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The Voice of SSPC: The Society for Protective Coatings

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By Dr. David Tordonato, P.E., and Dr. Allen Skaja, P.C.S., U.S. Bureau of Reclamation

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By Gary Hall, Consultant

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Photo courtesy of David Johnson, U.S. Bureau of Reclamation

Photo courtesy of Sauereisen

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Photo courtesy of Ming Court

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The Society For Protective Coatings

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Editorial

No Way to Run a Railroad

The government shutdown last month really made me wonder what the future will hold for my children and my grandson.

There is a famous NFL clip with Vince Lombardi, the Hall of Fame coach of the Green Bay Packers, exclaiming on the sideline during a game, "What the hell's going on out here?" I am saying the same thing right now about the way our government is operating.

Before I go any further, I want to state that I am neither far-left nor far-right in my political thinking. I consider myself in the center and there are things I like about both parties. I just want you to think about how this was handled and what caused the shutdown.

The Republicans took the stance of defunding the Affordable Care Act (ACA), and without money to fund the law, it would not be enacted. I cannot understand this approach, because whether anyone likes it or not, the ACA is the law of the land, passed by Congress when the Democrats controlled both the House and the Senate. Even if the House prevailed by not funding the ACA, the Senate, which is still controlled by the Democrats, made it very clear that they would not support such legislation. It was dead on arrival in that legislative body.

The President has determined, rightly or wrongly, that this bill would be his legacy, and we all know politicians love to leave a legacy. So even if the Senate had gone along with the House in defunding the ACA, the President would have vetoed the legislation, which then would have required a two-thirds majority of both the House and the Senate to pass the legislation.

As I was doing my daily jog at lunch, I was listening to a talk show and the host made such a point. A caller then berated the host about the law, calling it the worst legislation in the history of our nation. The caller missed the entire point that the host was making. I totally support what the host was saying; it did not make sense to handle the situation this way, by holding hostage the financial stability of the U.S. and the entire world. The government shutdown and the threat of default did not pass what I call the "common sense test." John McCain said something similar on one of the Sunday morning talk shows.

The radio talk show host also noted that some estimate that this government shutdown cost the country $21 billion before Federal employees receive their back pay, at a time when our country is running historic deficits. The host then stated that the Republicans should have kept their mouths shut, given all the problems people have had in initially signing up for the ACA. He further suggested that if, in the near future, there are other problems in implementing the law, the public would have grown to support immediate changes.

My point is that sometimes it is better to step back and pick your battles. An SSPC Past President gave me a card years ago with the Serenity Prayer: "God grant me the serenity to accept the things I cannot change, the courage to change the things I can, and the wisdom to know the difference." I still carry that card, and sometimes I need to refer to it more.

We Americans deserve better than what we are getting from our legislators, and they need to know it. I think many of them do not have the wisdom to know what battles to fight and how to do it. When this fiasco started, I wrote my Congressman and two Senators, both Republican and Democrat, and expressed my opinion, and I will really do some soul searching when they are up for re-election. As I have challenged you in previous editorials, please do the same and push for a government that does not allow this country to operate in a crisis mode on a consistent basis. As Bob Schieffer said, in words to the effect on his Sunday CBS *Face the Nation* show, "We have elected the best 'kick-the-can-down-the-road' folks we ever could have."

Bill Shoup

Bill Shoup
Executive Director, SSPC

WJTA-IMCA Closes 30th Expo, Elects New Board Members

The WaterJet Technology Association and Industrial & Municipal Cleaning Association (WJTA-IMCA) welcomed over 900 attendees from 30 countries to its 30th annual Conference and Expo, held Sept. 9–11, 2013, at the George R. Brown Convention Center in Houston, TX.

Attendees took in a pre-conference workshop, *Waterjet Technology: Basics and Beyond;* educational Boot Camp sessions; live demonstrations; paper presentations; and an exhibition hall with 57 exhibiting companies.

WJTA-IMCA also held an awards ceremony at the conference. Kenneth C. Carroll of Birenbaum & Associates received the Pioneer Award, for his significant contributions to the development of the WJTA-IMCA.

WOMA Corporation, Kärcher Group, won the Safety Award for the development of remotely-controlled waterjetting equipment, and for bringing robotic waterjet cleaning equipment to a wider market.

WJTA-IMCA also recently held elections for its Board of Directors for the 2013–2015 term.

Bill Gaff, vice president of sales and marketing for Vacuum Truck Rentals, LLC, and Vacuum Truck Sales and Service, was elected as Chairman of the Board. The newly elected Board officers are:

- President George A. Savanick, Ph.D., consultant;
- Vice President Bill McClister, vice president of equipment and technology with Veolia ES Industrial Services, Inc.;
- Secretary Kathy Krupp, maintenance process leader with The Dow Chemical Company; and
- Treasurer Larry Loper, president and director of sales for High Pressure Equipment Company.

Other newly elected Board members are:

- Fred D. Clark, chief executive officer and corporate secretary, IVS Hydro, Inc.;
- Kay Doheny, owner, Jack Doheny Supplies, Inc.;
- Mohamed Hashish, Ph.D., senior vice president of technology, Flow International Corporation; and
- Gary Noto, chief executive officer, Aquilex HydroChem.

Serving their remaining terms on the board are Luis Garcia of Channel Safety & Marine Supply, A Northern Safety Company; Kerry Siggins, chief executive officer of StoneAge, Inc.; and Forrest Shook, president of NLB Corp.

top: Kenneth C. Carroll accepts the Pioneer Award.
bottom: Vice President Bob Carvajales (left), President Jochen Trautman (center), and Sales Director Dennis Chisum (right) of WOMA Corporation, Kärcher Group, accept the Safety Award.
All photos courtesy of WJTA-IMCA

Bill Gaff, Chairman

George A. Savanick, Ph.D., President

Bill McClister, Vice President

Kathy Krupp, Secretary

Larry Loper, Treasurer

Fred D. Clark

Kay Doheny

Mohamed Hashish, Ph.D.

Gary Noto

Luis Garcia

Kerry Siggins

Forrest Shook

OSHA Offers New Online Resources

OSHA recently launched two new web resources to assist companies with keeping their workers safe.

The first resource is a toolkit to identify safer chemicals that can be used in place of more hazardous ones. This toolkit walks employers and workers step-by-step through information, methods, tools, and guidance to either eliminate hazardous chemicals or make informed substitution decisions in the workplace by finding a safer chemical, material, product, or process. The toolkit is available at osha.gov/dsg/safer_chemicals/index.html.

OSHA created another new web resource, the Annotated Permissible Exposure Limits, or annotated PEL tables, which will enable employers to voluntarily adopt newer, more protective workplace exposure limits. OSHA's PELs set mandatory limits on the amount or concentration of a substance in the air to protect workers against the health effects of certain hazardous chemicals, and OSHA will continue to enforce those mandatory PELs. Since OSHA's adoption of the majority of its PELs more than 40 years ago, new scientific data, industrial experience, and developments in technology clearly indicate that in many instances, these mandatory limits are not sufficiently protective of workers' health.

The annotated PEL tables provide a side-by-side comparison of OSHA PELs for general industry to the California Division of Occupational Safety and Health PELs, National Institute for Occupational Safety and Health-recommended exposure limits, and American Conference of Governmental Industrial Hygienist threshold limit values. The tables are available at osha.gov/dsg/annotated-pels/index.html.

CORRECTION

Photographs on the following pages in the October *JPCL* should have been credited as follows:

Pages 37 and 38: *iStockphoto.com/mikeuk*

Page 41: *Ralph Baker, courtesy of Sherwin-Williams Protective & Marine Coatings*

Pages 55, 69, and 83: *iStockphoto*

JPCL regrets the omissions.

OSHA Extends Comment Period on Proposed Silica Rule

In response to requests for an extension, OSHA has extended the public comment period on the Notice of Proposed Rulemaking on Occupational Exposure to Crystalline Silica for an additional 47 days, from Dec. 11, 2013, to Jan. 27, 2014. The notice of proposed rulemaking was made available to the public on OSHA's website Aug. 23, 2013, and published in the *Federal Register* on Sept. 12, 2013.

OSHA is also extending the deadline to submit notices of intention to appear at its informal public hearings by an additional 30 days, from Nov. 12, 2013, to Dec. 12, 2013. Public hearings are scheduled to begin on March 18, 2014. The duration of the hearings will be determined by the number of parties requesting to appear. The hearings are expected to continue for several weeks.

The extended comment period and public hearings will be followed with a post-hearing comment period. Members of the public who filed a timely written notice of intention to appear will be able to submit post-hearing comments to the docket.

Additional information on the proposed rule, including five fact sheets and procedures for submitting written comments and participating in public hearings, is available at http://www.osha.gov/silica/. Members of the public may comment on the proposal by visiting http://www.regulations.gov.

The BUZZ on PaintSquare.com

By Anita Socci, JPCL

HOT TOPIC


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The U.S. government takes a hiatus

Though I've made it a steadfast rule in the Buzz not to mix politics with painting, I couldn't ignore the multitude of comments made by readers to the Oct. 7–11 Poll (see below) that quickly became the Hot Topic for this month's Buzz. Scan the QR code below to see what everybody's talking about.

Most Popular Poll

Whom do you hold *most* responsible for the U.S. budget impasse and government shutdown?

43%	**House Tea Party Republicans**
40%	**President Obama**
11%	**The Senate**
7%	**The House of Representatives**

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PSN TOP 10

(As of Nov. 4)

- **Painter Loses in Sherwin-Williams Case**
- **Billionaire Sues over Yacht Coatings**
- **Paint Chemicals Smoke Out Carboline**
- **Corrosion Blamed for Drooping Bridge**
- **Bridge Deck Defects Spark Legal Storm**
- **L.A. Sues over Crumbling $240M Runway**
- **Nuclear Plant Finds Blister, Corrosion**
- **Ups, Downs Mark Sherwin-Williams' Q3**
- **Low Bidders Sue MnDOT over Award**
- **Navy Charges 4 in 2 Diving Deaths**

MOST POPULAR QUIZ

(as of Nov. 4)

Oil contamination on the substrate or in the atomizing air of conventional spray equipment is most likely to cause what type of coating defect?

Michael Beitzel 20/21
L. Steven Moore 20/21
Robert Cloutier 20/21
Paul Hunter 20/21
Robin Hasak 20/21

Results

Get the coatings industry buzz at paintsquare.com, or scan the QR code with your smart phone for instant access!

On Ballast Water Treatments and Coatings

Do water treatment processes to stop the transfer of invasive marine species in ballast water affect the performance of ballast tank coatings?

From Lynda Speed
Safinah

There is little experience with continual, regular use of ballast water management systems (BWMS) installed on vessels or long-term testing, so there is not one definitive answer to this. What is known is that it depends on the

- ballast water treatment process used;
- quality, salinity, and organic content of the ballast water; and
- age and condition of the coating in the ballast tanks.

The ballast water treatment systems that use what are termed "Active Substances" (such as hypochlorite electrolysis, chlorine dioxide, sodium hypochlorite, peroxy-acetic acid, or ozone) are the systems that may have a direct effect on organic material like epoxy tank coatings. These systems are designed to kill the live organisms in the ballast water. However, ballast tank coatings are also composed of organic materials, most commonly epoxy technology that can be affected by these active substances.

Some active substances are more aggressive oxidants than others, and the amount of active substance delivered into the ballast water also varies among systems. The systems with active substances must be approved by IMO by following the G9 procedure, which, among other criteria, requires a minimum efficacy of the system using specific, defined conditions and organisms. However, in real-life seawater, composition varies, as does the number of organisms present. Hence, there can be a situation where there is an excess of active ingredients that last for a longer period of time and result in the active ingredients having an impact on the coating system.

The International Paint & Printing Ink Council (IPPIC) submitted a document to IMO (MEPC 64/INF.21), which stated:

"BWMS systems solely using chlorine as an Active Substance in concentrations below 10 mg/l in seawater entering the ballast tanks do not pose a significant risk of having a detrimental effect on most coating systems."

Hence, it is important that the BWMS is installed, operated, and maintained so that excessive concentrations of Active Substance are not generated.

The Ballast Water Management Convention will apply to new building projects, as well as existing vessels. While the ballast tank coating on a new vessel will be required to comply with the IMO PSPC and so will be in good condition, the coatings in older ballast tanks are likely to be in a poorer condition or have been damaged, leaving potential for the coating to be breached and the underlying steel to be corroded. Because most of the active substances are oxidizing agents, these will increase the rate of corrosion if present in the tank.

Perhaps the best way to find the answer is for a vessel with an installed BWMS that is used regularly to have some coated test panels placed in the tank. This will expose the coatings to realistic conditions over time and enable them to be easily removed and assessed. Any volunteers?

JPCL

Q&A WITH JOHN P. PSARIANOS

BY CHARLES LANGE, JPCL

John P. Psarianos is the Estimator and Project Manager for Anka Painting Co., Inc., an SSPC-QP 1 and -QP 2 certified coatings contracting company based out of Palisades Park, NJ. He is responsible for the company's day-to-day field operations, including pre- and post-construction submittals, scheduling, purchasing, and quality control, as well as preparing cost estimates. In addition to his PCS certification, he is a NACE Level 3-certified Coating Inspector, an ASPE Certified Professional Estimator (CPE), an ICorr Painting Inspector—Level 2, and an SSPC-certified Quality Control Supervisor (QCS). John also serves as Vice Chairman of the Metropolitan NY Section of NACE International, and he recently had a technical paper published in *Estimating Today* about estimating bridge painting projects. He holds a B.S. degree in Engineering from the New Jersey Institute of Technology.

JPCL: You have a financial background. How did you get your start in the protective coatings field?

JP: By chance, really. In early 2006, I was working as a financial analyst, assembling cash-flow models and valuations—I didn't like it very much. I grabbed some lunch one day with a friend, who brought along a gentleman that was working on the Verrazano-Narrows Bridge in New York City. I was intrigued; I always loved bridges, even as a kid. I interviewed with the company he was working with, and a few months later, I was working on the Verrazano tower and cable painting contract.

JPCL: Your company does a lot of coatings work on bridges in New York City/New Jersey area. What are some of the challenges you face in completing bridge jobs in such a busy, high-traffic area? Do you enjoy solving the challenges bridges present?

JP: Creating and maintaining access to the steel is by far the trickiest part of what we do in the bridge segment. The congested highways and dense population don't help much.

No two structures we paint are the same. The challenge is working smart and utilizing the tools at our disposal to keep everyone safe while being productive. We've learned that to be productive, we have to be able to adapt to the traffic. We develop our traffic control plans in-house and incorporate detours whenever feasible.

JPCL: Compared to some of the 30- and 40-year veterans in the coatings industry, you're relatively new to the game. Do you feel like you are still learning new things about the industry? Do you think continuing education is important, no matter how many years' experience one might have?

JP: Every day I learn something new. Continuing education is a very important facet of our industry and what I do. However, I think it's also very important to diversify your educational base and strengthen other skills as well, such as general bridge inspection, tools, software and technology, safety, etc.

Continuing education and technology will continue to play a critical role in a person's advancement in the construction industry—especially in the coatings industry. It's great to be young in this industry, as I think there is tremendous room for growth in the future.

JPCL: What do you think are some of the most important qualities that a young person looking to enter the coatings industry must possess?

JP: I think someone considering coming into our industry should be aware that there is no such thing as a 40-hour workweek. We work days, nights, weekends, and holidays—whatever it takes to get the job done. Furthermore, we're always under the gun. It's not uncommon to see a stapler flying across the office on a bad day. Being able to withstand the pressure is also a prerequisite in our line of work.

As with anything, to be successful you have to love what you do, day-in and day-out.

JPCL: What is the best piece of advice you've received, either related to your work or just life in general?

JP: My father instilled in me my work ethic. He always pushed me to work a little harder and to be a little better. He tells me all the time that things can get difficult quickly, even when times are good. That mentality always played a role in my work.

JPCL: What is your favorite thing about the work you do?

JP: Estimating—by far. I enjoy preparing quantity take-offs and compiling estimates, particularly when the project is complicated and multi-year.

JPCL: Is there a past project that you've worked on that was particularly challenging, memorable, or fun to work on? What stands out about this project?

JP: My first project probably was the most memorable. Climbing around on the Verrazano-Narrows Bridge was pretty amazing. I was given the opportunity to dive right into the deep end that year, and I learned so much from a lot of smart people. It was a great experience.

JPCL: What has been the highlight of proudest moment of your career thus far?

JP: Earning my certifications. It sure wasn't easy. It took a lot of time and many long nights to get it all done.

JPCL: What are some of your interests outside of work? How do you like to spend your free time?

JP: Free time?! I'm not sure what that is anymore! However, I'm one of the lucky few in the industry who doesn't have to travel for work, so when I do get some time off, I'm able to stick around and spend it with my wife and family.

Cases from
the F-Files

The Case of...
The Compromised Propane Tank Coating

**By Jayson L. Helsel, P.E., PCS
KTA-Tator, Inc.**

**Richard Burgess, KTA-Tator, Inc.
Series Editor**

*Fig. 1: Intercoat delamination
Photos courtesy of KTA-Tator, Inc.*

The exterior coating system on six propane tanks was delaminating after only one year of being stored under cover in Mexico. Could the system be repaired? Or was it a total loss?

A gas transmission company had all six of the propane tanks fabricated and coated in Mexico for a U.S. facility. The specified surface preparation was Near-White blast cleaning in accordance with SSPC-SP 10/NACE 2, followed by application of a 100%-solids polyurethane coating system. The coating thickness was specified to be a minimum of 20 mils. Although the coating could have been applied in one coat, preferably by plural-component spray, to meet the specification, the polyurethane could also have been applied in more than one layer if done within a limited recoat window. After completion, the tanks were reportedly stored under cover until shipment to the facility in the northeastern U.S. nearly a year later. After the tanks had arrived on site, problems with the coatings were observed when the tanks were installed on concrete footings. The coatings appeared to be delaminating between layers or between what appeared to be two coating layers and the steel substrate. High-voltage and low-voltage holiday testing performed by the facility owner revealed numerous holidays.

The investigator visited the site to examine the coatings and to determine what repairs were necessary. Additionally, the intended painting contractor for repair work was onsite to "sweep blast" test sections on the tank exterior to help determine the viability of this method as part of a repair procedure.

The Site Visit

The exterior tank coatings were visually examined, the total coating thickness was measured, and the adhesion and hardness of the coatings were assessed. The evaluation focused on one tank where sweep blasting of test sections was scheduled to be performed.

Visual Assessment

The black coating had a slightly rough or textured appearance over the tank exterior surfaces. Numerous areas on the tank had been previously marked where the coating was delaminating or holidays had been detected.

The marked areas showed where a thick, top coating layer had delaminated from an underlying layer. All layers were black; there was a clean separation between layers where delamination occurred (Fig. 1). The top coating layer surrounding these areas could be further removed (to the underlying layer) with moderate ease by scraping with a utility knife. When adhesion was evaluated by making a cut through the coating (as further described below), the thicker top coating layer separated from the underlying layer in the same manner. An odor characteristic of a polyurethane was also noted when the coating layer was cut into.

There were also areas of coating delamination that appeared to nearly reach the substrate, as evidenced by rust on the surface of the remaining film. The substrate was partially visible through a non-continuous remaining coating layer (Fig. 2, p. 18). A relatively large area on one tank (approxi-

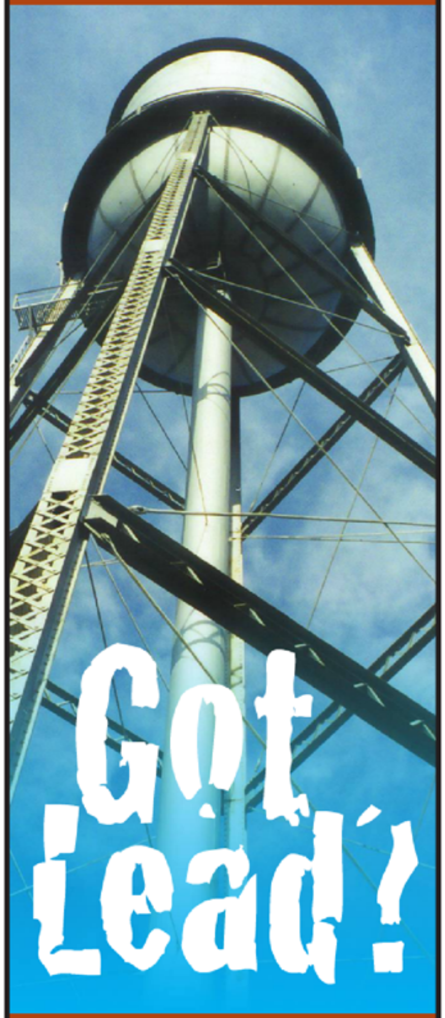


Fig. 2: Failing coating

mately 1 square foot) showed this condition. The coating surrounding the delaminated area was irregular and appeared overly thick with sagging present. Other irregularities in the coating film were present along the side of the tank where craters and voids had formed in the top coating layer (Fig. 3). The top coating layer was easily removed when scraped with a knife.

Coating Thickness

The total coating thickness was determined over various tank surfaces using an electronic coating thickness gage. The total coating thickness on the initial tank examined ranged from 20 to 46 mils, with an average of 34 mils. Most readings were over 30 mils, and only one area near the end of the tank had readings consistently below 30 mils. Thickness measurements on one of the larger areas where the top layer of coating had delaminated from the underlying layer showed that the underlying (or first) layer ranged from 9 to 12 mils.

Thickness measurements for another tank ranged from 23 to 35 mils, with an average of 29 mils. Measurements over a large area of delamination where rust was present ranged from minimal (below 0.5 mils) to approximately 10 mils. Thickness measurements on a third tank ranged from 25 to 30 mils, with an average of 27 mils.

Coating Adhesion

Coating adhesion was evaluated in accordance with ASTM D6677, Standard Test Method for Evaluating Adhesion by Knife. This method involves making two intersecting cuts through the coating to the substrate, with the smaller angle of the cuts between 30 degrees and 45 degrees. The point of the knife is then employed at the vertex of the angle to attempt lifting up the coating from the substrate or underlying coating. The result is rated from 0 to 10 according to the descriptions given by the method. A rating of 0 represents a coating that can be easily peeled from the substrate to a length greater than ¼ inch, while a rating of 10 represents a coating that is extremely difficult to remove.

The adhesion evaluation of the tank coatings resulted in ratings of 2 to 6, with most tests rated as 4 (Fig. 4). The loss of adhesion was typically between the thicker top

Fig. 3: Craters in surface

coating layer and an underlying layer. Adhesion was also determined by subjectively probing the coating with a utility knife. Subjective probing utilizes the user's experience with the amount of force required to disbond the coating film. Adhesion evaluated in this manner was rated as poor to fair, with the same mode of forced failure occurring between coats.

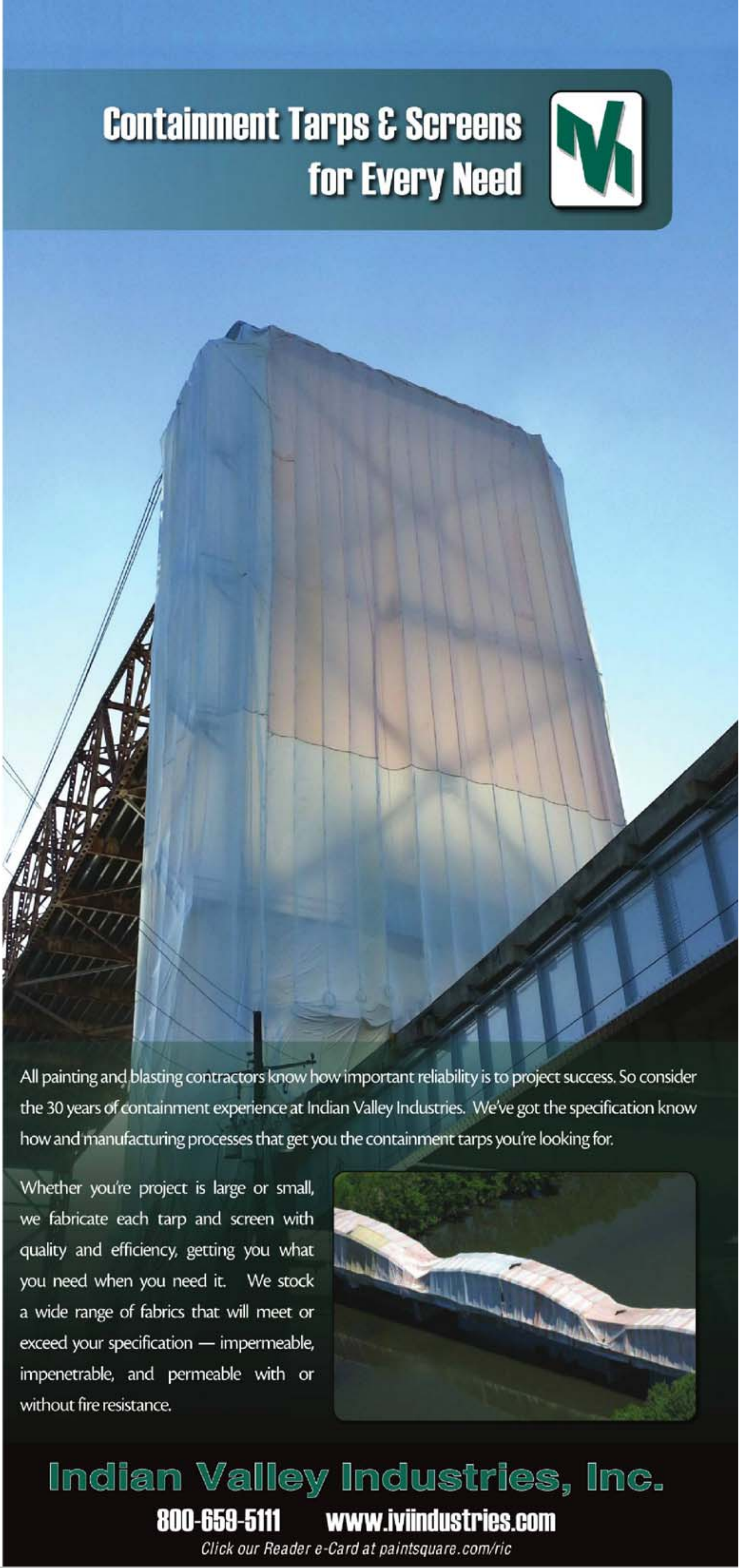
Coating Hardness

Coating hardness was measured using a Type D durometer. Hardness values are determined by pressing the instrument firmly down on the coating surface. The instrument has a pointed indentor at the bottom that contacts the coating surface and is depressed when the test is performed. The movement of the indentor triggers a dial scale reading from 0 to 100, with 0 indicating a softer surface and 100 a harder surface. Measurements on the tank coatings ranged from 45 to 75, with most readings between 50 and 60.

Test Sections

Three test sections on the first tank, each approximately 2 feet by 2 feet, were prepared by abrasive blast cleaning. The intent was to "sweep blast" the exterior surface and remove the poorly adhered top coating layer. Two areas were prepared near the middle of the tank, where the coating was generally thicker than 30 mils. In both areas, the top coating layer was easily removed, leaving a pock-marked coating layer with nearly bare steel visible in por-

Fig. 4: Poor adhesion



tions of the prepared surface (Fig. 5). The coating that remained was adhered and intact when scraped with a knife, and was uneven or irregular in appearance. Coating thickness measurements generally revealed 10 mils or less of coating remaining.

The third test section was prepared near the end of another tank, where the total coating thickness was typically less than 30 mils. When this area was sweep blasted, little coating was removed compared to the coating removed from the first two test sections. The remaining coating was intact when scraped with a knife and was uneven or irregular in appearance, particularly near the top of the area where more coating had been removed. Coating thickness measurements revealed 20 to 25 mils of coating remaining. Representative samples of the exterior tank coatings were obtained during the visit for laboratory analysis.

Fig. 5: Close-up after blasting

Analysis of Problems

Due to the observation of significant voids throughout the coating, the samples were evaluated under a digital microscope. The examination revealed that voids were present throughout coating cross-sections and on the back side of delaminated coating samples.

The voids present throughout the coating layers, the noticeable odor when cutting into the coating, and low hardness readings indicated a likely problem with application or curing of the tank coatings. The coating product data sheet stated that the cured coating should have a minimum durometer hardness value of 70.

The voids were characteristic of "foaming" that can occur when a fast cure (i.e., plural-component) coating is applied at the incorrect ratio of A and B components. Thinning of the coating, which was not recommended (the product data sheet stated "do not thin"), could also have contributed to the problem. The rough textured surface suggested that application may have been by roller, which is allowed but not recommended by the coating manufacturer.

The consistent separation between coat-

ing layers, as revealed by adhesion testing, also indicated that the recoat time may have been exceeded when the top coating layer was applied.

The product data sheet stated that, “a second coat may be applied over the first, if it is applied within the recoat window. Otherwise, roughening of the surface will be necessary to ensure good intercoat adhesion.”

While further laboratory testing could have been performed to verify curing issues or improper mixing, there already appeared to be clear evidence that coating integrity was compromised, based on the relatively poor adhesion and voids present throughout the coating layers. Time constraints on performing coating repairs and placing the tanks into service also limited the extent of laboratory testing.

The preparation of test sections by sweep blasting generally revealed that the top coating layer was easily removed. Although the remaining coating was intact, the coating surface was uneven and irregular. Further examination of photos of the test section surface showed that the remaining coating layer had widespread voids over the surface.

The presence of voids indicated that the existing coating layers, including intact coating that would remain after sweep blasting, would have compromised integrity. Given the criticality of the coating application (underground storage tanks with cathodic protection), there was substantial risk of future coating failure in attempting to sweep blast and overcoat the tanks with a similar coating.

Based on the site evaluation and laboratory results, the existing coatings were recommended to be completely removed by abrasive blast cleaning in accordance with SSPC-SP 10 and replaced with a new 100%-solids polyurethane coating. Application of a new coating was recommended to be in strict accordance with the manufacturer’s recommendations, including by plural-component spray.

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JPCL

Laboratory Evaluation of Metalized Coatings for Use on Reclamation Infrastructure

Dr. David Tordonato, P.E., U.S. Bureau of Reclamation, and Dr. Allen Skaja, P.C.S., U.S. Bureau of Reclamation

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Metalizing, or thermal spray coating (TSC) application, is used to provide corrosion protection to steel and concrete engineering structures. It offers several advantages over conventional coating technology, including

- no cure time,
- no VOCs,
- good impact resistance and UV light resistance (compared with epoxy),
- no temperature or humidity restrictions for application, and
- potential for long service life with less downtime for coating maintenance.

Disadvantages include

- not compatible with impressed current cathodic protection (CP) systems found on many structures;
- higher initial cost (30–40 percent);
- increases the substrate temperature, which may be unacceptable in certain situations; and
- service life in immersion that can vary significantly depending on water chemistry, environmental conditions, and coating material. Flowing water may also decrease service life.[1]

Zinc-metalized dam gates. Photo courtesy of Dave Johnson, USBR

Metalizing was developed in the 1930s but has seen limited use in the intervening years due to economics. In the past, application rates for metalized coatings were slow, making the process an expensive alternative to conventional coatings. However, advances in equipment have resulted in faster production times due to greater reliability and greater material deposition rates. The average spray rate has increased from 7.5 lb/hr to 35 lb/hr for aluminum.[2]

In the polymeric coatings industry, regulations are driving changes by reducing the VOC limits. Facility owners are searching for alternatives to coating systems such as vinyl resins, which were once commonplace for corrosion protection in fluctuating immersion conditions.

Old coatings systems now banned, such as lead-based paints, were surface tolerant. Modern coating systems have more stringent and expensive surface preparation requirements, frequently requiring a Near-White Metal blast. Furthermore, coatings are becoming more expensive to purchase and apply. Plural-component systems, for example, may require expensive application equipment. They also create a greater chance of applicator error and, hence, premature failure. Many of the newer systems have expected service lives that are much shorter than their predecessors'. All of these factors mean metalizing is becoming a more attractive and economically viable option for corrosion protection.

Metalizing has been used successfully and cost-effectively in several exposure environments, but the Bureau of Reclamation's (Reclamation) experience with it has been mixed. As a result, Reclamation's Materials Engineering and Research Laboratory (MERL) conducted further research on the use of metalizing in freshwater immersion and fluctuating immersion service. This article gives background on metalizing, including previous research findings, and it describes Reclamation's recent research findings.

Background

Metalizing is fairly well understood. Several resources provide overviews for the facility owner on topics such as surface preparation, materials selection, application parameters, and health and safety.[2-5] For corrosion protection of steel, the most common TSC materials used are aluminum, zinc, 85/15 Zn/Al alloys, and 90/10 aluminum/aluminum oxide metal matrix composite (MMC). These materials are typically found in wire or powder form. Sometimes magnesium is added to aluminum.[5]

Thermal spray coatings are deposited using either flame spray or electric arc spray, which typically produces a higher deposition rate. Arc sprayed coatings also have higher adhesion (up to 7,000 psi) versus flame spray (up to 4,000 psi).[4] Arc spray has less porosity and greater density, due in part to the kinetic energy imparted to each individual particle.

Coating density and porosity are important factors in corrosion protection. If the coating is too porous and has inadequate thickness, it will offer little barrier protection and will function primarily as a sacrificial anode, and, potentially, coating service life will be significantly reduced. Porosity typically varies from 3 to 18 percent, depending on application.[4]

Metalized Coating Testing

Results of evaluation of metalized coatings on steel, in various exposures, by various researchers have been mixed due to the number of variables that can affect performance, including exposure conditions, coating type/configuration, and application parameters.[6-17] The results of these studies were considered when developing standards for metalizing still used today; a 19-year study conducted by the American Welding Society (AWS)[6] is cited by SSPC: The Society for Protective Coatings (SSPC) and other standards organizations. The Canadian Standards Association (CSA) and British Standards Association (BSA) have also developed standards for use of TSCs under various service environments.[18-19]

Metalizing Case Studies and Examples

Although metalizing is far less common than the use of polymeric coatings, it has a documented record of use in a multitude of exposure conditions.

Atmospheric Exposure

Metalizing is commonly used in Europe and the U.S. on bridge structures. In addition, metalizing has been used in lieu of galvanizing on radio towers. While these applications show that metalizing can be competitive from a life-cycle cost standpoint, the exposure conditions are not directly relevant to Reclamation's needs. Reclamation is looking for a coating to provide corrosion protection in the freshwater immersion and fluctuating freshwater immersion environment.

Immersion and Fluctuating Freshwater Immersion

Metalizing has been utilized successfully to protect equipment subject to fluctuating immersion in a variety of geographic locations at U.S. Army Corps of Engineers (USACE), Salt River Project, and Metropolitan Water District of Southern California (MWD) facilities.[3,20-22] Reclamation has limited experience using metalizing (primarily zinc with various topcoats) on hydraulic infrastructure, including Blue Mesa (Gunnison, Colorado), Glen Canyon (Paige, Arizona) and McClusky Canal (near Wilton, North Dakota). Reclamation's experience has been mixed. Each of the systems was inspected in the spring of 1999 after 8 to 11 years of service, and the performance varied, with poor results at Glen Canyon Dam (blisters after 8 years) and good performance elsewhere.[23]

SSPC predicts a service life of 25–35 years for tainter (radial) gates using an 85/15 Zn/Al system.[24] A 1966 Reclamation study noted rust after just 6 months in flowing freshwater.[1] The coating failed after just 3 years in service. This result contrasts sharply with the conclusions of the AWS report, which were based on tests in flowing seawater. SSPC estimates a service life of 30–40 years in penstocks using an 85/15 Zn/Al system.[24] Metalizing has the potential to reduce life-cycle costs, but Reclamation needed to perform additional research to ensure the best system is used.

Methodology

For the current study, 3- x 6-inch mild steel panels, solvent cleaned and blasted to obtain a 4- to 5-mil profile, were coated on both sides with various thermal spray materials (Table 1).

Aluminum, zinc, and 85/15 (Zn/Al) are commonly used for thermal spray, and wires were obtained easily. The desired Al/Mg alloy was eventually located in wire form, and the aluminum/aluminum oxide alloy was created manually by combining powders to achieve the proper ratio. An electric arc spray process was used to minimize porosity.

Two sealer systems were tested: a solvent-borne, two-component epoxy system and a single-component moisture-cure urethane-based sealer. The sealers were brush applied to both sides of each test panel. After application of the urethane sealer, small bubbles were forming on the urethane-sealed panels. This is thought to have been caused by gas bubbles escaping from the porous structure of the metalized coating. However, no issues of out-gassing were encountered with the epoxy system.

Table 1: Materials Tested

Alloy	Designation	Form	Unit cost (per pound)
Aluminum	A	1/16" diameter wire spools	$4.54
Zinc	Z	2-mm diameter wire spools	$3.70
85/15 Zn/Al	ZA	2-mm diameter wire spools	$5.84
95/5 Al/Mg	AM	1/16" diameter wire spools	$7.18
90/10 AL/AL_2O_3	AA	Aluminum powder+ Al_2O_3 powder	$10.00

The purpose of the sealer is to block the pores of the TSC and prevent the electrolyte from reaching the substrate. It is not necessary to build up a thick coat; the target dry film thickness (DFT) of each system was in the range of 1–2 mils. The aluminum- and zinc-coated systems ended up a bit thicker at approximately 5–6 mils for both sealers. At this thickness, the material will behave and protect as a topcoat as opposed to a sealer.

The test program for the current study involved testing several metalized coating systems with and without sealers. Scribed and unscribed panels were immersion-tested in a dilute Harrison solution (DHS) consisting of 3.5 g/l NH_3SO_4 and 0.5 g/l NaCl and deionized (DI) water. This is a modified version of ASTM D870. Prohesion (PRO) samples were rotated between the accelerated weathering test (QUV) and salt fog test chambers (ASTM D5894). In a modified Prohesion test, a second group, "BOR test" group, was rotated among QUV, salt fog, and immersion testing as follows: QUV-FOG-IMMERSION-FOG. Both groups were rotated at one-week intervals. In addition, a group was subjected to high velocity immersion in deionized water (DIFT). The velocity across the samples is estimated to be between 25 and 30 ft/s. This setup simulates flow rates in penstocks and outlet works throughout Reclamation's infrastructure (Fig. 1). The test matrix is presented in Table 2.

Fig. 1: High Flow Water Test set up. Samples are placed inside the PVC pipe. Figures courtesy of the authors.

Unsealed metalized coatings are unaffected by UV light; however, the seal coat could be susceptible to degradation. The results from this test provide a direct comparison to the corrosion perfor-

Table 2: Test Methods and Parameters

Group	Panels	QUV	Salt Fog	Immersion (dilute Harrison)	Immersion (deionized water)
DI	1 scribed 1 unscribed				X
DHS	1 scribed 1 unscribed			X	
PRO	2 scribed	X	X		
BOR	2 scribed	X	X	X	
DIFT	2 scribed				X (Flowing)
Adhesion	1 unscribed				

mance of traditional coatings tested by Reclamation.

The panels were each tested for approximately 5 months (5,040 hours). About midway through the test, each scribed panel was rescribed to ensure bare metal exposure. The immersion test was interrupted periodically to examine and weigh the samples.

Results

The samples were dried, weighed, and photographed at the conclusion of the test program. In general, the BOR and PRO tests were the most aggressive, with the BOR test being slightly worse in terms of the amount of oxidation observed on the TSC surface. Nearly all samples exhibited this type of corrosion to some degree. Systems with thick seal coats fared better, but systems with thin seal coats showed significant damage. These tests seem to suggest that a thin "seal" coat does little to prevent damage under cyclic test conditions. Immersion in deionized water (static and flowing) as well as immersion in a DHS resulted in less corrosion compared to the cyclic exposure of the BOR and PRO tests.

The unsealed ZA panels showed unacceptable levels of blistering in all tests except for the PRO test (i.e., any test where immersion service was encountered). The BOR test cycle also produced blistering in the Al/Mg samples.

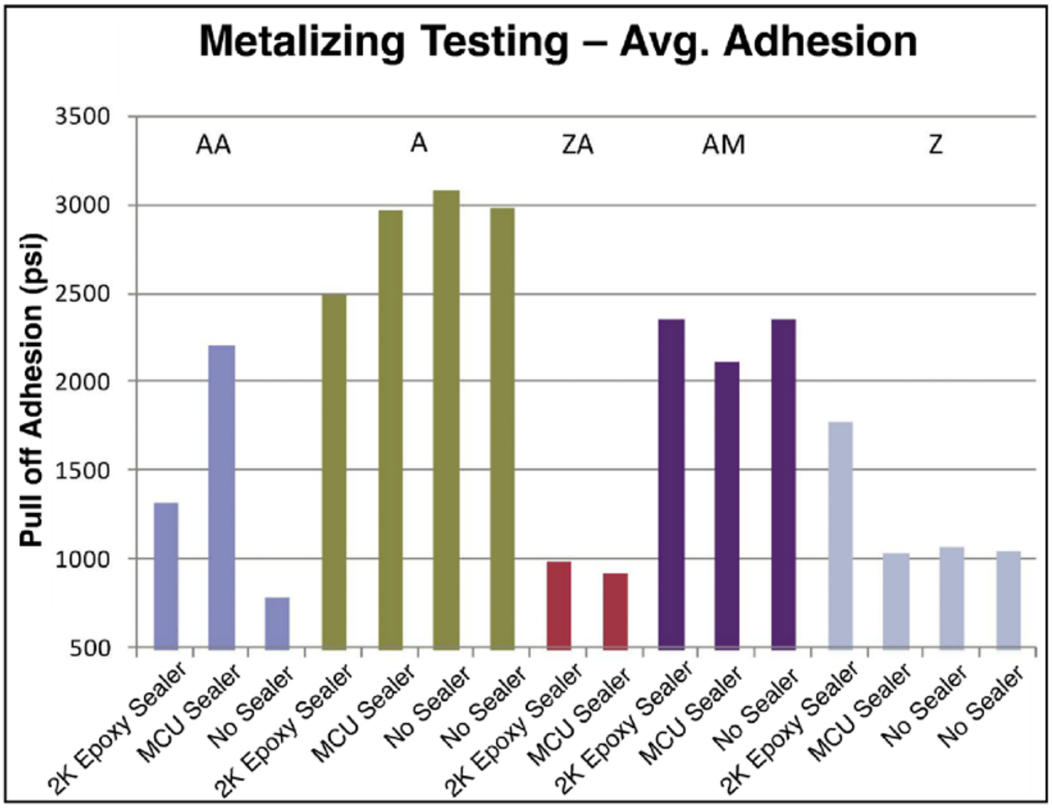


Fig. 2: Pull-off adhesion data for thermal spray systems prior to testing.

- **Weight Change:** Weights of unsealed samples were measured before and after testing. Immersion samples were periodically dried overnight and weighed during testing to track any weight change trends. Before weighing, each sample was rinsed and lightly cleaned to remove any loose scale accumulation. Most of the oxidation remained visible on the surface. The samples were then dried in an oven and weighed.

Except for the zinc-metalized panels, most samples actually gained weight during testing. For zinc, the most severe weight loss occurred when samples were constantly immersed in the Harrison solution. This resulted in over 12 grams of metal loss, approximately one-third of the overall coating weight. At this rate, the coating was expected to last no longer than 15 months. The BOR test also produced some weight loss, which was likely due to the samples being immersed 25 percent of the time. In contrast to the BOR samples, the PRO samples each gained weight during the test. DI water immersion of the zinc panels resulted in minor weight loss, while the high-flow test was more severe.

One goal of the project was to test the effect of flowing water on the metal consumption rate. For zinc, the static deionized plates lost 0.6 percent of the coating weight. The DIFT samples lost 4.6 percent of the coating weight. Direct comparison does not account for the fact that one side of the DIFT sample was facing the mounting substrate and not exposed to high flows. Had both sides been exposed, one could expect the weight loss to nearly double. Clearly, the flowing water immersion is a more aggressive environment for zinc metalizing, but comparing DHS and DI immersion samples suggests that water chemistry plays a more important role since the highest weight loss occurred in stationary DHS immersion. Had the high flow test been performed with DHS, it is expected that this configuration would have resulted in even greater rates of metal loss.

The weight gain of the remaining samples can be explained by the oxidation process. Oxidation was still visible on all of the samples (including zinc). Weight could reasonably be expected to increase initially during the corrosion process and then begin to decrease as the oxidation was removed from the surface. The observed weight gain indicates that aluminum oxide is more stable and difficult to remove even under high flows. It was interesting that the ZA samples also gained weight in every test, which suggested that the oxide formulation differs significantly from the oxide formed by pure zinc. Given these results, one would expect superior performance and longevity for ZA compared to zinc. However, the blistering noted in immersion is problematic.

- **Adhesion Test Results:** Each plate was tested for pull-off adhesion strength in accordance with ASTM D4541. In Fig. 2 (p. 26), the results show that aluminum metalized samples produced the highest adhesion strengths. No adhesion testing was performed on unsealed 85/15 panels. These values meet or exceed the adhesion requirements set by the SSPC paint manual: 500, 700, and 1,000 psi for zinc, ZA, and aluminum respectively.[24]

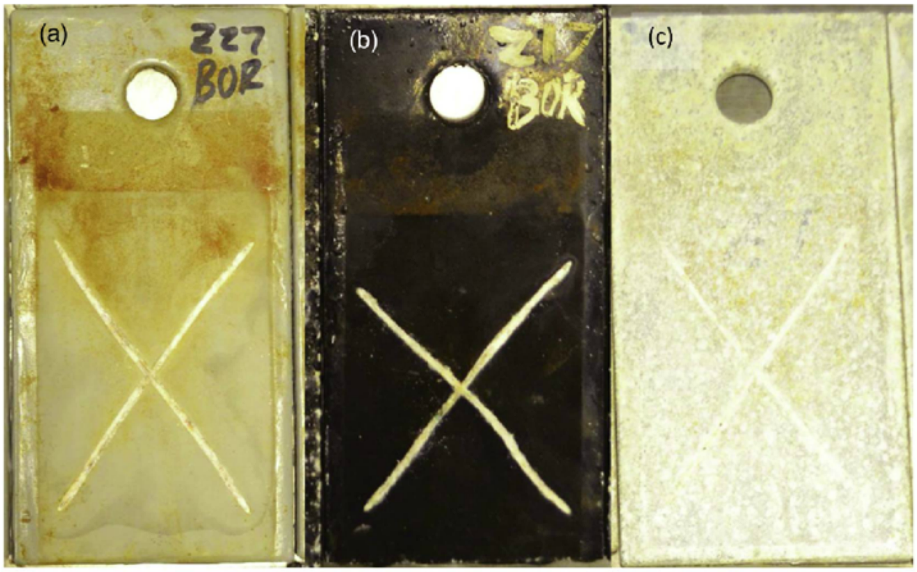


Fig. 3: Effect of thick seal coat: Zinc systems tested in the BOR cycle after 5,040 hours. (a) epoxy seal, (b) urethane seal, (c) unsealed

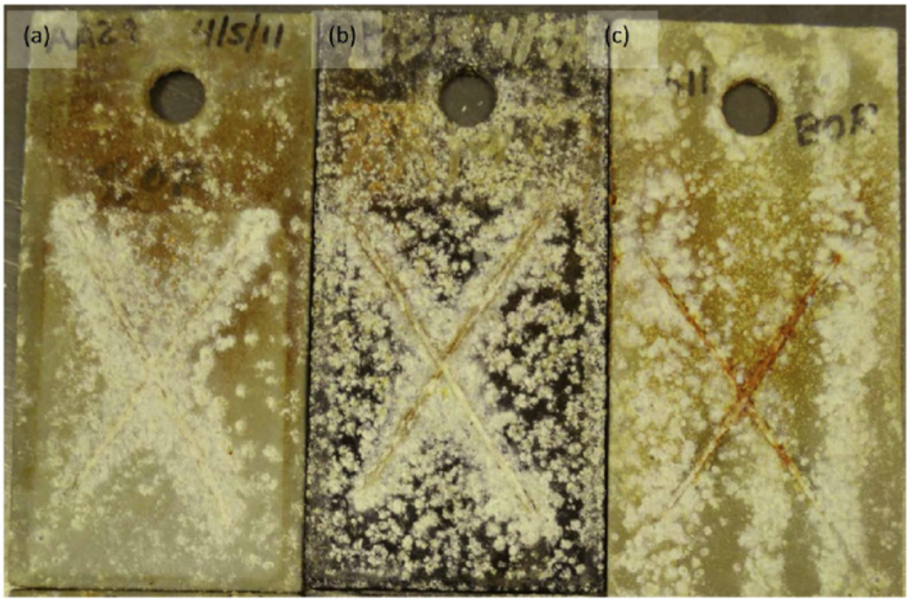


Fig. 4: Effect of thin seal: Aluminum/Al_2O_3 systems tested in the BOR cycle after 5,040 hours. (a) epoxy seal, (b) urethane seal, (c) unsealed

Discussion

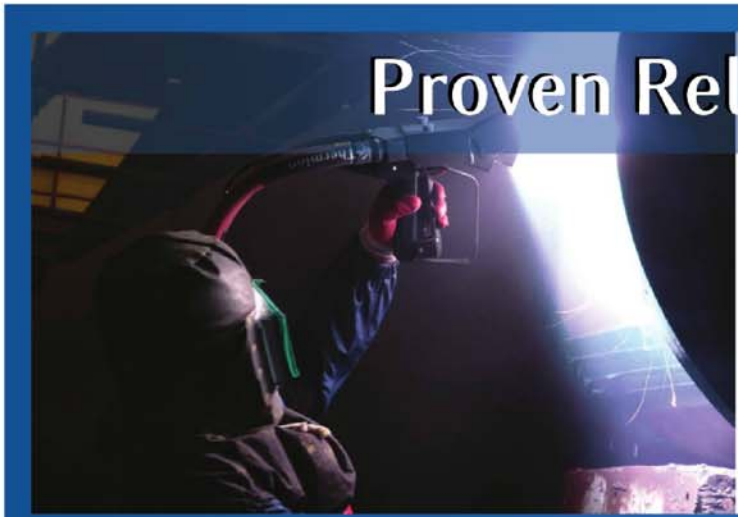
Substrate Protection at Coating Defect

One benefit of TSCs is that they offer passive CP when substrates are coated with metals that are more active on the galvanic series (aluminum, zinc, and magnesium in the case of steel). This effect enables localized protection to the steel where the coating becomes compromised. To evaluate the effectiveness of this protection, the scribed areas of each panel were examined visually. CP is evident when no iron oxide (rust) was inside the scribe. In general, the zinc-based TSCs appeared to provide more effective CP versus the aluminum-based TSCs. The AM samples provided slightly better CP versus pure aluminum. The seal coat did not appear to negatively affect the TSC's ability to cathodically protect the scribe. Using the BOR test as the benchmark, there was no noticeable decrease in either the amount of oxide present in the scribe or the oxide:rust ratio.

General Corrosion Protection

Metalized coatings protect the substrate from general corrosion via CP and by functioning as a barrier to break the electrolyte path (i.e., not allowing a corrosion cell to form). The primary function of the coating is that of a barrier. Only when the electrolyte reaches the substrate should any CP begin. Sometimes, the metalized coating will corrode autogenously when placed in a corrosive environment, eventually reaching a state of passivation once a protective oxide layer has formed, preventing further corrosion. Visual inspection of the panels can give an indication of how much corrosion has occurred and provides insight into how long a particular coating could be expected to last before becoming consumed entirely.

- **Effect of Test:** In general, the immersion tests appeared to produce less oxidation than the cyclic testing. The BOR and PRO samples were similar in appearance at the test conclusion.
- **Effect of Alloy:** The zinc alloys, in contrast to the other coatings, tended to produce a more uniform layer of oxidation. Zinc oxidation was finer and more easily removed from the panels with a fingernail or brush.
- **Effect of Seal Coat:** The thick seal coat appeared to prevent the oxidation of the underlying coat. This was most evident for the zinc-based systems (Fig. 3). However, some chalking and UV degradation were observed on both systems.



However, on systems where the seal coat was applied with a lower DFT, there was no significant performance advantage. Figure 4 (p. 28) shows slightly increased oxide deposits in the areas immediately adjacent to the scribe and significant deposits elsewhere on sealed and unsealed systems.

- **Blistering:** The blisters observed on the ZA samples were hollow inside, which suggests that they could be caused by formation of lower-density oxides within the coating, causing the coating to expand and buckle away from the substrate. MWD observed similar results during laboratory testing of 85/15 Zn/Al TSC panels in raw and treated water.[22] USACE has also observed cohesive failures of a flame-sprayed, vinyl-sealed 85/15 Zn/Al system after 8 years in service at the Belleville locks and dam.[3] The authors noted that the failures are likely due to blister formation as a result of expanded oxide formation.
- **Other Considerations:** Other factors such as ease of application, cost, and availability of materials should also be considered when selecting a TSC system. For example, one of the applicators experienced difficulties applying the 85/15 material. This is believed to be due to oxidation that occurs on the wire surface, which can have a destabilizing effect on the arc. Specialized thermal spray equipment is therefore required to apply the ZA material. The aluminum/aluminum oxide alloy was not readily available in wire form and cost significantly more to obtain as a powder. Given the lack of any observed performance advantage, it makes little sense to select this material over pure aluminum wire.

Another aspect to consider when specifying a thermal spray process is the potential difficulties in metalizing complex structures. The physical size of the gun can make it difficult to coat interior crevices and other recessed areas with electric arc spray. One potential solution is to use a soldering process known as the hot bar method. In this process, a zinc bar about ¾ inch x ½ inch x 6 inches is melted onto a substrate in areas that are inaccessible to the spray gun. Alternatively, a zinc-rich coating could be used to cover otherwise inaccessible areas.

- **Safety:** MWD frequently uses metalized coatings on radial gates and other structures with infrequent/alternating immersion. Metalizing does present a potential fire hazard, and care should be taken to avoid spraying in proximity to flammable chemicals (i.e., solvents used for cleaning). However, the electric arc generates significantly less heat than flame spray, which results in a cooler substrate. Air-supplied respirators are recommended. Other personal protective equipment similar to that worn during welding is required.

Conclusions

Five thermal spray alloys and two sealers were investigated using laboratory testing that included immersion, accelerated weathering, and adhesion. All the coating systems tested appear to offer some degree of corrosion protection to the steel substrate; the unscribed and undamaged areas of all of the plates remained corrosion free throughout the test. However, problems were noted with some systems, such as blistering, application difficulties, and excessive weight loss during testing. The following conclusions from this study are offered.

- Metalized coatings may provide a significant life-cycle cost advantage over organic coatings on equipment subject to fluctuating immersion such as radial gates, stoplogs, and partially exposed trashracks. Conventional organic coatings have a shorter service life in fluctuating immersion environments. Metalized coatings are superior to polymer coatings when rapid return to service is needed, during cold weather applications, or where VOC emissions are restricted. Metalizing is not compatible with impressed-current CP systems.
- The service life of all metalized coating systems will depend heavily on factors related to the service environment, such as immersion duration and frequency, as well as water chemistry. Avoid using zinc or aluminum in immersion environments with extreme pH (below 6 or above 12). The use of zinc should also be avoided in flowing water.
- Of the systems tested, the pure aluminum system is believed to offer the best combination of corrosion protection and expected service life in immersion or fluctuating immersion. In addition, aluminum is easy to apply, is relatively low in cost, and exhibited greater adhesion strengths compared to the other systems.
- Aluminum systems appear to offer good general corrosion protection to steel but reduced CP to areas where the coating is damaged, especially in water with low levels of conductivity, i.e., reservoirs fed by snowmelt.
- Further research and evaluation are needed to accurately determine an expected service life, determine ease to repair defects, and determine a method to deal with crevice corrosion.
- Due to blistering, ZA and AM systems are not recommended on equipment where immersion is likely.
- Zn/Al appears to produce an oxide that is more stable than that of pure zinc. The samples lost no weight during testing, and visible corrosion was less than what was observed in the other unsealed panels. These results warrant investigation into a modified Zn/Al alloy that produces a stable oxide without blistering in immersion.
- The AA samples produced significant amounts of oxidation

reactants that tended to be dispersed randomly on the plate rather than uniformly. Furthermore, the material was more difficult and expensive to apply and offered no performance advantage over pure aluminum in terms of corrosion protection.

- Both sealants tested offer increased corrosion protection when applied with sufficient DFT. However, both sealants are susceptible to degradation from UV light. In addition, the use of a sealer removes some of the advantages of TSCs, such as immediate return to service, fast application, and fewer restrictions on environmental conditions.

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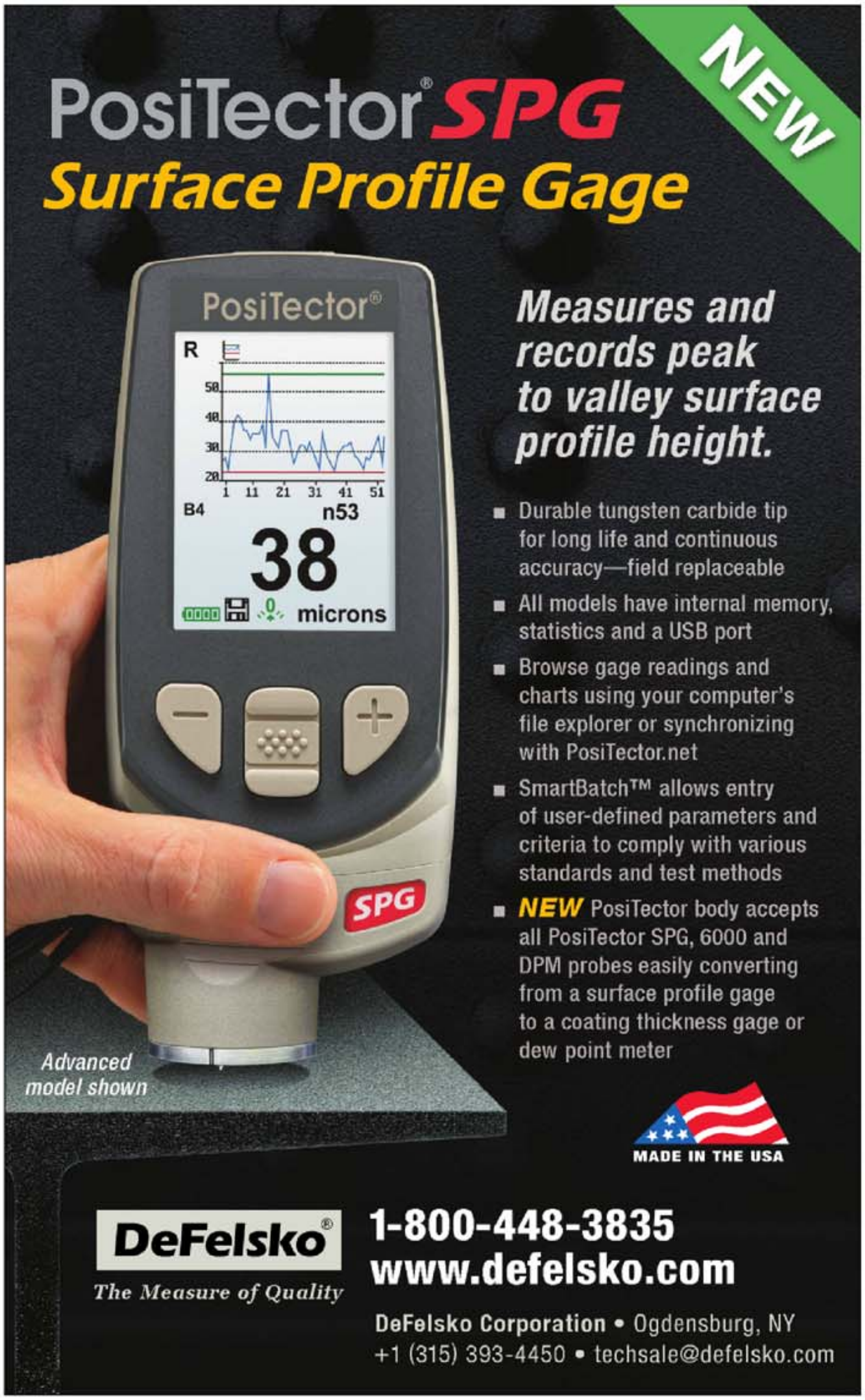

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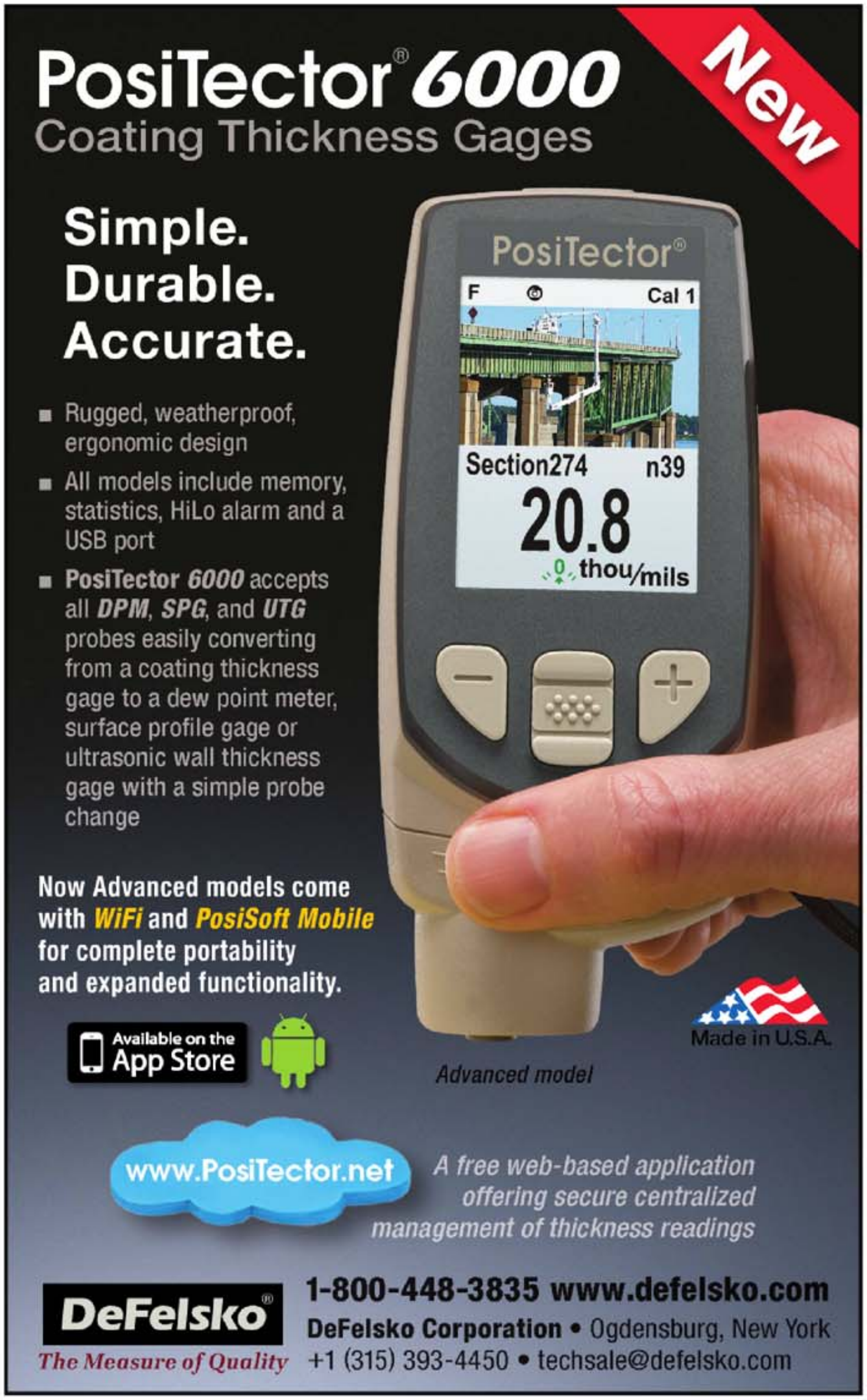
Allen Skaja joined the U.S. Bureau of Reclamation as a Coatings Specialist. His experience is in evaluating coatings for corrosion protection and testing coatings to deter the attachment of zebra/quagga mussels. He has a BS in chemistry and a Ph.D. in coatings and polymeric materials.



Outside view of Bunker C crude oil storage tank with a floating roof. Surface preparation of the tank interior will be followed by application of a vinyl ester coating.
All photos courtesy of Sauereisen

Understanding the Basics

By Gary Hall, *JPCL* Contributing Editor

Unsaturated polyester resins based on maleic and fumaric acids have been known since the 1920s. In the late 1930s, the modern form of these resins was introduced when Charleton Ellis combined styrene with unsaturated polyester.

Polyester and vinyl ester resins have been used in severe chemical environments for 50 years in the form of mortars for chemical-resistant brickwork and in fiberglass reinforced plastic (FRP). These successes led to the development of chemical-resistant coatings and linings based upon these resins that offer superior resistance to a broad range of chemicals, especially acids, and to higher temperatures than most other coating types like epoxies and polyurethanes.[1]

The terms "coatings" and "linings" are used throughout this article. For the purposes of this article, linings are composed of glass fabric, mat, or woven roving saturated with the chosen resin. They are applied in sheets of fiberglass reinforcement saturated in resin, which are then laid against the substrate and rolled in place using a ribbed roller. Coatings are usually thinner than linings and are applied as a mixture by brush, roller, airless spray, and plural component spray.

This article describes the basic chemistry of polyesters and vinyl esters, properties, concerns with the materials, and application methods.

Editor's Note: This article is the eighth in JPCL's 2013 series on generic coating types.

# of Chemical-Resistant Polyesters and Vinyl Esters

Basic Chemistry

Unsaturated polyesters are formed by the reaction of a dibasic organic acid, such as phthalic or maleic acid, and an alcohol or polyol such as ethylene glycol. Unsaturated polyester resin (usually called a "polyester resin" or "polyester") is a thermoset that can be cured from a liquid state under the proper conditions. A wide range of polyesters, including partially aromatic and aromatic versions, can be made by using different acids, glycols, alcohols, and monomers, each with different properties (Fig. 1 on p. 36).

Polyester resins used in coatings are typically pale-colored, viscous liquids consisting of the polyester dissolved in a monomer, usually styrene. Styrene reduces the viscosity of the resin, making it easier to handle. Styrene is called a reactive diluent because it is involved in the curing of the polyester resin, as well as in reducing viscosity. They cure through a free radical mechanism. The free radicals are produced by reaction of an organic peroxide, such as methyl ethyl ketone peroxide (MEKP), and a reducing agent, typically a cobalt salt. This type of free radical initiation is known as a redox (reduction-oxidation) reaction. When added to the resin, the MEKP splits into two free radicals [RO• + ROO•], each of which then react with the styrene, causing it to form another free radical.

These styrene radicals then react with the carbon-carbon double bonds (-C=C-) adjacent to the ester groups along the length of the polyester resin molecules forming cross-links between adjacent polymer molecules, without creating by-products. The uncured polyester molecule has multiple reactive sites along the length of the molecule. Multiple cross-link sites ensure that the molecules are tightly bonded to each other. This allows for high mechanical strength and excellent chemical resistance, but it also introduces rigidity to the cross-linked network. This irreversible reaction results in a dense and complex network of intertwined polymers with excellent chemical resistance. Polyester resins and vinyl ester resins are highly reactive, have a short shelf life, and will gel or set on their own upon standing. Warm temperatures hasten this reaction. Inhibitors are often added during manufacture to prolong storage life. Refrigeration is also often recommended. Even with the use of inhibitors and refrigeration, the shelf life of polyester and vinyl ester resins is typically three months or less.

Saturated dicarbonic acids are used in polyesters to control cross-link density and to optimize the properties of the cured polymer network. The three most commonly used dicarbonic acids and their contributions to the cured network are shown in the box on p. 36.

To formulate vinyl ester and polyester coatings, the coating manufacturer will add other materials, including initiator; accelerator; and typical coating raw materials such as thixotropes, fillers, and pigments. Flake glass and silane-treated micaceous iron oxide (MIO) are often preferred fillers because they beneficially reduce coating permeability. Fillers are often in the range of 45–50% by weight. There is also some evidence that flake glass will help limit the length of cracks that may form in the coating due to stresses in service.

Vinyl ester resins, a special subclass of polyesters, are similar to polyester resins in that both contain multiple ester groups and are cured in the same way. There are, however, some significant differences in the polyester resins and vinyl ester resins used to

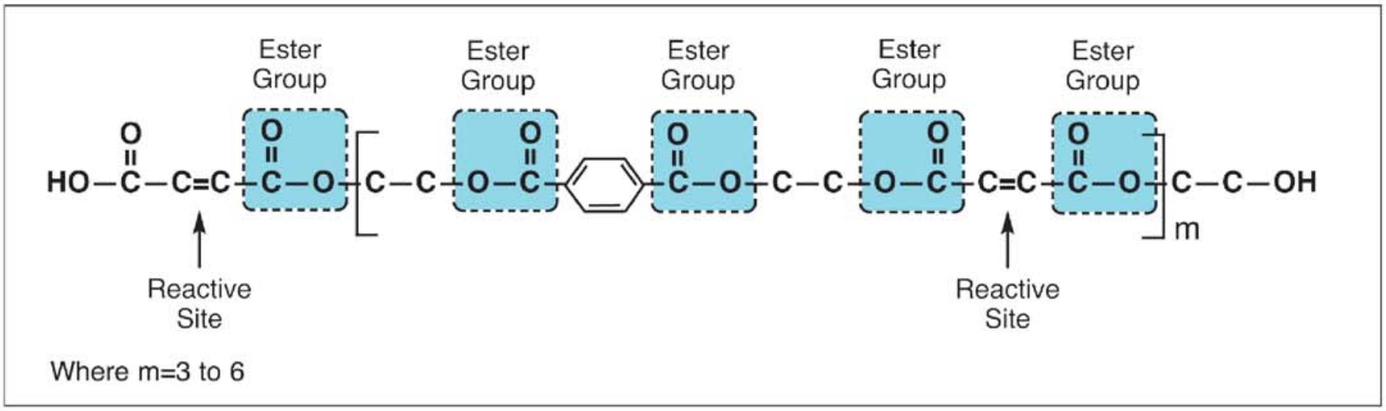


Fig. 1: Unsaturated polyester polymer

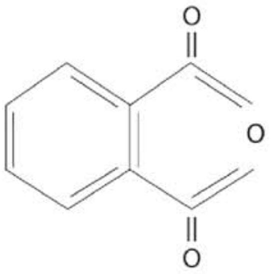
formulate corrosion-resistant coatings. The main difference is that a polyester resin molecule has several reactive ester sites along its length, while a vinyl ester resin has only two ester groups, both in the terminal or vinyl position. This has a significant effect upon the properties of the resulting cured polymer. Since the reactive sites in a vinyl ester resin are only found in the terminal positions of the chain, cross-linking can only occur at these sites, in contrast to several cross-link sites on a polyester chain. Terminal attachment between two polymer chains means that, unlike what occurs in polyester polymers, the entire polymer chain between reactive ester sites is not cross-linked to another polymer chain. The portion of the polymer chain that is not cross-linked is able to absorb shock and impact, making vinyl esters tougher and more resilient than polyesters.

Having only two ester groups per molecule imparts an additional advantage to vinyl esters. In aqueous environments, ester groups are susceptible to hydrolysis, which causes degradation of the polymer; thus, vinyl esters exhibit better resistance to water and many other chemicals than their polyester counterparts. For these reasons, vinyl esters are often used in highly corrosive environments where other resins fail. Vinyl esters will also function at higher temperatures than polyesters and epoxies. The structure of the polymer between the reactive sites has a profound effect upon the chemical and physical properties of the vinyl ester resin.

The vinyl ester resins most often used in chemical-resistant coatings have an epoxy backbone to which terminal ester end groups are attached. These resins are the reaction products of an addition reaction of an epoxy resin with an unsaturated carboxylic acid, which results in terminal double bonds. Several epoxy resins are used in commerce. The bisphenol a diglycidyl ether epoxy, typically called bis A epoxy, and the epoxylated phenol-formaldehyde novolac, typically called novolac epoxy, are the two most commonly used. The epoxy vinyl ester resins produced are frequently referred to as bis A epoxy vinyl ester resins and novolac epoxy vinyl ester resins respectively. Commonly used acids

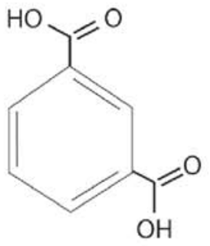
The Three Most Commonly Used Dicarbonic Acids Used to Control Cross Link Density in Polyesters

Phthalic acid anhydride



- •Most commonly used
- •Good overall properties
- •General purpose resin
- •1-step condensation

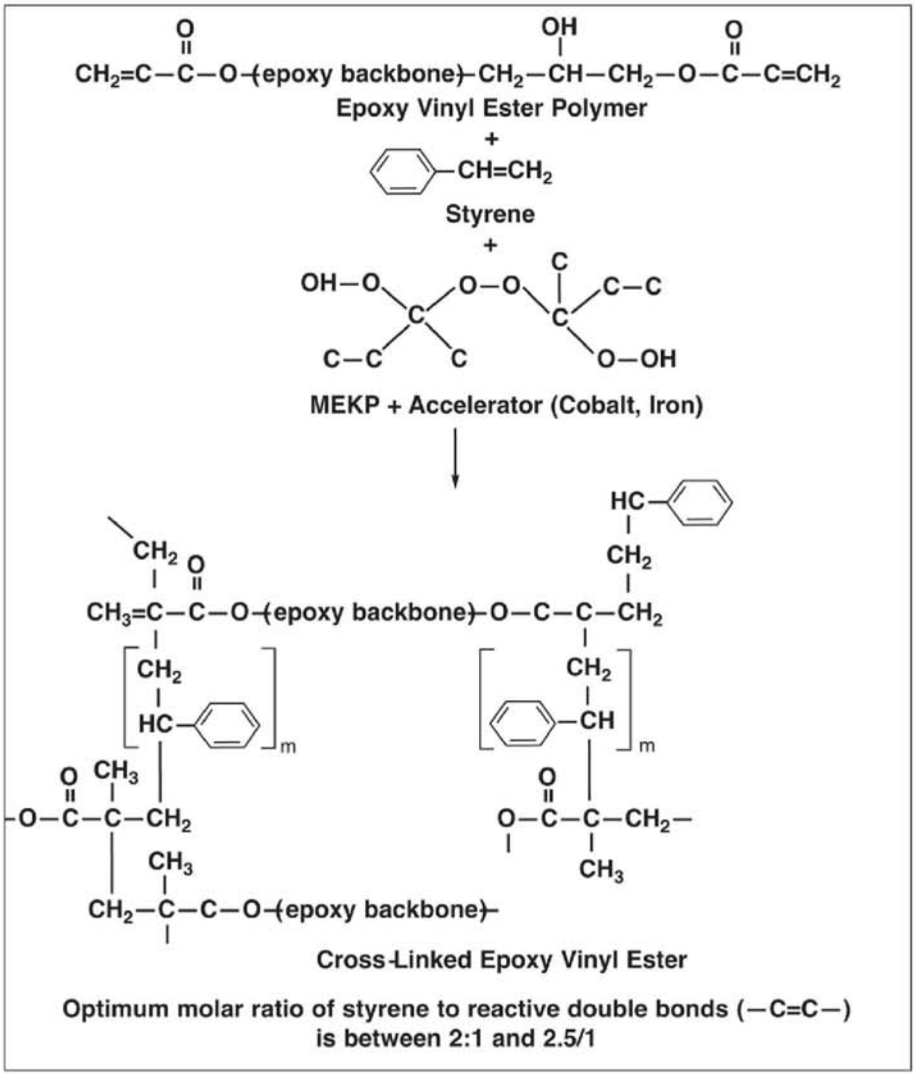
Isophthalic acid



- •Chemical resistance
- •Best weathering
- •More costly than anhyd.
- •2-step condensation

Terephthalic

- •Increased Tg
- •More costly than anhyd.
- •2-step condensation



Optimum molar ratio of styrene to reactive double bonds (—C=C—) is between 2:1 and 2.5/1

Fig. 2: The physical and chemical properties of epoxy vinyl ester resins depend on the type of epoxy resin used, its molecular weight, and the acid used.

include acrylic acid, methacrylic acid, isophthalic acid, terephthalic acid, maleic anhydride, and fumaric acid. The physical and chemical properties of the resulting vinyl ester resin depend on the type of epoxy resin used, its molecular weight, and the acid used (Fig. 2).

Other modifiers can be used to impart special properties. For example, toughened vinyl esters can be made by incorporating modified liquid rubbers like carboxy-terminated butadiene-acrylonitrile co-polymers (CTBN), epoxy-terminated butadiene-acrylonitrile rubber (ETBN), core shell rubbers, and certain vinyl-modified hybrid urethanes. Toughening vinyl ester resins is usually done to increase properties like temperature resistance, glass transition temperatures (Tg), heat distortion limits (HDT), water resistance, and fracture toughness. Generally, when additives are used to improve elongation and flexibility, chemical resistance will decrease. Flexibilized polyester and vinyl ester resins are typically limited to formulating primers and are rarely used as topcoats.

There is considerable interest in two newer technologies for curing vinyl ester resins. Styrene is a prohibited ingredient in some applications, such as in potable water or in contact with food, and for some customers due to health considerations.

Cobalt carboxylates have already been classified as "CMR2 Reprotoxic" by the European Chemical Agency (ECHA), which means they are carcinogenic, mutagenic reproductive toxins. In Europe, manufacturers must conform to a wide-ranging directive known as REACH (Registration, Evaluation, Authorization, and Restriction of Chemicals). European manufacturers are under pressure to eliminate cobalt (Co^{+2}) from coatings and composites. All other cobalt compounds will eventually be evaluated, and those that are capable of forming the Co^{+2} ion will be prohibited. Cobalt napthanate and cobalt octoate will both form the Co^{+2} ion. This means that manufacturers must search for replacements for both cobalt salts and styrene. Other transition group metals such as copper, manganese, and iron have the ability to start the redox reaction needed to initiate the cure, without having carcinogenic or mutagenic characteristics. Other monomers may be used in place of styrene, some of which are neither hazardous air pollutants (HAPs) nor volatile organic compounds (VOCs), resulting in a "styrene-free" vinyl ester. These other monomers include tert-butyl styrene, vinyl toluene, diallyl phthalate, and trimethylolpropane triacrylate. The latter two are neither HAPs nor VOCs and are more expensive.

The use of ultraviolet light (UV) to cure vinyl ester coatings is gaining in interest and in importance. These coatings also use free radical initiators to initiate cure, but instead of MEKP, a photo initiator is added to the resin. When exposed to UV light, the photo initiators become "excited" and then decompose to generate the free radicals. Radiation-cured resins offer the potential to reduce air pollution and to reduce carcinogens in the environment because they are solvent free. In practice, UV-curable vinyl esters are somewhat limited in their applications because the uncured coating must be exposed to the proper wavelength of UV light at the required intensity. This generally requires placing the UV light source close to the freshly applied coating, while maintaining a uniform distance from the coating. This is not always possible, especially at construction sites.

Various types of fillers are typically added to polyester and vinyl ester coatings to impart distinct characteristics to the coatings and change specific properties of the coating, such as cost, permeation, abrasion resistance, and flexibility (Table 1).

The earliest linings were reinforced with chopped fiberglass or woven roving (woven fiberglass fabric). Later, silica and other mineral fillers were added to improve the release of the heat generated during cure, reduce shrinkage during cure, and reduce the coefficient of thermal expansion (cte) of the coating to better match the cte of the steel or concrete substrate. These earliest linings were either roll-applied or applied by trowel. Later developments included the use of mineral flakes, like mica, and glass flake, which decreased permeation by water vapor and slightly extended the maximum service temperature in wet environments.

Performance Critical Properties

Today's industries present such diverse chemical and thermal environments that no single resin can withstand the many combinations possible. A variety of resin types is required. The resin chemistry will largely determine how a particular resin behaves in any given chemical/thermal environment. Different resins may well yield widely different results in the same environment. The type of resin chosen will be the principal factor in determining whether a coating will perform as expected.

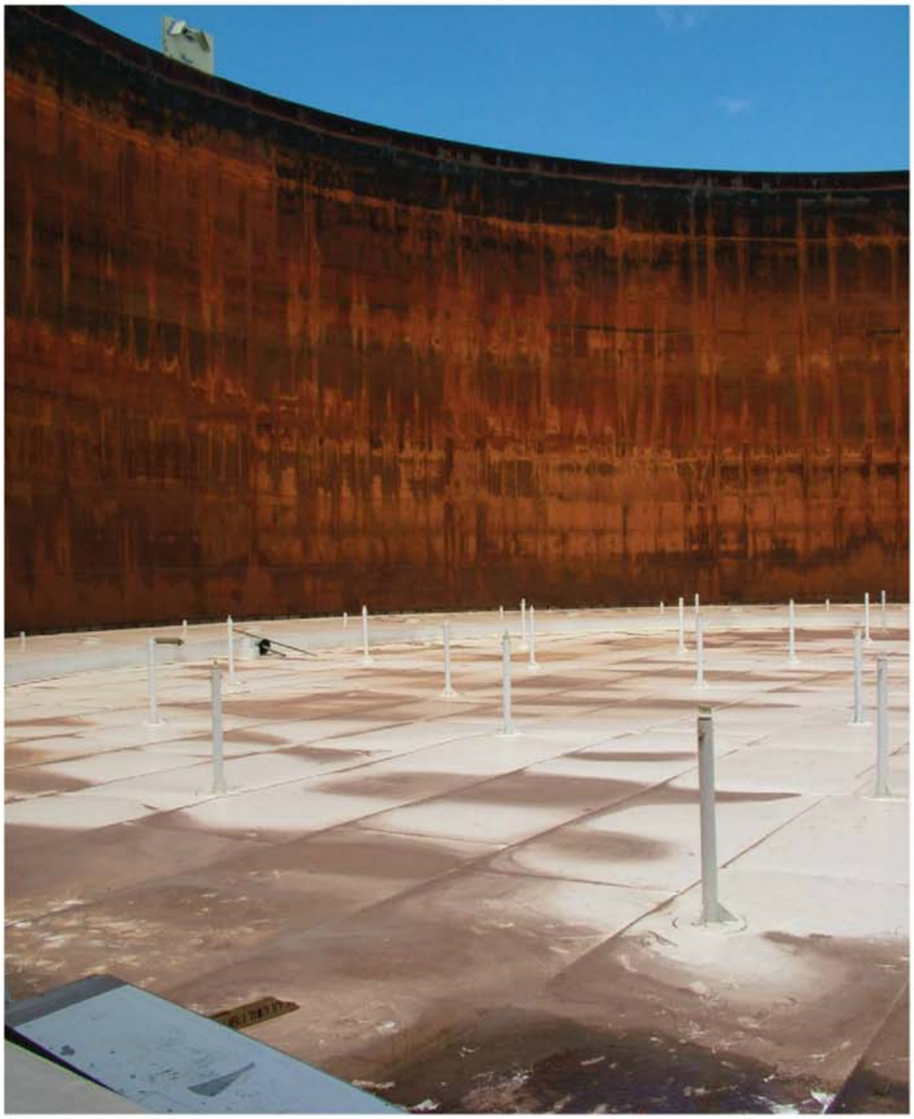
Flexibility

As noted earlier, vinyl ester and polyester resins are relatively brittle, especially the polyester resins due to the greater number of cross-link sites along the polymer. Unfilled resins generally have a tensile elongation of about 2 to 5%, although some manufacturers offer modified resins with elongations as high 12%. These flexible resins are not as chemical resistant as the unmodified resins, nor do they have the thermal stability or mechanical properties required to function as a topcoat.

Flexibility and elongation properties of

Table 1: Common Fillers and Properties Imparted

Filler	Coating Properties
Graded & cleaned silica	Low cost, good permeation resistance, good abrasion resistance, reduces thermal expansion, most common filler used
Mineral fillers	Improved abrasion resistance, improved fluoride resistance, non-skid; e.g., garnet, anthracite, granite
Carbon fillers	Electrical conductivity, fluoride resistance
Carbon fiber veil & weave	Fluoride resistance, reduces shrinkage, electrical conductivity
Chopped "C" glass fiber	Improved flexural modulus of elasticity, chemical resistance, shock resistance, reduces thermal expansion
Chopped fiberglass mat	Improved chemical resistance, decreased shrinkage, reduces thermal expansion
Woven fiberglass fabric	Bidirectional reinforcement, improved strength, reduces thermal expansion
"C" glass veil	Excellent chemical resistance, decreased shrinkage, reduces thermal expansion
Ceramic fillers	Specific properties such as lower thermal conductivity, fluoride and alkali resistance, abrasion resistance depending upon the filler (e.g., alumina, silicon carbide, vitreous silica, hollow ceramic and glass beads, etc.)



Tank wall above floating roof before surface prep

these materials are critical to designing a lining system that will not crack in service. It is not as simple as incorporating reinforcement, because reinforcement will reduce elongation capability. Special attention must be paid to areas of high strain, areas where the substrate tends to bend or flex, discontinuities, or localized areas where the temperature on the coating is significantly higher than or lower than the surrounding coating.

The coating manufacturer must be consulted to ensure that the coating has the necessary properties to withstand the intended service conditions.

Adhesion

Vinyl ester and polyester coatings have good adhesion to a properly prepared substrate. Both concrete and metallic substrates will require a surface profile to ensure mechanical anchoring so the coating will remain bonded when exposed to the stresses generated during cure and operating conditions. Profile amplitudes, top of peaks to bottom of valleys between peaks, will vary with coating thickness. A minimum profile is about two mils, but can be as high as five mils for very thick liners. Many of these coatings will also use a primer to enhance adhesion.

Chemical Resistance

Because chemical resistance is the most important property for these materials to have, manufacturers spend large amounts of time and money evaluating the resistance of their products to an extremely wide range of chemicals and temperatures. A quick look at the chemical resistance charts that the coating and resin manufacturers publish will reveal hundreds of different chemicals and temperatures in which they have tested their products. Each of the different types of resin has a different resistance to a given chemical environment. There are some generalities that can be made, but there are many exceptions. It is imperative that the user consult the coating or resin manufacturer about each application to ensure that the wrong material is not used.

Bisphenol A epoxy vinyl esters are generally not as chemical resistant as novolac epoxy vinyl esters, but, again, exceptions exist. The novolac vinyl esters are not recommended for calcium or sodium hypochlorite exposure, whereas the bis A vinyl ester is recommended. It must be noted, however, that the bis A vinyl ester must use benzoyl peroxide as the initiator for hypochlorite exposures. MEKP-initiated systems will fail after a relatively brief exposure, especially at temperatures above 100 F (~38 C). Due to the improved chemical and thermal stability imparted to the polymer by the epoxy backbone, vinyl esters generally have better chemical resistance and temperature resistance than polyesters; however, there are several environments where the less expensive polyesters are preferred. The bis A fumarate polyesters exhibit resistance to a wide range of chemicals, including strong alkalies that will attack other polyesters and vinyl esters. Another class of polyesters is the chlorendic polyesters. These chlorinated polyesters have excellent resistance to strong mineral and oxidizing acids, for example, chromic acid. Chlorendic polyesters are the best choice for chromic acid exposures.

They are not, however, recommended for alkaline exposures.

Vinyl ester and polyester resins offer resistance to aggressive chemicals at elevated temperatures. In some environments, especially wet ones, these resins can withstand temperatures up to 400 F (204 C), e.g., wet fossil fuel flue gas. As a result, these resins find uses as protective linings for concrete, tanks, secondary containment, flue gas ducts and stacks, floor and wall coatings, structural steel, and process vessels.

Always consult the manufacturer of the coating, because differences in formulations will affect how two coatings made from the same resin will perform. If time permits, ask the manufacturer to prepare cured samples that can be placed in the expected environment for evaluation and testing.

An additional comment is in order regarding chemical resistance charts published by coating and lining manufacturers and resin manufacturers. Most of these tests were conducted according to ASTM test methods, as they should be. However, the ASTM methods are not performance specifications; rather they are detailed instructions on how to conduct the tests. They do not establish pass/fail criteria. The decision as to whether a particular product is recommended for a given environment is left to the individual product manufacturer.

Areas of Concern

There are certain characteristics of polyester and vinyl ester based coatings and linings that require the exercise of caution when using them. One of the primary concerns is the high coefficient of thermal expansion (cte) of both types of resin. Unfilled and unreinforced polyester resins have a cte that is approximately 4 to more than 10 times as great as that of carbon steel and concrete. This large difference will cause problems whenever the temperature changes significantly or too rapidly. Problems could include disbondment, cracking and edge curling. Coating and lining manufacturers are very much aware of this situation and incorporate fillers and reinforcements in their linings and coatings to reduce the cte as much as possible. Fillers like glass fiber, glass flake, and silica have relatively low thermal expansion and are widely used for this purpose, as well as for their reinforcement properties.

Another problem area for these resins is the inherent shrinkage that occurs during cure, which can have undesired effects, such as cracking and disbondment of coatings and delamination in FRP linings shortly after the resin is fully cured.


Under floating roof before surface prep

When curing, these resins are exothermic. The heat developed during cure and the shrinkage occurring at the same time will result in a residual tensile stress that often results in disbondment and cracking. These thermal excursions and volume changes, both from thermal expansion and shrinkage, mandate that linings and coatings be reinforced to prevent premature failure.

When curing these resins, one must be aware of the inhibiting effect of atmospheric oxygen and excessive atmospheric moisture on cure. Both oxygen and moisture inhibit the cure at the surface where the resin makes contact with the environment. Crosslinking is prevented, leaving a surface that is soft and lacking in chemical resistance. The thinner the coating, the more critical this effect becomes. Different resins are affected to different degrees, but all are affected. To overcome this problem, most coating manufacturers supply a "gel" coat or a specially formulated topcoat that has a small amount of a paraffin wax dissolved in styrene. As the coating or lining begins to cure, the paraffin migrates towards the air side surface. Since it cannot evaporate at ambient conditions, a thin film of paraffin is distributed over the air-exposed surface. The paraffin wax acts as a physical barrier to both oxygen and moisture, thus preventing cure inhibition. The paraffin will be removed by the chemical and/or thermal conditions once the lining is placed into service, leaving a properly cured and fully resistant lining in place.

Polyester and vinyl ester linings and coatings are more sensitive than some other coatings to application conditions. If temperatures are outside of the specified range, cure problems may arise. If the substrate is not properly cleaned, the contaminants may interfere with cure of material adjacent to the substrate. Atmospheric contaminants, too, can interfere with cure. Installers must ensure that all of these potential problems are accounted for during application and approved by the coating manufacturer. These potential problems may require heating the application area and the substrate's surface; cooling the application area and the substrate's surface; dehumidifying the application area; or tenting it to protect it from weather, sunlight, and local air pollutants that may otherwise fall onto the substrate and the freshly applied lining/coating.

The user should be aware that there will be a small amount of styrene remaining in the cured resin. This will release from the coating/lining over time and if the cured sys-

Start of vinyl ester coating on wall above floating roof

tem is smelled close up, the styrene odor will be noticeable for a brief period after cure.

Some applications will require a forced post cure in order to develop full chemical resistance and maximum mechanical properties. If required, a two-hour post cure at 120 F (49 C) is generally sufficient. Consult the coating/lining manufacturer for recommendations.

Polyester and vinyl ester coatings share concerns with other coatings, as well. For example, it is not advisable to apply any coating or lining on concrete or other porous surfaces in direct sunlight or in the presence of soluble salts on the substrate. UV radiation will damage many organic coatings, including polyesters and vinyl esters, causing photo degradation (e.g., chalking of coatings).

Application Methods

For surface preparation, environmental controls, and worker protection, much of what is needed for polyester and vinyl ester linings is needed for their coatings counterparts. But lining application differs from coating application, and each will be discussed separately.

Several types of linings incorporate combinations of trowel-applied protective barriers and some form of fiber glass reinforcement; stand-alone systems also exist.

These materials are aggregate-filled resins designed to be applied by hand trowel or by power trowel. The aggregate can be just about any of those listed in Table 1, or others. Silica is by far the most common filler, but where fluoride resistance is required or where improved abrasion resistance or some other characteristic is needed, other aggregates are used. These systems typically consist of a primer, followed by a trowel-applied layer than can range from ⅛-inch (~3-mm) to as much as ½-inch (~12.5-mm). Over this, one or more layers of a fiberglass fabric or veil may be laid to reinforce the liner. (If fluorides or strong alkalies are expected, either synthetic veil or carbon fiber should be substituted for the fiberglass.) These types of liners are generally used to protect concrete floors. They provide both chemical resistance and excellent mechanical properties, including abrasion resistance.

The fiberglass is then saturated with resin and rolled with a ribbed roller to eliminate air pockets and to ensure that the fiberglass is fully wet with the resin. A final top layer of the trowel-applied material is then applied and sealed with a gel coat. These systems are typically packaged as three-component units. The resin and initiator (MEKP, etc.) are first mixed together thoroughly. Next, the aggregate is mixed until uniformly dampened, at which point the mix is applied.

These same types of linings can be applied by a method called "pour and spread" or "broadcast." The resin/initiator mixture is spread evenly over the floor with a screed rake to a uniform thickness. The aggregate is immediately spread, or broadcast, over the wet resin, either manually or by mechanical device. The aggregate is broadcast until the aggregate can no longer sink into the resin and the resin can no longer wet the aggregate ("broadcast to excess"). After the resin cures, all loose aggregate is removed with brooms or a shop vac. The surface is then sealed with a liberal coat of resin/initiator, pigmented as desired, and followed by a gel coat. This installation method is faster than troweling, but cannot be used on vertical surfaces and floors with a severe slope. These systems can be applied from 1⁄16-inch (~1.5-mm) to as thick as ½-inch (~12.5-mm).

Trowel-applied linings may also be filled with silane-treated micaceous iron oxide (MIO) or silane-treated glass flake. Flake-filled liners offer superior permeation resistance. These are usually three-component systems applied by trowel. Immediately after troweling, the surfaces are compacted by rolling with a short nap paint roller to help remove entrapped air near the surface and to help ensure that the flakes are lying flat. The flakes are typically up to ⅛-inch (~3-mm) in diameter. These flakes overlap each other in layers, creating a tortuous path that makes penetration by liquids much more difficult.

Polyester and vinyl ester coatings for industrial applications may be applied by one of two generally preferred spray methods. Both use airless, high-pressure spray equipment to apply the coatings. In one method, called "hot potting," the resin mixture and initiator are mixed together and then pumped through a material hose to the spray gun. The material is atomized at the spray gun as it is being applied to the substrate. Pressures at the gun tip are typically 5,500 to 6,300 psi.

The second method is plural-component spraying. Plural-component equipment pumps the resin side and the initiator through separate material hoses to the mixing point.

Spray-applied coatings will typically use smaller fillers so they can pass through the spray tip, which can have an opening as small as 0.029 inches (0.74 mm). This includes products made with glass or MIO flake. The flakes in spray-applied coatings do not align themselves parallel to the substrate as uniformly as in the trowel-applied systems but still improve permeation resistance and help provide crack resistance.

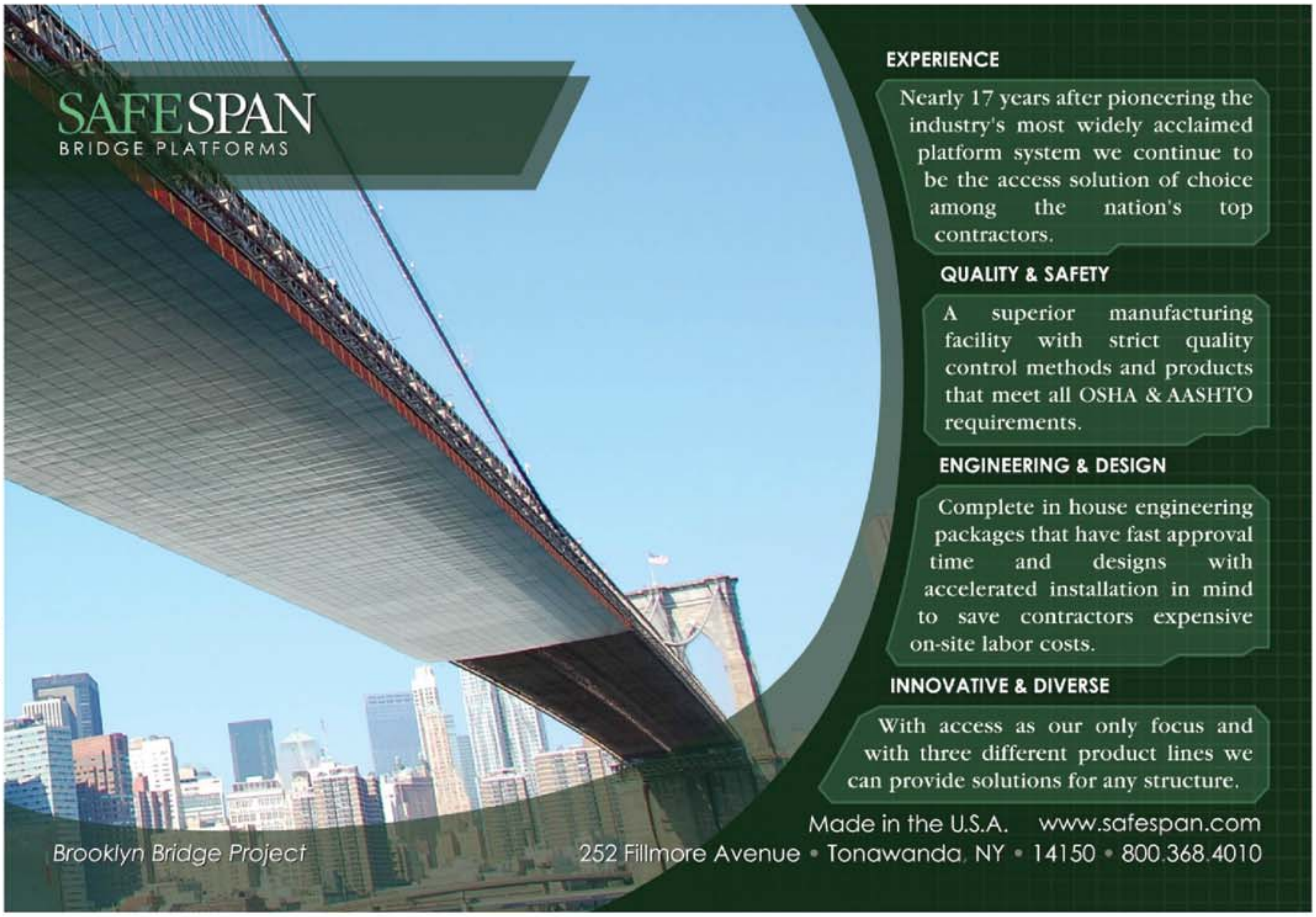
Other special fillers may be used, such as carbon for fluoride or alkali service, or glass fiber for flexural modulus and tensile strength improvement, or alumina for abrasion resistance.

Application by spray reduces the overall cost of the installation because the time required to apply the material is typically approximately 10% of the time required to hand apply a liner by trowel.

Because polyester and vinyl ester coatings and linings are relatively brittle, they will break if stretched too much. Thus, when placed over substrates that can move significantly, the coatings will crack. Concrete is famous for its tendency to crack with age. If a brittle coating or liner is placed over concrete that develops a crack, the coating above it will crack as well, a phenomenon called “reflection cracking.” To prevent reflection cracking in the coating, first coat the concrete with a highly flexible coating, such as a flexibilized epoxy, urethane, or rubber, called a crack-bridging membrane. The polyester/vinyl ester coating/liner is then placed over this membrane, which can accommodate the high strains generated by the crack opening as it moves and can thus prevent reflection cracking.

Environmental, Safety, and Health Considerations

Both styrene and cobalt have environmental, health, and safety (EHS) concerns. These concerns mandate that workers take precautions, in accordance with OSHA, EPA, and any other relevant federal, state, or local EHS regulations, when handling polyester and vinyl ester resins. For example, first among



these precautions is use of a properly-fitted respirator in compliance with OSHA requirements. OSHA also requires additional protective equipment, including chemical-resistant gloves, face shield or protective goggles, long-sleeved shirt or a full body protective suit, and protective foot gear. If the application is indoors, local ventilation with sufficient capacity to withdraw the styrene vapors is required. All equipment should be electrically grounded to prevent sparking and accidental ignition of the styrene vapors.

The precautions above are not intended to be exhaustive. As with all coatings and linings, always consult the correct Safety Data Sheets (SDS) as well as the appropriate EHS resources (personnel and regulations) before applying polyesters or vinyl esters. Similarly, before you begin the work, take all of the protective measures required. If you become exposed to the product through inhalation, skin contact, or other means, follow all recommended medical procedures.

Summary

Polyester and vinyl ester coatings and linings have a long and successful history of corrosion resistance in a wide range of chemical and thermal environments. They possess high mechanical strength and adhesion as well as low permeation and excellent chemical resistance, even in elevated temperatures. A variety of coatings and linings utilize many different fillers and reinforcements that help impart specific properties. Care must be exercised in using these materials over substrates that move and over concrete that might have, or might develop, cracks. It is strongly recommended that the user consult with the coating/lining manufacturer for each application to ensure that the system will perform as expected and that operating conditions will not result in premature failure. Most important, protection of workers, the public, and the enviornment must never be ignored.

Reference

1. W. R. Slama, "Polyester and Vinyl Ester Coatings," *JPCL*, May 1996, Generic Coating Types Series, p. 88.

Gary R. Hall, now retired, was manager of research and development at Sauereisen, Inc. (Pittsburgh, PA). He was with Sauereisen for 45 years. Hall is active in NACE, ASTM, and the American Institute of Chemical Engineers. He is a contributing editor for *JPCL* and also is a recipient of one of *JPCL*'s 2012 Top Thinker awards. **JPCL**

TAKE IN SSPC 2014's SPECIAL

SSPC 2014 featuring GREENCOAT

SSPC 2014 featuring GreenCOAT, to be held at the Coronado Springs Resort in Lake Buena Vista, FL, Feb. 10–13, 2014, will offer attendees and their guests a variety of scheduled special events and awards ceremonies. For details about the full conference, including the technical sessions, workshops, training and certification programs, and exhibition, visit sspc2014.com, and look for the SSPC 2014 Advance Program in the December 2013 *JPCL*.

ANNUAL BUSINESS MEETING AND AWARDS LUNCHEON

Join SSPC President Ben Fultz, the Board of Governors, and Executive Director Bill Shoup at 11:30 a.m. on Monday, Feb. 10, to hear SSPC's Annual Report and to honor the 2014 award recipients at the Annual Business Meeting and Awards Luncheon. Awards to be presented at this year's luncheon include the eighth annual SSPC Structure Awards, the SSPC Honorary Life Member Award, the John D. Keane Award of Merit, the Coatings Education Award, the Technical Achievement Award, the Women in Coatings Impact Award, the President's Lecture Series Award, the Outstanding Chapter Awards, the Outstanding Publication Award, and the *JPCL* Editors' Awards.

SSPC Structure Awards

The eighth annual SSPC Structure Awards will honor teams of contractors, designers, end users, and other personnel for the excellence and expertise demonstrated on industrial and commercial coatings projects. Awards to be presented are:

- The William Johnson Award for outstanding achievement in aesthetic merit in industrial or commercial coatings work;
- The E. Crone Knoy Award for coatings work that demonstrates innovation, durability, or utility;
- The Charles E. Munger Award for a coatings project that demonstrates the long service life of the original coating;
- The George Campbell Award for the completion of a difficult or complex coatings project; and
- The Military Coatings Award of Excellence for exceptional coatings work performed on U.S. military ships, structures, or facilities.

JPCL will feature this year's Structure Awards winners in a photo essay next spring.

SSPC Past President Steve Collins (2012–2013) cuts the ribbon at the SSPC 2013 exhibit hall. Courtesy of SSPC

SSPC Honorary Life Member

This honor is bestowed on an individual by the Board of Governors for extraordinary long-term activity on behalf of SSPC. To become an honorary life member, an individual must be nominated by a Board member and approved by two-thirds of the Board of Governors. Only one honorary life membership is awarded each year.

John D. Keane Award of Merit

Named for SSPC's executive director from 1957 to 1984, this award acknowledges outstanding leadership and significant contribution to the development of the protective coatings industry and to SSPC.

Coatings Education Award

This award is given for significant development and dissemination of educational material and technical information relating to protective coatings and their application.

Technical Achievement Award

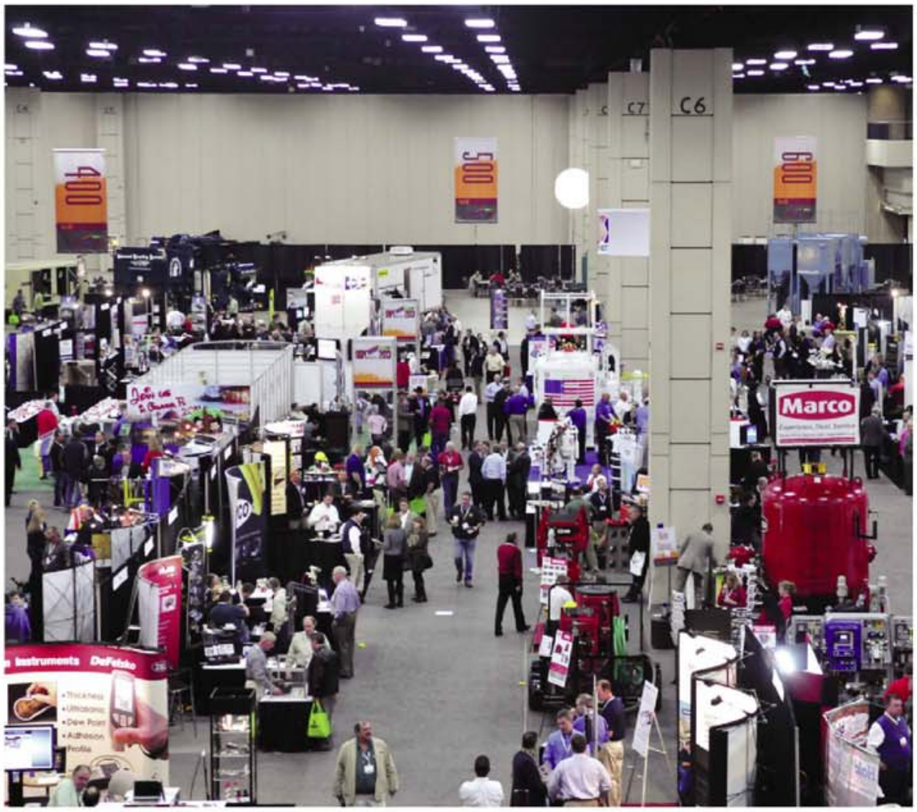
This award is presented annually to recognize outstanding service, leadership, and contribution to the SSPC technical committees.

Women in Coatings Impact Award

This award, which will be awarded for the first time ever this year, was created to recognize women whose contributions to the coatings industry have created a positive impact on the culture of the industry. These women are leaders in their profession and demonstrate commitment to the advancement of the coatings industry, among many other things.

President's Lecture Series Award

Handpicked by the SSPC President, this technical presentation is chosen for its reflection of the coatings industry and profession. Past winning papers offered thought-provoking and relevant information important to the growth of the industry. The presentation will be highlighted in the Onsite Guide, and the winner will be recognized at the awards luncheon.



SSPC 2013 exhibit hall
Courtesy of SSPC

SSPC Outstanding Publication Award

This award is given annually to the author(s) of the best technical paper or presentation from the SSPC International Conference and Exhibition or *JPCL* that scores highest in the following categories:

- Clarity of expression and organization,
- Originality of content or presentation,
- Importance to the protective coatings industry, and
- Effectiveness of figures, tables, and examples.

SSPC selects a panel of judges from SSPC and *JPCL* to vote on the award.

Attendees enjoy food at the SSPC 2013 Welcome Reception
Courtesy of SSPC

***JPCL* Editors' Awards**

The same panel of judges selects the recipients of the *JPCL* Editors' Awards, which also recognize excellence in technical writing. Winners are selected from a field of more than 100 eligible papers from SSPC 2013 and *JPCL* articles published between May 2012 and July 2013. Awards are also based on clarity, originality, significance to the industry, and effective use of illustrations.

SSPC Outstanding Chapter Awards

Each year, SSPC presents awards to the Outstanding North America Chapter and the Outstanding International Chapter. Chapters are evaluated on their overall operation and the creativity and quality of the events held each year.

OPENING CELEBRATIONS

Welcome Reception

Monday, Feb. 10, 5:30–7:30 p.m.

Sponsored by Carboline, this welcome reception is an opportunity to enjoy hors d'oeuvres and cocktails amongst SSPC Board members, staff, colleagues, and business acquaintances. SSPC and Carboline will also be giving away an iPad at the reception; you must be present to win.

Exhibit Hall Grand Opening

Tuesday, Feb. 11, 5:00 p.m.

The ribbon will be cut, and the doors to the SSPC 2014 exhibit hall will open amid great celebration. Attendees can enjoy food and drinks as they explore the variety of suppliers and other exhibitors.

CLOSING CELEBRATIONS

Exhibit Closing Blast

Thursday, Feb. 13, 1:30–3:00 p.m.

The exhibit hall opened with a bang, so SSPC will close it with a blast! With no technical sessions scheduled in opposition, attendees can enjoy food and drinks as they take one last trip through the exhibit hall.

Learn traditional Chinese cuisine techniques at the Art of the Wok Cooking Class at Ming Court
Courtesy of Ming Court

SSPC 2014 Closing Party

Thursday, Feb. 13, 7:00–9:00 p.m.

Celebrate the closing of another successful SSPC show in style! Gather with friends old and new and enjoy food from the buffet to put a cap on the week.

SPOUSE AND GUEST TOURS

Two optional tours for attendees' spouses and guests are available. Tickets for the tours must be purchased separately.

Alligator & Airboat Tour at Wild Florida

Tuesday, Feb. 11, 9:00 a.m.–2:00 p.m.

Take an eco-tour that you will never forget! Take a closer look at alligators and exotic wildlife as you glide through 4,200 acres of untouched nature preserve located in the headwaters of the Everglades. This swamp is

Get an up-close look at Florida's exotic wildlife at Wild Florida
Courtesy of Wild Florida

free of any development and is 100% pure Florida wilderness. The fun doesn't stop with the airboat tour! Enjoy natural Florida on the 500-foot dock that overlooks the swamp or have your picture taken holding a baby alligator. The property offers an amazing array of wildlife, including bald eagles, deer, cows, boars, turkey, alligators, and more. The brand new wildlife park is appealing to all ages with its truly exotic animals. You will lunch at the authentic barbecue restaurant. A gift shop with unique take home items is another option. Make sure to bring a camera and capture the beautiful nature of Wild Florida!

Art of the Wok Cooking Class at Ming Court

Wednesday, Feb. 12,
11:00 a.m.–2:30 p.m.

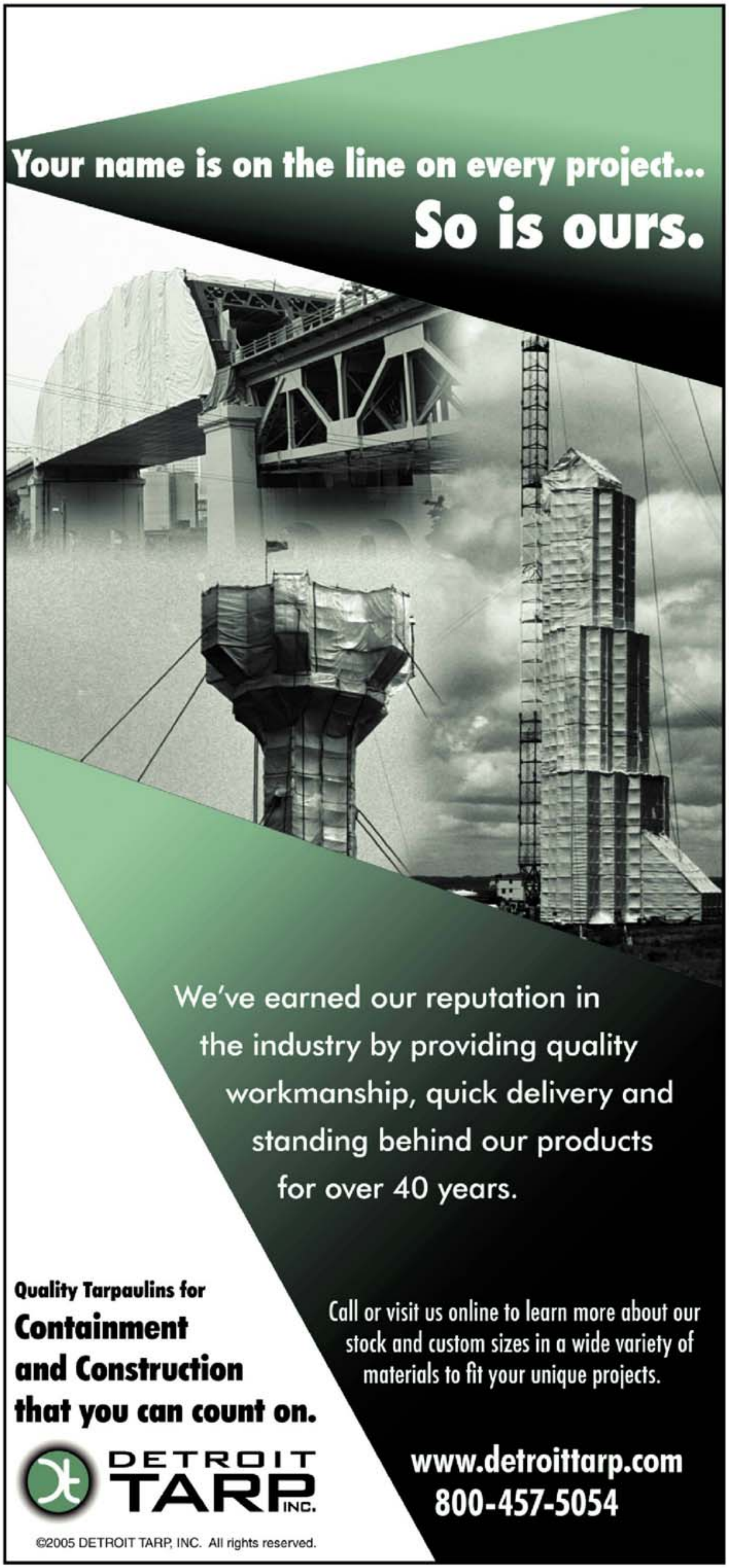
Ming Court embodies the art of innovative Oriental dining in a spectacular setting based on the centuries-old architecture of the Ming Dynasty and situated on two acres, surrounded by beautiful garden settings. This popular class introduces guests to the origins of Oriental cuisine, authentic cooking techniques, and special ingredients used in the preparation of Chinese cuisine. Presentations are conducted by a senior staff member, and the cooking demonstration is conducted by Ming Court's executive chef. The program focuses on the art of using a wok to create delicious traditional foods. Note: There must be a minimum of 20 guests. **JPCL**

EXHIBITORS AT SSPC 2014

The following is a list of companies planning to exhibit at SSPC 2014 featuring GreenCOAT, current as of press time.

Abrasives Inc.
AIR Systems International
Allnex
ARID-DRY
ARS Systems
Atlantic Design
Barton International
Belzona Inc.
Benjamin Moore/Corotech
Binks
BlastPro Manufacturing
Bullard Co.
Carboline Company
CESCO/Aqua Miser
Chlor*Rid International Inc.
Church & Dwight Co., Inc.
Clemco Industries Corp.
CoatingsPro Magazine
CSI Services
Dampney Co. Inc.
DeFelsko Corporation
Dehumidification Technologies, LP
Denso North America Inc.
DESCO Manufacturing Co., Inc.
Detroit Tarp Inc.
Dex-O-Tex div. of Crossfield Products Corp.
DoD Office of Corrosion Policy and Oversight
Doosan Portable Power
The Dow Chemical Company
DRYCO, LLC
Dustless Blasting
DUSTNET by EMI International
Eagle Industries
Elcometer
EnTech Industries
Excalibar Minerals LLC
Fischer Technology Inc.
FS Solutions Group
Geoblaster Equipment
Gill Industries
GMA Garnet (USA) Corp.
Grace Distributing Inc.
Graco Inc.
Green Diamond Sand Products
Greener Blast Technologies, Inc.
Greenman-Pedersen, Inc.
Harsco Minerals
HippWrap Containment
HoldTight Solutions Inc.
HRV Conformance Verification Associates
IBIX North America
Indian Valley Industries
Industrial Vacuum Equipment Corp.
Intl. Marine and Industrial Applicators LLC
International Paint
IRIS (Intelligent Reporting Inspection Software)
JAD Equipment Co.
Jotun Paints, Inc.
Kennametal, Inc.
KTA-Tator, Inc.
Marco
Mascoat
Mohawk Garnet, Inc.
Moisture Control Company
Monarflex by Siplast
MONTI Tools Inc.
Montipower, Inc.
Mosebach Manufacturing Company
NACE International
National Equipment Corp.
Novatek Corp.

Olimag Sand
OPTA Minerals, Inc.
Painters & Allied Trades LMCI
Pinnacle Central
Polygon
PPG Protective and Marine Coatings
Pretox Systems/NexTec Inc.
PTQ Safety Goggles LLC
Purdy/Bestt Liebco
Rhino Linings Corporation
Ring Power Corporation
Rototexx
Royce International
SAFE Systems
Safety Lamp of Houston
SAFWAY Services
Sand Express
Sauereisen
Schmidt Engineered Abrasive Systems
Seal for Life
Seymour Midwest
The Sherwin-Williams Company
Spider
Sponge-Jet
Sulzer Mixpac USA, Inc.
Super-Flex LLC
Surface Prep Supply
Tank Industry Consultants
Tarps Manufacturing
TDJ Group
Technology Publishing/PaintSquare
Tesla NanoCoatings
Thomas Industrial Coatings
Tnemec Company
Trace Industrial Supply, LLC
Tractel Inc. Griphoist Division
TruQC
TWRS - The Warehouse Rentals & Supply
Uni-Ram Corporation
U.S. Minerals
Van Air Systems
VersaFlex Incorporated
W Abrasives
Wagner Systems Inc.
Western Technology Lights



Training Courses

Michelle Mercado and Gordon Kuljian instructed 22 students at SSPC's NAVSEA Basic Paint Inspector (NBPI) course, held August 26–30 at the Pearl Harbor Shipyard in Pearl Harbor, HI. This five-day inspection course was developed by Naval Sea Systems Command (NAVSEA) to train coatings inspectors to inspect critical coated areas on ships, as defined by U.S. Navy policy documents. The course also provides the technical and practical fundamentals for coating inspection work for any steel structure projects other than ships.

There were 18 students who attended the SSPC PCI Level 1 and 2 courses, held August 19–24 at Kansai Altan Boya Sanayi A.S. in Izmir, Turkey. These courses were sponsored by Insignia FZE and instructed by Mohamed Hamalawi, Tolga Diraz, and Melih Iyigullu.

According to course attendee Seda Omercikoglu, the program offered "many experiences" and "lots of knowledge" related to protective coatings, which in turn "opened up new ideas at my work." Omercikoglu also noted, "I had the chance to meet new colleagues who are from different companies and fields."

Sponge-Jet in Newington, NH, hosted SSPC's C7 Abrasive Blasting Program from September 10–11. Gary Duschl instructed the course's seven students on the basics of dry abrasive blast cleaning of steel, including the principles of surface preparation, surface cleanliness, surface profile, dust and debris control, and abrasives.

SSPC Offers Free, Web-Based Bridge Preservation Training

SSPC has announced the offering of three new web-based training courses, sponsored by the Federal Highway Administration (FHWA) and offered free of charge, covering topics in bridge preservation. The three courses cover:

- Safety During Bridge Preservation,
- Coating and Painting Bridge Superstructures, and
- Sealing and Waterproofing Bridge Decks.

This training is geared toward individuals who perform and/or supervise bridge preservation activities in the field, including bridge preservation contractors, as well as State DOT and Local Public Agency personnel and consultants. It was developed with the input of industry experts associated with SSPC, AASHTO, ARTBA, and the University of Kentucky.

Please visit sspc.org/training/Training-FHWA-Bridge-Preservation/ for more details on how to access the training modules.

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- Deck/floor planers with integrated vacuum connection
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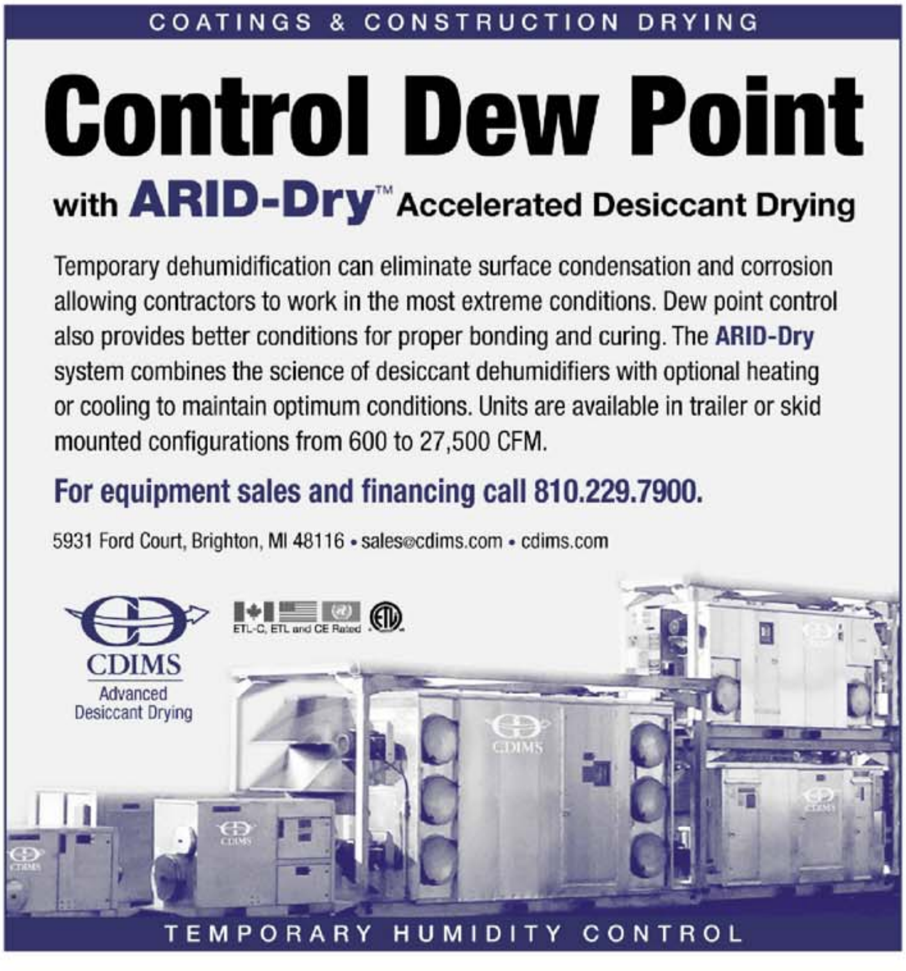

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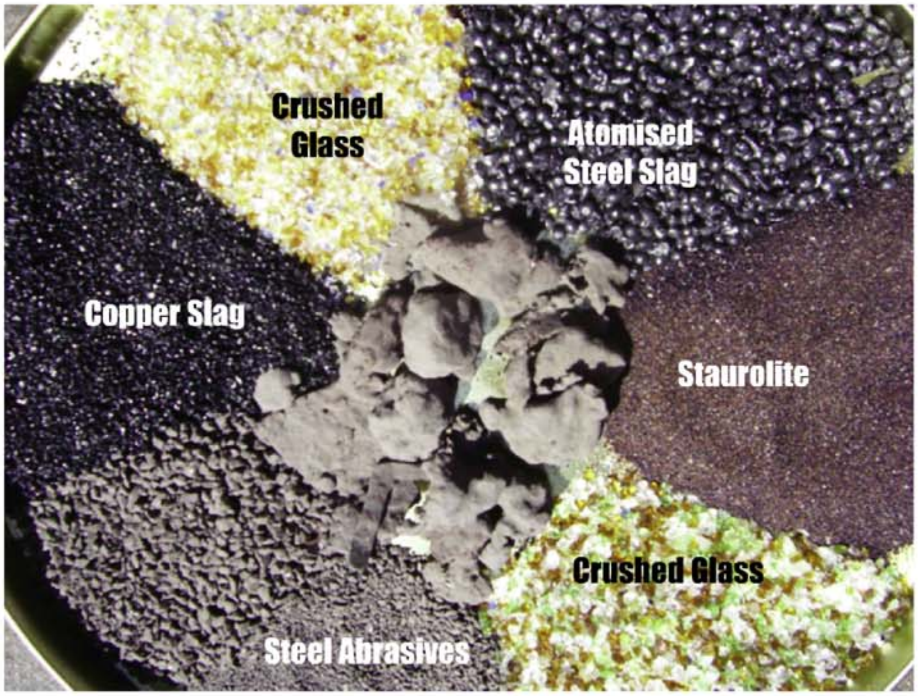
Assuring the Quality of Abrasives

When you clean steel by abrasive blasting, you need to produce a finish that will allow maximum adhesion of the coating. Thus, you need to create the specified profile and the specified degree of cleanliness, such as SSPC-SP 10/NACE No. 2, Near-White, or Sa 2½, Very Thorough (ISO 8501-1).

The abrasive itself will affect both the profile and the degree of cleanliness of the steel. To achieve the appropriate profile, you must use the right size abrasive, and to achieve the specified cleanliness, you must use abrasive that will effectively cut away rust, scale, old paint, and other contaminants that may be on the surface. You also must be sure that the abrasive is clean, so that it does not recontaminate the surface. This bulletin deals with assuring the quality of the abrasive you are using. It will explain how to check for cleanliness, size, and if you are recycling the abrasive, the proper operating mix.



Courtesy of David Dorrow, President, Mineral Aggregates

Documents from the Supplier

Your abrasive supplier will have processed the abrasive before selling it to you. This process normally involves cleaning the abrasive, testing it for chemical content, grading and separating it according to size, drying it, and preparing it for shipment in bags or bulk units. ISO standard specifications exist for abrasives: the 11124 series covers metallic abrasives, and the 11126 series covers non-metallic abrasives.

When you purchase the abrasive, you will receive a safety data sheet (SDS) describing its chemical makeup and the precautions you need to take when using it. You can also request documents on sieve analysis and detailed chemical content from a laboratory analysis. In addition to these assurances from the supplier that the abrasive meets your requirements, there are some simple tests you can conduct to verify that the abrasive is what you ordered and is acceptable for use.

Editor's Note: This article is updated from the December 2005 version, which was based on the original, written in collaboration with Ernestine McDaniel of the Coatings Society of the Houston Area.

Abrasive Cleanliness

Abrasive needs to be clean; otherwise, the contaminants on the abrasive will be transferred to the surface being blasted. The most detrimental contaminants on abrasive are water, oil, grease, and soluble salt levels higher than those allowed. Any of these contaminants, once transferred to the steel, can cause failure of the coatings applied over them.

One simple way to detect oil and grease is to place a handful of abrasive in a clean glass jar containing clean water. Place a lid on the jar and shake it vigorously. If a film of oil appears on the surface of the water, then the abrasive is not clean enough to use. This test is also described in ASTM D7393, Standard Practice for Indicating Oil in Abrasives.

Checking for oil and grease contamination is especially important when you are recycling the abrasive. In this situation, oil and grease can easily be picked up from the steel surface or from faulty equipment, so it is useful to check for oil and grease at regular intervals during the blasting-recycling process. ASTM D7393 provides recommended testing frequencies.

This test of abrasive with water in a jar will also let you see how much dust or dirt is in the abrasive. If the water gets very cloudy or if dust rises to the surface of the water, then the overall cleanliness of the abrasive should be questioned. Excessive dust or fines in the abrasive means more time cleaning the surface before painting.

Visual inspection should let you determine if the abrasive is dry. Alternatively, ISO 11125-7 gives a method for determining whether there is moisture in metallic abrasives, and ISO 11127-5 gives the method for non-metallic abrasives. To keep your abrasive supply dry, make sure that it is stored properly, off the ground, and under shelter. Avoid using abrasive that has been exposed to the elements because of torn bags, improper storage, or other reasons. Damp or wet abrasive will clog up your blast equipment, prevent efficient operation, and cause pinpoint rusting on a steel surface.

Detection of salt or other chemical contaminants on the abrasive can be done in the laboratory or with specialized equipment in the field. If you suspect chemical contamination, you can check for contaminants with litmus paper. The abrasive should be nearly neutral; that is, it should have a pH of 6–8. If the pH is higher or lower, the abrasive may be chemically contaminated, though a higher or lower reading is not a definitive indicator.

You can do a conductimetric analysis to check for salt contamination with a minimum amount of equipment in the field. One such method is described in ASTM D4940, Standard Test Method for Conductimetric Analysis of Water Soluble Ionic Contamination of Blasting Abrasives. In this test, combine equal amounts by volume (300 ml) of pure water and abrasive, and after agitation, a waiting period, and further agitation, filter the slurry, and check the water for conductivity with a conductivity meter. This test will let you know if ionic contaminants (i.e., salts) are on the abrasive.

According to ASTM D4940, a typical conductivity value for highly contaminated abrasive is 500 µmhos/cm, while a typical conductivity value for a low level of contamination is 50 µmhos/cm.

The use of a conductivity meter to check for salts is mentioned in SSPC's four abrasive specifications: SSPC-AB 1, Mineral and Slag Abrasives; AB 2, Cleanliness of Recycled Ferrous Metallic Abrasives; AB 3, Ferrous Metallic Abrasive; and AB 4, Recyclable Encapsulated Abrasive Media. The meter is also referenced in SSPC Guide 15, Field Methods for Retrieval and Analysis of Soluble Salts on Steel and Other Nonporous Substrates, and ISO 11127-6 for non-metallic abrasives. ISO 11127-7 gives a method for the detection of water-soluble chlorides with non-metallic abrasives.

Field test kits are also available for the rapid determination of chloride contamination of abrasives.

Abrasive Size

The size of abrasive you use will influence the speed of cleaning and profile created on the steel. The initial condition of the surface will influence the choices that must be made. Larger particles are most effective for removing old paint, layers of rust, and mill scale. However, they create a deeper anchor profile. Small particles are most effective for removing oxides. They are also needed if the steel is pitted.

A typical slag abrasive mixture is a 10–40 gradation. These numbers mean that, typically, at least 90% or more of the abrasive will pass through a #10 sieve (10 lines per inch) and be retained on a #40 sieve (40 lines per inch). Particles will be in the range of approximately 0.1 to 0.025 in. (2.5 mm to 0.6 mm) in diameter. The larger particles provide more impact energy, and the smaller particles provide optimum coverage. Steel abrasives are more dense and harder than slag abrasives. Therefore, finer particles are used in making up the gradation.

The size and hardness of abrasives are two factors that will determine the profile and anchor pattern of the steel. So it will be necessary to select abrasive that creates the profile range specified in contract documents.

Occasionally, the size of the abrasive will be specified for a cleaning job, but more often, only the profile size will be specified (and is the preferred method). You can check abrasive size with sieve analysis as described in ISO 11125-2 and 11127-2 for metallic and nonmetallic abrasives, respectively. Or you can check abrasive size using ASTM C136, Test Method for Sieve Analysis of Fine and Coarse Aggregates, which is referenced in SSPC-AB 1 and AB 3. The sieve analysis is conducted with screens readily available from industrial supply houses.

You can check profile height per ASTM D4417, Standard Test Method for Field Measurement of Surface Profile of Blast Cleaned Steel, with replica tape, visual comparators, or digital profilometers to see that it conforms with specifications. If the profile height is greater than the specified range, then use smaller abrasive. If the profile height is less than specified, then use larger abrasive. SSPC-PA 17, Procedure for Determining Conformance to Steel Profile/Surface Roughness/Peak Count Requirements, provides requirements for determining compliance with the specified profile range.

Operating Mix

When recycling abrasive in a centrifugal blast machine, a field-portable recycling system, or a vacuum blaster, abrasive will break down. As the abrasive is used, it breaks up and is worn down as it impacts with the work surface. A separator in the recycling system should remove abrasive "fines," that is, particles that are too small to be useful for cleaning. Add fresh abrasive to the system at regular intervals to account for the loss from breakdown and to maintain an operating mix of abrasive sizes that will effectively clean the steel and create a consistent profile.

Quality Control

You can make sure that the abrasive you use will not have a detrimental effect on coatings performance by making a few routine checks, such as testing for cleanliness in a jar of water, measuring abrasive size with a sieve analysis, and measuring profile with replica tape.

More elaborate testing, such as conductimetric analysis or laboratory testing for salts, may be required in some instances. JPCL

Correction to September ATB

On p. 16 of the September 2013 Applicator Training Bulletin, "Tools and Methods of Hand Tool Cleaning," the following statement should read as follows. "For example, if a bid specification calls for a steel surface to meet C ST2, it tells the applicator that the initial condition of the steel is rusted and it must be hand tool cleaned and have a faint metallic sheen, as shown in the photo depicting C ST2." The original statement incorrectly references "C SA2."

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Kelly-Moore Paint Co., Inc.
Kolona Painting & General Construction, Inc.
Landmark Structures
Long Painting Co.
Magnum Energy Services LTD.
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Puget Sound Coatings Inc.
Quality Coatings of Virginia, Inc.
Redwood Painting Co., Inc.
Rust-Oleum Corp.
Shinko Co. Ltd.
Sil Industrial Minerals, Inc.
South Bay Sand Blasting & Tank Cleaning
StonCor Group Canada–Carboline/Plasite Coatings Group
Sturgeon Services International
Surface Technologies Corp.
T. F. Warren Group
Tank Industry Consultants, Inc.
Termarust Technologies
The Brock Group
Tri-Krete Coatings Inc.
TSC Training Academy
V.H.P. Enterprises, Inc.
Williams Specialty Services, LLC

Patron Members

360 Construction Co., Inc.
A & K Painting Co., Inc.
A & S Industrial Coatings
A-1 Coatings Co.
A. Laugeni & Sons, Inc.
A. W. Chesterton Co.
AA-1 Services, Inc.
ABC Applicators, Inc.
Abeka Celik–Abeka Steel Co.
Aberfoyle Metal Treaters Ltd.
ABESCO Construction Development Corp.
Ability With Innovation LLC (AWI)
Abrasives Inc.
ABS–American Bureau of Shipping
Absolute Equipment
Abu Dhabi Construction Co.
ACME Industrial Piping
Adelphi Inc. DBA G-Force Contracting
Advanced Industrial Services, Inc.
Advanced Painting Systems Inc.
Advanced Polymer Coatings, Ltd.
Advanced Recycling Systems, Inc.
Advantage Steel and Construction LLC
Aetna Bridge Co.
Ahern Painting Contractors, Inc.
AIR Systems International
AJC Sandblasting Inc.
Akzo Nobel International Paint (Suzhou) Co., Ltd.
Al-Jazeera Paints Academy
Alabama Painting, Inc.
Alaron Nuclear Services
All Painting Contractors Inc.
All-Safe Industrial Services, Inc.
All-Star Cleaning & Preservation
All-States Painting, Inc.
Allied Painting Inc.
Allnex USA Inc.
AlpAccess
Alpha Painting and Construction Co.
ALS Industrial Services
American Construction & Coatings LLC
American Industrial Hygiene Assoc.
American Suncraft Construction
American Tank & Vessel, Inc.
Americlean
Ameritec Industrial & Commercial Coatings
Amherst Maintenance Inc.
Amstar of Western New York
Anchor Paint Mfg. Co.
Anka Painting Co., Inc.
Anticorrosivos y Acabados AYA
APBN Inc.
Applewood Painting Co.
Applied Coatings & Linings
Applied Corrosion Technology Co. LLC
Arena Painting Contractors, Inc. (APC)
Arid Dry by CDIMS
Arizona Coating Applicators, Inc.
Armour Painting & Cleaning Services Inc.
Arrow Construction Co., Inc.
Astron General Contracting Co., Inc.
Atlantic Design Inc.
Atlantic Painting Co., Inc.
Atlas Painting & Sheeting Corp.
Atlas Steel Coatings Inc.
Automatic Coating Ltd.
Axxiom Manufacturing Inc.
B&B Corp.
Banchang Protective Coating Limited Partnership
Banjobphan Engineering Co., Ltd.
Barnes Painting
Barton International
BASE Group
BASF Corp.
Basic Industries, Ltd.
Bass Rocks Construction Corp.
Bayer MaterialScience Trading (Shanghai) Co., Ltd.
Baytown Painting, Inc.
Bazan Painting Co.
Beach Coatings, Inc.
Belzona
Bilton Welding & Manufacturing Ltd.
BIS Salamis, Inc.
BJC Heavy Industries Ltd.
Black Bear Coatings & Concrete
Blackstone Contracting Group
Blastal Coatings Services, Inc.
Blastech Enterprises, Inc.
Blastline Institute (BISP)
Blastrite Pty. Ltd.
Blendex Industrial Corp.
Boville Industrial Coatings Inc.
Bridges R Us Painting Co., Inc.
Buckman Laboratories, Inc.
Bullard Co.
BYK Additives & Instruments
C & K Johnson Industries, Inc.
C.A. Hull
C.E. Adkins & Son Inc.
C.W. Beal, Inc.
Cabrillo Enterprises, Inc., dba R.W. Little Co.
Cactus Coatings Ltd.
Caldwell Tanks, Inc.
California Engineering Contractors, Inc.
Caligari Gerloff Painting, Inc.
Camabo Industries Inc.
CanAm Minerals/Kleen Blast Abrasives
Canfield & Joseph, Inc.
Cape Environmental Management Inc.
Capitol Finishes, Inc.
Cardolite Corp.
Carneys Point Metal Processing, Inc.
Carolina Painting Co., Inc.
Carr Coatings, LLC
Catamount Environmental, Inc.
CavCom Inc.
CB Tech Services, Inc.
CCI Industrial Services
CCS Consulting Service, Inc.
CDV Industrial EIRL
Cekra Inc.
Central Sandblasting Co., Inc.
Century Industrial Coatings
Certified Coating Specialists Inc.
CESCO/Aqua Miser
Chariot Robotics
Chicago Area Painting Apprenticeship School
Chlomil, Inc., dba Phoenix Maintenance Coatings
Chlor*Rid International
Church & Dwight Co., Inc.
Cianbro Corp.
Clara Industrial Services Limited
Clark & Pattison (Victoria) Ltd.
Classic Protective Coatings, Inc.
CleanBlast, LLC
Cleaner Blast
Clemtex, Inc.
CMP Coatings, Inc.
Coastal Cleaning LLC
Coastal Coatings, Inc.
Coating Services, Inc.
Coating Systems, Inc.
Coatings & Painting, LLC
Coatings Unlimited Inc. (WA)
Coatings Unlimited, Inc.
Coblaco Services, Inc.
Colonial Processing, Inc.
Colonial Surface Solutions, Inc.
Color Works Painting, Inc.
Commercial Sand Blasting & Painting
Commercial Sandblast Co.
Commodore Maintenance Corp.
Concare Inc.
Consulex
Copia Specialty Contractors, Inc.
Corcon Inc.
Corporacion MARA S.A.
Corporación Peruana de Productos Químicos S.A.
Corrosion and Abrasion Solutions Ltd.
Cosmos Industrial Services Inc.
County Group Companies
Crescent Coatings & Services, Inc.
Crown Painting, Inc.
CSI Services, Inc.
Culbertson Contractors
Custom Engineering Co.
Cypress Bayou Industrial Painting, Inc.
D.H. Charles Engineering, Inc.
DACA LLC
Dampney Co., Inc.
Daubert Chemical Co.
Davis Boat Works, Inc.
Dawson-Macdonald Co., Inc.
DeFelsko Corp.
Dehumidification Technologies, LP
Delta Coatings, Inc.
Demos Painting & Decorating, Inc.
Denso North America Inc.
Derochie Painting Ltd.
Derrick Co. Inc.
DESCO Manufacturing Co., Inc.
Detroit Painting & Maintenance, Inc.
Detroit Tarpaulin, Inc.
Devco Sandblasting & Ind. Coatings Inc.
Devox S.A.
Diamond Vogel Paint Co.
Distribuidora Kroma S.A. de C.V.
Diversified Container
Dixon Engineering, Inc.
DMA Floors
Doosan Portable Power
DRS Environmental Systems
DRYCO, LLC
Dubai Coating Limited
Dumond Chemicals
Dun-Right Services
Dunkman Paint & Wallcovering, LLC.
Dunlap, Inc.
Duoleng New Material Co., Ltd.
Dur-A-Flex, Inc.
Dura-Bond Pipe, LLC
E. B. Miller Contracting, Inc.
E. Caligari & Son, Inc.
E.J. Chris Contracting Inc.
Eagle Painting & Maintenance Co.
Eagle Specialty Coatings
Earl Industries, LLC
EASE Painting and Construction
East Coast Painting & Maintenance, LLC
Eco CorFlex
EcoQuip, Inc.
EDCO–Equipment Development Co., Inc.
EDECO Peru S.A.C
Elcometer
Elektro-Physik USA, Inc.
ELINERS
EMI International LLC
EMW Industrial
EnDiSys
Endura Manufacturing Co. Ltd.
ENECON Corp.
EnTech Industries, LLC
Environmental Coating Services LLC

Continued

SSPC Organizational Members

Environmental Planning & Management
EPAcoat, Inc.
EPMAR Corp.
Era Valdivia Contractors, Inc.
Erie Painting and Maintenance, Inc.
Ervin Industries
Euro Paint LLC
Euro Style Management, Inc.
Evonik Degussa Corp.
Excalibar Minerals LLC
Excel Engineering & Contracting Co.
Extreme Coatings, Inc.
F.T. Farfan Limited
F.T.I. District Council 57 J.A.T.F.
Farr Construction Corp.
Farwest Corrosion Control Co.
FCS Group LLC
Fedco Paints and Contracts
Finishing Plus
Finishing Systems of Florida, Inc.
Fischer Technology, Inc.
Forecast Sales
Frey Coating Solutions, Inc.
FTI of DC77
Fuel Tank Maintenance
Fuller Western
G & M Painting Enterprises, Inc.
G & S Manufacturing LLC
Gaditana de Chorro y Limpieza, S.L.
GapVax Inc.
Garden State Council, Inc.
Gartner Coatings, Inc.
Gateway Industrial Services
Gemstone, LLC
General Coatings Corp.
General Dynamics NASSCO–Earl Industries (fma United Coatings Corp.)
General Dynamics/Information Tech.
General Insulation, Inc.
Geoblaster Equipment
George G. Sharp, Inc.
Gill Industries, Inc.
Glavin Coating & Refinishing Ltd.
GMA Garnet (USA) Corp.
Golden Triangle Industries, Inc., dba Pro-Cure
Goodman Decorating Co., Inc.
Goodwest Linings and Coatings
GPI Southeast, Inc.
GPPC, Inc.
Graco Inc.
Green Diamond Sand Products
Greener Blast Technologies
Groome Industrial Service Group
Growell Blastec Co., Ltd.
GS Engineering & Construction Corp.
Gulf Coast Contracting, LLC
Gunderson, Inc.
Guzzler Manufacturing, Inc.
H.I.S. Painting, Inc.
Hadek Protective Systems Inc.
Hadley Brothers Painting, Inc.
Hall Industrial Contracting, Ltd.
Hanes Supply, Inc.
Haraco Services Pte. Ltd.
Harrison Muir, Inc.
Hartman-Walsh Painting Co.
HCI Chemtec Inc.
HCI Industrial & Marine Coatings Inc.
HDR-Schiff Associates
Hempel-HaiHong
Henkels & McCoy
Hercules Painting Co.
High Steel Structures, Inc.
Highland International, Inc.
HippWrap Containment
HoldTight Solutions Inc.
Honolulu Painting Co., Ltd.
Howell & Howell Contractors, Inc.
HRV Conformance Verification Associates, Inc.
Hunnicutt's, Inc.
Huntsman Polyurethanes
IBIX North American Headquarters Surface Technologies LLC
Icarus Industrial Painting & Contracting Co., Inc.
IDS Blast Finishing
IMETECO S.A.
Impresa Donelli, S.R.L.
In-Spec Corp. Pte. Ltd.
Indian Valley Industries, Inc.
Induron Coatings, Inc.
Industrial Corrosion Control, Inc.
Industrial Marine, Inc.
Industrial Painting Limited, Inc.
Industrial Painting Specialists
Industrial Technical Coatings, Inc.
Industrial Vacuum Equipment Corp.
Insulating Coatings Corp.
Intech Contracting LLC
Integrated Structural Concepts
Inter-City Contracting, Inc.
InterMoor Inc.
International Flooring & Protective Coatings, Inc.
Interpaints SAC
Intertek Industry Services
Ionion Painting
IPAC Services Corp.
Iron Bridge Constructors, Inc.
ISG, dba Universal Inc.
IUPAT, District Council #5
J. Goodison Co., Inc.
J. Mori Painting Inc.
JAD Equipment Co. Inc.
Jag'd Construction, Inc.
Jal Engineers Pvt. Ltd.
Jamac Painting & Sandblasting Ltd.
Jeffco Painting & Coating, Inc.
Jerry Thompson & Sons, Inc.
Jet De Sable Houle Sandblasting Ltd.
Joaquin Riera Tuebols S.A.
John B. Conomos, Inc.
John W. Egan Co., Inc.
Jos. Ward Painting Co.
Jotun Coatings China
Joyce Safety Industrial Co. Ltd.
Jupiter Painting Contracting Co., Inc.
K.V.K. Contracting Inc.
Kane, Inc.
Keene Coatings Corp.
Kennametal Inc.
Kern Steel Fabrication, Inc.
Kimery Painting, Inc.
Kiska Construction, Inc. (KCI)
Klicos Painting Co., Inc.
KMX Painting, Inc.
KNK Painting & Coating, Inc.
Knowles Industrial Service Corp.
L & L Painting Co., Inc.
L. Calvin Jones
L. F. Clavin & Co., Inc.
L.M. Temperature Control, Inc.
LBI, Inc.
Ledcor Coating & Insulation Ltd.
Leighton Associates, Inc.
Liberty Maintenance, Inc.
Limnes Corp.
Lindner Painting, Inc.
Line-X Corp.
Linita Design and Mfg. Co., Inc.
Lithko Restoration Technologies
Llamas Coatings
LorRich Enterprise, Ltd.
Luckinbill, Inc.
Luoyang Hong Feng Refractories and Abrasives Co. Ltd.
M & D Coatings Inc.
M & J Construction Co.
M & R Painting, Inc.
M Shiroma Painting Co., Inc.
M. Painting Co., Inc.
M. Pallonji & Co. Pvt. Ltd.
MacDonald Applicators Ltd.
Madison Chemical Industries Inc.
Madison Coating Co., Inc.
Maguire Iron, Inc.
Main Industries Inc.
Mandros Painting, Inc.
Manolis Painting Co., Inc.
Mansfield Industrial
Manus Abrasive Systems, Inc.
Marcom Services, LLC
Marine & Industrial Coatings, LLC
Marine Metal Coatings, Inc.
Marine Specialty Painting
Marine Steel Painting Corp.
Marinis Bros., Inc.
Mascoat Products
Mason Painting, Inc.
Matheson Painting
Matsos Contracting Corp
Max Access, Inc.
Maxlife Coatings
MB Environmental Consulting
McCormick Industrial Abatement
McCormick Painting Co.
McElligott Partners Pty. Ltd.
McKay Lodge Conservation Laboratory
MCSA (Mantenimiento y Construcciones, S.A)
Metain S.A.
METCO Materials Evaluation & Tech. Corp.
Michelman-Cancelliere Iron Works
Midsun Specialty Products Inc.
MIK Industrial LLC
Miller Precision Manufacturing and Integration
Milspray LLC
Minerals Research & Recovery, Inc.
MMLJ, Inc.
Modern Protective Coatings, Inc.
Mohawk Garnet, Inc.
Monarflex by Siplast
Monoko, LLC
MONTI Tools Inc.
Mosebach Manufacturing Co.
MST Inc. (Modern Safety Techniques)
MTEST
Municipal Tank Coatings
Murphy Industrial Coatings
N. A. Logan, Inc.
N G Painting, LP
N. I. Spanos Painting, Inc.
NACE International–The Corrosion Society
National Coating and Linings Co.
National Coatings, Inc.
Natrium Products, Inc.
Negocios Metalurgicos SAC
Nelson Industrial Services, Inc.
New England Sandblasting and Painting
NexTec Inc.
Niagara Coatings Services, Inc.
NM Caribbean Insulation Services Ltd.
NOR-LAG Coatings Ltd.
Norfolk Coating Services, LLC
North West Tank Lining & Inspection Inc.
Norton Sandblasting Equipment
Novatek Corp.
Novetas Solutions
NUCO Painting Corp.
Nuplex Resins LLC
O.T. Neighoff & Sons, Inc.
Odle, Inc.
Oil States Industries (Asia) Pte. Ltd.
Oilgon Solutions Sdn Bhd
Olimag Sand, Inc.
Olympus & Associates, Inc.
Olympus Painting Contractors, Inc.
Ontario Painting Contractors Association
OPT CO
Opta Minerals, Inc.
Optimiza Protective & Consulting, SL
Oregon Iron Works, Inc.
Orfanos Contractors, Inc.
P & S Painting Co., Inc.
P & W Painting Contractors Inc.
P S Bruckel Inc.
P.C.I. International, Inc.
Pacific Dust Collectors and Equipment
Pacific Painting Co., Inc.
Pacific Titan, Inc.
Pacific Yacht Refitters Inc.
Paige Decking
Paige Floor Covering Specialists
Paint Inspection Ltd.
PaintEcuador
Panco Resources and Engineering Consultancy Services
Panther Industrial Painting, LLC
Paragon Construction Services of America Inc.

SSPC Organizational Members

Park Derochie, Inc.
Paso Robles Tank, Inc.
Paul N. Gardner Co., Inc.
PCI Advanced Protective Coating
PCI Roads, LLC
PDM Bridge LLC
Peabody & Associates, Inc.
Pen Gulf, Inc.
Performance Blasting & Coating
Petrochem Insulation Inc.
Phillips Industrial Services Corp.
Phoenix Development & Construction, Inc.
Phoenix Fabricators & Erectors Inc.
PhotoFusion Inc.
Piasecki Steel Construction Corp
Pinnacle Central Co.
Pinovo AS
Planet Inc.
Plasma Coatings
Plastic Powder Coating Co. LLC
Poly Delta Coatings
Polyguard Products
Pop's Painting
Poseidon Construction
PPG Industries China
Praxair Surface Technologies
Precision Industrial Coatings, Inc.
Preferred, Inc.–Fort Wayne
Prime Coatings, Inc.
Pro-Spec Painting, Inc.
Professional Application Services, Inc.
PROINBEL
Prospectrum Coatings BVBA
Providence Painting, Inc.
PT Berger Batam
Public Utilities Maintenance, Inc.
Purcell P & C, LLC
Purdy Corp.
QED Systems, Inc.
Qindao Advanced Marine Material Technology Ltd.
Quality Linings & Painting, Inc.
Quantum Technical Services
Quincy Industrial Painting Co.
Quinn Consulting Services, Inc.
R & B Protective Coatings, Inc.
Rainbow, Inc.
Raven Lining Systems
Raydar & Associates, Inc.
Recal Recubrimientos, SA de CV
Redi-Strip Metal Cleaning Canada Ltd.
Reglas Painting Co., Inc.
Rhino Linings Corp.
Righter Group, Inc.
Ring Power Corp.
RML Construction
Robert W. Britz Co., Inc.
Rockwood Corp.
Rogers Industries
Rotha Contracting Co., Inc.
Roval USA Corp.
Royal Bridge Inc.
Royce International LLC
RPN Recubrimientos Polymericos Del Noroeste
Rust Bullet, LLC
S & D Industrial Painting Inc.
S & S Bridge Painting, Inc.
S & S Coatings, Inc.
S. David & Co., Inc.
Sabelhaus West, Inc.
SAFE Systems, Inc.
Safety Lamp of Houston
Saffo Contractors, Inc.
Safway Services, LLC
Sahara Sandblasting and Painting Ltd.
Samac Painting
Sand Express
Sauereisen
Scott Derr Painting Co.
Seal For Life Industries LLC
Sealteks, Inc.
Seaside Painters & Sandblasters
Seaway Painting LLC
Secondary Services, Inc.
Seifert Construction Inc.
Seminole Equipment, Inc.
Service Contracting, Inc.
Servicios Tecnicos Industriales y Maritimos, S.A. (SETIMSA)
Seymour Midwest
Shanghai Congsheng Coating Equipment Co. Ltd.
Shanghai Liangshi Blasting & Coating Equipment Co. Ltd.
Shanghai Zenhua Heavy Industry Group
Shenzhen Asianway Corrosion Protection Eng. Co., Ltd.
Sherwin Williams Brasil
Sherwin-Williams Industrial & Marine Coating China
Shopwerks Inc.
Sigma Enterprises LLC
Simpson Sandblasting and Special Coatings, Inc.
Skinner Painting & Restoration
Skyline Steel LLC
SME Steel Contractors
Smith Construction Group
Soep Painting Corp.
Soil & Materials Engineers, Inc.
Southern Paint & Waterproofing Co.
Southern Road & Bridge, LLC
Southland Painting Corp.
Spartan Contracting, LLC
Specialty Application Services, Inc.
Specialty Finishes, LLC
Specialty Groups, Inc.
Specialty Polymer Coatings, Inc.
Specialty Products, Inc.
Spensieri Diversified LLC
Spider
Sponge-Jet, Inc.
SRI Construction LLC
Stantec
Steel Fabricators of Monroe, LLC
Steel Management System, LLC
Steele Consulting Inc.
Stork Technical Services
Stork Technical Services USA, Inc.
Structural Coatings, Inc.
Stuart Dean Co., Inc.
Sulzer Mixpac USA, Inc.
Sunbelt Rentals
Super-Flex LLC
Superior Industrial Maintenance Co.
Superior Painting Co., Inc.
Surface Prep Supply
Surface Preparation & Coatings, LLC
Sutton Corrosion Control, Inc.
SVMB
Swalling Construction Co., Inc.
Swanson & Youngdale, Inc.
Symmetric Painting, LLC
T & W Industrial Services LLC
T-Tex Equipment L.P.
Tamimi Co. Commercial Division
Tank Services, fma Midwest Tank Services, Inc.
Tarpon Industrial, Inc.
Tarps Manufacturing, Inc.
TDA Construction, Inc.
TDJ Group, Inc.
Techno Coatings, Inc.
Tecnico Corp.
Temp-Coat Brand Products, LLC
Terry Mcgill Inc.
Tesla NanoCoatings, Inc.
Testex, Inc.
Texas Bridge, Inc.
TFT-Pneumatic, LLC
The Aulson Co., Inc.
The Aulson Co., LLC
The Blastman Coatings Ltd.
The Corrosion Institute of the Caribbean
The Gateway Co.
The Nacher Corp.
The Rodriguez Corp.
The Rose Corp.
The Warehouse Rentals and Supplies
Thermoset Resin Formulators Association TRFA
Thomarios
Thomas Industrial Coatings, Inc.
Thomson & Thomson, Inc.
Tidal Corrosion Services LLC
Tidewater Staffing, Inc.
Timco Blasting & Coatings, Inc.
Tioga, Inc.
Titan Industrial Services
TJC Painting Contractors, Inc.
TMI Coatings, Inc.
TMS Metalizing Systems, Ltd.
TOA Paint (Thailand) Co., Ltd.
Topline Limited
Tower Inspection Inc.
Tower Maintenance Corp.
TQC B.V.
Tractel Inc., Griphoist Division
Travis Industries, Inc.
Tri-State Painting, Inc.
Trimaco LLC
TruQC LLC
Turman Commercial Painters
Turner Coatings Inc.
Turner Industries Group, LLC
UHP Projects, Inc.
Umicore Hunan Fuhong Zinc Chemicals Co. Ltd.
Uni-Ram Corp.
Unifab Industries, Ltd.
United Decorating Inc.
Universal Acoustic & Emission Technologies, Inc.
US Coatings, Inc.
US Minerals/Stan Blast
Utility Service Co., Inc.
V & T Painting LLC
V. V. Minerals Private Limited
Van Air Systems
Vanwin Coatings of VA, LLC
Venus Painting
Vermillion Painting & Construction
VersaFlex Incorporated
Versatile Painting & Sandblasting
Ville Platte Iron Works, Inc.
Vimas Painting Co., Inc.
Vision Painting & Decorating Services, Inc.
Vision Point Systems
VMP Research & Production Holding JSC
VRSim, Inc.
Vulcan Painters, Inc.
W Abrasives
W Q Watters Co.
W S Bunch Co.
W. W. Enroughty & Son, Inc.
Wagner Systems Inc.
Washington Industrial Coatings, Inc.
Wasser High-Tech Coatings, Inc.
Watson Coatings Inc.
Waveland Services Inc.
Wenrich Painting, Inc.
West Coast Coatings & Equipment LLC
Western Industrial Services, Ltd.
Western Industrial, Inc.
Western Technology, Inc.
WGI Heavy Minerals, Inc.
Wheelabrator
Wheelblast, Inc.
WIWA LP
Wolf Installations, Inc.
Wooster Brush Co.
Worldwide Industries, Inc.
Worth Contracting
Wuhan Hengyitong Corrosion Engineering Co. Ltd.
Wuxi Ding Long Trading Co., Ltd.
X'lam Leeo Technology Co., Ltd.
Xinjiang Hongshan Coatings Co., Ltd.
Yejian New Material Co., Ltd.
Yellow Creek Coating Services
YungChi Paint & Varnish (Kunshan) Co., Ltd.
YYK Enterprises, Inc.
Zachry Industrial, Inc.
Zebron Corp.
Ziegler Industries Inc.
ZRC Worldwide

JPCL