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CELEBRATING 35 YEARS 1984 2019

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The Society for Protective Coatings

THE 35TH ANNIVERSARY ISSUE

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35 YEARS OF JPCL: SSPC EXECUTIVE PERSPECTIVES

A FEW WORDS ON THE PAST

By Terry Sowers, Senior Member Services Advisor, SSPC

As an almost 30-year employee of SSPC, I could probably fill an entire issue of JPCL on our history. Since that isn't an option, I would like to touch on some of things from my view that have had a great impact on the organization today—and how JPCL has helped spread that positive impact to the industry as a whole.

One of these is the development of individual training and certification programs. In the late 1990s, SSPC had only four courses: Fundamentals of Protective Coatings (C1), Planning and Specifying Protective Coatings Projects (C2), Lead Paint Removal (C3) and Lead Paint Removal Refresher (C5). We held four training weeks each year and held courses at the SSPC conference, training maybe 200 students in a year. After the development of C3 and C5, SSPC created a licensing program for the delivery of these courses, which now train 600–800 students each year.

At the urging of some of our members who recognized the need in the industry, the Abrasive Blast Cleaning Program (C7) was created by subject matter experts with funding from equipment-manufacturer members. Once completed, C7 sat on the shelf for a few years until NAVSEA required its Standard Item 009-32. This first craftworker course then became an "overnight success" that lead to the realization that other craftworker courses and certifications would be of great benefit to our industry. SSPC took a leadership role in working with our members to create those programs that are now the industry standard for excellence for craftworker training.

Around this time, SSPC also started administering the NAVSEA Basic Paint Inspector certification program and began developing its own inspection certification programs for steel and the only Concrete Coating Inspection course in the industry. SSPC became a provider of International Association of Continuing Education and Training continuing education units and received accreditation for our Protective Coating Inspector program by the American Bureau of Shipbuilding, Bureau Veritas, Lloyd's Register and RINA. This was a major step in SSPC becoming recognized as a premier international training and certification provider as well as a catalyst for the development of several international chapters and SSPC's international membership growth.

SSPC now has over 150 course options and holds more than 600 classes each year for more than 7,000 students. Our licensee program has grown to include our inspection courses and craftworker courses that are offered all over the world. There are now more than 16,000 individuals holding SSPC certifications. This is quite a leap from the four training weeks of the 90s.

The SSPC QP programs have also had a tremendous impact on the organization and the industry. The QP 1 program, a first of its kind in the coatings industry, was in the final stages of completion when I started at SSPC. There are now eight QP programs for contractors and inspection firms, all created in compliance with SSPC consensus standards, that help asset owners preserve and maintain structures. There are now more than 430 contractors participating in the program.

While several chapters have operated in Canada since the early 90s, SSPC was a primarily a domestic organization for most of its history. As we began establishing more international chapters, the organization's bylaws were revised in 2009 to require one international board member position. Gunnar Ackx won the election for the first international board member and will complete his final term on June 30. Currently, SSPC has 15 international chapters, and in 2017 the Latin American and Asia Pacific advisory councils were formed to develop a strategy for continued growth in those areas.

I've had the privilege of working for three executive directors in my career at SSPC. The first, Bernie Appleman, established our reputation for technical excellence. The second, Bill Shoup, put us on a financial path that allowed us to purchase our global headquarters and fund the development of much needed programs and services for our members. Bill Worms, who is the current executive director, is focused on taking the organization to the next level. In his three years at SSPC he has emphasized improving our IT systems and structures, creating more formal processes and continuing our growth internationally.

In 1989, when I came to SSPC, it was situated on one floor of a renovated parking structure in Pittsburgh with 12 individuals in the office. Today, the SSPC global headquarters in Greentree, Pennsylvania houses our own print shop, the new Mobile Training Unit, 40 employees and a beautiful vegetable garden! Our business structure includes six departments and 49 total employees, including several who work remotely.

Over the past 35 years, JPCL has partnered with SSPC to provide our members and JPCL readers with all of the information that is critical to their work. In the early 1990s, JPCL frequently featured important information on new lead regulations and training that was not just helpful, but necessary for contractors, facility owners and regulators. As other regulations have affected the work of our members, JPCL has helped to educate the industry. Throughout its history, JPCL has been a key resource for providing information on our training programs, standards, new technologies, regulatory and other important issues to our members.

So much has changed over the years, but the one thing I can say that hasn't changed is the dedication of the staff and members to work together to further the mission of SSPC: to inspire learning, advance knowledge and elevate performance in the industry through training, certification and education of the workforce, communication of advances in technology, and promotion of the use of protective coatings.

JPCL and SSPC have worked together over these many years to ensure that our members receive the most accurate and timely information. JPCL is truly "The Voice of SSPC."

SSPC ON THE FRONT LINE

LOOKING TO THE FUTURE

By Bill Worms, Executive Director, SSPC

I hope you've enjoyed a unique glimpse of the storied past of SSPC from the perspective of a veteran staff member. I, on the other hand, would like to provide you with a view of what I foresee for the future of both SSPC and JPCL, as we approach SSPC's 70th anniversary in 2020.

For those familiar with SSPC, you know that the genesis of the organization was in 1950 at the Mellon Institute (now Carnegie Mellon University). The foundation of SSPC at that time could be summarized in three words: academia, technical and standards. As Terry outlined, our evolution since that time has been tremendous.

Today, SSPC can be summarized in three different words: training, certification and education. This is not to say that we have lost our roots as a standards and technical organization, but to emphasize that we have taken those inherent aspects of our DNA and transformed them into practical programs that are now being used to train and certify craftworkers, supervisors and engineers on a global basis.

Looking into the future, the three words that come to mind are: youth, technology and international. Let me explain.

If there is one common concern I hear in my domestic and international travels, it is that the workforce is aging, and there is a shortage of qualified workers. SSPC has recognized this and devoted resources to educating our youth about the attractive career opportunities within our industry. We will continue promoting and licensing our programs to trade schools and technical colleges, participating in job fairs and employment events, and partnering with other organizations as we work to ensure a sustainable source of workers. We have been successful in licensing our training programs to a several institutions already, and we look forward to expanding this both domestically and internationally.

The technology aspect is well underway within SSPC, but is in its infancy relative to where I foresee it going and where it needs to be. This endeavor is far-reaching and includes a variety of aspects from website enhancements for an improved member experience, to social-media marketing, to a broader portfolio of gamified e-learning modules for training and educating workers. Over the past few years, SSPC has invested heavily in our IT and digital infrastructure. We have upgraded our financial platform, our e-learning portal (SSPC University) and our website, just to name a few. SSPC now has video and social-media capabilities which were non-existent only a few years ago. The investments in these tools will continue, since they are necessary for us in our ever-evolving digital society, as we work to extend our reach in delivering our products and services to both domestic and international audiences, and to our youth.

International demand for SSPC standards, training and certification has grown significantly over the past few years. Approximately 20% of all SSPC members reside outside of the United States. Despite the growth, we are still addressing only a small portion of the international community. SSPC will continue to expand our international reach through regional technical conferences, more chapter engagements and increased translations of our materials. We currently have major initiatives underway in Saudi Arabia, Malyasia and Brazil, and our presence and relevance on an international basis will continue to grow. To date, we have either added SSPC resources, or have developed partnerships with other organizations in Brazil, China, England, Malaysia and Saudi Arabia, and this international expansion will continue to accelerate in the next few years.

So, what is my vision for SSPC? It will be accelerated global growth, concentrated efforts on youth and workforce development, and expanded use of technology to increase our reach and relevance. I will close with the following quote: "Some succeed because they are destined to, but most succeed because they are determined to." I can guarantee that the dedicated and passionate staff of SSPC are determined to succeed!

And, of course, JPCL will continue to play a key role in being "The Voice of SSPC." Reflecting SSPC's overall international efforts, that role will expand to include other languages, as we have recently seen with the launch of JPCL En Español.

20 SSPC Scholarships Awarded

SSPC is pleased to announce that 20 students have been awarded college scholarships through the Society's 2019–2020 Scholarship Program. Each recipient has been awarded $2,500 in recognition of his or her impressive academic work. In addition, each student will receive a one-year membership to SSPC.

This year's recipients are:

- Karan Bansal, North Dakota State University;
- Stephanie Brand, University of Illinois, Urbana-Champaign;
- Nomikos Christoforos, St. Petersburg College;
- Panagiotis Christoforos, St. Petersburg College;
- Jessica Davison, University of Southern Mississippi;
- Zoriana Demchuk, North Dakota State University;
- Tyler Kleinsasser, South Dakota School of Mines & Technology;
- Abby Longhofer, Florida State University;
- Kristy McGaughey, Duquesne University;
- Ashley Mieczkowski, Virginia Tech;
- Samanbar Permeh, Florida International University;
- Karina Reynolds, University of Southern Mississippi;
- Milad Rezvani Rad, University of Alberta;
- Andrew Schiffer, West Virginia University;
- Margaret Schiffer, West Virginia University;
- Grant Shepherd, Sewanee, University of the South;
- Arnold Sison, University of Oklahoma;
- Noah Van Hyning, University of Akron;
- Cheng Zhang, University of Akron; and
- Meredith Zona, University of Pittsburgh.

The SSPC Scholarship Program is funded in part by the proceeds from the Phil Calvo Memorial Golf Tournament, held each year in conjunction with the annual Coatings+ conference.

In order to be considered for the SSPC scholarship, a candidate must be a high-school senior planning to enroll full-time or a student already enrolled full-time in an accredited institution of higher learning that has a three or four-year curriculum. The candidate must also be a member of SSPC in good standing, or a child or grandchild of an SSPC member in good standing. Awarded scholarship funds are applied to the direct costs of the student's education courses. To coordinate this effort, SSPC works with the institutions' financial aid offices to ensure proper use of the funds.

The 2020–2021 Scholarship Program application will open in January of 2020, with applications due by April 30th.

For more information about the SSPC Scholarship Program, please contact Christine Lajzo at lajzo@sspc.org.

Explosions, Fire Erupt at Philly Refinery

A fire broke out early in the morning on June 21 at the Philadelphia Energy Solutions Refining Complex—a crude oil refinery in South Philadelphia. It was the result of several explosions.

Around 4:00 a.m., the initial explosion occurred, followed by two additional explosions, ultimately ensuing a massive fire. According to *The Philadelphia Inquirer*, the fireball that resulted from the explosions was captured by a weather satellite in space due to the incident's intense heat. Other local news reports stated that the blast could be felt as far as southern New Jersey and Delaware County, Pennsylvania.

Located within what was previously a Gulf Oil Corp. refinery was the impacted unit, which produces alkylate (a booster used for gasoline octane). Although the complex has two alkylation units, the affected unit uses a deadly chemical, hydrogen fluoride, as a catalyst.

According to Philadelphia Deputy Fire Commissioner Craig Murphy, the general vat area—where the fire had been burning—contained propane and butane, which was being fed by a main source. With PES unable to gain access to the proper valve to shut off the continuously burning gases, PES firefighting teams and the Philadelphia Fire Department decided to confine and contain the blaze. "It is safer if it burns itself out," Murphy said, adding that, "whatever's blowing out of the main blows right into the atmosphere." Officials have since gone on record to say that none of the chemicals were released in the explosion.

In the days after the explosion, until PES teams could successfully shut off the main, crews continued to pour water on nearby pipes and tanks to keep them cool. Officials reported that the fire had been effectively extinguished by the afternoon of June 22.

As a result of the incident, five refinery workers suffered minor injuries and were treated at the scene. Neighboring residents were also advised to shelter in place until officials reported that tests for 81 chemicals determined safe air quality, which took place only a few hours after the blasts.

The fire's cause and origin are being investigated by OSHA; the Bureau of Alcohol, Tobacco, Firearms and Explosives; the U.S. Chemical Safety and Hazard Investigation Board; and the fire marshal's office. PES spokesperson Cherice Corley told reporters that the investigative team may examine whether PES properly maintained the refinery during its most recent "turnaround," when the refinery was shut down for major repairs. At this time, officials have not yet released details on what caused the explosions.

However, on June 26, PES CEO Mark Smith said that the plant will be permanently shut down next month as a result of the fire damage, according to multiple news reports.

PAINTSQUARE COMMENTS

In Response to "FIU Bridge Designer Testifies" *(PaintSquare News, June 25)*

Photo: National Transportation Safety Board.

Over a year after the deadly pedestrian bridge collapse at Florida International University, and a day after OSHA released an investigative report that laid blame upon the bridge designer, the project's lead technical designer testified during a pretrial hearing regarding evidence. In his testimony, W. Denney Pate told a judge earlier this month that his phone accidentally wound up in the washing machine, destroying data like call records, according to Engineering *News-Record*.

Mark Taylor:
"Way too convenient. This is now a criminal cover-up in addition to criminal negligence."

Peter Kenimer:
"Wow ... tampering with evidence much? I don't know how I could live [with] myself after knowing something that I designed killed anybody, let alone multiple people, then destroying incriminating evidence. Just own up; the jail time won't be pleasant, but [it's] deserved."

John Edwards:
"The dog ate my homework! Bad dog!"

Problem Solving Forum

paintsquare.com/psf

How do admixtures to concrete (such as hardeners and anti-dust compounds) affect coating adhesion? What can be done to eliminate or minimize negative effects?

Zenith Czora, Porex Dovco:

"The types and uses or functions of concrete admixtures dictate the chemistry and the chemical reaction within the cement or minerals in the concrete mix. Admixtures are most often based on oils, petroleum products, glass silicates, inert and chemically active fillers, and wax stearates. Admixtures that function as densifiers or hardeners do form a glassy surface when overly applied, which is difficult to be coated over. Damp-proofing admixtures are based on wax stearates and or silicone/siloxane that prevent surface wetting. When those types of admixtures are present in the concrete, there is no way to minimize negative effects. To be able to apply coatings on a concrete surface with those types of admixtures, the concrete surfaces need to be abraded or ground to [an] acceptable profile ... Otherwise, a special type of bonding primer designed to prime a very dense and glassy surface can be used. A test patch should be carried out to ensure the compatibility of the coating system."

Warren Brand, Chicago Corrosion Group:

"The short answer is, they don't. As long as the concrete is hard, porous and has a profile for adhesion, and there's no film on the concrete, you're good to go. Of course, make sure all of the other requirements based on the coating selected are in place. Some coatings can be applied (so they say) over 'green' concrete, while others require a 30-day cure."

Pierre Hebert, Mapei Inc.:

"If I may add to a very well-written answer by Ms. Czora, whenever mechanical preparation is selected to address such a condition, ensure that all fines are properly eliminated from the pores. More than often, when I ask where is the brush attachment on vacuuming equipment, I generally hear back, 'I dunno.' This is unfortunate because agitating the surface with the brush attachment fitted on the vacuuming equipment is, by far, way more effective in helping to pick up small particles. Applying a coating or an adhesive on a dusty surface (albeit, even as a trace) should be considered a 'no-no.' Lastly, I would suggest the applicator considers verifying the absorption rate following the ASTM F3191 field test (including a time-stamped photo with a date) as part of his or her documenting the substrate condition before beginning subsequent work."

35 YEARS LATER:

HOW WOULD THREE PROBLEM SOLVING FORUM QUESTIONS FROM 1984 BE ADDRESSED TODAY?

BY KEN TRIMBER, KTA-TATOR, INC.

As companies and organizations celebrate milestone anniversaries, it is common for them to reflect not only on their own histories, but also on how the industry around them has changed since their founding. As JPCL celebrates its 35th anniversary, readers who were involved in the protective coatings industry in 1984 will certainly have their own examples of changes that have occurred since JPCL was first published as the voice of SSPC.

When asked to write an article on differences in the industry since JPCL was launched, it was necessary to establish a baseline for comparison. And what better source of information on the state of the painting industry in 1984 than articles in the first JPCL magazines, as the well as the initial questions posted to the Problem Solving Forum?

In this article, three PSF questions and summarized responses from 1984 follow, along with a discussion of the same questions today, 35 years later.

CURE OF INORGANIC ZINC-RICH PRIMER (JULY 1984)

Is it true that insufficient curing of ethyl silicate inorganic zinc-rich coatings prior to topcoating is responsible for many coating failures? If so, what methods can be used to verify that proper curing has been achieved?

(Submitted by Curt E. Huber, Cives Steel Company.)

Summary of 1984 Responses

(Submitted by Thomas L. Starr of Georgia Institute of Technology; S. John Oechsle of Metalweld Inc.; John Al Lanning of Porter Coatings; and Thomas Ginsberg of Union Carbide Corporation.)

1. Topcoating an insufficiently cured ethyl silicate inorganic zinc-rich primer can lead to poor cohesive strength of the primer and poor intercoat adhesion. Research by Georgia Tech showed that the cure times among the manufacturer's formulations varied, but there was a significant dependence on relative humidity for all of them.
2. The Georgia Tech research indicated that the cure reaction could be followed in the laboratory using diffuse reflectance infrared spectroscopy. It also revealed that an MEK rub test appeared to be a reliable method for assessing cure.

Fig. 1: Failure of incompletely cured inorganic zinc-rich primer. All coats were shop-applied. Photos courtesy of KTA-Tator, Inc.

3. A coin scrape test (scratching the surface with a coin to see if the zinc shines or is gouged and removed), pencil hardness, and pull-off adhesion were noted as possible tests, with a caution that the results will vary by product type.

Today's Response

It is well known that ethyl silicate inorganic zinc-rich primers will disbond (either cohesively within the zinc, or adhesively to the substrate) if topcoats are applied before the primer has properly cured (Fig. 1). It is also known that ample moisture is needed in the form of relative humidity for curing to take place. The coating manufacturer's product data sheets provide curing times based on the relative humidity and temperature that must be followed as a minimum. But it is also good practice to conduct confirmatory testing of the cure prior to topcoating.

The most common test is ASTM D4752, "Standard Test Method for Measuring MEK Resistance of Ethyl Silicate (Inorganic) Zinc-Rich Primers by Solvent Rub," which was developed as a result of the Georgia Tech research that associated MEK resistance with degree of cure. A cotton cloth saturated with MEK is rubbed along a 6-inch length of the coating and back again, using finger pressure—this motion is termed a double-rub. After 50 double-rubs, the test area is evaluated according to a 0–5 scale with 0 representing complete removal of the coating and 5 representing no effect (Figs. 2 and 3). The coating manufacturer will establish the rating needed before the primer is deemed to be cured adequately for topcoating.

Fig. 2: MEK rub test underway with no effect on the inorganic zinc primer.

Fig. 3: MEK rub test of an inorganic zinc primer showing significant effect.

Another test is pencil hardness (ASTM D3363, "Standard Test Method for Film Hardness by Pencil Test"). Pencils with lead of different hardness are systematically pushed across the surface at a 45-degree angle, starting with the hardest lead (i.e., 6H). Leads of progressively lesser hardness are used for each subsequent test until the coating is no longer scratched or gouged. The first pencil that does not scratch or gouge the surface represents the hardness. The manufacturer will stipulate whether they support the use of this test and, if so, the minimum hardness value that needs to be achieved before topcoating.

In the laboratory, infrared spectroscopy is also still used to determine cure (Fig. 4).

When the relative humidity is very low, some contractors will mist water on the primer to expedite the cure. Because of concerns with achieving proper cure, especially at lower relative humidity, some specifiers have changed products from inorganic zinc to organic (epoxy) zinc, especially for shop work when multiple coats are applied prior to shipping.

Fig. 4: An infrared spectrometer is used to assess the cure of inorganic zinc-rich coatings and as a method for confirming that the coating material supplied to the project site is consistent with the material that was originally qualified.

ASSURING LOT-TO-LOT CONSISTENCY OF COATINGS (AUGUST 1984)

With the increasing popularity of propriety formulations and performance specifications, what tests and criteria can a coatings user specify to assure consistent lot-to-lot performance of his supplied coatings?

(Submitted by Thomas L. Starr, Georgia Institute of Technology.)

Summary of 1984 Responses

(Submitted by Richard R. Ramsey of Florida Department of Transportation; Walter W. Kaminski of E.I. du Pont de Nemours & Company; Richard R. Drisko of Naval Civil Engineering Laboratory; and S.M. Solomon of Port Authority of New York and New Jersey.)

1. It is not feasible to conduct a complete material analysis, but certain tests can provide confidence that the batches are consistent—infrared spectrum, weight per gallon, viscosity, percent total solids, percent pigment, hiding, sag, drying time, curing time, pot life, gloss and color.
2. Manufacturers should be required to provide a certificate of compliance that the batch meets previously set standards.

Today's Response

It is becoming more common for specifications to include provisions for removing samples of liquid coating from the jobsite for laboratory testing (Figs. 4 and 5) to confirm that certain attributes match the values reported by the manufacturer, or match the material that was originally qualified.

In the bridge industry specifically, when materials are selected from the systems listed in the AASHTO National Transportation Product Evaluation Program's online DataMine, the characteristics of the products subjected to the initial battery of tests that led to the listing are available to member agencies for use in making comparisons with jobsite batches. Some of the relevant coating identification tests conducted during the initial AASHTO NTPEP testing include the following (the tests that are most commonly included in specifications for batch conformance testing are designated with an asterisk):

- Fourier Transform Infrared Spectroscopy (FTIR)*;
- Volatile Organic Compound (VOC) Content;
- Epoxide Value;

Fig. 5: Testing the viscosity of jobsite material is one of the tests run to confirm that the coating is similar to the manufacturer's reported values.

Fig. 6: Example of a standard fixed-alignment pull-off adhesion tester available in 1984.

- Amine Value;
- Isocyanate Group Content;
- Hindered Amine Light Stabilizer (HALS) – Qualitative Analysis;
- Total Solids, Percent by Mass (individual components and mixed product)*;
- Pigment, Percent by Mass (pigmented component and mixed product)*;
- Metallic Zinc Content Percent by Mass in Primer*;
- Total Solids, Percent by Volume (individual components and mixed product)*;
- Mass per Volume in Grams/Liter (individual components and mixed product)*;
- Viscosity – Stormer (individual liquid components and mixed product)*;
- Viscosity – Brookfield (mixed product only);
- Pot life via Stormer Viscosity (25%, 50%, 75%, 100% of stated pot life);
- Sag Resistance; and
- Dry-to-Touch and Dry-to-Handle Times.

Tests not included in this list that may also be performed include color and gloss; however, these tests are conducted on the dry film.

If the values for the jobsite batches match the values in the DataMine, or the manufacturer's published ranges for products that are not included in the DataMine, there is good confidence that significant changes to the coatings have not been made.

TENSILE ADHESION TESTING (OCTOBER 1984)

Tensile adhesion testing seems to provide erratic results. The values will sometimes vary by a few hundred psi with the dollies only a few inches apart. Also, the instrument may show coating to withstand 1,000 psi, even though it can be easily removed with a knife blade. Why do these inconsistencies occur and how reliable are the results? *(Submitted by Nicolas J. Gerold, Herron Consultants.)*

As a point of background, the tensile adhesion tester available at the time the question was raised was a fixed-alignment adhesion tester, which required gluing a ¾-inch-diameter aluminum test dolly (½-square-inch surface area) to the surface of the coating (Fig. 6). After the adhesive cured, the claw of the instrument was attached to the head of the dolly and a handwheel was turned in order to apply a pulling force to the dolly by compressing either Belleville washers or a spring housed in the barrel of the instrument.

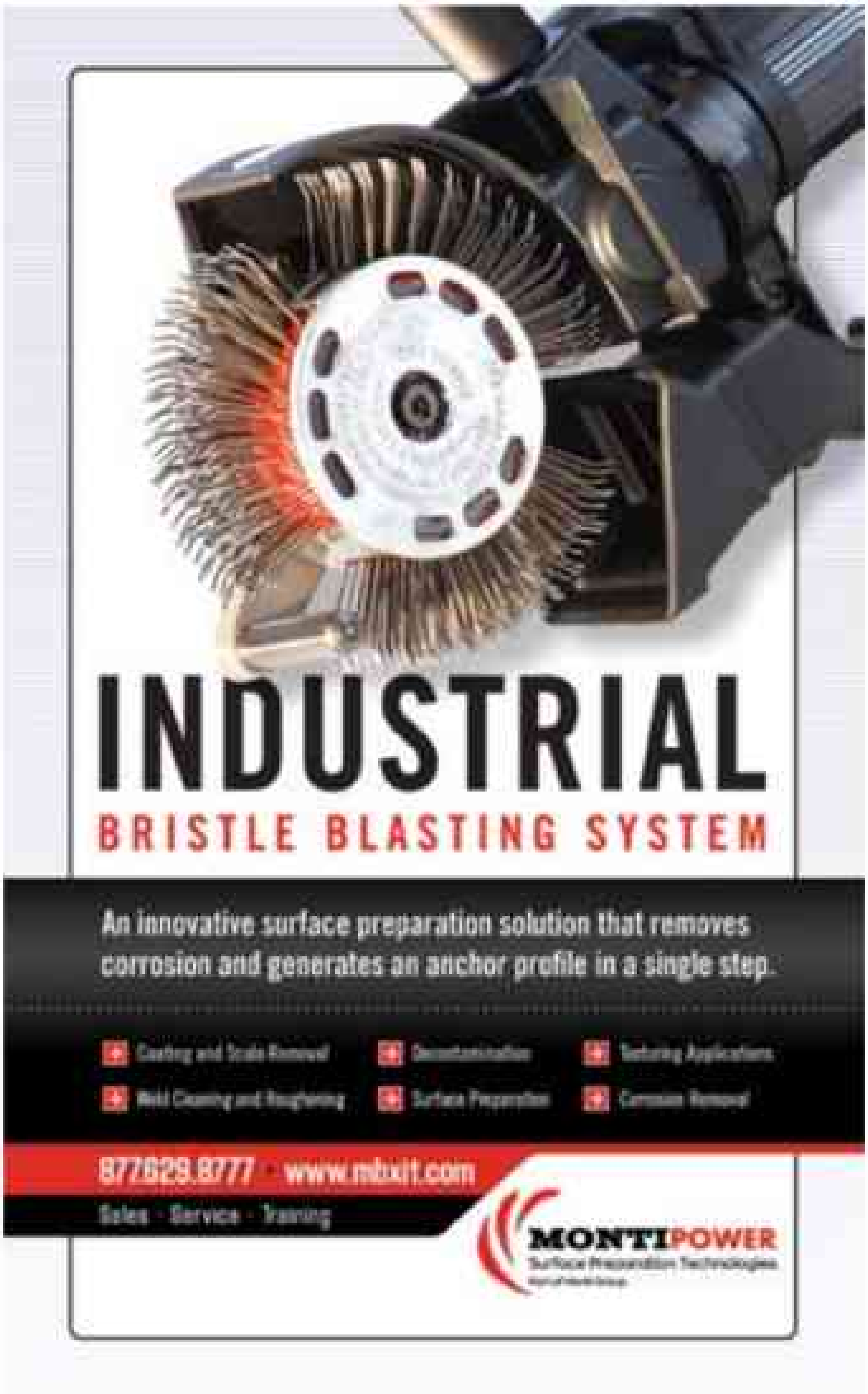
Summary of 1984 Responses

(Submitted by Joseph F. Padovich, KTA-Tator, Inc.; Art L. Cunningham, Rust-Oleum Corporation; R.K. Fisher, Fisher Instruments and Navigational Services; and John Fletcher, Elcometer.)

1. The speed at which the handwheel is turned will vary between operators, effecting the length of time the coating is under stress.
2. Dollies can be misaligned during placement. The dolly has to be pulled perpendicular to the surface.
3. Light-gauge metal can flex during testing, effecting the results.
4. The adhesive has to be applied continuously across the surface.
5. A 1-inch hole saw is often used to score around the dolly through the coating to restrict the application of the tensile stress to the area beneath the dolly.
6. Problems with achieving consistent results can be attributed to the tester, the test method, or the product being tested. If any of the two are held constant, the third can be determined. For the tester, calibration is done using laboratory

tensile testing machines. With no field method for verifying its calibration, the accuracy of the instrument at time of use is unknown. ASTM D4541 provides broad guidance on controlling the test method to minimize errors in operation. If the equipment and test method are controlled, differences in results would be attributed differences in the tensile strength of the product being tested.

7. Adhesion failures occur in a number of ways, singly or in combination, including:
   a. Adhesive (glue) failure, leaving the coating intact;
   b. Coating failure within or between coats;
   c. Failure of coating to the substrate; and
   d. Failure of the substrate (e.g., concrete).
8. The results obtained with the fixed-alignment adhesion tester cannot be compared with knife-testing results because they assess two different attributes of the coating. The adhesion tester measures the tensile adhesion while the knife test determines the shear strength. Failure of shear strength might occur with a fraction of the stress required for tensile failure. Coatings can have a high tensile strength and a low shear strength, and vice versa.



Today's Response

More is known today about the testing of pull-off strength of coatings. ASTM D4541, "Standard Test Method for Pull-Off Strength of Coatings Using Portable Adhesion Testers," has been expanded since 1984 to include five additional types of instruments:

- Test Method A: Fixed-Alignment Adhesion Tester, Type I (since discontinued);
- Test Method B: Fixed-Alignment Adhesion Tester Type II;
- Test Method C: Self-Alignment Adhesion Tester Type III;
- Test Method D: Self-Alignment Adhesion Tester Type IV;
- Test Method E: Self-Alignment Adhesion Tester Type V; and
- Test Method F: Self-Alignment Adhesion Tester Type VI.

In 2006, ASTM International published an interlaboratory study conducted by ASTM Subcommittee D01.46 involving five tester types, six generic coating systems and seven laboratories.[1] The study demonstrated that adhesion values on the same coating system vary by tester, and that the fixed-alignment tester produces comparatively lower values than the self-aligning hydraulic and pneumatic testers.

There are a number of benefits to the self-aligning adhesion testers. They apply a continuous, uninterrupted pulling force to the loading fixtures, eliminating the intermittent force applied when manually turning the handwheel. The instruments also automatically align themselves to the loading fixtures to assure that the force is always applied perpendicularly through the fixtures, eliminating the possibility of concentrating the force across one small area of the fixture and creating shear stress. Because the pounds-per-square-inch values reported by the instrument are based on distributing the force across the surface area of the loading fixture. If the force is concentrated across a smaller area, the conversion from force to psi is incorrect.

More is also known today about the attachment of the loading fixtures. After the adhesive is applied, the fixture should not be twisted on the surface as twisting may create gaps in the adhesive. After the adhesive is applied to the fixture, it should be firmly pushed onto the surface, but not twisted. More is also known about scoring the coating. While scoring of heavy coating may be necessary to avoid the Band-Aid effect of the surrounding coating on the results, scoring can also fracture the coating, weakening its pull-off strength. The standard recommends against scoring coatings less than 20 mils in thickness.

A paper presented at the 2001 SSPC annual conference concluded that there are several variables that can influence tensile (pull-off) adhesion test data[2]. These variables include the type of adhesive that is used to attach the loading fixture, the time period the adhesive is permitted to cure before initiating tensile forces, and the test device that is ultimately chosen to perform the testing. It recommended that specifications specifically state the type of adhesion tester that is to be used and perhaps the type of adhesive to employ when conducting this type of testing, since different pull/push mechanisms can produce different results. It also recommended that the specification clarify whether the specified minimum adhesion value is the average of at least three tests or the minimum value of any single test.

With all of this considered, the most significant improvement in tensile adhesion testing is in the equipment itself—the application of a continuous, uninterrupted force to the loading fixture and self-alignment to apply the force perpendicularly through the loading fixture. Other improvements include the ability to control the rate of the applied load, various diameter loading fixtures (i.e., 14 and 20 mm for metal substrates and 50 mm for concrete substrates), and curved loading fixtures for use on convex/concave surfaces. One manufacturer has also addressed the 1984 comment regarding calibration by developing portable equipment for verifying the accuracy of their adhesion tester.

And as indicated in 1984, the pull-off strength of the coating determined with the adhesion testers cannot be compared with the shear strength of the coating, determined by the knife tests, such as ASTM D3359, "Standard Test Methods for Rating Adhesion by Tape Test," and ASTM D6677, "Standard Test Method for Evaluating Adhesion by Knife."

CONCLUSIONS

The industry has done a good job of addressing many of the concerns that have been raised in the past. In the examples mentioned, standards and specifications were created or improved and new equipment was developed. And for 35 years, JPCL has been there every step of the way, providing an excellent vehicle for identifying problems and sharing solutions, and will hopefully continue to provide such a valuable service well into the future.

ABOUT THE AUTHOR

Kenneth A. Trimber is the president of KTA-Tator, Inc. He has over 45 years of experience in the industrial painting field and is a NACE-certified Coating Inspector, an SSPC Protective Coatings Specialist, an SSPC C-3 Supervisor/Competent Person for the Deleading of Industrial Structures and is certified at a Level III nuclear coating inspection capability in accordance with ANSI N45.2.6. He is a past-president of SSPC, a member of the SSPC Standards Review Committee, and chairman of the SSPC Commercial Coatings Committee, Surface Preparation Committee and the Containment Task Group, as well as past-chairman of the ASTM D01 committee and author of *The Industrial Lead Paint Removal Handbook*. Trimber was also the first editor of JPCL's PSF series from 1984 through 1995.

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1. ASTM RR:D01-1147, "Research Report to D4541 Standard Test Method for Pull-Off Strength of Coatings Using Portable Adhesion Testers." ASTM International; Feb. 2009.
2. Corbett, W.D., KTA-Tator, Inc. "Tensile Adhesion: Specifying the Test? Specify the Test Instrument." SSPC 2001 Annual Conference, Atlanta, GA; Nov. 11–14, 2001.

CELEBRATING 35 YEARS 1984 2019

THIS MONTH IN ...

1984

The July 1984 issue in JPCL's first publication year featured an emphasis on zinc-rich coatings, including "Zinc-rich Primers: A Survey of Tests, Specifications, and Materials," by Dean M. Berger, and "Economics of Zinc Coating Systems for Corrosion Protection," by A.H. Roebuck, Hugh Morrow, III, and Dale C.H. Nevison.

1991

After OSHA released its "Working with Lead in the Construction Industry" guideline to protect workers and the environment from exposure to lead, including from lead-based coatings, JPCL reprinted the rule in its entirety, along with, "The Cost of Lead Paint Removal: Achieving Realistic Bid Prices," an article by Louis G. Lyras that discussed cost factors for coating projects that required containment to deal with these new lead considerations.

1995

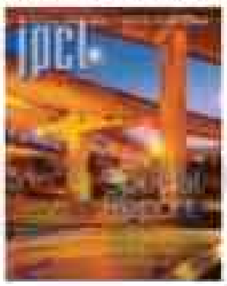
Former JPCL contributing editor Lloyd Smith authored "Introduction to Generic Coating Types," the first in a 16-part monthly series that provided basic information about the standard, generic classification of protective coatings.

2000

In "The Future of Pipeline Coatings," Dr. D. Fairhope of BP-Amoco offered a synopsis of how pipeline coatings have developed over the years, as well as an overview of the major factors likely to influence the development of pipeline coatings for the oil and gas industries, including construction costs, health and safety considerations, and higher pipeline operating temperatures.

2012

JPCL published its "Special Report: Following the Basics for Protecting Concrete" issue, which covered the necessary information on applying and maintaining concrete protective coatings, including concrete repair tips, surface prep considerations, standards considerations and more.



Pictures Worth 1,000 Words

Spawn / Getty Images

From left: Former SSPC President Executive Director Bill Shoup presents an award to Randy Nixon.

Photos courtesy of SSPC unless otherwise noted.

From left: Bernie Appleman, SSPC's first Executive Director, and former JPCL contributing editor Lloyd Smith.

From left: The late SSPC board member Phil Calvo, longtime JPCL author Carl Angeloff and Shoup.

Former JPCL Editor Karen Kapsanis.

JPCL founder Harold Hower, Technical Editor Brian Goldie and former Editor Steve Byers.

From left, Coatings industry veterans Dan Adley and Ken Tator, with Maureen Tator

From left: Former SSPC President Russ Brown and the late Eric S. Kline, longtime SSPC member and committee chair

From left: industry experts and JPCL contributors Bill Corbett and Dwight Weldon

Multiple-award-winning JPCL authors Mike O'Donoghue, Lee Meitus and Vijay Datta

From left: Cornell and former JPCL staff members Patty James Mutchler, Gina Fishman, Marian Welsh and Bernadette Landon.
Photo courtesy of Patty James Mutchler.

From left: Andy Folmar of JPCL, with friend.
Photo courtesy of Patty James Mutchler.

BRIDGE PAINTING: PROGRESS THROUGH COMMUNITY

dvoevnore / Getty Images

BY ROBERT KOGLER, RAMPART LLC

Bridge painting has come a long way over the past 35 years. Paint materials have evolved from inexpensive, commodity- and specification-based products into high-performance, environmentally accommodating, manufactured construction materials. Equipment manufacturers have matured from relatively simple operations into technical, customized problem-solvers; bridge owners and other engineers have worked to optimize long-term performance and life-cycle cost. Contractors are now experts not only at blasting and painting, but at access as well, working on some of the world's most challenging structures without disruption to traffic and operation, and perhaps most importantly, all of this has been accomplished while achieving monumental strides in worker safety and lowering the impact on the surrounding environment.

Thirty-five years ago, bridge painting was generally viewed as a somewhat inconvenient maintenance burden, often achieved only after multiple deferments and usually with the last few dollars available in the budget. The dramatic impact of regulations and the increasing demand for performance by bridge owners has driven major changes in all aspects of bridge painting over the past three decades. None of these benefits would've been achieved without the unique community of practice that exists within SSPC, and the conduit of knowledge that has been provided on a monthly basis by the JPCL.

CHANGE ALL YOUR PAINTS—AND LIKE IT

Throughout the 1980s and 90s, dramatic changes to materials, work practices and the overall level of technical knowledge and expertise within this industry sector took place.

Virtually all of the paint materials historically used on bridges required changing due to the push of impending environmental regulations. This change was monumental, but through the efforts and innovation of raw-material and finished paint suppliers within our industry, compliant and better-performing materials were produced. Public-sector engineers from the states, transportation authorities and the federal government worked together to embrace these changes and sort out and apply the performance benefits that became newly available. Cooperative test programs such as NEPCOAT in the Northeast gave way to the National Transportation Product Evaluation Program (NTPEP) such that paint manufacturers and bridge owners could work together to develop and share data on paints. This effort not only provided a level playing field for performance evaluation of bridge paints, but also effectively raised the bar on performance itself. There was some pining for the old, forgiving lead-based paints, but the data clearly shows that modern coatings outclass the old technology and certainly have achieved and even exceeded environmental and worker-safety goals that initially seemed so challenging.

THE SHARP END OF THE SPEAR

In hindsight, the story of the evolution of bridge-painting contractors (along with their equipment and containment partners) is truly miraculous. Bridges are always open for business and from the perspective of cleaning and painting, they are also almost always located outdoors, and their designs are most challenging. Depending on the specific bridge, cleaning and painting is an almost impossible job. Yet, there is no doubt that innovation, and particularly, industry-wide cooperation has allowed the bridge-painting-contractor community to meet these challenges while improving overall quality and performance.

Access has evolved from picks and scaffolding to suspended and mobile containments that not only capture waste but keep conditions inside safe for workers. Quality and compliance are self-governed through the SSPC Painting Contractor Compliance Program (PCCP). While only about half of the state DOTs mandate this program, there is no doubt that it has had an immeasurable impact on safety and bridge-painting quality nationwide. The industry has been transformed in several ways over the last 35 years, but the evolution of the contractor community through their own self-imposed cooperative mandate of quality and safety stands out.

The changes in bridge painting over the past 35 years have been universal and positive. Work remains to be done as the neglect in maintenance of the bridge inventory has imposed a difficult challenge to the nation; however, the community that has coalesced within SSPC—with the knowledge beacon of JPCL—continues to innovate to meet these challenges. The community of paint manufacturers, owner and consulting engineers, equipment and surface-preparation material suppliers, and contractors and workers has a unique forum to discuss and foster progress within SSPC. This community met and defeated the VOC and lead challenges over the past decades and can certainly successfully take on the challenges of quality, performance and cost control that lie ahead.

ABOUT THE AUTHOR

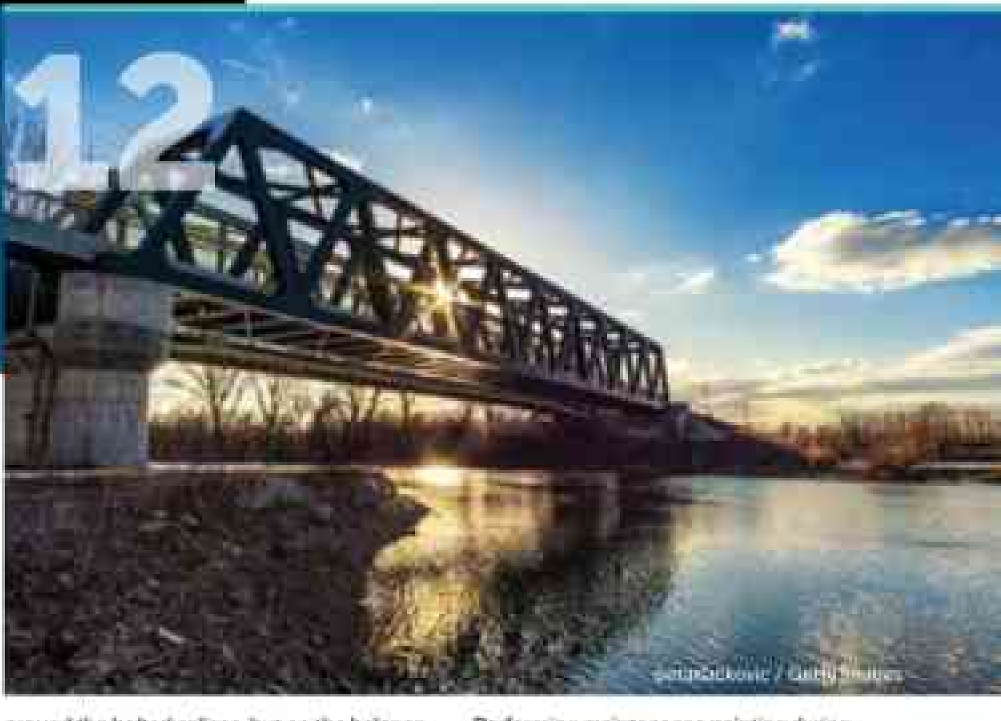
Bob Kogler, principal with Rampart LLC, has been a corrosion and durability engineer for his entire professional career. He has worked extensively for the U.S. Navy and the U.S. Federal Highway Administration managing and executing corrosion and coating technology and research efforts for the past three decades. Kogler's work has spanned from the laboratory to field testing, to development of specifications and standards, to implementation and oversight of coatings and corrosion technology applications for infrastructure and marine system owners. He is a past-president of SSPC and is currently on the Standards Review Committee.

Excerpted from JPCL January 2012
F-Files: Mechanisms of Failure

2012

THE CASE OF ... TOO MANY CHOICES

By Eric S. Kline, KTA-Tator, Inc.



This is the story of a steel bridge in the northeastern U.S., but it could be true of a bridge anywhere in the U.S. The structure, although nearly 50 years old, was sturdy and still within its design life. The State Department of Transportation (DOT) district maintenance engineers, during review and planning, determined there was no need to consider demolition and replacement of the bridge. However, it was determined that a deck overlay replacement should be part of the bridge-deck maintenance program. The DOT wanted to address the paint system as part of the same contract letting.

The paint condition was judged to be "fair to good" during the most recent biennial inspection. Some coating breakdown was noted around the bolted splices, but on the balance of the structure, the coating appeared to be in satisfactory condition. With the bridge having been constructed in the 1960s, there was little doubt that the original coating system consisted of a multi-layer lead alkyd system, likely applied directly over mill scale. The agency knew that it was a matter of time before the coating system would require maintenance. Performing maintenance painting during deck replacement work seemed like a logical progression.

THE INVITATION FOR BIDS

Funding for maintenance operations was tight, as is usually the case with state agencies. Nonetheless, the state decided to advertise the deck replacement and elected to include two

The left side of the angle shows old primer; the right side does not. Photo courtesy of KTA-Tator, Inc.

alternate bidding scenarios for maintenance painting.

AT THE JOBSITE

Contractor A chose to exercise Option 2 (SSPC-SP 7, Brush-Off Blast Cleaning and overcoating). His logic in bidding both options for the same price was that most of his costs in the project lay in mobilization and the environmental, health and safety costs (including containment) associated with the existing lead-based system. After these costs were incurred, the main difference in cost between Option 1 and Option 2 was the comparative effort in preparing the surface of the steel to achieve an SSPC-SP 6, Commercial Blast, as well as to apply a three-coat system, instead of the less rigorous SSPC-SP 7, brush-off blast followed by application of a two-coat system.

From left, a magnified view of the substrate beneath the old coating system; and a magnified view of the substrate where only the new coating system was present. Photo courtesy of KTA-Tator, Inc.

Contractor A chose Option 2 because by his calculation, Option 2 would require significantly less labor and material (abrasive and coatings), thereby increasing his margin on the project. During the ensuing construction season, work proceeded accordingly. The contractor mobilized, prepared the steel surface according to the requirements of SSPC-SP 7, and applied the approved two-coat epoxy mastic-polyurethane coating system.

THE AFTERMATH

Within two years of the maintenance work, DOT maintenance personnel observed minor peeling of the coating on corners, edges and connections. Projecting that the peeling and disbonding problem would worsen and become more widespread, the agency contracted with a coatings consulting firm to independently investigate the cause of the localized coating disbondment.

The investigation revealed that while some small areas exhibited disbonding, the coating system was generally performing as expected, and the majority of the coated structure did not show signs of premature failure. Further, it was noted that the coating system in the failing and non-failing areas had been applied within the specified thickness limits of 6–10 mils (4–6 mils of epoxy mastic and 2–4 mils of polyurethane).

DISCUSSION AND CONCLUSION

There are a number of factors to consider in this project. First, the agency offered two cleaning and painting options and allowed the contractor to make his choice between those options. One should anticipate that the contractor would choose the option that would expend the least amount of labor and materials and thereby improve the profit margin on that job. If the owner had retained the right to select the maintenance painting option, there is little doubt that he would have chosen Option 1, removal and replacement of the coating system, over Option 2, overcoating. The fact was that with no difference in price, the Option 1 requirement to *replace* the aged system would have afforded the DOT with longer-term corrosion protection to the bridge and would have been the chosen option.

Secondly, before providing the bidders with the option for overcoating the existing aged alkyd system, the owner should have considered and investigated whether there was risk inherent in applying a new coating system over the old coating, irrespective of the degree of surface preparation of the steel beneath the old system.

The post-project investigation determined that the coatings applied were those specified, that they were mixed and applied to the correct thickness, and that even in the failing areas, there was some evidence of abrasive impingement of the mill-scale-covered surface. Thus, it would appear that Contractor A complied with the coating specifications for Option 2.

In hindsight, the DOT learned that the SSPC Overcoating Guide (SSPC-TU 3 "Overcoating," May 1, 1997, Editorial Revisions November 1, 2004) should have been consulted before allowing and accepting bids for the overcoating option (Option 2).

Excerpted from JPCL, June 2009

A TOWERING TALE OF BRIDGE COATING: HOW CALTRANS KEPT QUALITY HIGH AND COSTS LOW

By W.H. (Bill) Hansel, PCS, California State Department of Transportation

The Vincent Thomas Bridge (VTB) connects San Pedro with Terminal Island and serves as a major artery for the transport of goods to and from the Los Angeles/Long Beach Harbor. Owned by the California State Department of Transportation (Caltrans), the VTB is 6,060 feet long. Its main suspended span is 1,500 feet long; its side spans are 500 feet long each; and its two approach spans are 1,780 feet each. The towers are 365 feet tall. The bridge consists of 92,000 tons of Portland cement, 13,000 tons of lightweight concrete, 14,100 tons of steel and 1,270 tons of suspension cable.

Construction began in May 1961 with work on the substructure. The bridge's cable anchorages were the first ever to be set entirely on pilings. No rivets were used in constructing the bridge, making it the first in

Beams traversing roadway for upper tower scaffolding support. Photo courtesy of Caltrans.

the United States to be constructed entirely with welds. The bridge was opened to traffic at midnight on Friday, November 15, 1963 and has undergone two seismic retrofits; the first was completed in 1980 (after the Sylmar Quake) and the second was completed in 2002 (after the Northridge Quake).

QUAKE DOESN'T SHAKE SCHEDULE

At 11:42 a.m. on July 29, 2008, a 5.4 (Richter Scale) earthquake occurred in Ontario, California. Moments later, the VTB tower and scaffolding began swaying violently. The employees followed the "Emergency Action Plan," evacuating the work area and meeting at the designated evacuation spot. All employees were safely accounted for. After the earthquake ended, and it was safe for them to do so, the painters could visually inspect the bridge for obvious signs of damage. They found only superficial damage, which they reported to the Area Bridge Maintenance Engineer. The scaffold contractor sent its Safety Officer and a Competent Person to inspect all levels of the scaffolding. A representative from Caltrans also walked the scaffolding and inspected the bolt-up steel supporting the upper scaffolding. No damage to the scaffold was found. The site was re-opened for work. Despite the earthquake, workers completed the job on time.

TWO CREWS = TIME AND $ SAVED

Using the scaffolding and containment contractor and the in-house painting crew streamlined the VTB project, maintained high-quality work and saved Caltrans $700,000. The savings was related to the difference between the cost of the third-party crew assembling the scaffold (which they do faster and cheaper than the in-house crew) and the ability of the in-house crew to clean and paint with no downtime between the tower halves. The two-crew system thereby reduced the rental expense for the scaffold and saved Caltrans' from at least doubling the time needed for the project.

2014

Excerpted from JPCL May 2014

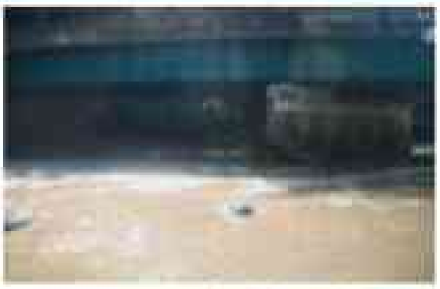
BRIDGE COATING PERFORMANCE: TWO-COAT VS. THREE-COAT SYSTEMS

By Shameem A. Khan, Maryland State Highway Administration

Photo: Pamela Simmons.

In 2006, the Federal Highway Administration, through the Innovative Bridge Research and Construction Program (IBRC), initiated an examination of the performance and cost savings of several coating systems in an effort to provide information about innovative materials and technologies to state, county and local bridge owners.

The Maryland State Highway Administration (SHA) conducted a four-and-a-half-year performance evaluation that compared two different two-coat paint systems against



(Left) Bridge No. 0700300 in Maryland was selected because it provided three coating surfaces independent of one another, is in a humid environment, and suffers from leaky joints and an old concrete deck with high salt concentrations. Winter salt spray can penetrate cracks in concrete bridge decks. When the deck dries, the salt remains. Photos courtesy of the author.


Coating System J, the elastomeric acrylic, showed blistering, peeling and corrosion on approximately 20% of the total surface area. Photos courtesy of the author.

its standard three-coat system, consisting of an organic zinc primer, a polyamide intermediate and an aliphatic urethane finish coat (currently the "state-of-the-art" system for most states).

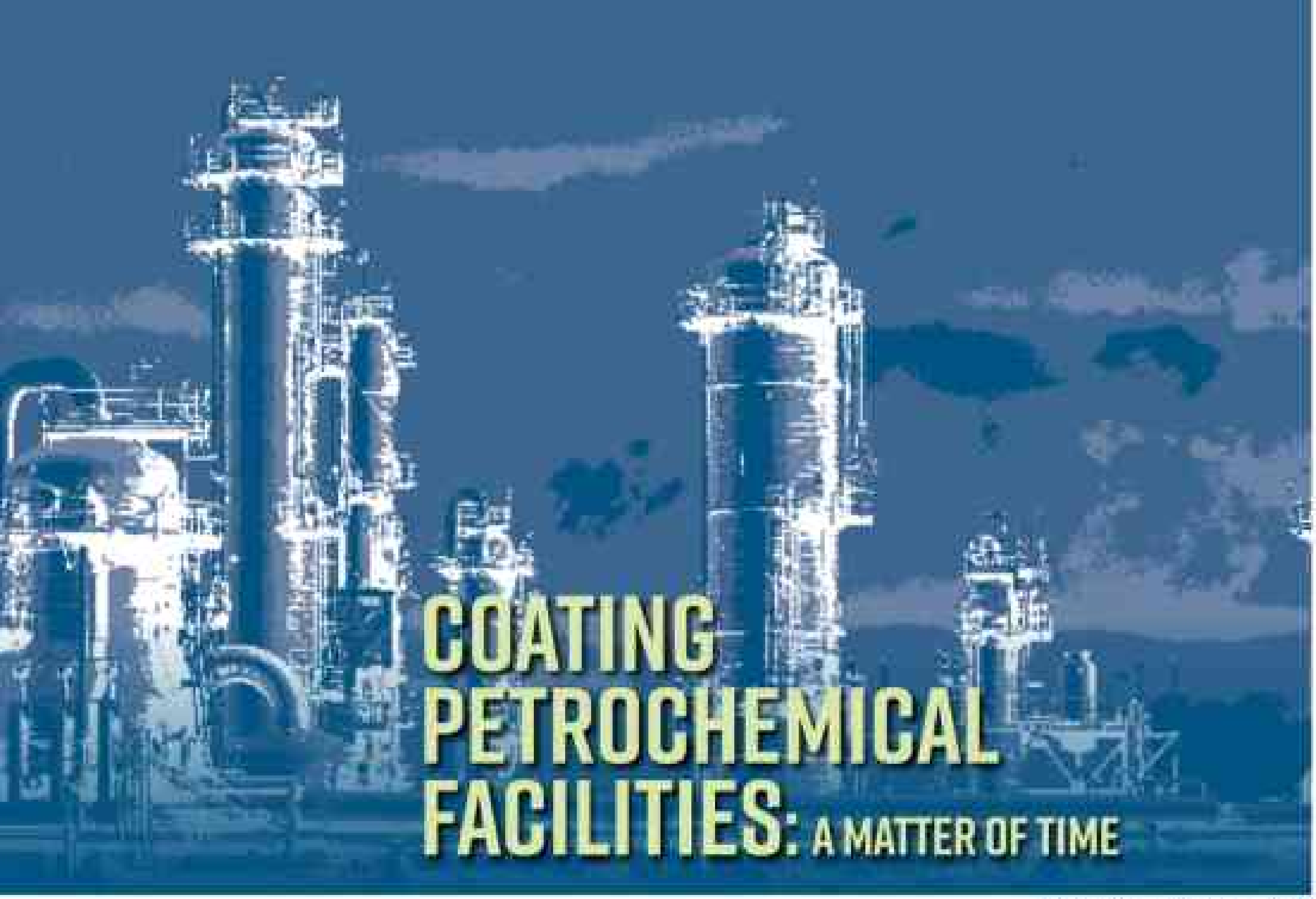
COATING SYSTEMS

The three coating systems selected were applied at specific locations defined in the Framing Plan. System C was the SHA's standard three-coat system used for maintenance painting of existing bridges. The two-coat systems, referred to as Systems J and K, were selected for comparison because of their use in the industry as alternative systems.

CONCLUSIONS

While the purpose of using two-coat systems is to reduce painting costs, this research indicated that the two-coat systems tested over blast-cleaned surfaces were not cost-effective when compared to the traditional three-coat system.

System C, the standard three-coat system presently used on existing bridges in Maryland, continues to be the best performing paint system, according to this research project. During cleaning and painting operations, the project had full-time, third-party inspection, with periodic visits by SHA office staff. These inspections ensured that the contractor performed all activities in accordance with the required project specifications. ***JPCL***



COATING PETROCHEMICAL FACILITIES: A MATTER OF TIME

VanderWolf-Images / Getty Images

BY PETER BOCK, PERFORMANCE POLYMERS AMERICAS LLC

The year 1984 was a great time to be a young up-and-coming (future) industrial-paint expert. Coating technology was improving significantly, partly as a response to newly enacted or pending legislation, and partly because of improved technology.

Every oil-company headquarters and regional office, and sometimes even individual plants, had a knowledgeable "paint guy." His office bookshelf was crammed with loose-leaf binders, and always prominent among them were two large red bound books—the two-volume set of the SSPC Standards: "SSPC Surface Preparation" and "SSPC Coating Systems."

Maintenance of offshore drilling rigs and production platforms led technology. Environmental conditions were severe, to say the least, and wise owners realized the huge replacement costs involved. Abrasive blasting and coating application on-site at offshore facilities were so difficult and costs were so high that using the best coatings made sense. One coat of inorganic zinc over perfect surface preparation was tried and worked for some. More common were multicoat systems like a five-coat vinyl system that had a 15-minute recoat interval but was loaded with lead and had volume solids in the 25% range.

Offshore maintenance had full-time inspectors on every project, partly because once the inspector got to the structure, there was nowhere else for him to go. The inspector walked around with a tally book in his back pocket and wrote a nightly report in longhand with smeary carbon-paper copies if the structure didn't yet have a copy machine.

In much of the onshore oil-field and petrochem world, coal-tar epoxy was still first choice for its high volume-solids, high per-coat and total DFT, and relatively low cost. Eight mils per coat at 75% solids and $15 a gallon achieved twice the build and at barely over half the price of a maintenance epoxy. Alkyd was cheaper but dried too slowly and didn't build or hold up.

Gas pipeline companies were redoing their compressor stations, metering locations and pig traps at any place where pipe came out of the ground. Gray epoxy was replacing red lead and umpteen topcoats from the annual maintenance ritual of putting another coat of aluminum on everything that didn't run away or wave in the wind. Surface preparation was greatly improved, since before, there had been none.

Of course, up in the piney-woods country of eastern Texas, northern Louisiana, Mississippi, Arkansas and even southern Georgia, if the compressor and sand pot worked and something came out of the nozzle, that was "sandsweep." If sand actually hit the pipe or tank being blasted, that was a "commercial blast," and if it removed some of the old paint down to bare metal, that was a "near-white blast."

And there was endless amazement among the lesser-expert contractors: "What do you mean we have to mix two cans together before we start painting?" Occasionally, a day or two later there was also the plaintive telephone call: "We forgot to mix the second part in; will it still dry, and if not, can we just paint the second part over what's already on the tank?"

Today, in 2019, the two large red bound books still exist, although more often on a digital tablet, a laptop or in a corporate database than in actual paper form. Both volumes have expanded to include newer processes and coating systems.

The painting industry has done a miraculous job of reformulation. Lead, chromium, asbestos and most of the solvents are gone, and yet today's systems give as good or better corrosion resistance than their wicked ancestors from 35 years ago. Surface-preparation methods have widened to include environmentally friendly processes such as UHP washing and vapor blasting.

Qualified, certificated paint inspectors are on almost every project, holding iPads or smartphones. Many of the younger ones don't even know what a tally book is. Corrosion engineers have replaced the owner's paint guys and are as likely to be women as men. The trusty five-gallon paint pot has turned into a computer-monitored, heated, recirculating plural-component application machine, and the contractors know how to use them.

For today's young industrial paint specialist, it's a great time to be in the business. For an old grizzled veteran, like the one who wrote this article, it's great to see how far we have come.

ABOUT THE AUTHOR

Peter Bock is a petrochemical coatings, insulation and CUI specialist based in Houston. He has 42 years of corrosion-control experience worldwide and teaches annual courses on CUI. Bock is a NACE-certified Coating Inspector (Level III), is active in industry organizations, has been widely published and has presented numerous papers. He is past chairman of the NACE Central Area Board of Trustees, is a JPCL contributing editor, a JPCL Readers' Choice Award recipient and the recipient of two JPCL Editor's Awards.

From JPCL, February 2012

WHEN UNDERCOVER AGENTS CAN'T STAND THE HEAT: COATINGS IN ACTION AND THE NETHERWORLD OF CORROSION UNDER INSULATION

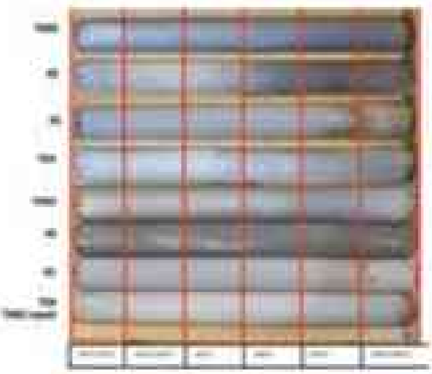
By Dr. Mike O'Donoghue, Vijay Datta, Adrian Andrews, Sean Adlem and Matthew Giardina, International Paint LLC; Nicole de Varennes, Linda G.S. Gray and Damien Lachat, RAE Engineering; and Bill Johnson, Acuren Group Inc.

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's 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.

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

- TSA: Thermal spray aluminum (1 coat at 10 mils' DFT).
- Coating No. 1: Modified silicone copolymer (2 coats at 10–12 mils TDFT). Stated temperature resistance up to 650 C in continuous service and suitable for CUI service.
- Coating No. 2: Inorganic polymer with MIO (2 coats at 12–16 mils' TDFT). Stated to withstand intermittent exposures up to 720 C and prevent CUI.
- TMIC: Titanium modified inorganic



Overview of all samples after CUI cyclic testing. Photo courtesy of the authors.

copolymer (1 coat 7–8 mils' DFT). Stated to withstand cyclic CUI environments for pipes to 400 C and 650 C in continuous operation.

Aside from the successful applications in the field, these studies strongly indicated 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.

Preparation of TSA weld joints. Photo courtesy of the authors.

TMIC applied to protect TSA weld joints. Photo courtesy of the authors.

Inspection of TMIC after one year in service showing no coating breakdown or rusting. Photo courtesy of the authors.

CASE HISTORIES

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 4–5-day cycle. Previously, several different polymeric coating technologies had been used to protect the dryers, and in all cases, the coatings had failed within six 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 TDFT of 8–10 mils. One year later, the dryer units were inspected, showing no rusting or coating degradation. At present, the dryers have operated for over six years without any indications of CUI.

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.

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.

From JPCL, July 1996

TIPS ON LINING ABOVEGROUND STORAGE TANK BOTTOMS

By Bob Hummel, The Sherwin-Williams Company

gong hangxu / Getty Images

Chemical and petrochemical companies are becoming more proactive in protection of aboveground storage tanks, largely due to environmental concerns and a stricter regulatory climate. Tank owners and operators have a heightened awareness of the high costs and penalties associated with spills of hazardous materials. Typical costs of ground remediation at a contaminated site can easily run into millions of dollars. In addition to environmental damage, cleanup costs, fines and the threat to public health, the damage to a company's image can be enormous.

Concerns about storage-tank leakage are valid. There are more than 868,000 petrochemical storage tanks across the U.S. Most range in capacity from 1,000 barrels (1,600 cubic meters) to more than 265,000 barrels (421,000 cubic meters), with diameters from 25–300 feet (7.5–90 meters). All tanks

MrLightBox / Getty Images

are subject to corrosion, which can lead to severe degradation of tank bottoms and leakage.

To prevent corrosion and preserve tank integrity, a variety of lining systems can be applied to tank interiors. The proper specification and application of lining systems to tank interiors can limit internal corrosion of the steel tank bottom and is perhaps the most cost-effective way to prevent hazardous material spills and extend the service life of tanks. Properly specified and applied, tank-bottom lining systems can effectively inhibit corrosion for 10–20 years.

LINING SELECTION

Linings are selected for tank interiors based on a number of factors including tank construction; the integrity of the bottom and shell plates; tank condition and corrosion rates; tank contents; and previous repairs and linings. The costs of materials and application are also factors.

INSPECTING TANK INTERIORS

Before selecting lining systems for tank bottoms, the operator should visually inspect the tanks. Visual inspections require opening the tanks, a procedure that must be performed with the highest regard to safety.

Once a tank has been opened, it must be certified as "safe for entry" in accordance with the OSHA regulation before inspection or other activities. An explosion-proof exhaust system must be used to ventilate the tank. The exhaust system should be grounded to the tank and equipped with special air-quality gauges. Equipped with special alarms, the gauges will monitor air quality throughout the entire operation. Low-voltage, explosion-proof lighting is also required.

Inspectors should examine tank bottoms, shell seams and plates, roof interior surfaces, floating-roof seal assemblies and appurtenances, common tank appurtenances, and access structures. Corrosion rates and pitting can be measured with magnetic flux leakage methods.

The tank should have a sound foundation and a suitable pad before lining application. Cone-roof and floating-roof tanks have support legs connected to the bottom of the tank and these areas may require specialized techniques to apply linings. Welded tanks typically require less surface preparation than riveted tanks. Rivets, butt straps, skip welding and other surface irregularities make linings more difficult to apply.

INFLUENCE OF PRODUCT

The product stored in a tank over the life of the lining system is a crucial consideration in lining selection. Because some lining systems provide greater corrosion resistance to certain chemicals than others, tank contents—and future contents if swing service is a possibility—must be considered.

THE CONDITION OF THE PREVIOUS LINING

If the tank was previously lined, the existing lining should be removed. The tank owner should also determine why the existing lining system failed.

PREPARING INTERIOR TANK SURFACES FOR LINING

In general, most linings require abrasive blast-cleaning to Near White (SSPC-SP 10/NACE No. 2) or White Metal (SSPC-SP 5/NACE No. 1). Depending on the lining, proper adhesion requires surface roughness from 1.5–4 mils (38–100 micrometers). A prime coat may also be necessary.

Necessary repairs to the steel tank bottom should also be made before blasting. Non-destructive tests should be conducted to determine the thickness of the steel bottom plates. Typically, perforations of the tank floor are repaired by welding steel patches onto the surface. Consult API Standard 653 for information on repairing tank bottoms.

Blasting should be performed with abrasives that are free of oil or other contaminants. Selection of abrasive size and type is based on the type, grade and surface condition of the steel to be cleaned as well as the desired surface profile.

Following blasting, all substrates should be fine-swept, blown down and vacuumed to remove abrasive, dust and other foreign material that could interfere with the adhesion of the lining.

LINING SYSTEM APPLICATION AND INSPECTION

As with surface preparation, lining application should be performed strictly according to the manufacturer's directions. Spark or holiday testing is conducted to assure that there are no pinholes or imperfections in the surface that could allow future corrosion of the steel substrate.

CONCLUSION

Tank bottom linings provide an economical solution to the corrosion problems of petroleum storage tanks. When properly specified and applied, lining systems can extend the service life of aboveground storage tanks and offer an economical solution to tank bottom replacement.

From JPCL, February 2014

POLYUREA "LOOSE" LINERS: A FLOATING FIX FOR CRACKED CONCRETE SECONDARY CONTAINMENT

2014

By Kristin Leonard, Bechtel Corp.


rysick / Getty Images

While installing a typical thin-film coating system in a chemical plant in the western U.S., extensive dynamic cracking was discovered in concrete chemical secondary-containment structures. After multiple failed attempts to repair the cracks using standard thin-film coating products, the decision was made to proceed with process equipment installation in the hope of maintaining the construction schedule while the coating details could be evaluated.

The challenge was to use a coating system that delivered chemical resistance while acting as a "band-aid" over the damaged concrete to provide 100% containment. A polyurea/geotextile liner was selected on a trial basis because of the system's flexible and chemical-resistant properties, as well as the relatively swift installation time.

CHOOSING THE SYSTEM

During the system-selection process, potential coating materials underwent weeks of rigorous chemical testing, including monitoring for a number of failures that would eliminate a candidate. Different epoxy formulations were tested based on basic knowledge of their overall chemical resistance. Concrete test specimens were prepared in accordance with ASTM D5139, "Standard Specification for Sample Preparation for Qualification Testing of Coatings to be Used in Nuclear Power Plants" and subjected to 24- and 72-hour immersion in chemical process fluid. Upon removal from the immersion bath, the specimens were allowed to dry and were inspected for discoloration, swelling, blistering and loss of adhesion. After all test results were analyzed, an epoxy novolac system was selected because it provided the best chemical resistance of all the formulations tested.

DYNAMIC CRACKING DISCOVERED

During surface preparation, the removal of laitance exposed extensive cracking in the concrete secondary-containment structures. Assuming the cracks were caused by concrete shrinkage, application of the thin-film system continued. Within days of coating application, however, cracks through the coating system were evident. The project team made multiple attempts to repair the coating with rigid epoxy filler materials, but none were successful. Coating work was stopped and a concrete specialist was brought in to evaluate the defects.

Based on the size and characteristics of the cracks, and taking the environmental conditions into consideration, many of the cracks were determined to be dynamic (constantly moving). Given that the thin-film epoxy system had already completed the chemical resistance testing, the project team requested a crack-repair method be developed and evaluated.

PROPOSED CRACK REPAIR PROCEDURE

The proposed procedure required cracks to be routed out to a minimum of ¼-inch on either side of the crack. Once routed, a closed-cell foam backer rod would be placed in the crack and covered with an elastomeric caulk. Bond breaker tape would be installed to allow the crack to move as needed without disturbing the coating system above and a fiberglass mat reinforcement would be required before application of two coats of the thin-film, chemical-resistant epoxy novolac.

In addition, a crack-mapping program would enable field engineers to evaluate the cracks at various times during the day, measuring crack widths and lengths, and the locations of the cracks plotted on area design drawings.

DESIGN AND INSTALLATION DETAILS

The loose liner system, composed of a 12-ounce geotextile fabric topcoated with a plural-component, spray-applied polyurea, would allow the system to float

The polyurea/geotextile loose liner system contoured to surfaces to which it was applied. Photo courtesy of Bechtel Corp.

Installation of the liner in sump. Photo courtesy of Bechtel Corp.

over the damaged concrete without requiring direct adhesion to, or removal of, the previously applied thin-film epoxy coating. The polyurea was sprayed directly over the textile, and it contoured to the surface on which it was applied.

The most complex design detail developed was the installation of the system into sumps and trenches. These areas presented narrow access, causing difficulty in manipulating the textile and installing the mechanical anchors. This design would require fewer anchors to be installed, as the geotextile installed over the horizontal base mat would hold the fabric in place over the vertical walls of the sumps and trenches. However, the thickness of the fabric/polyurea system prevented the prefabricated sump grating covers from fitting the sump opening as designed. The final design detail included the use of 1-inch batten strips mechanically installed approximately 1 inch from the top of the sump wall to support the weight of the geotextile. The polyurea was then sprayed over the batten strips and angle iron to complete the sump coating.

LESSONS LEARNED AFTER APPLYING THE LINER

A mock-up exposed three main issues that needed to be modified. The first was the formation of small voids around the edges of the anchor washers. The simple solution was to add a bead of polyurea caulk to seal the edges of the washers prior to coating application.

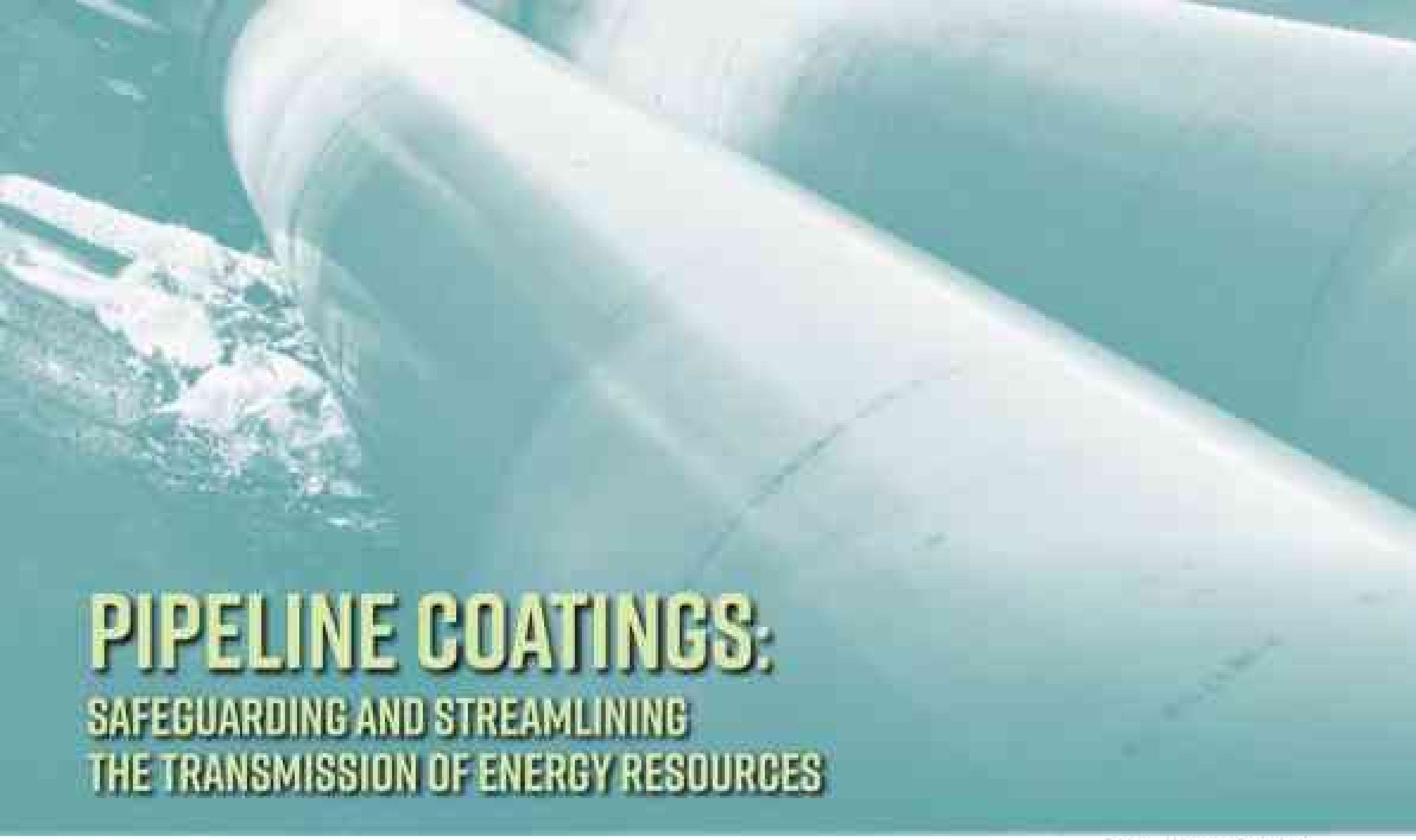
The second was the formation of "bird mouths," or puckers, along the fabric seams. Heat created during the plural-component application of the polyurea lifted the top layer of the seam, which formed a gap and exposed bare concrete. Working closely with the coating manufacturer, the design was modified to seal the seams using a slow-setting, brush-grade version of the polyurea. A 2-inch-wide line of polyurea was applied between the layers of the geotextile seam and then firmly pressed together using a smooth-seam roller. Full coating application proceeded after all seams were set.

The final challenge was fabric "tenting" away from the surface at the vertical/horizontal transitions. To address this flaw during future installations on-site, several variations of fabric layout and anchoring locations were tested to determine the best installation method. The anchor installation order was modified in design detail and called for the exterior batten strip to be fully installed prior to any anchor bolts being placed in the base mat.

CONCLUSION

Polyurea/geotextile loose liner systems are viable solutions to extensively cracked and damaged concrete structures that require chemical-resistant linings. The floating liner permits 100% containment without concrete repair, surface preparation or removal of previous coatings.

The chemical resistance will be based on the formulation of the topcoat used. This specific polyurea formulation was tested for very specific chemical resistance; however, it could be effective in other chemical containments. It is recommended to work closely with the coating manufacturer of choice to determine the chemical resistance of proposed coatings. ***JPCL***



PIPELINE COATINGS:
SAFEGUARDING AND STREAMLINING THE TRANSMISSION OF ENERGY RESOURCES

Photo by Pamela Simmons

BY DR. JEFFREY DAVID ROGOZINSKI, SHERWIN-WILLIAMS PROTECTIVE & MARINE COATINGS

Transmission pipelines serve as the oil and gas industry's arteries for transporting raw and refined materials to help fuel the world. The coatings industry bears responsibility for not only protecting pipeline resources, but also enabling their efficient use. It's our charge to develop, apply and maintain protective coatings that mitigate pipeline corrosion and facilitate the economic transmission of these materials to help safeguard the quality of life for future generations.

While pipeline owners and operators bear ultimate responsibility for the safe, secure operation of their assets, the coatings industry plays a major role. Formulators have the responsibility to develop high-performance exterior coatings that can withstand the rigors of field installations and underground or underwater service. Suppliers also have a duty to promote efficiencies and cost savings by enabling increased pipeline throughput and enhanced corrosion resistance with interior coatings. Meanwhile, applicators must coat pipes properly and inspect their work to ensure it's free of holidays. Installers must then make and coat girth welds carefully in the field and repair any coating damage prior to burying pipelines. And finally, inspectors wield the responsibility of flagging any coating performance deficiencies—well before they become dangerous—to initiate repairs.

With so much at stake, the pipeline industry has never been complacent. Key players consistently initiate concurrent improvements in coating performance and testing requirements. With each new development, the industry raises the bar on performance and safety. As a result, advancements in coating technology are enabling faster applications, reducing corrosion potential and lowering operating costs. In addition, new and developing standards are ensuring that the industry focuses on safety at every turn.

TECHNOLOGY ADVANCEMENTS ENHANCE PROPERTIES

Advancements in coating technologies have enabled numerous performance improvements. Today's better resins and additives have allowed formulators to improve the adhesion, barrier properties and overall durability of coatings. Additionally, pipeline coatings now offer better resistance to abrasion and damage, as well as enhanced resistance to long-term microbial, chemical and moisture attacks.

Applicators are realizing broader application windows with easier-to-use coating formulations that improve application quality and facility throughput. For example, newer fusion-bonded-epoxy systems are delivering consistent low porosity during application, which substantially improves long-term barrier properties and helps to minimize cathodic-disbondment potential when a pipeline is buried.

Pipeline installers are noticing better flexibility and damage resistance that help coatings maintain their integrity when transporting, backfilling and pulling back pipes. Better abrasion resistance translates to fewer required repairs in the field, enhancing installation efficiencies. In addition, new, small-batch coating kits and cartridges are enabling field-applied coatings to be more efficient with faster girth-weld applications and faster returns to service when making repairs.

Pipeline owners and operators benefit as well, with enhanced performance capabilities that deliver long-term protection to increase safety, mitigate risk and reduce overall ownership costs.

STRICTER STANDARDS ELEVATE SAFETY

Each of the aforementioned players has a hand in influencing the standards that promote safe, secure pipeline operation. Such standards continue to elevate coating performance requirements, such as reducing allowable cathodic-disbondment diameters, increasing coating flexibility requirements and handling hotter operating temperatures.

Tightening standards helps the industry enhance overall safety. Better yet, the world is working toward developing codified international specifications as industry players come to agreement on how to best protect pipelines and public health.

THE ROAD AHEAD

We don't need a crystal ball to know pipeline infrastructure will expand in the near future and beyond so the world can move tapped resources to and from remote areas more efficiently and across longer distances. Such expansion introduces the need to move materials faster through pipelines using high-performance linings. It also raises the need for exterior pipeline coatings that can withstand hotter operating temperatures to accommodate fluids extracted from deeper wells. Formulators are already addressing these developments.

It's also conceivable that pipelines will need to move alternative sources of energy and even water—the potential hot commodity of the future—within the same oil-and-gas pipeline infrastructure. If so, coating science will need to catch up to this unique swing service possibility.

Time will tell where the pipeline industry lands over the next 35 years, but we can be sure it will continue to develop and deploy increasingly advanced coating technologies—backed by unified global standards—that better mitigate corrosion potential and enhance pipeline safety.

ABOUT THE AUTHOR

Dr. Jeffrey David Rogozinski is Global Product Director for Sherwin-Williams Protective & Marine Coatings. With over 28 years of coatings experience, he is a member of multiple coatings societies and is an active consultant on global specification writing, including CSA, ISO, ASTM and NACE. Serving as the company's subject matter expert for the pipeline industry, he is responsible for the development of protective coatings, powder coatings, resins and additives.

Excerpted from JPCL, February 2013

IN SITU PIPELINE COATING PROCESS PASSES SAUDI DESERT TEST

By Baker S. Hammad, BSH Engineering Consultant Office

Image Pixel / Getty Images

The in situ coating process has proven in many parts of the world to be a viable alternative for rehabilitating corroded pipe interiors with a wide range of diameters and lengths. Compared to replacement with new pipeline, this one-run field process is cost-effective. The coating effectively controls internal pipeline corrosion through the application of multiple coats of a high-build liquid epoxy that covers the entire internal surface of the pipeline including girth welds, corrosion pits, channels or general corrosion and other internal pipeline imperfections, thus delaying leaks and extending the remaining pipeline service life.

Surface, buried and subsea pipelines have been coated in various geographies ranging from the North Sea, North America, Continental Europe and Africa to Hong Kong and Indonesia.

HOW THE PROCESS WORKS

The in situ internal coating process is primarily based on the use of scrapers propelled by either compressed air or nitrogen. The coating is required to deliver:

- Consistent coverage;
- A moisture barrier;
- Resistance to the product transported across the scoped operating temperatures;
- High levels of adhesion when applied and over its useful life;
- No adverse reaction to the pipeline;
- Sufficient physical strength to resist erosion;
- A non-toxic and environmentally benign coating; and

Mechanical scraping (top) and brush cleaning. Figures courtesy of MOGSIL.

- Attractive costs relative to other viable solutions.

Generally completed within 30 days, depending on the pipe length, diameter and internal condition, the in situ internal pipeline cleaning and coating process comprises the following steps, which were undertaken in most of the projects.

1. Field Inspection and Planning: This phase of the operation involves gathering the necessary technical information, including pipe diameter; suitability of line for the passage of scrapers; elevation profile; mapping of junctions, joints, restrictions, and other features, such as access at the launcher and receiver sites; planning and logistics.
2. Site Preparation: This phase calls for procedures such as installing specialized launchers and receivers; mobilizing compressors and dryers; installing (drop-out) spools and shoes; setting up effluent handling facilities; establishing the fuel and water supply; training for operator induction; and situating mobile workshops, compressors, and storage facilities for consumables. It is important for the compressor string to deliver dry and particulate-free air into the pipeline.
3. De-oiling/Dewatering: Depending on the hand-over condition of the pipeline, this phase has the objective of delivering a hydrocarbon-free pipeline that will allow the surface preparation phase to begin in earnest. All effluent will be disposed of in a manner acceptable to the client or facility owner.
4. Mechanical Cleaning: This phase requires removing all loose material (such as rust, mill scale and dust) on the internal surfaces of the pipeline and is achieved through multiple-run passes of mechanical and brush scrapers through the pipeline in conjunction with water flushes, if necessary.
5. Chemical Cleaning: This phase targets the removal of all iron oxide and mill scale and leaves the internal pipe surface cleanliness comparable to a Near-White Metal finish (SSPC-SP 10/NACE No. 2). This is achieved by running a dilute HCl solution containing a corrosion inhibitor between two acid-resistant scrapers. The solution is titrated before and after its passage through the pipeline to determine the degree of depletion of the concentration of the solution. The effluent is also tested for solids. Batching of HCl solutions will continue until both the depletion and solids tests are within acceptable parameters. HCl is then purged from the line with a water rinse; the rinse water is also tested for pH, chlorides and solids. Water rinses continue until these parameters are again within acceptable limits. Where possible, the line at drop-out spools and other access points, such as pipe ends, should be inspected visually to confirm the cleanliness of the pipeline.
6. Passivation: This phase serves to remove any oxidation (rust blooming/flash rusting) that results from the previous water rinses and to stabilize the metal surface to prevent any further oxidation. Passivation is completed by running a pH-balanced phosphoric acid wash through the pipeline.
7. Inhibited Water Rinse: To buffer the low pH of the phosphoric acid in the pipeline and further passivate the pipeline, a dilute inhibited water batch is run through the pipeline.
8. Drying: To ensure that the pipeline is dry before applying the coating, two procedures are undertaken: solvent drying and dry-air purging. Solvent drying involves running suitable solvent batches through the line to remove moisture from the pipeline. Dry-air purging is done slowly using dehydrated air that is tested until dew point measurements are within acceptable limits.
9. Coating Application: The coating is a specially formulated polyamide or amine-cured epoxy to ensure a longer pot life and hanging-properties needed for the coating to bond to the internal pipe wall at the 12 o'clock position during and after the coating application. The coating is applied between two modified urethane coating scrapers and, depending on the pipe length and size, is applied over a number of multiple runs, with appropriate coating drying periods, to deliver the specified dry film thickness.
10. Testing and Quality Control: Throughout the process and after coating, numerous tests and other quality-control measures are undertaken to ensure the quality and long life of the final coating.

FIELD APPLICATION

A 40-centimeter (16-inch) crude-oil trunk line was selected to test the in situ internal coating method described previously and offered by one of the oil field service specialist pipe coating companies in Saudi Arabia. The trunk line used in the trial is 10 kilometers (6 miles) long and links two gas and oil separation plants' lateral lines, which connect several oil wells in the Empty Quarter desert. The corrosion identified was a combination of general internal corrosion and pitting, and had resulted in a number of leaks recently after the pipeline was commissioned.

CONCLUSION

The test run at the Arabian desert's oil field confirmed the usefulness of the internal pipeline in situ coating process in providing a cost-effective solution for the rehabilitation of corroded and pitted pipelines, delivering effective life extension to the pipelines services. The process can be completed with limited downtime for the pipeline, requiring access to the pipeline for approximately 30 days depending on the pipeline length and diameter.

Uncoated flange area of line pipe. Photo courtesy of Dudley J. Primeaux and Todd Gomez.

2014

From JPCL, July 2014

PIPELINE REHABILITATION: ADVANCES IN POLYUREA SPRAY APPLICATION

By Dudley J. Primeaux II, PCS, CCI and Todd Gomez, PCS, VersaFlex Inc.

Polyurea technology is not new to pipelining work, with basic application dating back more than 15 years. Much of this work was either performed by hand-spraying (large-diameter pipe) or simple robotic systems for individual joint sections of pipe. Continued work over the years has proven that in-place pipelines can be commercially completed by robotic systems and recent work has even shown that in addition to long, straight runs, robotic developments have allowed for lining both 45-degree and 90-degree radius bends in a pipeline system. Pipelines of nominal diameter (1 inch or 2.5 cm) and up to 96 inches can easily be lined using polyurea spray elastomer technology with robotic application systems. Robotic application development works hand-in-hand with special-performance modified polyurea systems, which have been fine-tuned allowing for application thickness of up to 1 inch in a single pass.

TRENCHLESS REHAB METHODS

Alternatives to digging up and replacing pipeline systems are a number of trenchless technology options that are gaining in use and acceptance. These options can save up to half of the overall cost compared to traditional trenching methods, and as a result are advantageous to consider.

Pipe Bursting and Jacking

This method employs forcing a slightly smaller diameter pipe into the existing host pipe sections. The forced pipe can include steel, polyethylene (PE) or polypropylene (PP), or PVC. This method requires a large excavation "footprint" for access to an end of the existing pipe, but not complete excavation. This process is more suited for straight runs and does not work well for pipe bends.

Cementitious Lining

This process provides for a very economical advantage and concrete is fairly sound; however, this method cannot be used in aggressive (highly acidic) environments or where highly abrasive or erosive action is present because the concrete can crack over time. To employ the cementitious lining method, cleaning of the host pipe is required, followed by minimal surface-preparation procedures.

Cured-in-Place Pipelining

CIPP is an emerging technology that was introduced about 20 years ago and has been used quite extensively. A polymer-impregnated "fabric sock" is inverted into the end of a pipe section and formed in place to the existing pipe using hot air or hot water. The typical polymer systems are either epoxy or vinyl-ester-based materials. This process covers lateral intrusion, but does allow for pipe bends. Because the fabric sock is of one size in the run, varying pipe diameters in the system cannot be completely accommodated. Annular space between the CIPP and the host pipe does exist and can lead to leakages.

Sprayed-in-Place Pipelining

SIPP, a newer concept than CIPP, employs the use of robotic application heads to deposit liquid, thin- and thick-film lining systems to the interior surfaces of prepared pipe. This procedure uses polymer technologies such as epoxy, vinyl ester, polyurethane and polyurea. Because the lining is deposited in a spray fashion, lateral tie-ins remain open and clear. This process can accommodate various pipe diameters as well as radius bends.

SIPP AND POLYUREA

The use of the polyurea spray technology has proven to be a successful coating type for utilization of SIPP for a variety of coating and lining applications given its fast reactivity and 100%-solids formulation base.

Hand-spray application is well-suited for large diameter pipe systems, but not very practical for smaller diameter pipe sections. For prelining joint sections of pipe, a simple robotic spray head or a retractable lance spray gun can be used. The pipe is rotated and the spray lance pulled from the pipe. This is a very practical approach and is employed using not only polyurea systems, but also epoxies and polyurethanes, as well as other coating types.

High revolution-per-minute spinning cup. Photo courtesy of Dudley J. Primeaux and Todd Gomez.

An area of great concern is the use of more elastomeric systems and the point of termination in the pipe. For flanged pipe, the material must be carried out and onto the flange. Otherwise, hydraulic effect from liquid flow could disbond the applied lining causing collapse and plugging inside the pipe.

ROBOTIC IN-PLACE POLYUREA APPLICATION

To effectively rotate a section of pipeline that is already in the ground, the polyurea system is dispensed onto a spinning disk and the centrifugal force broadcasts the material onto the pipe. This method was successfully used in 1989 by the Texaco Chemical Company. The polyurea system used had a 3–6 second gel time. This concept was employed in order to have an entry-free installation.

A variety of configurations have been employed in pipeline polyurea application depending on the internal diameter of the pipe and include rotating a spray gun on a pulled cart; multiple spray guns attached to a large, slow-spinning plate (primarily for vertical work); and spray guns attached to a swinging arm for ride-on-type units in large-diameter application work. The most common methods used to deposit the fast-set polyurea (PUA) are a high revolution-per-minute (RPM) spinning cup or a high-pressure, static mix tube fitted with a hollow cone spray tip. For larger diameter pipe work, a robot with rotating plural-component spray guns should be used. Each of these two methods has its own set of characteristics.

The spinning-cup method produces oscillation movement that simulates hand-spray work. This allows for uniform application and keeps the spray orientation perpendicular to the host pipe substrate.

With the high-pressure static mix and hollow cone spray, the spray pattern is not perpendicular to the host-pipe substrate. In some cases, depending upon the condition of the pipe substrate, a secondary pull through in the opposite direction might be required to ensure uniform coverage.

The proportioning equipment used to feed the spray head is standard high-pressure, high-temperature, plural-component equipment. The hose bundle can be up to 600 feet and operates from a computer-controlled hose reel so that speed of pull can be adjusted to provide the required applied film thickness. Closed-circuit TV enables real-time viewing and recording of the installation work.

POLYUREA TYPES USED IN SIPP

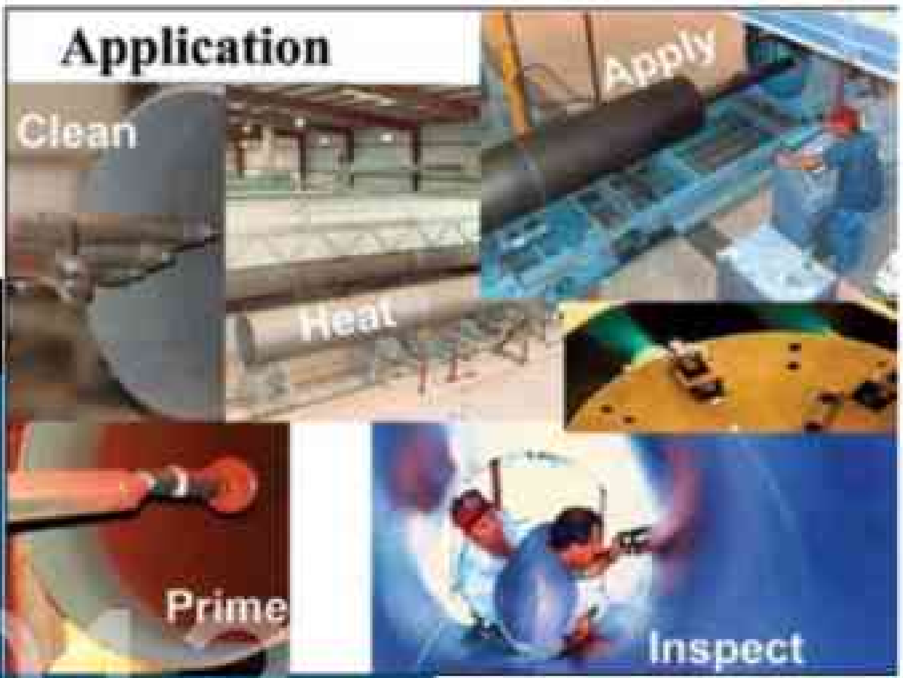
Depending upon the type of pipelining work to be performed, various polyurea systems can be used to meet specific application requirements. As noted previously, the polyurea systems used are the fast-gel-time systems, so that varying thickness of application can be accomplished in one pass through the pipe.

Relevant to the specific industry use, polyurea is very well-suited for multiple application options. Based on the water and chemical makeup that the coating will come into contact with, varying degrees of shore hardness and structural integrity of systems are utilized for the best performance needed.

In an effort to further improve application thickness and coverage of SIPP systems, especially in small diameter pipe, equipment and systems have been designed to apply via electrostatic deposition. For this electrostatic work, the polyurea systems must be a slower version to pass through the smaller spray deposition head. These are typically thin-film applications (10–20 mils, 254–508 µm).

CONCLUSION

The use of polyurea technology is a valid solution for pipelining application work and the use of a thick-film system conforms to the interior surface of the pipe with no annular space. The fast set of this technology allows for thickness build of lining material in a single pass, and therefore, rapid return to service. Since this application process also employs the same 100%-solids nature of polyurea technology, a level of safety and more environmentally-friendly application results can be achieved.



Application of internal linings is straightforward: clean, heat, prime (if necessary), apply FBE, cure, cool and inspect. Photos courtesy of Alan Kehr.

Excerpted from JPCL, December 2012

APPLYING FBE TO PIPELINE INTERNALS

By Alan Kehr, Anti-Corrosion, LLC; and Dennis Graham, Yellowgate Consulting, LLC

2012

Internal plastic linings have more than 50 years' successful use in downhole tubulars. Linings have been used to provide corrosion mitigation, mechanical damage resistance and flow efficiency in water and gas transmission lines for nearly as long. Linings prevent product contamination during transport and provide safety (in case of potable water transmission). For gas transmission lines, linings prevent formation and buildup of black powder. When hydrostatic testing is used, a liner speeds the water removal and drying process. Fusion-bonded epoxy (FBE) is one choice in the arsenal of materials available for lining pipe used to transport water, gas, oil or refined products. An FBE lining provides insulation properties, raising the wall temperature one to two degrees Celsius for deep-water pipelines.

FBE APPLICATION

There are differences in the steps, depending on expected service and lining material selection. For example, due to the harsh environment for coatings exposed to well conditions in the oilfield, the application process follows the guidelines of NACE SP0191-2008. There are special application needs that may require modification of the FBE material to make it suitable for internal application. For example, melt-point, gel-time and flow characteristics may need optimization to prevent powder buildup on the guns, avoid overspray roughness of the lining due to powder falling on gelled coating, and avoid drips and sags. However, regardless of the service or material, there are basic application steps common to all FBE linings:

- Inspect incoming pipe, including tests for salt contamination;
- Remove oil/salt (if required);
- Blast-clean;
- Prime (if needed);
- Heat pipe;
- Apply FBE;
- Cure; and
- Inspect applied lining.

Inspect incoming pipe: Review tally sheets (documents that arrive with each truckload, railcar load and barge) and confirm the pipe description. The documents describe the pipe's diameter, wall thickness, weight and length. Check incoming pipe for uncoatable rough edges, pits, raised seams, cracks, bevel damage and dents. Visually inspect internal diameter for debris. Select random pipe for internal chloride contamination checks. The area for salt inspection needs to be blast-cleaned to a size larger than the test site to allow access to residual salt.

Remove oil/salt: For downhole tubulars, the first step in cleaning is thermal picking for several hours in an oven set in the range of 315 C to oxidize hydrocarbons. If test results show positive for chloride contamination, all pipes receive cleaning before entering the production line in the coating plant. Phosphoric acid wash is not suitable for internal chloride elimination because it's not possible to ensure 100% removal of the acid. Instead, brush-blast the inside of the pipe, remove spent media and pressure-wash at 2,500 psi (17 Mpa) or more with deionized water. Use compressed air to remove water and dry the internal surface. This cleaning step can be done days before the application process begins as long as the storage environment does not cause recontamination.

Blast-clean: The pipe must be at least 3 C above the dew point at the time of blasting. Higher temperatures may facilitate the cleaning process by loosening mill scale. Typically, blast-cleaning is done with steel grit or other recyclable abrasive media with requirements similar to those for cleaning pipe before external FBE application. Usual specifications call for a White Metal blast on the steel surface with an anchor pattern from 40–100 µm from peak to valley.

Normally, the blast station is equipped with a pipe rotation device. There are two types of blast devices: compressed air and rotating wheel. Each process uses a lance for support. With current technology, wheels are used only for pipe 12 inches in diameter or larger. Air lances are used for all sizes of pipe, but lose cost-effectiveness with larger diameters (generally speaking, greater than 12 inches). Depending on the ease of cleaning and the required production rates, multi-lance stations may be needed. After blast-cleaning is complete, dry, oil-free compressed air is used to blow out dust and spent media.

Cleaning is a critical step in any coating process. (A) Internal blast cleaning of pipe. (B) Blast nozzles. (C) Measuring surface profile using replicator tape. Photos courtesy of 3M and Alan Kehr.

Prime: Not all coating systems or pipeline environments require a primer for good performance. If a primer is needed, two types of primers are in common use: firstly, a phenolic-based liquid with a typical thickness in the range of 19–25 µm. Avoid exceeding the manufacturer's recommended thickness. After application, the pipe is heated to flash off solvents and bring it to the temperature required for FBE application. This step must be controlled to remove all solvent before applying the powder topcoat, but it is important not to overcure the primer. If the primer is overcured, there will be insufficient residual chemical activity to effectively bond and react with the FBE resulting in poor adhesion between the two coatings.

The second type of primer is water-based. Temperature control and airflow during application are critical because of the tendency of steel to flash rust in the presence of water. Typically, the pipe is warmed to 80 C before application, and then clean, dry air is immediately blown down the pipe to ensure rapid drying. This water-based primer is not a thermosetting material, which means controlling timing of the heating step is not as big a concern as it is for a phenolic primer. Because the solids component of this type of primer is a very small percentage of the formulation, magnetic thickness gauges are not effective in measuring the thickness of the applied primer. The amount of applied primer is controlled by the quantity of liquid material sprayed.

In addition to optimizing FBE performance, primers are sometimes used to improve resistance to the environment within the pipeline. Also, a rotation device improves primer application uniformity, especially for larger diameter pipe.

Heat pipe: Pipe preheat temperature varies with the specific lining material requirements but is generally in the range of 160–240 C. There are two common types of heating equipment: induction coils and soaking ovens. An induction heating process has the advantage of rapid heat-up, which means the primer is not exposed to excessive time at application temperature. A slow heating process, such as an oven, can result in overcure of the primer. Another advantage is that, with the induction heating technique, the coating lance can follow the progress of the induction coil, resulting in a uniform temperature of application for the FBE. In other application arrangements, the entire joint of pipe is brought up to temperature before the application step begins.

In that case, or if a soaking oven is used, an automatic system rapidly moves the pipe from the heat station to the application station to minimize heat loss. With either heating method, if the entire pipe is brought to application temperature before FBE spray begins, then the temperature of the pipe can be ramped from one end to the other.

Apply FBE: Powder application can be done with either a lance or, for small-diameter pipe, a vacuum application system. The application lance should be equipped with a variable-frequency drive motor to allow the spray head to enter the hot pipe rapidly. The speed is then slowed to allow uniform application. One or more spray nozzles are used for powder application, and rotation of the pipe helps provide a uniform coating thickness.

The vacuum method relies on a timed release of aerated FBE. In this process, a charge of powder is fluidized and then drawn by vacuum through pipe that is rotating at a constant speed. In either application process, the pipe continues to rotate until all of the FBE reaches the gel state.

Cure: Most internal FBE lining materials have a long gel time and require a post-bake to provide sufficient time to complete the thermosetting cure reaction. With current technology, phenolic primers require a post-cure. Most often the post-cure step is accomplished with a soak oven. However, some FBE materials cure fast enough to skip this step, or the cure may be accomplished in a subsequent heat cycle used during the application of an external coating. In all cases, except for cool down cure, timing must be controlled to avoid overcure of the lining material.

Inspect Applied Lining: After post-cure, the pipe is allowed to cool to ambient, or is rapidly cooled by a water quenching process. The pipe is then visually inspected for sags or runs, checked for thickness using a magnetic gauge, and inspected for holidays. For dry holiday testing, the normal voltage is approximately 5 volts per µm. For a more precise calculation of the required voltage, reference the guidelines in NACE standard RP0490. An alternative is to use a 67½ V or a 90 V wet-sponge holiday detector. **JPCL**

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AUGUST 2019

SSPC COURSES

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Aug. 2	Navigating NAVSEA Standard Item 009-32, National City, CA
Aug. 5-9	NBPI NAVSEA Basic Paint Inspector, San Diego, CA
Aug. 5-11	PCI Protective Coatings Inspection, Pittsburgh, PA
Aug. 8	Using PA 2 Effectively, San Diego, CA
Aug. 12-16	Coast Guard Basic Paint Inspector, Ketchikan, AK
Aug. 19-23	Ground Vehicle Corrosion, Pittsburgh, PA
Aug. 20-22	CAS Coating Application Specialist, Theodore, AL
Aug. 26-31	BCI Bridge Coatings Inspection, Ft. Lauderdale, FL

CONFERENCES & MEETINGS

Aug. 12-14	NACE Central Area Conference, San Antonio, TX, nace.org

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31

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