity and inadequate performance. Second, the early thin film aluminum silicones have poor barrier properties in intermittent hot and wet service and poor resistance to thermal shock. Third, epoxy phenolics begin to thermally decompose, carbonize, and become ineffective at ~230 C.[19]

So coming to the fore in the present day are modified inorganic polymer coatings said to have attributes that may include the following.

- Cyclic and continuous temperature resistance to 400 C
- One coat, thick film applications at 7 to 8 mils DFT
- Flexible at elevated temperatures
- Barrier resistance and micro-crack resistance
- Long service life
- Ease of application
- Application to SSPC-SP 6 and water blasted surfaces
- Application to hot substrates up to 150 C
- Minimal to zero porosity
- Self repair and spot repair for TSA
- Sealer utility for TSA

Formulated to have enhanced barrier properties, some of these materials are said to have the added advantage of aluminum flake or micaceous iron oxide (MIO) pigments in their resin matrix.

Because of its ultra-high-temperature properties (>200 C), TSA was included as the benchmark for this study, and a new technology, titanium modified inorganic copolymer (TMIC), already demonstrated to be suitable for cyclic CUI service up to 400 C, was investigated as a repair patch on TSA in a laboratory simulation of a field touch-up.

UNDERCOVER AGENTS INVESTIGATE

In the *Mission Impossible* movie, our hero dons one of his many clever disguises, preparing for the mission to find the elusive data so crucial to his investigation. But now he is alone. His resources are tested to the limit with so many forces against him. All his faculties are sharply attuned as he strives against almost insurmountable odds. Will this testing time winnow the weak from the strong? All will be revealed....

And what did our own winnowing reveal about the four CIA coating technologies investigated here?

- TSA: Thermal Spray Aluminum (1 coat @ 10 mils DFT).
- Coating #1: Modified Silicone Copolymer (2 coats @ 10 to 12 mils TDFT).

Stated temperature resistance up to 650 C in continuous service and suitable for CUI service.

- Coating #2: Inorganic Polymer with MIO (2 coats @ 12 to 18 mils TDFT).

Stated to withstand intermittent exposures up to 720 C and prevent CUI.

• TMIC: Titanium Modified Inorganic Copolymer (1 coat 7 to 8 mils DFT).

Stated to withstand cyclic CUI environments for pipes to 400 C and 650 C in continuous operation.

The following tests were carried out.

A. CUI cyclic testing. ASTM D2485, ASTM G189, and the modified Houston Pipe test[20] were considered for evaluating CUI coating performance. Instead, the CUI cyclic test employed in the previous research[17] was used, as it provided an accelerated, significantly more aggressive environment favored by some facility owners. Also, coating performance under CUI conditions could be determined simultaneously over a wide range of temperatures, from 95 C to 445 C. In the CUI cyclic test, insulated, coated steel pipe was positioned vertically on a hot plate, resulting in a temperature gradient along the length of the pipe. The insulation was cyclically saturated with sodium chloride solution, and the pipe was cyclically cooled. Calcium silicate was used as the insulation because it is known to absorb and wick moisture, and hold 20-40 times its weight in water.

Uncoated steel pipe was prepared and subjected to CUI cyclic testing in exactly the same manner as the coated pipe to determine the corrosion occurring in the absence of a protective coating.

B. EIS testing. Electrochemical Impedance Spectroscopy analysis of the coatings was performed before and after CUI cyclic testing to assess changes in the barrier properties of the coatings.[21]

C. Cyclic salt immersion and high heat dry out. After CUI cyclic testing the four coatings were submitted to six weeks of another aggressive round of corrosive testing in which they were exposed to cycles of sodium chloride solution immersion alternated with dry heat at 200 C.

D. Adhesion, porosity, cracking, and flaking tests. After CUI cyclic testing, the four coatings were evaluated for adhesion loss, porosity, cracking, and flaking using optical and scanning electron microscopy (SEM).

CIA RECONNAISSANCE: OPERATION HIGH HEAT

Experimental

So where is our agent now? To find the "mole," he becomes a mole, delving deeply into convoluted terrain, finding false avenues of espionage and dangerous dead ends. Our hero, previously alone, now has other covert agents support and defend him. Yet his life is in danger. But he must carry on, for to step away is to admit defeat, and defeat would be catastrophic. What will he do next?.

In the same vein, which CIA agent will act as a mole and survive the ravages of corrosion under insulation?

Pipe Samples

The external surfaces of steel pipe (60 cm long, 5 cm inside diameter, 5 mm wall thickness) were abrasive blast cleaned to an SSPC-SP 10, Near White Metal, with a 2-3 mil profile using G40 steel grit. Each of the liquid coatings was applied to duplicate steel pipes by air spray and cured at 25 C for seven days. TSA was applied using flame spray. Other sections of prepared pipe were left uncoated to facilitate temperature determination under insulation and the corrosion behavior of bare steel under CUI cyclic test conditions.

Pre-formed calcium silicate insulation, 5 cm in thickness, was fastened around each pipe in clam-shell fashion. Aluminum foil was wrapped around the insulated pipe and secured, leaving both ends of the insulation open to facilitate the entry and drainage of the wetting solution (Fig. 1).

One of the TSA-coated pipes was prepared with an intentional repair patch of TMIC. The repair area was abrasive blast cleaned to bare steel (silica sand) to an SSPC-SP 5, White Metal. TMIC was brushed on in two coats with a total DFT of 9 mils on the bare steel area, overlapping the adjacent featheredTSA. The patch extended over one side of the lower half of the pipe, which was the area subjected to the highest temperature.

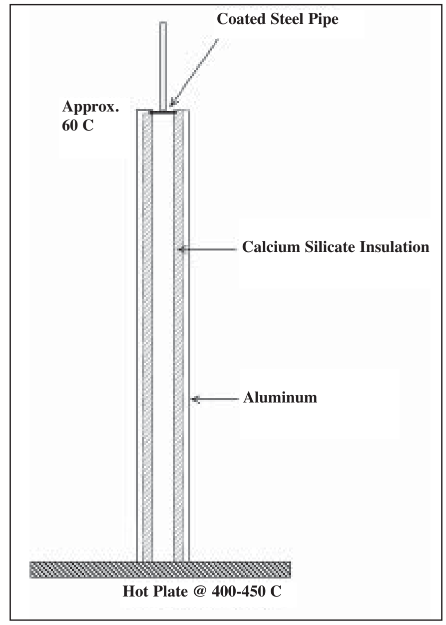

Fig. 1: Pipe sample schematic
Figures courtesy of the authors

CUI Cyclic Test Design

The CUI cyclic test was run twice with each of the four coatings. Each weekday morning, one liter of 1% sodium chloride (NaCl) solution was poured slowly into the insulation at the top end of the pipe sample. The liquid was mostly absorbed by the insulation, with only a small amount of drainage from the bottom. The four pipe samples were placed on the hot plates (Fig. 2), and the hot plates were turned on, reaching 450 C within 30 minutes. After 8 hours, the four pipe samples were removed from the hot plates, and another liter of 1% NaCl was poured slowly into the insulation at the top of each pipe. The re-saturated pipe samples remained off the hot plates overnight. This procedure was repeated five days a week, for six weeks, for a total of 30 cycles. After 30 cycles, the insulation was removed from the pipes and the coating performance evaluated.

CUI Pipe Temperature Gradient

The temperature of the pipe under the insulation was determined by placing thermocouples

Fig. 2: Experimental set-up (Left to Right: TSA, Coating #1, Coating #2, and TMIC)

between uncoated steel pipe and the insulation at 5-cm intervals. The assembly was otherwise identical to the coated samples. The instrumented pipe was placed on each of the hot plates, and the hot plate temperature was adjusted to achieve a temperature gradient from 445 C (bottom) to 95 C (top) as Table 1 shows. The insulation was not wetted with electrolyte in these measurements. The hot plate settings were maintained for the duration of the testing. The temperature profile measurement was repeated after each six-week test to confirm that it was unchanged.

Evaluation of Coating Performance after CUI Cyclic Testing

Coating performance was evaluated based on visual examination, including degree of rusting, blistering, flaking, and cracking (ISO 4628, Parts 2–5) and color change. Adhesion was evaluated using an X-scribe knife method (ASTM D6677).

EIS measurements (ISO 16773) were made before and after CUI cyclic testing, using the attached cell method in which acrylic tubes (2 cm in diameter) were cemented to the coating and filled with 5% NaCl solution at 23 C for 48 hours. Bode curves were run with Gamry EIS instrumentation, and coating impedance (Log Z) was read from each curve at 0.1 Hz. An interpretive guide for EIS is presented in Fig. 3. Attached cells were placed on the pipe where CUI temperatures were 100, 200, 300, and 400 C.

Cyclic Immersion in Salt Solution

The effect of CUI cyclic test conditions on the four coatings was further evaluated by subjecting one set of tested coatings to a cyclic salt immersion/heat test (insulation removed). The bottom 30 cm of each coated pipe (190-445 C) was immersed in a 5% NaCl solution at 23 C for 48 hours, after which the pipes were transferred to a convection oven at 200 C for 48 hours. The pipe samples remained in the oven over the weekend. Three cycles of immersion and dry heat were conducted each week for 6 weeks, with visual inspections at 2-week intervals.

CIA RECONNAISSANCE: RESULTS AND DISCUSSION

Figure 4 shows the appearance of the coated pipe samples after CUI cyclic testing, and Fig. 5 graphically shows the degree of rusting and cracking. Table 2 and Fig. 6, respectively, give the adhesion and EIS results. Duplicate coated pipe samples performed almost identically. Figure 7 shows the coated pipe samples after

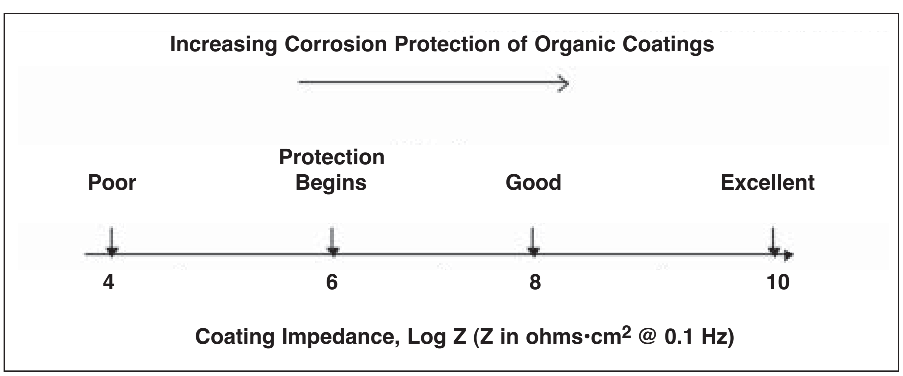

Fig. 3: Interpretation of EIS results[21]

subsequent cyclic salt immersion and heat, and Figs. 8 to 10, respectively, show the degree of rusting, cracking and flaking.

TSA in Action

CUI Cyclic Testing

The main effect of the CUI conditions was rusting in the hottest zone of the pipe (390 C to 445 C), presumably from corrosion of the steel substrate by sodium chloride solution that had penetrated the porous TSA coating. The degree of rusting was Ri 2 (ISO 4628-2), or rusting over about 0.50% of the affected area. The TSA did not blister, flake, or crack. Except for rusting, the only visible changes were a slight loss of metallic luster above 250 C and patches of a thin white deposit, which was presumably residues of salt, insulation or aluminum oxide formation (Figs. 4 and 11).

The TSA retained excellent adhesion to the steel substrate (Table 2), and no coating could be removed by prying with a stout knife.

The TSA (pre-test) initially had very low impedance, Log Z = 2.6, consistent with the metallic nature of the coating. Exposure to CUI conditions resulted in a small increase in impedance that is attributed to the formation of oxides and/or insoluble salts. They add electrical resistance to the metallic coating by filling the pores of the coating.

Cyclic Immersion in Salt Solution and Dry Heat

Subsequent exposure to cyclic salt immersion and dry heat produced little change in the TSA. It showed no significant increase in rusting and did not blister, flake or crack. Visually the TSA became more dulled

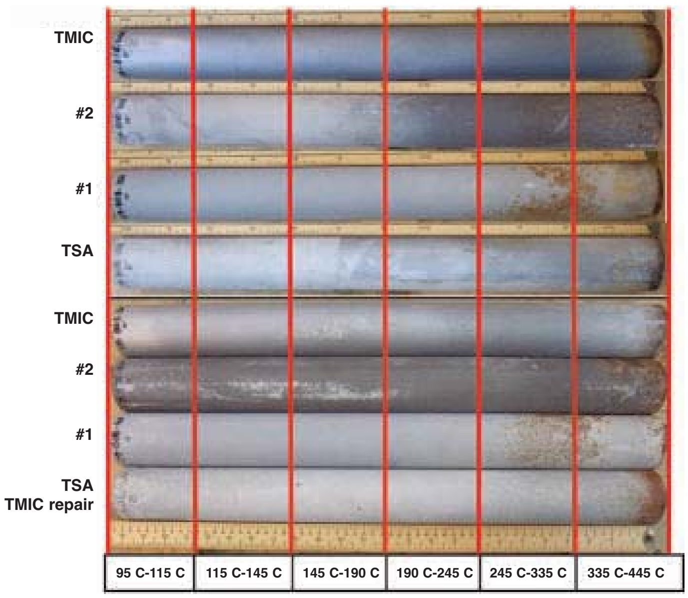

Fig. 4: Overview of all samples after CUI cyclic testing

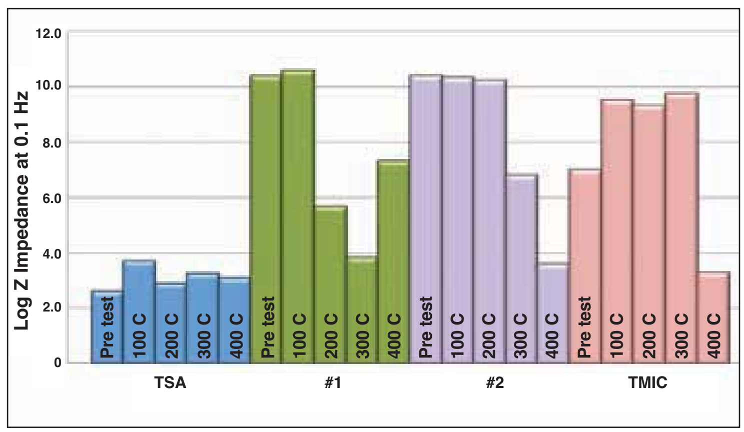

Fig. 6: EIS results of tested and untested CUI pipes

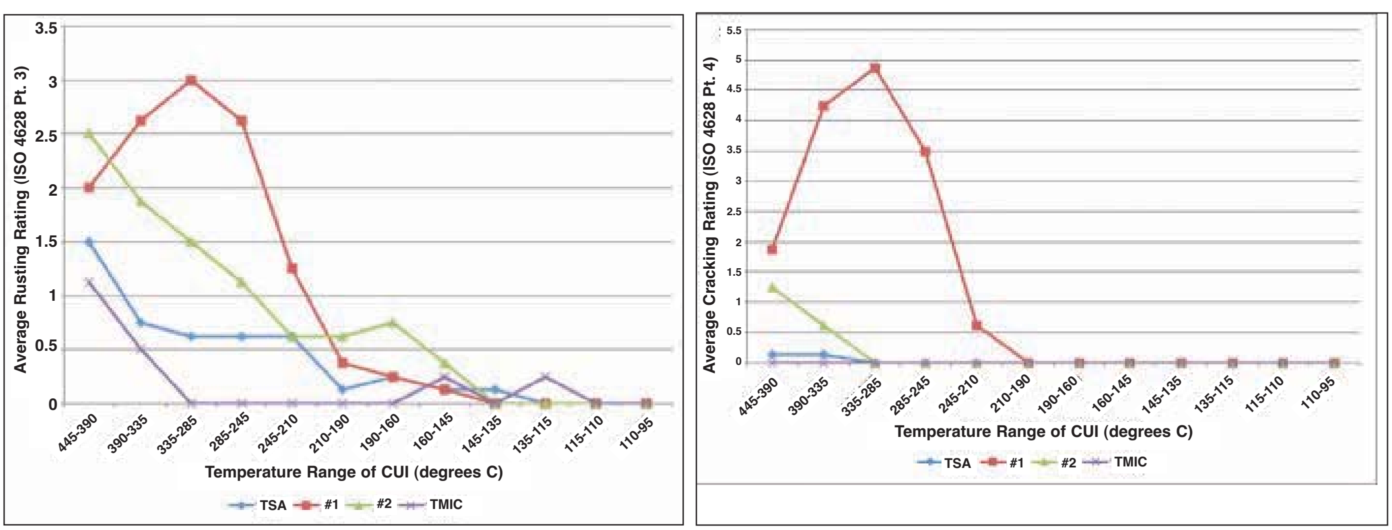

Fig. 5: Average rusting (left) and cracking (right) in the coatings after CUI cyclic testing

Fig. 7: After cyclic immersion in salt solution with dry out

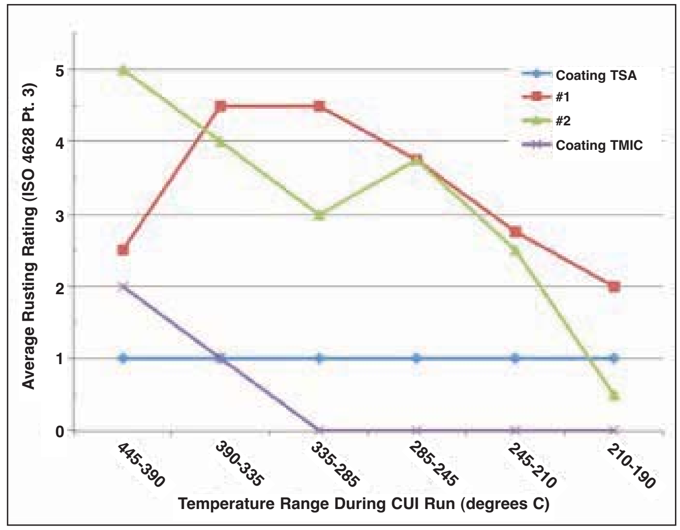

Fig. 8: After cyclic immersion in salt solution with dry out—average rusting

and yellowed, but this appeared to be staining as a result of salt and rust deposits that accumulated in the immersion solution.

TMIC Repair Patch on TSA in Action

CUI Cyclic Testing

No deterioration or rusting was observed on the TMIC repair patch (Figs. 4 and 12) except for a longitudinal, hairline crack in the TMIC/TSA overlap area from 335 to 445 C. The crack contained no rust, indicating it did not penetrate to the steel substrate. The TMIC patch showed a slight to moderate loss of metallic luster and general dulling above 245 C, with only a slight dulling elsewhere. Adhesion of the TMIC to the steel substrate and the TSA in the overlap area was excellent (Table 2) with cohesive separation only occurring during the prying action.

Coating #1 (Modified Silicone Copolymer) in Action

CUI Cyclic Testing

Coating #1 deteriorated significantly more than TSA (Figs. 4 and 13). Moderate to severe rusting (ISO 4628-3 Ri 2 and Ri 3, Fig. 5) was observed above 250 C. Below 250 C, a small amount of pinpoint rusting occurred, with no rusting below 190 C. Most of the rusting was

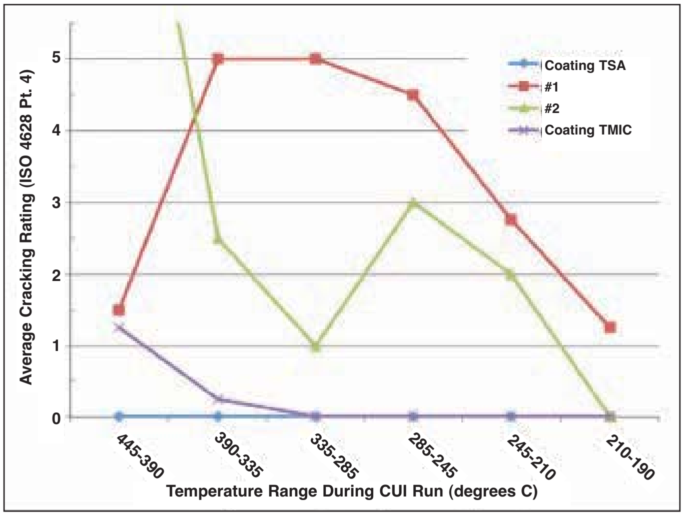

Fig. 9: After cyclic immersion in salt solution with dry out—average cracking

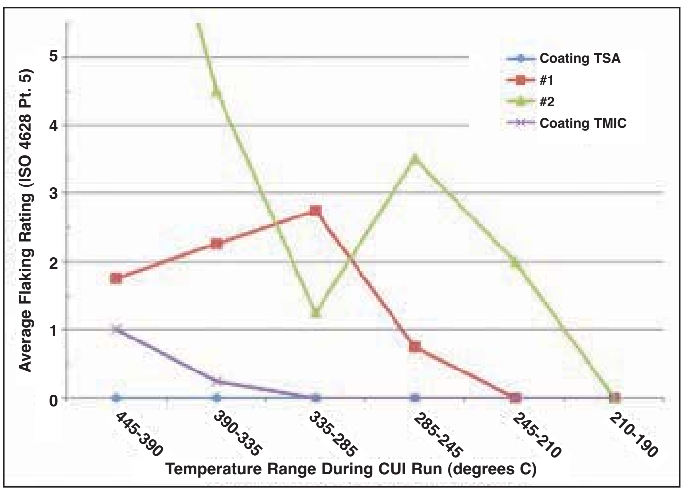

Fig. 10: After cyclic immersion in salt solution with dry out—average flaking

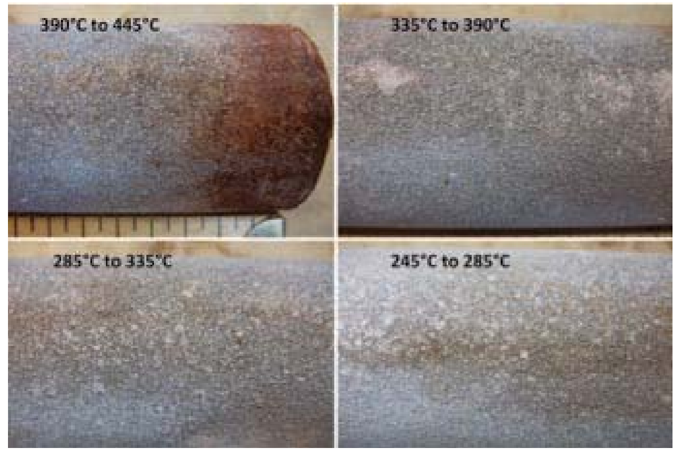

Fig. 11: TSA after CUI cyclic testing

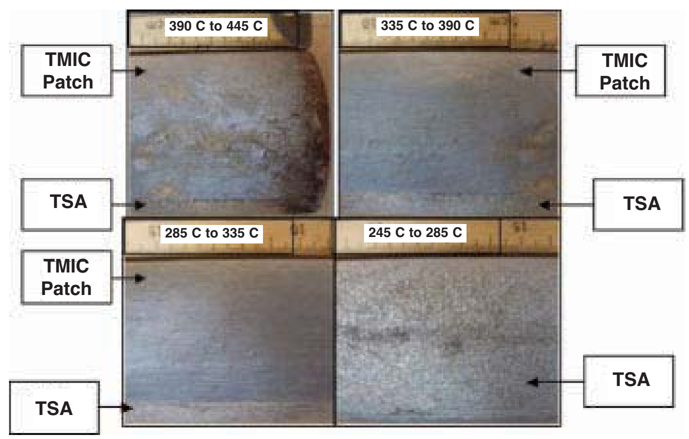

Fig. 12: TSA with TMIC patch after CUI cyclic testing

associated with cracking of the coating. The cracking consisted of crescent shaped cracks above 390 C (ISO 4628-4, Rating 2, Sigmoid), randomly orientated cracks between 390 and 250 C (ISO 4628-4 Rating 4 and 5, NP) and progressively fewer cracks below 250 C, with no cracks below 210 C. A small ring of coating around the pipe circumference at about 400 C was relatively crack-free. The coating did not blister or flake, and it darkened slightly above 250 C.

Coating #1 retained relatively good adhesion (Table 2). Above 200 C, adhesion dropped from a pre-test rating of 10 to ratings of 7 and 8.

Coating #1 (pre-test) initially had a relatively high impedance, Log Z = 10.4, indicative of excellent barrier properties. Exposure to CUI cyclic testing caused the impedance to drop by several Log Z units at 200 C and higher, consistent with cracking and physical breakdown in the coating. The impedance at 400 C (Log Z=7.3) was measurably higher because the coating was relatively free of cracks in this area.

CUI Immersion in Salt Solution

Subsequent exposure to cyclic salt immersion and dry heat resulted in further deterioration of Coating #1. The degree of rusting increased significantly above 190 C, with rusting now extending below 190 C into areas previously rust-free. The extent of cracking above 210 C also increased significantly, resulting in large areas of flaking where previously there had been none. The flaking was accompanied by large rusty patches of exposed substrate. The coating darkened and became severely dulled by rust above 250 C. It became moderately dulled and yellowed by the rust in the saline solution in the 190 C to 250 C region.

Coating #2 (Inorganic Polymer with MIO) in Action

CUI Cyclic Testing

Coating #2 deteriorated considerably more than Coating #1. Severe rusting (ISO 4628-3 Ratings 1 to 3) occurred above 290 C, and above 335 C, the coating looked swollen from corrosion product formation under the coating. Blistering, patches of severe flaking and severe cracking occurred above 390 C. The blisters were 2 to 4 mm in diameter (ISO 4628-2, size 4, density 2) and occurred over half of the pipe circumference. The flaking had a rating 1 to 5 (ISO 4628-5) and included two large flakes (2.5 x 5 cm and 1.5 x 2 cm) that revealed a heavily rusted substrate. The cracking was longitudinal (ISO 4628-4, Rating 3), with some cracks continuing into areas of the pipe at lower temperature down to 335 C (Figs. 4 and 14).

The degree of deterioration below 390 C progressively decreased, until no deterioration was visible below 250 C. The area of the coating above 190 C darkened moderately, whereas the area below 190 C lightened. Patches of a white deposit, presumably of salt or insulation, were present over the surface.

The coating completely lost adhesion above 335 C (Table 2, ASTM D6677, Rating 0) and could be lifted from the substrate in large chips. Below 335 C, the adhesion improved, with excellent adhesion retained below 250 C (Ratings 8 and 9).

Coating #2 (pre-test) initially had a relatively high impedance, Log Z = 10.4, indicative of excellent barrier properties. Exposure to CUI conditions produced little change in impedance at 100 C and 200 C, suggesting no deterioration had occurred. However at 300 C and 400 C the impedance dropped significantly, consistent with the visible coating degradation.

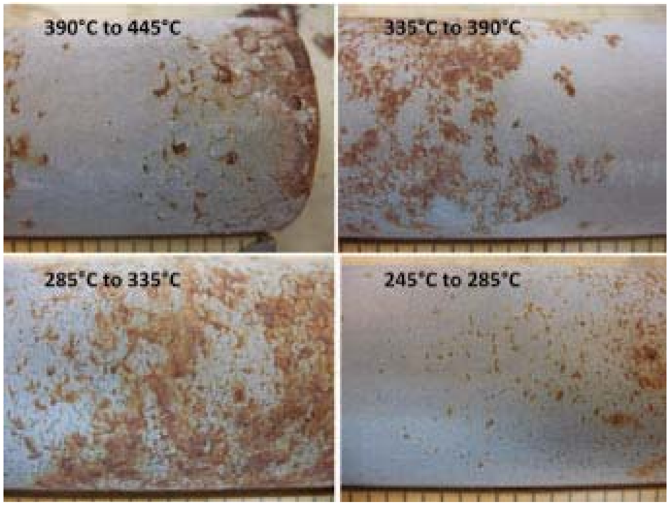

Fig. 13: Coating # 1 after CUI cyclic testing

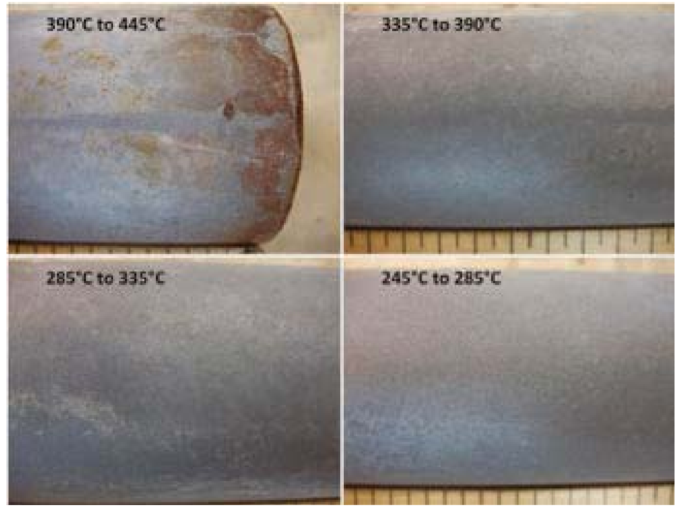

Fig. 15: TMIC after CUI cyclic testing

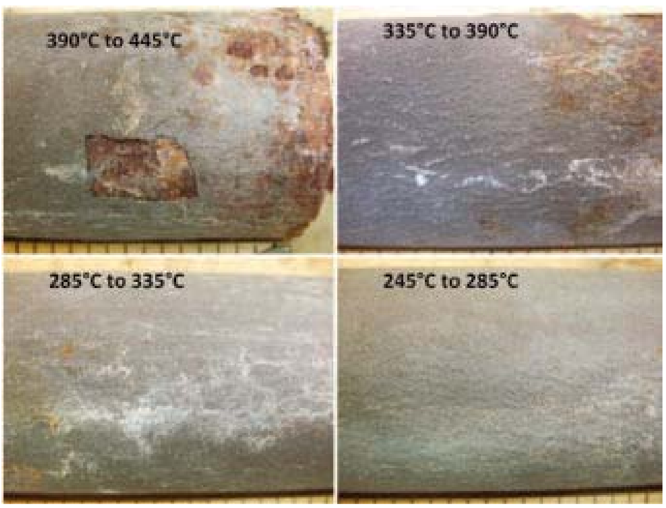

Fig. 14: Coating # 2 after CUI cyclic testing

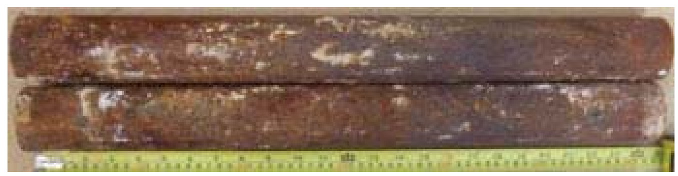
Fig. 16: Overall view of uncoated pipe samples

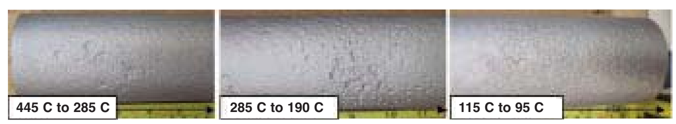

Fig. 17: Close-up view of uncoated pipe samples

TMIC in Action

CUI Cyclic Testing

TMIC performed generally as well as the TSA (Figs. 4 and 15). A ring of light rust and pinpoints of rust occurred from 335 C to 445 C (ISO 4628-3 Ri 0 and Ri 1). However, the rust stain was easily removed by lightly abrading the coating surface, indicating the rust did not originate from the steel substrate, but instead from transfer of corrosion products from the uncoated end of the steel pipe. The TMIC had no blistering, flaking, or cracking. A slight loss of luster and general dulling occurred above 190 C.

Adhesion to the substrate was excellent at 200 C and above, with no adhesive or cohesive separation observed during the prying action (Table 2). At 100 C, small (1 to 2 mm) chips could be pried cohesively from the pipe surface. The observations suggest that exposure to temperatures above 100 C improved the adhesion and toughness of the TMIC.

The impedance of TMIC initially (pre-test) was Log Z=7.0. Exposure to CUI conditions at 100 C, 200 C, and 300 C produced a significant increase in impedance to Log Z=9.3 to 9.7. Exposure to higher temperature reduced the permeability of the coating by completing the curing and cross-linking processes of the polymeric structure of the coating that had been applied at ambient temperature. The high impedance was consistent with the visually excellent condition of the coating. At 400 C, the impedance dropped to Log Z=3.3, close to the values observed for TSA.

Cyclic Immersion in Salt Solution

Pinpoint rusting increased somewhat in size and density above 335 C, with no rusting or any other type of degradation observed below 335 C. One quadrant of the pipe above 390 C developed mild flaking associated with pinpoint rusting. The flaking occurred cohesively and did not extend to the substrate. The coating below 335 C remained free of flaking. A few hairline cracks developed around half of the pipe circumference above 390 C. The coating became duller with more staining as testing progressed, where staining was presumably from salt and rust in the immersion solution.

Corrosion Rate of Steel under CUI Cyclic Testing Conditions

Uncoated steel pipe was subjected to the same CUI cyclic test as the four coatings. The steel pipe was covered with a thick layer of loose, red/black corrosion products at the end of the test (Fig. 16). The corrosion products were noticeably thinner and more adherent over the middle third of the pipe (160 C to 250 C).

The corrosion products were removed by glass bead blasting (Fig. 17) to better determine the metal loss and the nature of the corrosion. Between 285 C and 445 C, the steel surface had a high density of very small pits, 0.4 mm to 0.6 mm in diameter. The pits appeared to be deep, but were too small in diameter to accurately measure with a pit gauge. From 190 C to 285 C, large pits 2 to 10 mm in diameter were visible, with depths of 0.5 mm to 1.25 mm (mechanical pit gauge measurement). The 95 C to 190 C area of the pipe showed a mixture of both types of pitting but at much lower density.

Based on the deepest pit (1.25 mm) after 6 weeks of CUI cyclic testing, the pit corrosion rate was calculated as 10.8 mm/year. At this corrosion rate, perforation of the 5-mm pipe wall would occur in approximately 4.3 months.

POST CIA RECONNAISSANCE: MICROSTRUCTURE, POROSITY, COMPOSITION

Our Mission Impossible hero is shaken. Our hero finds that a friend can be foe after all, and conversely foe can inexplicably become friend. What was believed to be true is revealed to be false. What was once obvious and accepted is now in doubt. The tables have turned, a compromise reached, but what will be done with the secret data? Will the face of the future ultimately change?

As did our hero, we too rely on computer science, high-tech gadgetry to reveal and confirm our findings. Let us see where our investigations have led.

To complete the picture of how the four coatings reacted to the effect of heat, the microstructure and porosity of the coatings were examined at high magnification using optical microscopy, scanning electron microscopy (SEM), X-ray mapping, and EDXA.

General Observations

Optical microscopy was first employed with the intention of estimating porosity based

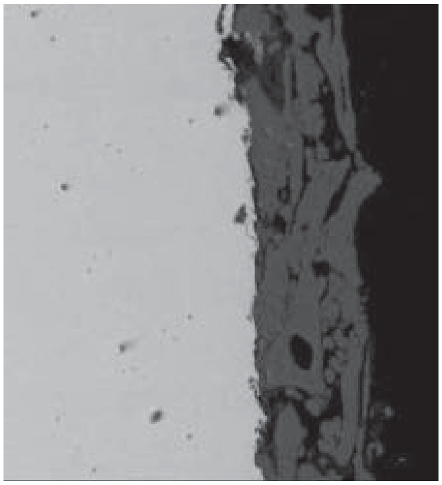

Fig. 18: SEM backscatter image of the TSA coating showing the coating with porosity present during coating application (100 x)

upon visual comparison to CSA Z245.20 (Canadian Standards Association). Early optical photomicrographs suggested there was porosity in the liquid-applied coatings, in some instances similar to that in TSA.

SEM was then used to afford a more quantitative value for porosity within the coating based on the cross section surface areas. This worked well for TSA and for Coating #1, where virtually no porosity was seen. However, it did not work well for TMIC because virtually all the dark areas in the TMIC's optical and SEM images were subsequently shown not resulting from porosity. This led next to taking higher magnification images. Through the use of a fluorescent green epoxy mounting medium, and polishing the samples, the dark areas of TMIC at all temperatures were shown to be back reflection of pigment. In contrast, the dark areas seen in the images of Coating #2 were spaces arising from coating breakdown (not true porosity) when the temperature increased beyond 200 C.

Selected areas near the coating-steel interface were examined at high magnification using X-ray mapping techniques. Each coating cross-section was analyzed using EDXA at various locations in the coating matrix.

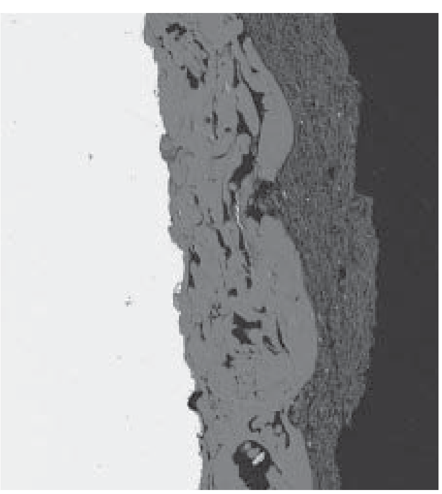

Fig. 19: SEM backscatter image of the TSA with TMIC repair patch at the 4 cm (400 C) location showing intact bond to substrate and between coatings (100 x)

TSA in Action

Inspection of the photomicrographs and SEM images showed that the porosity of the TSA according to the analysis from the Image Pro Plus software was approximately 12 to 20% (Fig. 18). This range is typical for TSA. As expected there was no evidence of structural changes in the TSA between 100 C and 400 C. The images also indicated excellent adhesion between the TSA and the abrasive blast cleaned steel substrate, in agreement with the knife adhesion tests previously discussed (ASTM D6677 adhesion Rating 10).

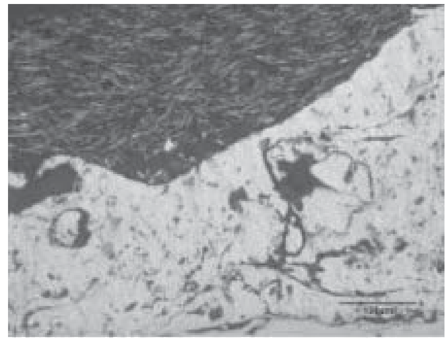

Fig. 20: Metallographic image showing the bond location between the TSA and TMIC repair patch at the 4 cm (400 C) location (200 x)

TSA with TMIC Patch in Action

The integrity of the TMIC coating that was applied as a repair patch to TSA did not appear to change as the exposure temperature increased from 200 C to 400 C. Figures 19 and 20 show, respectively, SEM and optical images of the repair system at 400 C and the unbroken and tortuous path of the aluminum flake platelets. Figure 21 shows the X-ray map and distribution of the main elements in the TMIC sample exposed to 400 C, namely silicon, aluminum, and carbon (titanium, although vital to the efficiency of TMIC, was below the detection limit). It is interesting to see the widespread distribution of carbon from carbon compounds that will have been thermally decomposed.[19]

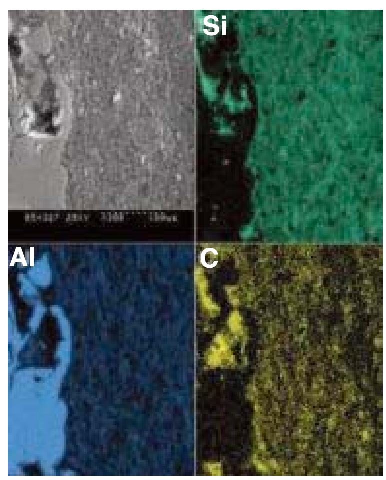

Fig. 21: SEM - X-ray mapping images showing the distribution of elemental constituents in the TMIC and TSA bond location (300 x)

Coating #1 in Action

As shown in Fig. 22, the coating was dense, and showed less than 1% porosity over the full test temperature range. The interface between the two coats during application was not visible. The coating structure consisted of the polymer matrix with entrained fillers and pigments with a wide variety of shapes and sizes (rods, plates, blocks, irregular fractured shapes). The morphology, distribution, and volume of the solid phases in Coating #1 would not be expected to present such a tortuous path for the ingress of water, oxygen, and deleterious salts compared to TMIC. It is noteworthy that at 400 C, the primer is cohesively stressed and shears, leaving a thin film of Coating

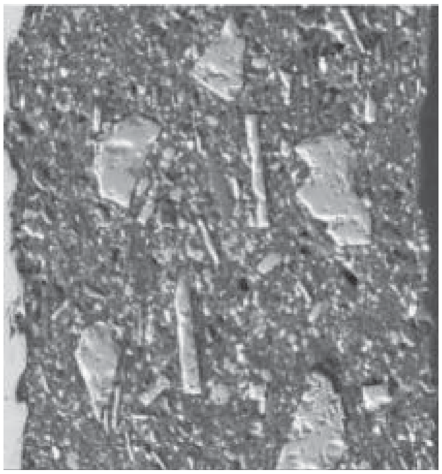

Fig. 22: SEM image of Coating #1 after exposure to 100 C at interface with substrate, showing coarse filler material in a dense matrix (300 x)

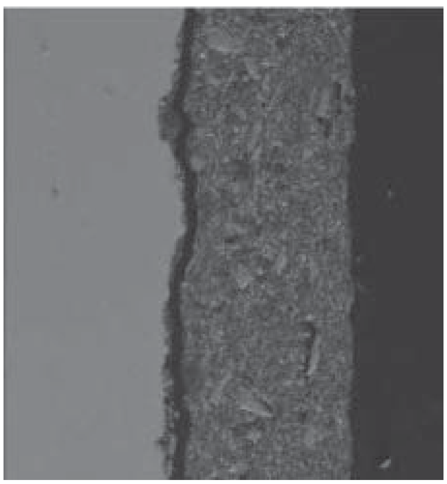

Fig. 23: SEM image of Coating #1 at interface with substrate, after exposure at 400 C showing disbondment at coating to substrate interface (100 x)

#1 adhered to the carbon steel substrate (Fig. 23).

Coating #2 in Action

The microstructure of Coating #2 was similar to Coating #1, but appeared to be simpler, with the larger particles dominating the morphology (Fig. 24). The coating retained good adhesion to the substrate with no corrosion products visible at the substrate. At 300 C, the onset of an intra-coat cohesive fracture line was discerned, where the MIO pigment in the primer was seen at the primer surface. By 400 C, the coating had lost integrity and

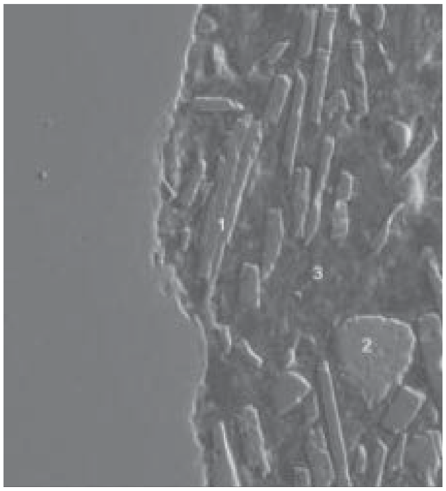

Fig. 24: SEM image of Coating #2 at interface with substrate, after exposure at 100 C showing coarse filler material and intact matrix (300 x).

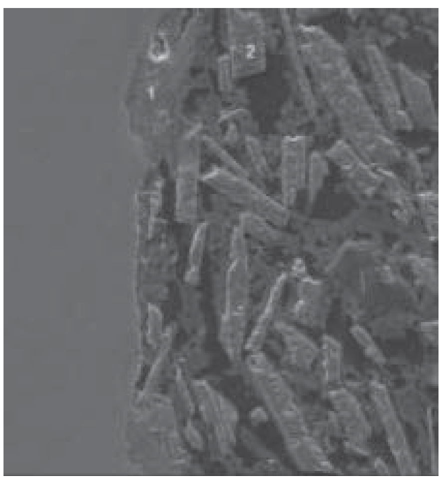

Fig. 25: SEM image of Coating #2 after exposure at 400 C showing coating matrix breakdown and fracture (300 x)

fractured, which allowed the ingress of the hot salt solution to reach the carbon steel substrate. The resulting oxidation was confirmed by the SEM images and EDXA on the carbon steel substrate, where iron, oxygen (likely iron oxide), and chloride ions were detected.

The cracks were filled with epoxy during sample preparation, helping to keep the coating sample intact during preparation (Fig. 25). These cracks served as a pathway for oxidation and corrosion on the substrate. Based on the space within the coating filled with fluorescent green epoxy, at 400 C, the apparent porosity of Coating #2 was about 9% (Fig. 26).

Fig. 26: SEM image of Coating #2 after image analysis to evaluate coating porosity after exposure at 400 C showing porosity level of 9% in the matrix (200 x)

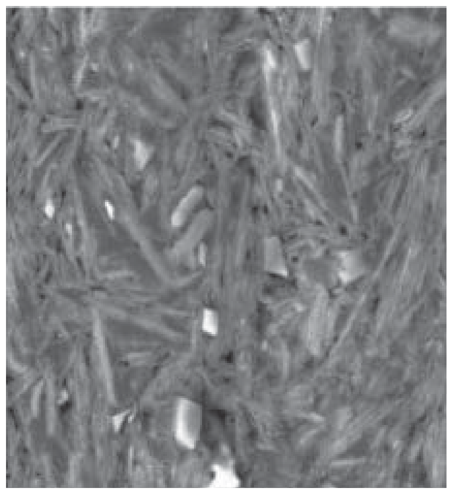

Fig. 27: SEM image of TMIC coating after exposure at 100 C showing interlacing of dense aluminum platelets in an inorganic matrix (1000 x)

TMIC in Action

The SEM images showed that there was virtually no porosity in TMIC (less than 1%) and the coating microstructure did not appear to change as the temperature increased from 100 C to 400 C. With no cracking or disbonding, the microstructure of TMIC remained essentially unchanged over the full temperature range, as was also observed for TSA (Figs. 27 and 28).

At 400 C, the TMIC microstructure was found to be fully intact with no evidence of degradation of the matrix (Fig. 28). The coating morphology consisted of a dense array of leafing aluminum platelets in a silicon-based resin system. Interestingly, TMIC had been applied at a lower film thickness than any

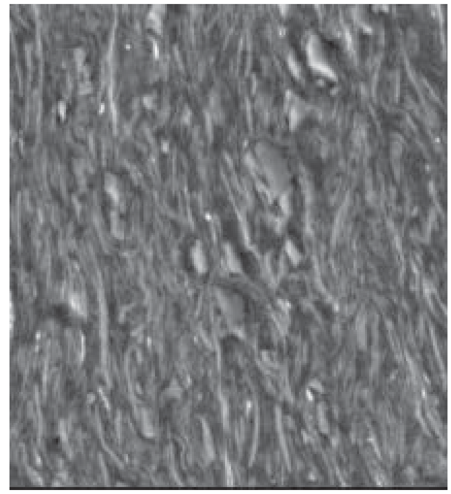

Fig. 28: SEM image of TMIC coating after exposure at 400 C showing interlacing of aluminum platelets in the intact inorganic matrix (1000 x)

other coating under test, and there was no evidence of separation or opening between the platelets. This may be in part due to the overlapping and interweaving nature of the aluminum platelets, thereby providing additional tensile strength in the circumferential orientation. The aluminum flake may potentially further improve coating integrity and performance at high temperatures by producing a reduced thermal differential or insulating effect across the coating from better heat transfer characteristics.

General Discussion of the CIA

Previous work by the authors[17] showed that TMIC technology was an excellent proposition for high heat and under-insulation service, and would make a perfect complementary product strategy for TSA. It was argued that TMIC could be used to repair and extend the life of TSA. In the present work, not only did TMIC perform almost as well as TSA in a standalone mode at 7-8 mils DFT, but it was virtually unaffected as a repair patch to TSA even at temperatures up to 400 C. More work needs to be undertaken, however, because of a hair line crack that developed at the transition between the TMIC and TSA at temperatures close to 400 C. More importantly, TMIC was shown to have heat resistance and corrosion resistance properties far superior to the other high-heat coatings investigated.

As a CIA agent, TMIC ranked #1 among the liquid-applied coatings by a considerable margin. Its barrier properties based on the CUI experiments (including cyclic immersion and EIS studies) revealed superior performance. Examination of the TMIC microstructure using optical microscopy, SEM, and X-ray mapping all confirmed that TMIC performs as a flexible coating in the CUI range of 60 C to 120 C, and at elevated temperatures up to 400 C. In addition TMIC had superior post-test adhesion than either Coating #1 or Coating #2. It was particularly interesting to note that EIS confirmed what is known about TMIC technology in that the inorganic polymer does not achieve full cross-linking until heated beyond 100 C.

Aside from the successful applications in the field, these studies strongly indicate that the specification of TMIC technology for facility owners in the industrial, marine and offshore sectors could be a step forward for CUI mitigation, particularly if ultra high (>200 C) cyclic environments are involved. Depending on the temperature, the application of the CIA agent TMIC should reduce the number of costly CUI inspections, cut the cost of pipe maintenance, lower life cycle costs, and markedly assist risk management practice.

CASE HISTORIES

Going Undercover with a TMIC Agent

Our hero has prevailed! All his strivings, sacrifices, and travails have been worth it. His has been a fact-finding journey of discovery into labyrinths of intrigue; a secret operation into untrammelled territory. The covert agent list was in safe hands once again; the lives of many were saved; the balance of power was assured, and our hero is ready to tackle the next assignment.

We too, have been on a journey of discovery, albeit more of a technical kind with our own undercover agents. As you can see our travels inside the world of 'coatings under insulation' have been no less stimulating, no less revealing. And we too, are ready for the next exciting assignment in the realm of protective coatings.

No matter how well it is designed, a laboratory simulation of a service environment will only approximate, or serve to indicate, what might be expected to happen in real life conditions. Accelerated performance will never fully reflect how a CIA agent will perform in real life service with all the attendant variables. That said, the following case histories outline the successful performance of TMIC in actual service conditions, success which could reasonably be anticipated based upon Operation High Heat.

France–TMIC Protection of TSA Field Joints

In 2007, in a refinery in France, some piping that was coated with TSA was overlapped with TMIC technology on the welded field joints. Given that welded joints are particularly susceptible to corrosion, TMIC technology was chosen for its barrier properties and high heat protection up to 400 C. Interestingly, a traditional thin film silicone aluminum had not met the facility owner's expectations and was subsequently replaced with a TMIC coating (Figs. 29 and 30).

Because of heat stresses created during welding, the welds are areas most at risk from corrosion. TMIC was applied on-site by roller and without involving hot work to protect field joints with TSA.

Texas Gas Dryer Unit

Gas dryer units in a Texas refinery with a history of rapid deterioration of coatings under insulation were selected for the first industrial field trial of TMIC technology. The dryer units cycle between -20 and 230 C over a 4- to 5-day cycle. Previously, several different polymeric coating technologies had been used to protect the dryers, and, in all cases, the coatings had failed within 6 to 12 months of service. Because of the lack of success with other coatings, and the inability to apply TSA to the on-site structures, the refinery decided to try TMIC to solve the CUI problem.

In 2004, the TMIC coating was applied to the dryers. Because of site safety and operational limitations, abrasive blasting was not possible, so the surface preparation consisted of SSPC-SP 2 and SP 3, hand and power tool cleaning, followed by two coats of the TMIC coating for a total DFT of 8-10 mils.

One year later, the dryer units were inspected, showing no rusting or coating degradation (Fig. 31). At present, the dryers have operated for over 6 years without any indications of CUI.

CIA CONCLUSIONS

TSA

TSA and TMIC both had similar performance and were the best of the four coatings during the CUI cyclic test runs. The majority of visible rusting was limited to the 390 C to 445 C section of the pipe. No blistering, flaking, or cracking was observed on the coating on either of the CUI test runs. However, minute pinpoints of rust could be observed from 140 C to 390 C after CUI cyclic testing.

During the cyclic immersion-heat testing, TSA performed the best, showing no signs of blistering, cracking, or flaking. While pinpoints of rust were visible from 135 C to 445 C along the pipe in some instances, they were minuscule, few in number, and appeared to have little effect on the surrounding coating. No significant increase in severity occurred to these pinpoints, even after 6 weeks of immersion and heating cycles.

The low EIS values were representative of the coating's metallic nature and hence low electrical resistance. The impedance of the coating increased over the course of CUI cyclic testing, implying porosity reduction, a desirable attribute of thermal spray coatings.

As expected, the TSA coating exhibited significant true porosity, which did not appear to be a factor with performance because the

Fig. 29: Preparation of TSA weld joints

Fig. 30: TMIC applied to protect TSA weld joints

Fig. 31: Inspection of TMIC after 1 year in service showing no coating breakdown or rusting

steel substrate was free of any evidence of oxidation or corrosion beneath the TSA. The TSA coating also appeared to retain bond integrity along the fusion line between the TSA and the steel substrate at all locations, including the 400 C location.

Coating #1

Coating #1 performed relatively poorly, with a major loss in performance at temperature above 250 C. From 210 C to 250 C, Coating #1 performed better, with little deterioration observed below 190C.

Coating #1 showed no signs of blistering or flaking during the CUI test, but consistently showed high amounts of non-preferentially oriented cracking from 250 C to 445 C. The cracking was tied to the development of flaking and loss of coating adhesion during immersion testing.

EIS tests showed that the barrier properties of Coating #1 were very good at 100 C, but fell significantly, mostly as a result of cracking and physical deterioration, as the temperature increased. However, at about 400 C where a small ring of the coating was relatively crack-free, the barrier properties were higher than those of the coating at 300 C (where cracking was observed).

Coating #2

Coating # 2 performed relatively poorly and saw a major loss in performance at temperatures from 290 C to 445 C as a result of rusting, blistering, cracking, and flaking, accompanied by corrosion of the steel substrate. From 250 C to 290 C, its performance was better, with little visible deterioration below 250 C. The deterioration became increasingly more severe during cyclic immersion testing, and after 6 weeks rusting and flaking were observed to temperatures as low as 210 C.

The barrier properties of Coating #2 dropped significantly at temperatures above 200 C, which coincided visually with the performance of the coating in both CUI runs, and after immersion testing.

SEM images, optical microscopy and X-ray maps showed the coating contained coarse MIO flakes within a silicon based binder matrix. The coating matrix appears to break down and fracture at higher temperatures resulting in coating integrity failure. The coating fractures allow for hot saline solutions to contact the carbon steel substrate and cause corrosion of the steel pipe.

TMIC

Applied to carbon steel pipes, and under repetitive cyclic thermal conditions, TMIC offers thermal resistance and corrosion resistance in the critical CUI temperature range of -4 C to 175 C. The performance of TMIC is equal to or better than the other coatings in this range. However TMIC outperforms the other liquid coatings at temperatures from 175 C to 400 C.

Both TMIC and TSA performed similarly, with both coatings sharing the best performance of the coatings during both CUI cyclic tests. The TMIC coating performed consistently well at temperatures below 335 C, with slight degradation occurring between 335 C and 445 C. This was also true of the TMIC brush-applied repair patch tested on the TSA coated pipe.

TMIC did not have any blistering, flaking, or cracking under CUI cyclic temperature testing. After additional testing in cyclic immersion, hairline cracks, and flaking were observed around pinpoints of rust above 390 C, which seemed to indicate that the rust pinpoints had increased in severity due to the cyclic immersion testing. Below 390 C, TMIC performed consistently well.

TMIC developed excellent barrier properties after CUI cyclic testing up to 300 C. However, at 400 C, the impedance plummeted into the range observed for TSA while otherwise demonstrating excellent performance in visual, microscopic/SEM, and physical tests. It is speculated that the close packing of aluminum flakes in the resin network may have resulted in initiation of fusion at 400 C. As a result, TMIC could have developed some of the metallic characteristics of TSA and thus exhibit reduced electrical resistance.

OPERATION HIGH HEAT COATINGS IN ACTION: RANKING

Overall, during CUI cyclic testing, the TSA and TMIC coatings provided the best performance for temperatures up to 445 C. Coating #1 had the next best performance, with varying degrees of deterioration beginning above 100 C. Coating #2 had the poorest performance, with degradation above 200 C being severe and significantly worse than that seen for Coating #1.

So what is the final analysis? Mission Impossible? Or is it Mission Possible? The answer depends on the coating agent and the operation temperature. Before the mission, all undercover agents were said to be capable of effective CUI countermeasures in Operation High Heat. However, the mission exposed that some important claims derived from fine work of coating formulators and material scientists were found wanting. In the present investigation, the old benchmark agent TSA and the new technology agent TMIC could stand the heat. But the new technology Coating #1 and Coating #2 could not. As in the movie *Mission Impossible*, we must all wait for a new adventure. In the meantime, industrial, marine, and offshore facilities have two great coating agents to recruit for CUI.

ACKNOWLEDGEMENTS

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16. Knudsen, O., Rogne, T., Rossland, T., "Rapid Degradation of Painted TSA," NACE Paper No. 04023, 2004, p. 6.
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20. Betzig, D., "Qualification Testing of High Temperature Coatings," 13th Middle East Conference and Exhibition, Paper No. 10136.
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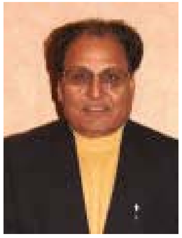
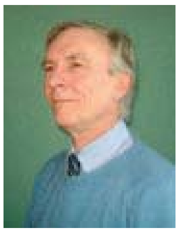
Mike O'Donoghue, PhD, is the Director of Engineering and Technical Services for International Paint LLC. He has 30 years of experience in the protective coatings industry.



Vijay Datta, MS, is the Director of Industrial Maintenance for International Paint LLC. He has more than 40 years of experience in the marine and protective coatings industry.



Adrian Andrews is the Technology Development Manager, International Paint LLC. He has 30 years of experience in the protective coatings industry.

Sean Adlem is the Sales Manager, Alberta Region Protective Coatings, International Paint LLC. Sean has over 20 years of experience in the protective coatings industry.

Matt Giardina, Business Development Oil & Gas Market for International Paint LLC, has 7 years of experience in the coating industry.

Nicole de Varennes is Coatings Laboratory Manager for RAE Engineering and Inspection Ltd. She has 7 years of experience in various aspects of industrial coatings.

Linda G. S. Gray, MSc, is a Senior Materials Specialist for RAE Engineering and Inspection Ltd. and has over 20 years of experience with industrial coatings.

Damien Lachat is a Coatings Technologist for RAE Engineering and Inspection Ltd., where he is involved in various aspects of industrial coatings testing and research.

Bill Johnson, AScT, is the Manager of Laboratory Services with Acuren Group Inc., in Richmond, BC. Bill has 20 years of experience in materials testing, failure analysis, scanning electron microscopy, and energy dispersive X-ray analysis.

JPCL

INORGANIC VS ORGANIC ZINC PRIMERS for OFFSHORE PLATFORMS

An End User's Point of View

By Massimo Cornago, Consultant*

Editor's Note: Massimo Cornago is one of 24 recipients of *JPCL*'s 2012 Top Thinkers: The Clive Hare Honors, given for significant contributions to the protective coatings industry over the past decade. The award is named for Clive Hare, a 20-year contributor to *JPCL* who shared his encyclopedic knowledge of coatings in many forums. Mr. Cornago's article is among a series of articles by award winners that will appear in these pages throughout the year. Professional profiles of all of the award winners, as well as an article by Clive Hare, will appear in a special 13th issue of *JPCL*, to be published in August 2012.

Due to the harsh environment at sea, good corrosion protection of offshore platforms is necessary to ensure that the design life of each structure is achieved. Success of the coating work depends on many aspects (paint specification, paint systems certification, surface preparation, coating application, certified inspectors' activity, etc.). Mainly, however, success of the coating depends on the environmental conditions and the procedures used to counteract adverse environmental exposures during application.

Sometimes it is not possible to have the best environment or, very often, to have enough time reserved for the painting activities, so it's necessary to have alternative approved paint systems that will give the same performance but can be applied in a shorter time. This article describes the approach of one oil company in the selection of different paint systems for the corrosion protection of offshore platform structures above the splash zone. In particular, the article focuses on the initial choice between different primers, either inorganic zinc or organic (epoxy) zinc at the newbuilding stage. The preliminary prequalification tests, and the procedures adopted will be described. In addition, the use of a polyurethane topcoat instead of an epoxy/acrylic for the maintenance system was evaluated.

** The author was formerly with ENI Exploration & Production, SpA, Italy.*

TEST PROGRAM

The purpose of the test program was to verify the application efficiency of a paint system composed of an organic zinc epoxy, intermediate epoxy, and epoxy acrylic topcoat, and compare this system to the one traditionally used by the company. According to the product data sheets, the organic zinc primer system has a reduced application time (with consequent reduction in operational costs) for the same quality and performance offered by the current system.

Paint Systems Compared

For the coating application efficiency tests, the paint systems shown in Table 1 were compared. System 3 is traditionally used by the company for new building, and System 4 is used in maintenance activities. Systems 1 and 2 are under evaluation for new building, and System 5 is an alternative maintenance system.

Description of Work

All the systems were applied on one-meter-long beams (HEB 500 steel joists). Surfaces were prepared by blasting with non-siliceous material to White Metal, degree Sa3 (in conformity with ISO 8501), and with a profile of 70-85 microns.

Both Systems 4 and 5 were applied on the same joist and divided in two identical halves for the gloss comparative evaluation of the two different topcoats.

In addition, three carbon steel plates

Table 1: Systems Compared

System 1	C/a	Organic zinc epoxy—75 microns Intermediate epoxy—200 microns Epoxy acrylic topcoat—75 microns
System 2	C/p	Organic zinc epoxy—75 microns Intermediate epoxy—200 microns Polyurethane top coat —75 microns
System 3	A2	Inorganic zinc—75 microns Epoxy polyamide—25 microns Epoxy polyamide—125 microns Fluorocarbon top coat—30 microns
System 4	C/Ma	Intermediate epoxy—200 microns Epoxy acrylic top coat—75 microns
System 5	C/Mp	Intermediate epoxy—200 microns Polyurethane top coat—75 microns

(150×70×15 cm) were arranged side by side, for every system, and given the same surface preparation and coating application method for each system.

The products used in System 3 (A2) were already available in the fabrication yard. However, they came from different suppliers, so the data obtained isn't as truly comparable as if the products had come from the same paint manufacturer. Nevertheless, this system has been used for many years, and the performance obtained is well known.

Preparation of Surfaces

The surface preparation of all joists and plates was executed in accordance with the Company Paint Functional Specification, which calls for blasting to Sa3 with a medium profile. The plates were washed with high-pressure water before blasting. The joists, unlike the plates, didn't require a pre-treatment and thus were directly blast cleaned.

Table 2: Environmental Conditions during Blasting and Coating

Date—Hour	Blast/Paint Cabinet	Temp. Air (C)	Temp. Humid Bulb (C)	Relative Humidity (%)	Dew Point (C)	Temp. Metal (C)
09/14—10:30	Blasting	27	20.5	63	19.5	31
09/14—11:45	Paint	28	21	64	17.8	30
09/14—12:01	Paint	28	21	64	17.8	30
09/14—17:00	Paint	27	22	63	19.5	28.5
09/15—11:20	Paint	27.5	24	72	22.7	28.8
09/15—14:20	Paint	26.5	26.5	72	21.5	28.5
09/15—14:50	Paint	28	25	78	23.9	29.5
09/15—15:15	Paint	28	23.5	72	23.2	28
09/16—17:00	Paint	27	20.5	63	19.5	31
09/17—09:45	Paint	22	18.5	73	16.2	30
09/18—11:30	Paint	27.5	21	57	18	34

Blasting operations were executed in the blasting cabinet in accordance with ISO 8502-4. The abrasive material used was Steel Grit 40.7, in accordance with ASTM D4285. The blotter test was used to ensure that the air used in the blasting and painting operation was free of oil and/or water.

The surface of all samples was therefore cleaned to White Metal, corresponding to ISO 8501, degree Sa3. Any metal flaws exposed after blast cleaning were eliminated through disk grinding.

The determination of roughness (or blast profile) was carried out in accordance with ASTM D4417, Method C (X-Coarse tape).

Table 3: Average Spot Dry Film Thickness Reading

Sample	1 C/a	2 C/p	3 A2	4 C/Ma	5 C/Mp
Total DFT (Microns)	350	380	290	310	315

Environmental Conditions

During all work operations, environmental data was recorded with a sling psychrometer and a contact magnetic analog thermometer. Environmental recordings were measured inside the blasting/painting cabinet.

Table 4: Adhesion Values and Fracture Modes

Sample	Average Adhesion Value (MPa) by Mechanical Instr.	Visual Observation (Detachment) (%)	Average Adhesion Value (MPa) by Pneumatic Instr.	Visual Observation (Detachment) (%)
System 1 C/a	5.5	80 topcoat 20 intermediate	12.5	100 topcoat 0 intermediate
System 2 C/p	6	80 topcoat 20 intermediate	12.5	70 topcoat 10 intermediate
System 3 A2	7	90 topcoat 10 intermediate	16	90 topcoat 10 intermediate
System 4 C/Ma	6	17 topcoat	12	5 topcoat
System 5 C/Mp	8	50 topcoat	14	6 topcoat

Paint Application

All the systems were applied by airless spray using two pumps produced by two different companies, although the pumps have the same operational characteristics.

The wet film thickness was measured during all application phases using a wet film comb. The dry film thickness during all the phases of systems application was carried out according to SSPC-PA 2, "Measurement of Dry Film Thickness with Magnetic Gauges." The instrument was calibrated by establishing the "zero" through four spot readings on the blast-cleaned substrate (random area by sample joists) and through measurements with plastic shims certified by the instrument manufacturer, 75 microns thick for primers, and 400 microns for topcoat systems.

Adhesion Determination

Adhesion tests were carried out in conformity with ASTM D3359 (cut), D4541 (pull-off) and ISO 4624 (pull-off) standards, as required by the Company Functional Specification. Tests according to the cut method were carried out using a knife and adhesive tape where the painting thickness exceeded 125 microns on all the systems, but only the pull-off results are given in this article. Tests with the pull-off method were carried out on the three full paint systems

"The [total drying] times... demonstrate a marked difference between the theoretical and the practical...."

by applying dollies on the surface with a two-pack composite epoxy, and were measured with a mechanical instrument.

Analysis of Completion Time of Finished Systems

The application of all tested systems was timed in order to compare theoretical times specified in the product data sheets and real times obtained in the climatic conditions present.

RESULTS AND DISCUSSION

After blast cleaning, the average roughness obtained was as follows.

- Joist 1: 80 microns
- Joist 2: 75 microns
- Joist 3: 72 microns
- Joist 4: 76 microns

The environmental conditions during the various stages of blasting and painting for the test samples are shown in Table 2.

As can be seen, the environmental conditions inside the blasting and painting cabinet were fairly uniform and always optimum for the work. The metal temperature was always at least 3 degrees C above the dew point. However, the climatic conditions outside the cabinet, because of several storms, caused a slowdown of drying time and coating of the inorganic zinc and intermediate epoxy polyamide.

The wet film thicknesses were in the range of 280–400 microns, and the average spot dry film thickness reading is given for each system in Table 3.

The adhesion values and mode of fracture for the different systems are given in Table 4.

For the total drying times, see Table 5.

The times shown in the Table 5 demonstrate a marked difference between the theoretical and the practical, and, importantly, the test systems show a large reduction with regard to the system conventionally used (A2). Such differences are possible, due particularly to the application of organic epoxy zinc, which, compared to the inorganic zinc, dries in about 3 hours. This primer offers quick overcoating and does not require an epoxy polyamide tie-coat application for pore saturation, and, in the final analysis, it is unrelated to relative humidity and can be applied at values below 50%.

CONCLUSIONS

The tests in yard have emphasized the following.

Table 5: Total Drying Times

Completion times	Paint System 1 Hours	Paint System 2 hours	Paint System 3 hours
Completed (yard)	27	27	96
Completed (product data sheet)	10	10	52
Movable (yard)	29	36	100
Movable (product data sheet)	12	18	54

1. Both paint systems 1 and 2 have shown total application times lower than those obtained by conventional system No. 3
2. The polyurethane topcoat system is liked better for its higher gloss, consistency, low volatile organic compound (VOC) content and high-solids content. This topcoat was already included in the system of paint provided for the area above the splash-zone and is an integral part of the last review of the Company Functional Paint Specification! (The fluoropolymer topcoat was removed from the paint specification because of a very high cost with not much difference in performance, and a polyurethane topcoat was substituted.)
3. Both systems 4 and 5 applied directly on the bare metal, without using primer, confirm good results in terms of adhesion, and so they are considered efficacious if used in maintenance. The polyurethane topcoat in system 5 is already used by the company.
4. Because of its lower dependence on climatic conditions, the organic zinc epoxy application is easier than the inorganic zinc application. However, attention has to be paid, particularly, to the film thickness and drying time. In addition, the absence of tie-coat application (a coat of paint between primer and intermediate) is more sensitive to mistakes in the formation of the zinc film. JPCL

Massimo Cornago, now a private consultant, most recently worked for ENI Exploration & Production, SpA, Italy. He has approximately 30 years of experience in the oil and gas industry, with much of his work focusing on coatings and corrosion engineering. He has been involved in research and development, corrosion studies, risk evaluation, chemical treatments, and active as well as passive corrosion protection. Cornago also has experience with problem solving and failure analyses, and he has performed inspections and provided assistance on jobs in the field. In addition, his expertise includes preparing analyses of technical specifications for paint and coatings work on new construction and on maintenance projects; qualifying coating application facilities, paint systems and coatings, paint manufacturers, and applicators; and management of paint and coating maintenance work in a variety of settings, including FPSO and offshore platforms. He is a NACE-certified coating inspector and has taught for NACE, AGIP, and the Associazone Italiana di Metallurgia (AIM). He is active in ISO and other industry organizations and has presented papers, chaired conference sessions, and published articles around the world.

SSPC, *JPCL* Present Editorial Awards in Tampa

At SSPC 2012 featuring GreenCOAT, SSPC and *JPCL* presented awards to recognize achievement in the protective coatings industry. SSPC 2012 was held in Tampa, FL, from Jan. 30 to Feb. 2. The awards were presented during the Annual Business Meeting & Luncheon, which was held on Monday, Jan. 30 at 11:00 a.m.

The Outstanding Publication Award and the *JPCL* Editors' Awards are described here. Other awards presented at the show will be featured in future issues of *JPCL*.

Outstanding Publication Award

This year, the Outstanding Publication Award went to Don Schnell, formerly of Dehumidification Technologies, LP, for, "Sizing DH for Water Tank Lining Jobs." The article appeared in the May 2011 *JPCL* on pgs. 20-26.

JPCL Editors' Awards

Six papers received *JPCL* Editors' Awards.

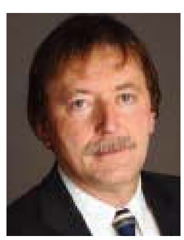
- "Angels and Demons in the Realm of Protective Coatings: The Underworld of VOCs," by Mike O'Donoghue, Ph.D.; Vijay Datta, MS; and Russell Spotten, International Paint, LLC; *JPCL*, April 2011, pgs. 14-29
- "An Inspector's Views from the Field: Should the World Start to Specify the Joint SSPC/NACE Standards?" by Lee Wilson, Consultant; *JPCL*, March 2011, pgs. 20-24
- "Painting Practices for Floating Production, Storage, and Offloading Systems," by Michael B. Surkein, Robert H. Rogers, and Sophia Woodley, ExxonMobil Development Corporation; *JPCL*, Feb. 2011, pgs. 26-41
- "Strategic Corrosion Protection of New Sewerage Overflow Tunnels," by Bob Maley, Corrosion Probe, Inc., and Steve Kelso, Sauereisen, Inc.; *JPCL*, Feb. 2011, pgs. 42-53
- "Testing Permeation Resistance in Coatings for Wastewater Structures," by Vaughn O'Dea, Caleb Parker, and Rémi Briand, Tnemec Company; *JPCL*, Sept. 2010, pgs. 16-28
- "Understanding Inorganic Zinc-Rich Primers and Specifications," by Dr. Ilhan Ulkem and Mike Winter, Worldwide Protective Coatings, International Paint, LLC; *JPCL*, Dec. 2010, pgs. 40-48

SSPC Now Offers the PCI Program Online

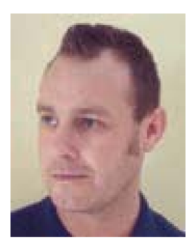
As of Jan. 15, SSPC now offers its Protective Coatings Inspector (PCI) Program online. The program begins on the 15th of each month and runs for 20 weeks, including the exam.

The objective of the course is to thoroughly train individuals in the proper methods of inspection surface preparation and installation of industrial and marine protective coatings and lining systems on an array of industrial structures and facilities. There are no prerequisites to attend the course; however, it is not an entry-level course.


Don Schnell


Mike O'Donoghue


Vijay Datta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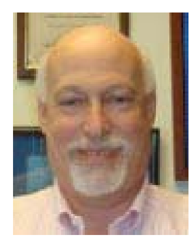
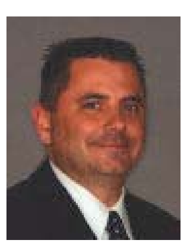
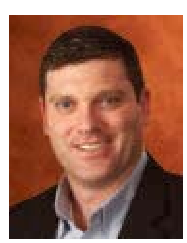
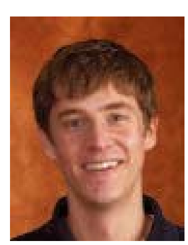
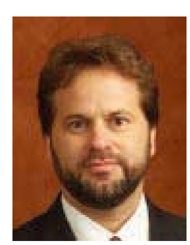

Michael B. Surkein


Bob Maley


Steve Kelso


Vaughn O'Dea


Caleb Parker


Rémi Briand

SSPC's PCI online course features units as a series of web pages that students can access at their convenience. Students can take the exam online as soon as they complete the units and quizzes. The exam is corrected automatically, and the student can download the certificate of training right away. To pass the PCI exam, candidates must score 70% or higher.

SSPC offers several other courses online. They include: Fundamentals of Protective Coatings (C1), Planning and Specifying Industrial Coatings Projects (C2), Basics of Nonferrous Surface Preparation, Basics of Steel Surface Preparation, Basics of Concrete Surface Preparation, Quality Control Supervisor (QCS), Marine Coatings, and Applicator Training Basics.

There are also opportunities for free educational webinars, offered jointly by SSPC and *JPCL*.

For more information on SSPC's online training, visit www.sspc.org/training/online-training-e-learning.

Training Held in Southeast Asia

SSPC recently certified another 11 people from the Southeast Asia area in the Protective Coatings Inspector (PCI) Program. SSPC has trained and certified over 300 people to the PCI Level 2 program.

SSPC would like to recognize the following people for helping out with the training event in Southeast Asia: Abdul S. Rashid, Abdul Quim (Bani), and Patrick Tan.

North Central Region Chapter Held Dec. Meeting

The SSPC North Central Region Chapter held a meeting in Minneapolis, MN, on Dec. 1 where Jennifer Merck of SSPC presented, "The Ins and Outs of SSPC Training." The meeting had over 30 people in attendance and was run by chapter chair, John Pfeffer from Polygon.

Utah Hosts CORROSION 2012

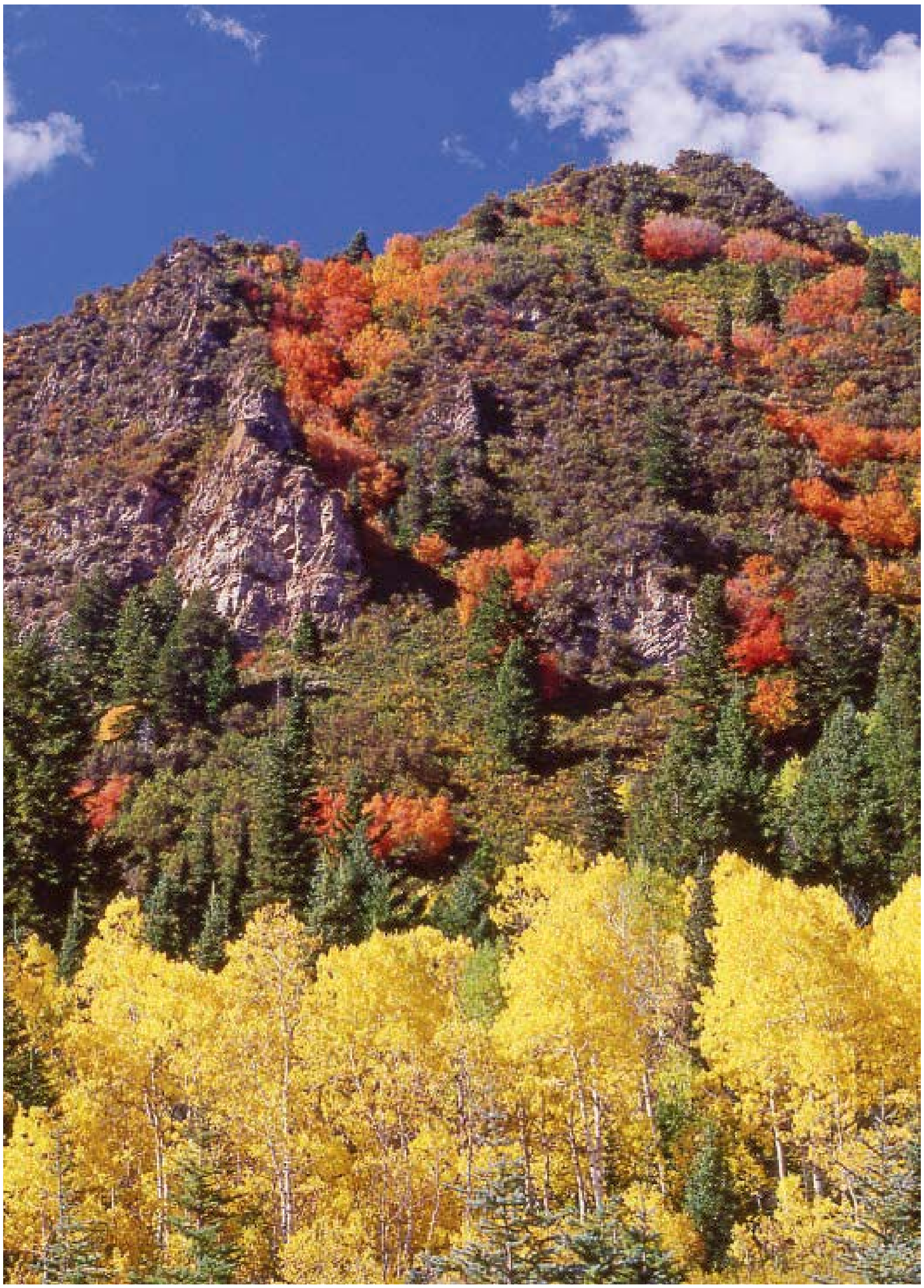


Photo courtesy of the Salt Lake Convention Visitors Bureau and photographer Steve Greenwood.

The NACE International annual conference and exhibition, CORROSION 2012, will be held in Salt Lake City, UT, from March 11 to 15 at the Salt Palace Convention Center. The show offers a technical program, special events, and hundreds of exhibits for corrosion professionals from industries including coatings and linings, infrastructure, marine industry, military, oil and gas production, petroleum refining, pipeline systems, and more.

The following information describes sessions that may be of special interest to persons involved with corrosion control through coatings. Information is current as of press time.

For more information, visit www.nace.org.

Technical Symposia, Committee Meetings, Workshops, & Forums

Sunday, March 11

- How to Avoid Premature Coating Failures, presented by Mark O'Brien, MARK 10 Resource Group, Inc. This tutorial will provide participants with practical knowledge to reduce or avoid premature coating failures.
- TEG 311X, Threaded Fasteners: Coatings and Methods of Protection for Threaded Fasteners Used with Structural Steel, Piping, and Equipment
- TG 148, Threaded Fasteners: Coatings for Protection of Threaded Fasteners Used with Structural Steel, Piping, and Equipment
- TEG 255X (01, 03), Coatings, Thermal-Spray for Corrosion Protection

• TEG 428X (02, 03), Hot-Dip Galvanizing for Steel Corrosion Protection

Monday, March 12

• STG 40, Corrosion Issues in Military Equipment and Facilities
• TEG 191X, Managing Corrosion with Polymers
• STG 44, Marine Corrosion (Session 1; Session 2 on Tues., March 13)
• STG 32, Advances in Materials for Oil and Gas Production (Session 1; Session 2 on Tues., March 13)
• TEG 224X, Corrosion in Nuclear Systems (Session 1; Session 2 on Tues., March 13)
• TEG 267X, Pipeline Integrity (Session 1; Session 2 on Tues., March 13)
• Contracts, Specifications, and Warranties in the Painting Industry, presented by Eugene Doerr III, REOD, LLC. The forum will cover questions related to contracts, specifications, and warranties.
• Joint Meeting of TG 260, TG 263, TG 264, and TG 312

Tuesday, March 13

• TEG 202X, Oil and Gas Production, Deepwater Corrosion, and Scale Control
• TEG 205X, Refining Industry Corrosion
• STG 61, Top-of-the-Line Corrosion Symposium
• TEG 043X, Corrosion Inhibitors, CP, and Other Corrosion Protection Methods for Reinforced Concrete Structures (Session 1; Session 2 on Wed., March 14)
• STG 02, STG 03, Oil/Gas Coating Technology Symposium (Session 1; Session 2 on Wed., March 14)
• TG 339, Railcars: Coating Application on Exterior Surfaces of Steel Railcars
• TG 378 (02), Waterborne Coatings on Railcars
• TG 379, Surface Preparation by Encapsulated Blast Media for Repair of Existing Coatings on Railcars
• TG 394 (04), Guidelines for Qualifying Personnel as Abrasive Blasters and Coating and Lining Applicators in the Rail Industry
• TG 271 (04), Removal Procedures for Nonvisible Contaminants on Railcar Surfaces
• TG 437 (02, 04), Maintenance Overcoating of Railcar Exteriors
• TG 456 (02, 03, 04), Coating Thickness Measurement, Methods, and Recording—Specific to the Railcar Industry
• TEG 291X, Land Transportation: Information Exchange on Corrosion and Coating-Related Issues

Wednesday, March 14

• STG 08, Corrosion Management (Session 1; Session 2 on Thurs., March 15)
• Coating Asset Management, presented by Terry Greenfield, CorroMetrics, LLC; Egil Lillerovde, AGR; and Mark Weston, Incospec. This forum will be comprised of coatings industry end users/owners that have implemented programs to better manage their protective coating assets. Each panel member will present a short description of their program, sharing successes and challenges. Content will include maintenance philosophies, condition surveys, and data management systems.
• TG 406 (02, 03, 04), Review of NACE SP0398-2006
• TG 444 (02, 03), Guidelines for Data Collection and Analysis of Railroad Tank Car Interior Coating/Lining Condition
• TG 451 (02), Corrosion-Resistant Non-Skid Surfaces for Railcar Exteriors

Thursday, March 15

• TEG 093X, TEG 145X, Vapor Corrosion Inhibitors and Rust Preventatives
• The Importance of Hands-On Training, presented by Frank Palmer, Frank Palmer Consultants. The presentation will provide

attendees with information to improve practical skills that cannot be achieved by reading a specification or product data sheet.

- Proper Application of Powder for High Performance, presented by Rodger Talbert, PCI. This presentation will cover methods of selection and process that lead to high performance of a powder coating finish.
- TEG 424X (03, 04, 35, 43), Liquid-Applied Thermal Insulative Coating for Atmospheric Service at 0 to 375 F
- Joint Meeting of STG 02, STG 03, and STG 04

Exhibitors

The following is a list of exhibitors, as of press time, that may be of interest to protective coatings professionals.

- 3M Corrosion Protection Products ...801
- Advanced Polymer Coatings 911
- AkzoNobel Coatings.....................2035
- Arkema Inc. 1240
- Belzona, Inc................................1932
- Berry Plastics 900
- Blair Rubber/MRC 1521
- Bredero Shaw..............................1300
- Canusa—CPS..............................1201
- Carboline Co. 901
- CHLOR*RID International Inc. 1507
- Corrpro Companies, Inc. 1033
- Cortec Corp. 1207
- Curran International, Inc. 2233
- The D.E. Stearns Co. 1115
- Dampney Co., Inc. 939
- DeFelsko Corporation...................1307
- Denso 1325
- Diamond Vogel Paint 1043
- DoD Office of Corrosion Policy and Oversight 443
- Elcometer, Inc. 1423, 1525
- Enerclear Services Inc..................2220
- Evonik Degussa 421
- Farwest Corrosion Control Co.—Corrosion Control Products 833
- Fischer Technology, Inc. 1601
- Georg Fischer Central Plastics, LLC 1516
- GMA Garnet Group.......................2406
- GPI (Greenman-Pedersen, Inc.).......1114
- Heresite Protective Coatings, Inc. ..1211
- Hi-Temp Coatings Technology 1602
- HoldTight Solutions Inc. 1639
- Hydrex Underwater Technology......1645
- ICORR Technologies 521
- International Paint 1933
- ITW PolySpec/Futura....................1508
- KTA-Tator, Inc. 1012
- Lubrizol......................................1210
- Mascoat Products........................1739
- MATCOR, Inc. 1233
- Monti Werkzeuge, GmbH 1701
- Montipower, Inc. 2015
- Opta Minerals One 513
- Platt Bros. & Co...........................1845
- PolyCorp 821
- Polyguard Products, Inc. 839
- PPG Protective & Marine Coatings .1118
- Radiodetection.............................2027
- REMA Tip Top/North America 2009
- Safway Services 1721
- Sauereisen 1834
- The Sherwin-Williams Company 933
- Specialty Polymer Coatings, Inc. (SPC) 1819
- Sponge-Jet, Inc. 1401
- Sprayroq Inc.................................416
- SSPC: The Society for Protective Coatings......................1839
- Stopaq B.V. 1800
- Sulzer Mixpac USA.......................2339
- Tapecoat/Royston........................1109
- TFT-Pneumatic, LLC 508
- Tinker & Rasor.............................1101
- Tnemec Co., Inc. 604
- Trenton Corp. 1533

ASTM To Offer Corrosion Testing Training

Corrosion Testing: Application and Use of Salt Fog, Humidity, Cyclic and Gas Tests, is a two-day, hands-on technical and professional training course presented by ASTM International (W. Conshohocken, PA). The course, intended for corrosion technicians, product test personnel, laboratory supervisors, and users of B117, will be held April 3–4 in Akron, OH; Sept. 18–19 in Detroit, MI; and Nov. 27–28 in Atlanta, GA.

According to ASTM, the course will provide a clear understanding of the proper application of ASTM B117, Standard Practice for Operating Salt Spray (Fog) Apparatus, and will provide information regarding corrosion testing in general so that attendees can understand the significance of the salt fog test. Operating salt fog apparatus and corrosion test equipment, mixing solutions, cleaning coupons and samples, and evaluating results and samples will be covered. The course is worth 1.5 CEUs.

For additional information, contact Eileen Finn, 610-832-9686; efinn@astm.org, or visit www.astm.org.

IPPIC Slates Marine Coatings Forum

The International Paint and Printing Ink Council (IPPIC) will hold its 4th Global Marine Coatings Forum Nov. 6–8, 2012, in Singapore at the Goodwood Park Hotel.

The Global Marine Coatings Forum provides a unique, interactive forum for exchanging views and gaining new perspectives on the future growth of the industry and the impacts of ever-increasing and stringent safety, health and environmental regulations, according to IPPIC.

In presentation and panel discussion format, the event is expected to shed new light on the most pertinent topics relating to the global marine coatings industry, including

- Performance standards for protective coatings;
- IMO standards for ballast water tanks;
- Implementation of the Antifouling Systems Treaty;
- Guidelines for preventing the spread of invasive species; and
- Reducing greenhouse gas emissions from shipping.

The Global Marine Coatings Forum draws attendees from all over the world representing coatings suppliers and formulators, ship owners, shipyards, regulatory bodies, and classification societies.

IPPIC is comprised of paint and printing ink trade associations representing Australia, Brazil, Canada, China, Europe, Japan, Mexico and the U.S. IPPIC provides a forum for information exchange and cooperation on the major issues and priorities facing the paint and printing ink industries worldwide.

More information is available at www.ippic.org/conferences/marine_coatings_forum.

ASTM Releases New, Approved Standards

ASTM has recently released new, approved copies of the following standards and has made them available for purchase. Visit www.astm.org for pricing information and to see all of ASTM's newly released standards.

- ASTM C1140/C1140M-11 Standard Practice for Preparing and Testing Specimens from Shotcrete Test Panels: This practice covers procedures for preparing test panels of dry-mix or wet-mix shotcrete and for testing specimens sawed or cored from the panels.
- ASTM C1758/C1758M-11 Standard Practice for Fabricating Test Specimens with Self-Consolidating Concrete: This practice covers procedures for fabricating test specimens in the laboratory or field using a representative sample of fresh self-consolidating concrete.
- ASTM D1652-11 Standard Test Method for Epoxy Content of Epoxy Resins: These test methods may be used to determine the epoxy content of manufactured epoxy resins and confirm the stated epoxy content of purchased epoxy resins.
- ASTM D4417-11 Standard Test Methods for Field Measurement of Surface Profile of Blast Cleaned Steel: These test methods cover the description of techniques for mea-

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suring the profile of abrasive blast cleaned surfaces in the laboratory, field, or in the fabricating shop.

NACE Issues New Marine Coating Standard

In October 2011, Task Group 402 of NACE International released a new coatings documentation standard designed to ease compliance with International Maritime Organization protective coatings requirements.

The purpose of SP0111-2011: "Coating Technical File in Accordance with the IMO Performance Standard for Protective Coatings" is to help people in the maritime industry comply with the IMO's Performance Standard for Protective Coatings (PSPC).

The coating technical file (CTF) refers to documentation of the selection, specification, installation, and inspection of coatings applied to a ship's seawater ballast tanks and double-skin spaces, along with documentation of in-service maintenance and repair of coating systems. The CTF stays with a ship during its lifetime.

According to NACE, the standard is intended to provide an efficient and accurate methodology for collecting, managing, and presenting the data required by the PSPC. NACE says the standard should also facilitate the ongoing corrosion management of these tanks and spaces, to help the installed coating systems reach their intended 15-year service life.

Optional formats and structures for the CTF are described, along with data required to comply with the PSPC.

For additional information on this and other NACE coating standards, visit www.nace.org.

Companies

Robert Hu Joins HallStar

Robert Shengkui Hu has joined The HallStar Company's senior management team as

vice president, research and development. He will initially report to and replace Gary Wentworth, who will retire from the specialty chemical company this year after overseeing the transition of his responsibilities.

Before joining HallStar, Dr. Hu served as vice president of global technology at Beckers Consumer Design Finishes (CDF), a division of Beckers Industrial Coatings/Lindengruppen, which specializes in coatings for consumer electronics and household appliances. He was responsible for the division's R&D strategy and patent portfolio.

Before Beckers, he held several key positions at PPG Industries, including technical director, industrial coatings in the Asia Pacific region.

Dr. Hu has a Ph.D. in Photochemical Science from Bowling Green State University and has completed MBA training from the University of Pittsburgh.

HALOX Hires Project Chemist

HALOX®, a division of ICL Performance Products LP, has appointed David Tarjan to

the role of project chemist. Tarjan has five years of lab experience developing new products, working within various solvent- and water-based coating systems, ensuring product quality and performance, and maintaining supplier relationships. At HALOX, he will work in the Technical Service Department, where he will assist with the research and development of new products, provide technical service support to customers, and ensure product compliance with quality, environmental, ISO, and laboratory safety standards.

Tarjan possesses a Bachelor of Chemistry degree from Northeastern Illinois University. Tarjan has held positions at Sherwin-Williams as a chemist and global liaison and at Valspar as a quality control technician.

Headquartered in Hammond, IN, HALOX provides corrosion and flash rust inhibitors to the paint and coatings markets worldwide.

Elcometer Expands Operations

Instrument maker Elcometer reports that it has expanded its Western Europe operation, with new products, offices, and personnel.

The UK-based company has doubled the size of its sales and service facilities in Germany and also has appointed Philippe Marzin as West European regional sales manager. Marzin will be responsible for all Elcometer sales offices in the UK, France, Germany, Belgium, and the Netherlands, as well as the company's Western European distribution network, Elcometer says.

Elcometer is a global supplier of coatings inspection, ultrasonic NDT, concrete inspection, and industrial metal detection equipment.

New U.S. Pigment Plant Planned

Rockwood Holdings Inc. has announced plans to build a $115 million production facility for iron oxide pigments in Augusta, GA—the first new U.S. production facility of its type in nearly 35 years. The plant will be part of Rockwood's Color Pigments & Services Division, which supplies colored pigments for construction, coatings, plastics, and specialty applications.

Rockwood says that the facility will reduce the company's dependence on imported raw materials as well as consolidate its operations in the U.S., create 80–100 new jobs, improve product quality, and reduce lead time. Construction of the facility is expected to take 18 months, with commissioning expected in the first half of 2013.

When the new plant opens, Rockwood will close its manufacturing facility in St. Louis, MO, and part of its facility in Beltsville, MD.

Valspar Opens R&D Center in China

Valspar Corp. reports that it has opened a new R&D center in Shunde, China, in December 2011.

The Valspar Applied Science and Technology Center will employ more than 200 scientists to support the company's continued growth in the Asia Pacific and its research and development efforts worldwide, the company says.

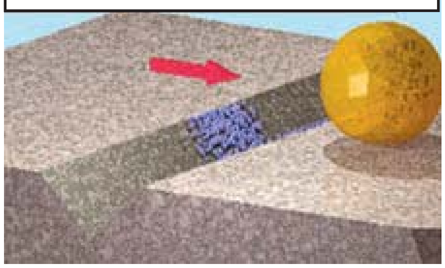
In China, the company produces and sells coatings for shipping containers, construction equipment, building products, consumer paints, and other end markets.

Research

Nanocoating Can ‘Repair and Go’

Researchers at the University of Massachusetts Amherst and the University of Pittsburgh are developing a nanocoating that may not only lengthen the period between recoating but also improve structural integrity by preventing small fractures from spreading, heading off larger problems and the need for a full-scale recoat.

Nanoparticles delivered to cracks by capsules in "repair-and-go" process



"This is particularly important, because even small fractures can then lead to structural failure, but our technique provides a strong and effective repair," says team leader and polymer scientist Todd Emrick.

The researchers used droplets (or capsules) of oil stabilized with a polymer surfactant and a nanoparticle solution. According to Emrick, the nanoparticle-containing capsules roll over damaged substrates, selectively deposit their nanoparticle contents into the cracked regions, and then move on.

The team used fluorescent nanoparticles that clearly showed their selective deposition in the cracked areas, which also gave rise to a precise method for detecting damaged substrates, Emrick said.

The work was published in *Nature Nanotechnology* and supported by the National Science Foundation's (NSF) Materials Research Science and Engineering Center on Polymers at UMass Amherst, an NSF Integrative Graduate Education and Research Traineeship (IGERT) award, the NSF Center for Hierarchical Manufacturing, the U.S. Department of Energy, and its Office of Basic Energy Science.

From *PaintSquare News*

Work Underway on Paint-on Solar Cells

A new, inexpensive "solar paint" is being developed at the University of Notre Dame. Researchers say that they have made a one-coat solar paint by incorporating power-producing nanoparticles, called quantum dots,

into a spreadable compound that can be applied to any conductive surface without special equipment.

The team's search for the new material, described in the journal *ACS Nano,* centered on nano-sized particles of titanium dioxide, which were coated with either cadmium sulfide or cadmium selenide. The particles were then suspended in a water-alcohol mixture to create a paste that, when brushed onto a transparent conducting material and exposed to light, created electricity.

The current downside, according to one researcher is the 1 percent light-to-energy conversion efficiency, which is "well behind the usual 10 to 15 percent efficiency of commercial silicon solar cells." The upside is that the paint "can be made cheaply and in large quantities." Researchers say that improving the energy efficiency somewhat might make a real difference in meeting energy needs in the future.

The research was funded by the Department of Energy's Office of Basic Energy Sciences.

From *PaintSquare News*

Products

PPG Unveils One-Component Marine Coating

PPG Industries (Pittsburgh, PA) has introduced in the U.S. PSX ONE coating, a one-component acrylic-siloxane engineered for inland marine, petrochemical, water, wastewater, and other application segments.

The coating is designed to provide color and gloss retention in a durable, lower-VOC formulation that can be applied by brush, roller, or spray, PPG reports.

PSX ONE offers abrasion resistance, wide cure-temperature flexibility, recoatability, and unique surface tension to minimize rust or dirt-streaking, PPG says. PSX ONE complements PPG's existing line of siloxane coatings.

More information: www.ppgpmc.com/northamerica

MSA Debuts Ultrasonic Gas Leak Detector

Safety equipment provider MSA has introduced the UltraSonic EX-5 Gas Leak Detector for detection of airborne leaks from high-pressure gas systems.

According to MSA, the detector is designed for use in offshore and onshore oil and gas installations, floating production storage and offloading vessels (FPSOs), petrochemical processing plants, power plants, and other facilities.

Some of the unit's features include a stainless-steel microphone that enables instant detection; a stainless-steel explosion-proof housing for corrosion resistance in harsh environments; and a three-digit LED display.

More information: www.msanorthamerica.com

Epoxy Made to Block Concrete Moisture

Arizona Polymer Flooring (APF) has launched VaporSolve Moisture Remediation Systems,

highly specialized epoxy coating systems formulated to isolate moisture-sensitive flooring from all levels of concrete moisture.

According to APF, the systems can be used when concrete has a known moisture problem; when concrete dries too slowly; or when concrete doesn't have a vapor retarder and future moisture conditions cannot be predicted.

VaporSolve products include primers, topcoats, and joint and crack fillers. Three systems are available—Basic, Ultra, and Fresh Concrete.

More information: www.apfepoxy.com

Most of the news this month is based on stories from *PaintSquare News, JPCL*'s sister publication, a free daily e-newsletter. To get even more news, sign up for the newsletter at paintsquare.com.

Photos courtesy of Saffo Contractors

Saffo Beats Schedule on Barefoot Landing Swing Bridge

By Charles Lange, Paint BidTracker

This month, we begin with a change from our usual Project Preview format to highlight a recently completed project.

The City of North Myrtle Beach (SC) awarded a contract of $907,000 to Saffo Contractors, Inc. (Wilmington, NC) to rehabilitate the Barefoot Landing Bridge, a 300-foot-long swing bridge over the Intercoastal Waterway. The owner initially requested bids for full removal and recoating, but was forced to revise the scope due to budgetary constraints. The contract was re-advertised with full removal and recoating as the base bid plus an alternate for overcoating. Saffo, SSPC-QP 1- and QP 2-certified, was awarded the contract as the lowest bidder for the overcoating option.

The project was delayed from the originally planned spring 2011 start as a result of public and political concerns, because the structure is the primary access point to tourist destinations on an island. Saffo eventually received the notice to proceed working on November 14, 2011, with a completion date of February 13, 2012. Utilizing the encapsulation system in lieu of complete removal saved the owner close to $1M.

The project schedule allotted 91 calendar days for completion, including a 49-day window for a detour. The detour enabled Saffo to lock the bridge in the open position, with cribbing on each end for weight stabilization, eliminating the strain of maritime traffic.

The overcoating alternate included pressure washing the steel, followed by hand-tool and power-tool cleaning of corroded areas (SSPC-SP 2 and SP 3). The steel was coated with a moisture-cured polyurethane coating and a polyurethane gloss enamel finish, as manufactured by Superior Products International (Rust Grip encapsulating coating and Enamo Grip finish). Saffo used coated-airbag tarpaulins on the sides and top and filter fabric on the bottom of the required containment structure.

Saffo completed the project on January 17, 2012, earning $54,000 through a $2,000/day incentive for each day before the required deadline in mid-February.

"This was a very successful project and is a great budget-friendly alternative to full removal of lead-based coatings on structures where the lead primer is still well adhered," said Nicholas Saffo, Owner and President of Saffo.

And now, we return to our regularly scheduled Project Preview programming.

Seacor To Paint Transformers in Key West

Seacor Painting (Campbell, OH) secured a $38,810 contract from the Key West Utility Board to clean and recoat surfaces of seven existing power transformers at various electric substations and power plants in the Key West, FL, area. The steel will be steam cleaned, pressure washed, hand and power tool cleaned or abrasive blast cleaned, and coated with a vinyl alkyd primer and a high-gloss silicone alkyd finish, or an approved equal system.

Hames To Coat Horace Wilkinson Bridge

Hames Contracting, Inc. (Alpharetta, GA) won a $3,185,000 contract from the Louisiana Department of Transportation and Development to clean and coat structural steel surfaces on the Horace Wilkinson Bridge in Baton Rouge, LA. The bridge, opened in 1968, is a 14,150-foot x 80-foot cantilever truss bridge with a 4,550-foot main span over the Mississippi River. The project requires SSPC-QP 1 and QP 2 certifications and involves abrasive blast cleaning the steel to a Near-White finish (SSPC-SP 10) and recoating with an organic zinc-rich primer, an epoxy intermediate, and a polyurethane finish. Containment according to SSPC-Guide 6 and waste disposal according to SSPC-Guide 7 will be used to handle the existing lead-bearing coatings.

Reservoir Recoating Contract Goes to Olympus

The City of North Las Vegas, NV, awarded a contract worth $706,574 to Olympus and Associates, Inc. (Reno, NV) to clean and coat an existing 7.5 MG steel water storage tank (32-foot-high x 201.5-foot-diameter), a surge tank, and above-ground piping. The contract, which requires SSPC-QP 1 and QP 2 certifications and a NACE-certified inspector on staff, also includes an alternate option to coat surfaces at an adjacent pump station. The water storage tank was built in 1977 and was last recoated in 1982. While initial testing indicated trace amounts of lead in the existing coatings, additional testing to confirm non-hazardous nature is required. The steel, including the underside of all non-fixed interior support columns, will be abrasive blast cleaned to a Near-White finish (SSPC-SP 10). The interior wall and ceiling surfaces will be lined with a three-coat epoxy system; the interior floor will be lined with a 100%-solids or high-solids epoxy system; and the exterior will be coated with an epoxy-polyurethane system.

Pedestrian Bridge Rehab Project Awarded

The City of South Bend, IN, and Northern Indiana Construction Co. (Mishawaka, IN) have agreed upon a $216,000 contract to rehabilitate the Chapin Street Bridge, a 144-foot-long x 9-foot-wide structural steel pedestrian bridge, and the associated concrete spiral approaches. Built in 1968, the city had originally planned on replacing the bridge before choosing to rehabilitate the existing structure instead.

The project includes abrasive blast cleaning structural steel surfaces and the orthotropic steel bridge deck to a Near-White finish (SSPC-SP 10). Structural steel will then be coated with an epoxy-polymer system, and the steel deck will be coated with an epoxy system with a non-skid additive on walking surfaces. The project also includes brush-off blast cleaning (SSPC-SP 7) and coating galvanized steel handrails with an epoxy system, as well as power-washing and coating concrete spiral approach surfaces, including the underside of the approaches and the support columns, with an anti-graffiti coating and surface sealer. Containment is required to capture the existing lead-bearing coatings.

Thomarios Gets Gravity Thickeners Contract

A contract valued at $584,533 was granted by the Northeast Ohio Regional Sewer District to Thomarios (Copley, OH) to repair and recoat existing gravity thickeners inside the district's Southerly Wastewater Treatment Plant. The project includes removing lead-based coatings from the six aluminum panel domes and aluminum walkways of the gravity thickeners and coating exterior walls with an elastomeric system.

Jupiter To Coat Six Bridges

Jupiter Painting & Contracting Co., Inc. (Croydon, PA) won a $2,327,427 contract from the New Jersey Department of Transportation to clean and recoat structural steel surfaces on six bridges over both water and roadways. The contract, which requires SSPC-QP 1 and QP 2 certifications, includes abrasive blast cleaning steel surfaces to a Near-White finish (SSPC-SP 10) and coating the steel with an organic zinc-rich primer, a high-build epoxy intermediate coat, and urethane finish. The contractor will use Class 1A containment according to SSPC-Guide 6 to capture the existing lead-bearing coatings.

JPCL

Crossword

by Andy Folmer, PaintSquare

In A HEPA Trouble

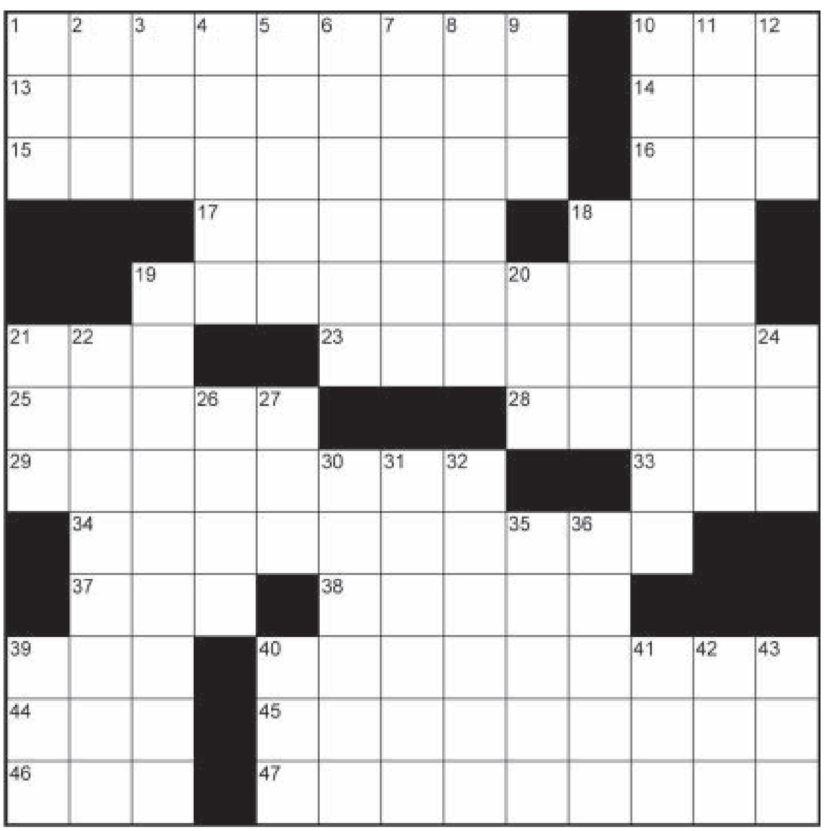
ACROSS

1 Disease of the liver
10 Sec. in an orchestra
13 Kind of park
14 Realm in the Middle Ages: Abbr.
15 Many-legged crawler
16 Actor McShane
17 FCC program to benefit schools and libraries
18 Wide-encompassing stud. loan
19 Arizona location of an 1862 battle
21 HST successor
23 1950s style inspired by Edwardian fashion
25 Go to see
28 Fresh-baked pie appeal, maybe
29 Went over a past event
33 Inquire
34 Mel Gibson historical war film
37 Matter for the courts
38 Mayor in "The Music Man"
39 Cambridge Univ.
40 Nickname for the "Patient Protection and Affordable Care Act"
44 Diamonds
45 Native American trickster god
46 Syllables of understanding
47 Playing it was the pinnacle for many Vaudevillians

DOWN

1 Sometime abbreviation for Acetic Acid
2 Radio comm. tech. also known as "moon bounce"
3 Bit of word play
4 "The sublime to the ridiculous is but ___": Napoleon
5 Platax ___: Pacific aquarium fish
6 Collision
7 Chew on a frozen ring, maybe
8 Absolutely
9 Jeanne d' Arc, for one
10 Small vessel used for communication to shore
11 Small windows above doorways
12 Stimpy's pal
18 Evolutionary biologist Ernst
19 Way to describe art critics, perhaps
20 Palm or BlackBerry, for short
21 Modern TV attachment
22 Marlene of "The Blue Angel"
24 It's milked in Tibet
26 Angers
27 Water faucet
30 "Rock the ___": 1982 hit for The Clash
31 It's a gas
32 Acronym for Distributed Risk Managment Process
35 "Dancing With The Stars" judge Carrie Ann
36 Medical dept. treating cancer
39 "O Sole ___"
40 Enzyme transferring a methly group on a molecule
41 Chemical prefix indicating the presence of nitrogen
42 Ref. to the Canadian Black Watch
43 Abbr. on many job listings

(Answer next month)



Answers to last month's puzzle

C	H	U	B	■	B	E	D	■	A	B	U	T
R	I	P	E	■	O	Y	A	■	V	I	B	E
E	D	D	Y	■	T	E	S	T	■	O	O	N
A	E	A	■	■	E	L	B	O	W	P	A	D
M	I	T	T	■	V	I	O	L	I	S	T	S
S	T	E	A	D	■	D	O	L	L	Y	■	■
■	■	■	B	O	A	■	T	E	L	■	■	■
■	■	P	A	T	T	I	■	D	I	S	C	S
O	V	E	R	T	O	N	E	■	S	K	I	P
A	C	A	D	E	M	I	A	■	■	O	R	I
T	A	R	■	D	I	O	R	■	J	A	C	K
E	S	L	A	■	S	N	L	■	C	L	U	E
N	T	S	C	■	M	S	S	■	U	S	S	R

The Takeaway

By Karen Kapsanis
JPCL

Too Much Rust for the Weary

Although I don't apply coatings to offshore platforms, pipeline that will be insulated, storage tanks, or any other industrial structure discussed in this issue, every article this month that mentions or even implies bare steel, coatings, and corrosion brought back a recent, painful, and humbling memory.

That's because this past (mild) fall, I decided to stop ignoring the rust on the inside rims of two wheel wells of my car. I showed the rust to a colleague who knows a lot about cars. He said, "That's nothing—it happens on lots of cars. A body shop will charge you plenty just to take off that little bit of rust and repaint it. You can fix it yourself with the right sandpaper and touchup paint. It might take a little elbow grease, but just be sure to get all the rust off, down to the bare steel, Karen, or you know what will happen." And he even explained why the inside rims of the wheel wells on my car had this problem—it's from the pebbles, debris, and water the tires kick up against the inside rim, breaking the paint, and exposing the steel to the perfect environment for corrosion.

So one relatively warm Saturday in early December, I took to my garage and worked on my car. Several hours and an incredibly sore back, shoulder, and arm later, I had sanded off as much of the ¼-inch-wide x 3-inch-long strip of rust and paint as I could from one wheel well and repainted the "bare steel." I know—I was using sandpaper on a car, not power tools on structural steel—but all I could think of was SSPC-SP 11 and power tool cleaning to bare metal. Was I even in SPitting distance?

My tiny bit of surface prep was a humbling lesson in how hard industrial painting contractors work, even using surface prep equipment that is much more sophisticated than sandpaper. The respect I have for them is more than I can articulate.

If you're not a contractor and you haven't had to clean anything to bare steel lately, go ahead—try it. Unless you are a true weekend warrior, I'm not sure you'll like it. But if you like it, could you stop by and take care of my other wheel well?