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The Voice of SSPC: The Society for Protective Coatings

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SSPC The Society For Protective Coatings

Staff

Editorial:

Editor in Chief: Karen A. Kapsanis / kkapsanis@paintsquare.com
Managing Editor & Directory Manager: Anita M. Socci / asocci@paintsquare.com
Editorial Assistant: Charles Lange / clange@paintsquare.com
Technical Editor: Brian Goldie / brianpce@aol.com

Contributing Editors:

Rob Francis, Gary Hall, Robert Ikenberry, Alan Kehr, Robert Kogler, Vaughn O'Dea, E. Bud Senkowski, Lloyd M. Smith, PhD, Dwight Weldon

Production / Circulation:

Director, Production Operations:
Milissa M. Bogats / mbogats@paintsquare.com
Art Director: Peter F. Salvati / psalvati@paintsquare.com
Production/Design Assistant: Daniel Yauger / dyauger@paintsquare.com
Production Assistant: Ken Tator / ktator@paintsquare.com
Circulation Manager: JoAnn Binz / jocbinz@aol.com

Ad Sales Account Representatives:

Publisher: Marian Welsh / mwelsh@paintsquare.com
Bernadette Landon / blandon@paintsquare.com
Bill Dey / bdey@paintsquare.com
Classified and Service Directory Manager:
Lauren Skrainy / lskrainy@paintsquare.com

PaintSquare:

Director of Operations: Andy Folmer / afolmer@paintsquare.com
Director of Technology: D'Juan Stevens / dstevens@paintsquare.com
Digital Media Production Manager: Tricia Chicka / tchicka@paintsquare.com
Vice President, Content and Marketing: Pamela Simmons / psimmons@paintsquare.com

SSPC:

SSPC Individual Membership: Terry McNeill / mcneill@sspc.org
SSPC Organizational Membership: Ernie Szoke / szoke@sspc.org

Finance:

Accounting Manager: Michele Lackey / mlackey@technologypub.com
Andrew Thomas / athomas@technologypub.com

Assistant to the President: Larinda Branch / lbranch@technologypub.com
President and CEO: Peter Mitchel / pmitchel@technologypub.com
President, International Operations: Harold Hower / hhower@technologypub.com

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SSPC's Annual Report

In this month's issue of *JPCL*, the SSPC annual report is presented. I feel that one of our most important staff functions is to communicate to our members the status of their association. In this annual report, we give a breakdown of significant accomplishments for the 2012 fiscal year, including membership growth, the breakdown of training classes and, lastly, a report of the financial status at the end of the year. I am glad to report—and the Board of Governors can verify—that SSPC remains fiscally strong, with membership and training both growing.

When I came to SSPC, the conference was the event that determined our financial success for the year. If we had a strong conference, we had a good year and, of course, the opposite was also true. We now have seven revenue centers that are fairly equal in their importance to the organization.

As I have noted many times in editorials, training and certification, both individual and corporate, have become the hallmarks of SSPC. And membership, both individual and corporate, and publications sales remain vital to the health of the organization. The development of additional revenue centers began in 1986 when a group of contractors started working on the Painting Contractor Certification Program (PCCP) that was eventually adopted in 1989. Training expansion really started in 1995 with the development of the C-1, Fundamentals of Protective Coatings, and the C-3, Lead Paint Removal Courses. Prior to then there had been other small courses given, but C-1 and C-3 began the momentum of expanded training delivery that carries on today. We now offer 41 courses, and 13 of those have a certification element tied to them. This shows the growth in products and services we now offer. Please take the time to read the annual report on page 65.

Next month's editorial will deal with an interesting article I read on leadership and why some executives fail. I find leadership to be an interesting topic that everyone can relate to whether they are in charge of a small organization such as SSPC or a large multi-national corporation employing thousands of people.

Bill Shoup

Bill Shoup
SSPC Executive Director

Webinar Explores Offshore Passive Fireproofing

PAINTSQUARE.COM jpcl SSPC The Society For Protective Coatings
Webinar Education Series

In April, the 2013 SSPC/*JPCL* Education Webinar Series continues with a free webinar investigating the requirements and certification necessary for offshore use of passive fireproofing materials.


Sean Younger

"Achieving Passive Fire Protection Offshore," presented on Wednesday, April 17, from 11:00 a.m. until noon, EST, will explain the required fire test standards, environmental exposures, and physical property testing, discuss the benefits and applications of industrial epoxy intumescent fireproofing materials, and review keys to success when installing epoxy intumescent systems.

Presenting this webinar will be Sean Younger, Fireproofing Market Specialist at the Carboline Company. Younger has been involved in the development, testing, and application of fireproofing products since 2000, gaining technical experience with both cementitious and intumescent fireproofing while working with Nu-Chem, Inc. and Carboline. He has provided extensive field support for many domestic and international fireproofing projects, including fixed offshore installations, floating production vessels, onshore processing plants, petrochemical plants, and many light industrial and commercial applications. For the past four years, Younger has been involved in fireproofing product line management, product testing, and new product development for Carboline. This webinar is co-sponsored by Carboline and Graco.

Registration, CEU Credits

This program is part of the SSPC/*JPCL* Webinar Education Series, which provides continuing education for SSPC re-certifications and technology updates on important topics.

SSPC is an accredited training provider for the Florida Board of Professional Engineers (FBPE), and Professional Engineers in Florida may submit SSPC Webinar Continuing Education Units to the board. To do so, applicants must download the FBPE CEU form and pass the Webinar Exam, which costs $25.

Register for this online presentation at www.paintsquare.com/webinars.

Industry Vet Opens Consulting Firm

Alison B. Kaelin, former Environmental, Health, and Safety Manager and Quality Assurance Manger for KTA-Tator, Inc., has left the company to open her own consulting firm. ABKaelin, LLC, headquartered in Pittsburgh, PA, will provide outsourced quality assurance, auditing, and consulting services to the protective coatings, construction, fabrication, and nuclear industries.

Kaelin plans to use her 25 years of experience to provide independent quality assurance support and auditing services related to compliance with 10 CFR 50, Appendix B and ASME NQA-1. Additionally, she will provide program review and development services, consulting, training, and contractor certification support.


Alison B. Kaelin

ABKaelin will also provide training and training program development, including:

- SSPC's C3, C5, Lead, Competent Person, and Safety;
- Coatings and Auditor training;
- Quality Assurance, Total Quality Manager, and Quality Control Supervisor training;
- OSHA 10- and 30-hour safety training;
- Client-specific training; and
- Environmental, Health and Safety training.

ABKaelin is in the process of obtaining certification as a woman-owned business enterprise. That certification should be completed later in 2013.

Kaelin is a NACE Certified Coatings Inspector, a Certified Quality Auditor through the American Society of Quality, and meets the requirements of a Lead Quality Auditor in the nuclear industry through ANSI N45.2.23. She was also the primary technical editor and instructor of the SSPC-C3 course. Kaelin won a *JPCL* Editors' Award at SSPC 2013, was a *JPCL* Top Thinker in 2012, and received SSPC's Technical Achievement Award in 2005.

SSPC Forms New Polymer Flooring Advisory Committee

SSPC has formed a new advisory committee for users, applicators, and suppliers of polymer flooring coatings applied to concrete.

The Polymer Flooring Advisory Committee:

- **advises the SSPC staff of public perceptions that affect industry confidence in the QP 8 certification program. (e.g. complaints, concerns);**
- **coordinates with the SSPC staff to sponsor special SSPC events (e.g. contractor meetings, town hall meetings, facility owners breakfasts, etc.);**
- **provides feedback to the SSPC staff on training or certification program initiatives or interpretations related to the polymer flooring industry;**
- **recommends possible projects or new standards to the C.7.1 committee; and**
- **advises SSPC staff on marketing and promotion initiatives for topics related to polymer floor coating.**

Additional information can be found at http://www.sspc.org/membership/polymer-flooring-home/.

If you are interested in becoming a member of this advisory committee, please contact Aimee Beggs at beggs@sspc.org.

Doug Wade: 1949–2013

On January 30, Douglas "Doug" Wade, former Field Superintendent, Operations Manager, and Director at NWS Inspection, Inc., passed away in Calgary, Alberta, Canada.

Douglas Wade

Wade was an SSPC Protective Coatings Specialist with almost 45 years of experience in the field. His career began in 1968 at H.M. Wade & Co., Ltd., his father's abrasive blasting and coating business. In 1975, Wade took over as president of the company, which became D.H. Wade & Co., Ltd.

Wade joined Kerr's Oilfield Coating Consultants in 1981 as a field inspector. In 1986, when the company became MoKer Coating Inspection Ltd., he was promoted to Field Superintendent, Operations Manager, and Director. He held that position through 1993, when the company became NWS Inspection, Inc., until his death.

Wade was a member of NACE International and served on SSPC's Board of Directors for the Southern Alberta and Saskatchewan Chapter. He was featured in the Protective Coatings Specialist column in the August 2012 *JPCL*. He is survived by his mother, Violet; his wife of 23 years, Monica; and other relatives and friends.

International Paint Opens Singapore HQ

International Paint, an AkzoNobel company, opened its new global Marine Coatings headquarters in Singapore, expanding the company's presence in the Asia-Pacific markets, where a significant proportion of global maritime activity takes place.

The company selected Singapore due to its strategic importance to customers and the wider shipping industry, as well as its central location within Asia.

The opening ceremony was attended by International Paint employees, customers, and the AkzoNobel Executive Committee member responsible for Performance Coatings, Leif Darner. Oscar Wezenbeek, Director sBU Marine Coatings, spoke at the ceremony, and the Guest of Honour was His Excellency Johannes W.G. Jansing; Ambassador of the Kingdom of the Netherlands to Singapore.

The company also unveiled two new fouling control products at the ceremony.

JPCL

Most of the stories on pp. 6 and 7 and more news can be found on PaintSquare News, *JPCL*'s sister publication, a free daily newsletter. To sign up for the newsletter, go to paintsquare.com/psn.

Problem Solving
Forum

On Sealing Cracks in Concrete

What is the most effective practice for crack sealing in concrete to prevent water intrusion in wastewater collection systems?

From Haktan Sahin
Sika Services AG, Switzerland

Reinforced concrete structures are cracked structures. Not every crack is a failure. If there is a leakage, such as separating cracks, it is clear that they have to be fixed because of exfiltration of the wastewater into the ground.

The most effective way to permanently fix leakages depends on the in situ situation and the required results. Figure 1 shows different requirements and helps to correctly select the materials that are generally used in different conditions. Besides having to be watertight, materials used in wastewater collection systems also have to be durable and resistant to aggressive chemicals.

In addition to the planning and documentation of the injection work, the correct choice of material, the correct equipment (such as packer, pumps) and the correct workmanship (drilling and spacing of the packer) are important. Therefore, a knowledgeable injection applicator is necessary.

		Boundary Conditions—Stage of Moisture			
		Dry	Wet	Flowing water without pressure	Flowing water under pressure
Target	Closing	EP-I, PUR-I, CG-I, CS-I	PUR-I, CG-I, CS-I	PUR-I, ZL-I, ZS-I	PUR-I*, CG-I*, CS-I*
	Waterproofing	EP-I, PUR-I, CG-I, CS-I, AC-I	PUR-I, CG-I, CS-I, AC-I	PUR-I, CG-I, CS-I, AC-I	PUR-I*, CG-I*, CS-I*, AC-I
	Force transmitting	EP-I, CG-I, CS-I	CG-I, CS-I, EP-I	CG-I, CS-I, EP-I	CG-I*, CS-I*
	Ductile	PUR-I, AC-I	PUR-I, AC-I	PUR-I, AC-I	PUR-I*, AC-I

Fig. 1: Material depending on target and stage of moisture

*additional work like e.g., pre-injection with polyurethane foam
EP-I Injection of epoxy resins
PUR-I Injection of polyurethane resins
AC-I Injection of acrylic resins
CS-I Injection of suspensions of microfine cement
CG-I Injection of cementitious grout

From Fred Goodwin
BASF Construction Chemicals LLC

Often the best way to answer a question is with more questions.

- First, why did the crack occur? If the cause of the crack is not considered, then any repair strategy has a greater likelihood of less than desirable performance. For example, if the crack is due to foundation settlement, further settlement will cause the crack to open wider or new cracks to develop. The concrete must be sufficiently sound to even attempt repairs.
- Is water continuously flowing from the crack? The first step is then to stop the flow of water. Leakage can range from slow, weeping leaks to geysers of high-pressure water, and the repair techniques often are different, depending on the flow rate. Materials such as rapid setting hydraulic cement (water plug) can be packed into the crack, or hydrophobic urethanes that rapidly foam and harden injected into the crack have been successful.
- Is the crack moving or dormant? If the crack is moving, then repair with a rigid material such as an epoxy or cementitious

mortar may fill the crack. But when new movement occurs, the crack can either reappear, or appear adjacent to the original crack if the forces responsible for the movement exceed the strength of the concrete and repaired crack. If the repair is performed with a flexible material such as a polyurethane (hydrophobic or hydrophilic) resin or conventional sealant, the water may be stopped, but load transfer through the crack is not addressed. Load transfer through the crack means that movement can reoccur in the crack when it is put into stress and that the structure will no longer act monolithically across the crack. With dormant cracks, this movement does not occur; however, any crack indicates the stress exceeded the strength of the concrete structure at some point in the history of the structure and can reoccur because the crack remains as a plane of weakness within the structure.

- Can the crack be repaired from the positive hydrostatic pressure side? The positive hydrostatic pressure side forces the repair into the concrete. The hydrostatic pressure side is usually easier to seal than the negative hydrostatic pressure side, where the water pressure is trying to remove the material sealing the crack. If the positive hydrostatic side can be accessed, sometimes a film or flexible sheet can be placed against the crack and backfilled to hold it in place. Many times, a combination of repair methods provides the most economical and durable solution.
- What are the environmental and safety concerns? If the crack repair is in a confined space, exposed to potable water, or subject to wetting and drying cycles, some materials may not be suitable. If groundwater contamination by the wastewater is an issue, sealing for both positive and negative hydrostatic pressure may be required. Leakage into or out of the structure may indicate a more severe issue than just the movement of unintended water.
- Where do I learn more? ICRI 340.1, Guide for the Selection of Grouts to Control Leakage in Concrete Structures (formerly No. 03738), provides checklists and guidance on material selection. ACI 350.1 is a specification for environmental containment structures. ISO/TR 16475:2011, Guidelines for the repair of water-leakage cracks in concrete structures, gives guidelines for the selection of a proper grout material to repair water leakage through cracks and other discontinuities in concrete structures.

JPCL

Q&A with Michael Doolittle

By Charles Lange, JPCL

Michael Doolittle is a project manager and former Field Service Manager with Tank Industry Consultants, Inc. (TIC). A 38-year veteran in the coatings industry and a 28-year employee of TIC, Doolittle is a Level III NACE Certified Coating Inspector, a NACE CIP Training Program Levels 1 and 2 instructor, and a PADI Certified Scuba Diver, involved in TIC's underwater tank evaluations. Doolittle lives and works out of TIC's Indianapolis headquarters.

JPCL: What is your background in the coatings industry?

MD: I grew up in Williams Bay, Wisconsin. After high school in the mid-1970s, I worked at the local marina, which owned, operated, and maintained large lake excursion boats. They were in the process of restoring the Yacht Polaris, an excursion boat that was built in 1898 as a private lake steamer for one of the original millionaires on Lake Geneva. The hull was riveted steel, and I ran the sand pot during the blast-cleaning of the hull, and then helped paint it. I remember the paint that was removed, and the paint we applied had a lot of "orange" in it and did not brush on very well. Knowing what I now know, I believe we applied vinyl red lead paint.

Then in the late-70s through the mid-80s, I spent time painting for various companies on ships, bridges, and tanks. My start specifically in water tanks was when I went to work for a water tank painting company from Chicago and worked my way up to foreman.

In 1984, I was foreman on a project in Glencoe, Illinois, where Tank Industry Consultants was the inspection firm. Shortly after the job was completed, I was hired and trained as an inspector by Crone Knoy. At that time, the firm was very small, and Crone had just moved the company out of his home office and into the back of a barbershop in Speedway, Indiana. The company was growing, and the following year I was offered an opportunity in the office to assist with managing the field department and inspection team.

One of the most awesome qualities Crone had was that he took great joy in "developing" people. He would provide a person an opportunity, mentor you, and if you took advantage of the opportunity, he would provide more of them.

JPCL: What qualities make a good coatings inspector?

MD: Honesty comes first. An inspector needs to be completely honest with everyone he or she deals with, or eventually the inspector will get caught and lose credibility. An inspector also needs to like to read. Between standards, technical bulletins, and other information to stay safe and up-to-date on the industry, reading is very important and something I do not see inspectors doing enough of. There is a lot of continuing self-education required to excel at this job. Also, some detective skills are required. An inspector cannot see absolutely everything that goes on during a project. He or she needs to be able to observe a situation, ask the right questions, quickly make an accurate assessment of the situation, and then be able to back up that assessment. Lastly is the ability and desire to travel. Very few projects are "close to home." Generally, if an inspector is working, he or she is traveling.

JPCL: What are some of the most common coatings problems you see with water tanks today?

MD: Coating manufacturers are making both interior and exterior coatings that are expected to perform well for an extended period of time, and although they are expensive, they greatly reduce the cost per year of the tank maintenance. The problem is, in order to obtain the service life, the entire process requires a very high degree of quality, which without consistency and knowledgeable inspection is difficult to obtain.

I also see that many clients are unable to take tanks out of service during time periods that are conducive to painting. Painting under adverse conditions becomes very risky, and it is also very expensive and labor-intensive to provide adequate enclosure, heat, and dehumidification to create the required atmosphere for proper application and curing of the coating. Many contractors are unfamiliar with what it takes to provide the required conditions, and often the cost exceeds expectations. While clients expect the projects to be performed under the adverse conditions, I am not confident that the coatings are going to provide the service life that projects done under more desirable conditions have shown to provide.

JPCL: Did you scuba dive before you did coatings inspection, or did you get into it as a result of the job requirements?

MD: Growing up at the lake, I learned scuba diving as a teenager. At TIC, we discovered in the mid-80s that some owners were having difficulty draining their water tanks for inspection. At that time, we were unaware of anyone that was diving in tanks, and we decided that it could be done safely as long as the tank was valved off and we acquired and used proper safety equipment. Even the technology for underwater photography was just being developed at that time.

JPCL: Have you gotten the opportunity to scuba dive anywhere interesting, outside of just water tanks?

MD: I spent time in the 70s and 80s diving and night diving in the glacier lakes in Wisconsin, but normally I just snorkel with my family in the Caribbean on vacation now. Our firm has commercially certified divers that are much more qualified than I am, and they dive in water tanks all over the world.

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

MD: I have had a great career in this business, from actually doing the work with the tools, getting the opportunity to excel with TIC, and providing what I deem to be a very good service and quality to the many clients over time. If I had to pick out a highlight, it would be my part in working with so many great fellow employees, as well as Crone Knoy, at TIC over the last nearly 28 years. We have developed what I believe is a very high-quality organization and system to assist water tank owners in obtaining the best new or rehabilitated water tank projects possible.

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

MD: I like water sports, such as water skiing and wakeboarding. I spend most of my free time with my wife and 8-year-old son. We also like traveling as a family, although I travel a lot for TIC, too.

JPCL

When a Good Idea Goes Bad

By Rick Huntley, PCS, KTA-Tator, Inc.
Richard A. Burgess, Series Editor

An American tobacco company owned a number of large buildings, essentially steel-framed warehouses covered with corrugated galvanized steel panels, at one of its facilities. The company used the warehouse buildings for the fumigation of the tobacco, during which the entire interior of the building is filled with a gaseous insecticide that kills tobacco-damaging insects.

Unfortunately, the joints of the steel panels were not completely sealed, allowing fumigation chemicals to escape. Therefore, the tobacco company chose to completely seal the building using a polyurea coating system.

Because this coating process was somewhat experimental, only one of the buildings was initially chosen for the application. If the coating application on the first building succeeded, then the additional buildings would also be coated.

The system chosen for application consisted a one-coat epoxy primer, followed by a coat of the polyurea product and a polyurethane topcoat. The 100% solids polyurea material, a two-component coating with a one-to-one mix ratio and a dry-to-touch time of 45 seconds, was reportedly designed to bridge cracks up to 1/8-inch wide. Application required using plural component equipment to apply the coating to a thickness of between 30 mils and 250 mils, in accordance with the product data sheet.

Figure 1: A large blister in the applied polyurea coating system.
Photos courtesy of KTA-Tator, Inc.

A review of the material's product data sheet found no recommendations for preparation or application to previously-painted galvanized steel surfaces. (The previous coating system was not identified.) The product data sheet did, however, call for a deep angular profile for steel surfaces. It also specified that if the surface is to be primed, that the primer should not completely fill the profile. In this case, the previously-painted galvanized steel was prepared using pressurized water to remove any loose coating. The product data sheet also recommended that if the 16-hour recoat time was exceeded between coats of the polyurea material, that the surface should be sanded before application of an additional coat.

Several problems arose during the coating application to the exterior of the fumigation building. The coating system faced adhesion problems, and in some cases blistered and delaminated. As a result, some of the areas were repaired by removing the loose coating and reapplying the polyurea coating. In some areas, several attempts were made to repair the coating. For instance, two of the walls required four repair attempts each. In other cases, an epoxy primer was applied to the polyurea before applications of subsequent polyurea coats in an attempt to attain better adhesion. The manufacturer's representative was present during much of the application.

Faced with the mounting costs of the repair and the uncertainty of the future performance of the coating system, the tobacco company decided to employ an independent coatings consultant to investigate the coating problems.

Field Investigation

A site visit was scheduled to examine the walls of the subject fumigation building, along with the entire roof. The building was covered with a medium gray coating, which exhibited blistering and delamination in sev-

Figure 2: A patch of the polyurea coating was easily separated from the yellow primer but also left small islands of polyurea stuck to the surface.

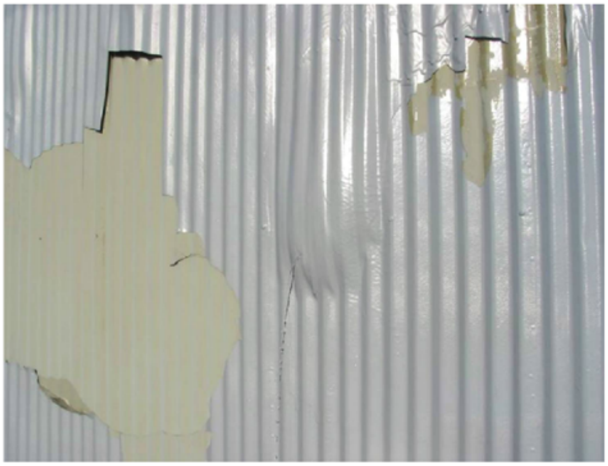


Figure 3: A large "sack" formed by the flexible polyurea coating leaked water when punctured near the base.

eral areas. The blisters were relatively large—some over 1.5 feet wide and 5 feet long—and in many cases, the tops of the blisters were close to a seam in the corrugated galvanized steel building's skin, while in other cases, the blister was in the middle of a panel away from any seam. The blisters also contained a considerable amount of water inside. The large blisters appeared in a teardrop pattern while in other areas the length (measured vertically) of the blisters was much greater than the width (measured horizontally).

In addition to the blistering, the polyurea coating displayed a sizable amount of cracking. Most of the cracks appeared on or around the runs, sags, or other accumulations of coating material. Some cracking also occurred where the coating appeared to be extremely thin.

The coating was delaminated in many areas, and pulling at the edge of the delaminated coating caused the delamination to continue, sometimes for several feet. The plane of delamination varied from location to location. In some areas, especially on the roof, the coating could be easily removed from the epoxy primer. The coating appeared to separate cleanly from the primer, leaving only small islands of gray coating material on the yellow epoxy primer.

In other cases, one thick layer of gray coating material could be removed from another layer of gray coating material. Furthermore, in other areas, a relatively thick layer of coating material was found to be delaminating from a thin amber resinous layer that was on top of another gray coating material. In each of the cases when the coating delaminated, the surface uncovered by the delaminated coating was smooth and exhibited no signs of sanding or other roughening.

A polyurethane topcoat appeared to adhere satisfactorily to the thick polyurea coat, but the polyurethane topcoat, when viewed microscopically, was found to have cracked significantly.

The application of the polyurea coating was extremely uneven, with numerous runs and sags and, as noted above, there were often large cracks in the topcoat along the runs and sags. In general, the polyurea coating was consistently flexible and appeared to have good tensile strength.

Coating samples from the walls and the roof were removed for laboratory analysis, consisting of visual and microscopic examination and infrared spectroscopic analysis.

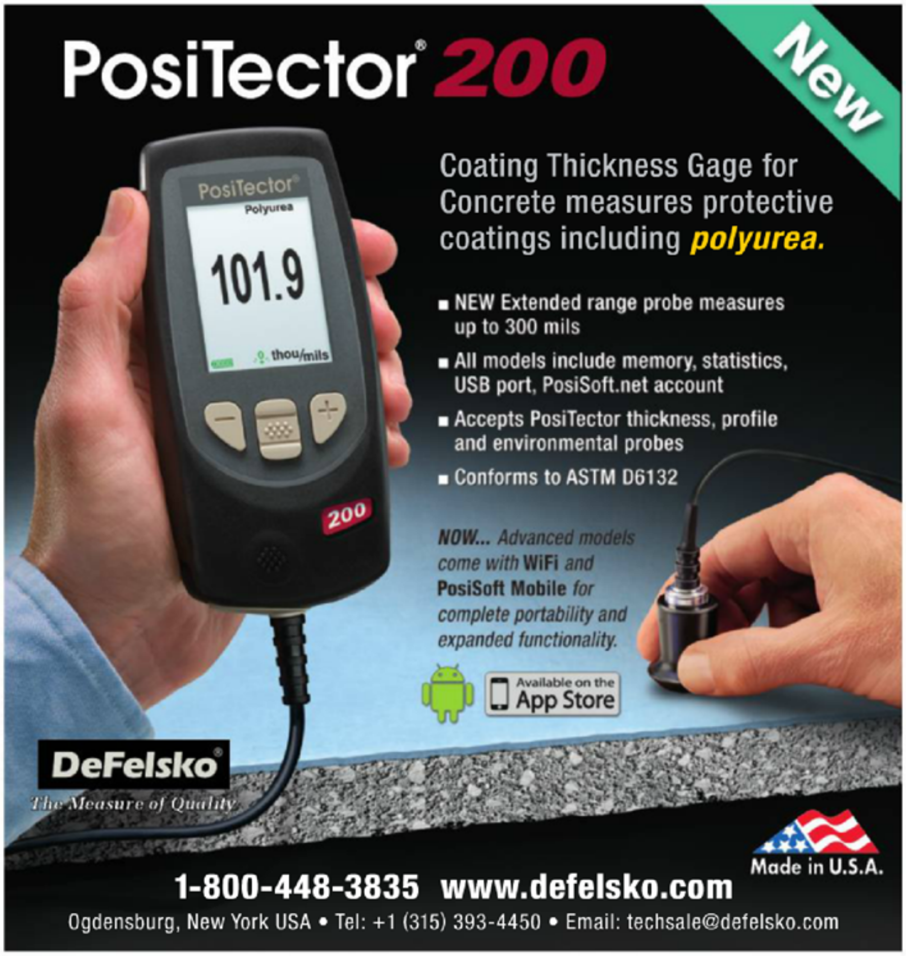
Laboratory Investigation

Visual and microscopic examinations of the paint chip samples were conducted. The examinations disclosed that the coating system consisted of a bluish-gray brittle topcoat with underlying flexible gray coats and an intermittent yellow translucent brittle coating. Often, there were multiple coats where the yellow primer was present between thick layers of gray coating. The total thickness of the coating samples range from as low as 10 mils to as high as 105 mils. The surface of the coating in the plane of delamination was relatively free of significant visible contamination and showed no indication of sanding or other mechanical abrasion.

Infrared spectroscopic analysis was performed, confirming that the coatings applied to the fumigation building were, in fact, the generic coatings that were specified for the project. The topcoat had a spectrum consistent with a polyol-cured polyurethane, the intermediate coat had a spectrum consistent with a polyurea, and the primer had a spectrum consistent with an epoxy. Analysis of the coating surface at the plane of the delamination failed to detect the presence of hydrocarbons or other contaminants that would contribute to poor adhesion and delamination.

Discussion

The field investigation and the laboratory analysis revealed that the cause of the polyurea coating's delamination and blistering was inherent poor adhesion of the coating to both the primer and, when applied in multiple coats, to itself. The poor adhesion allowed water to migrate between coatings and accumulate in areas, creating the large



blisters.

An epoxy primer from the manufacturer of the polyurea coating was used. The product data sheet for the primer recommended that metal surfaces be abrasive blast-cleaned to produce a deep angular profile, and that the epoxy primer be applied thin enough so that it did not cover the entire profile. A reasonable assumption could be that the remaining profile was necessary to ensure good adhesion of the polyurea to the epoxy primer.

The system designed for application to the fumigation building utilized a surface preparation method that provided no surface profile. As a result, there was no profile to increase the adhesion of the polyurea to the epoxy primer. In numerous areas, the polyurea delaminated from the epoxy primer, oftentimes resulting in large blisters. Even where the coating system exhibited no sign of blistering, the polyurea was usually only loosely attached to the primer, and could be removed with ease.

In most of the areas examined, more than one polyurea layer was applied. The thickness of a single application varied from less than 10 mils to more than 100 mils. When multiple coats of polyurea were present, poor adhesion was found between coats of the polyurea. The top layer of the polyurea could be removed by making a cut in the coating and lightly tugging at an edge. Because the polyurea intercoat adhesion problems were discovered before the project was completed, an attempt was made to improve intercoat adhesion by applying a thin layer of an amber-colored epoxy coating before the application of the additional polyurea coating.

Figure 4: The extent of the coating system failure was dramatic when viewed on large portions of the building exterior walls.

The product data sheet for the polyurea recommended sanding if the surface would be recoated after the 16-hour maximum recoat window. Sanding of a coating roughens the surface, improving the adhesion of subsequently-applied coats. No mention was made of the need for an additional coat of epoxy primer, and no evidence of sanding was found during the field investigation or in the laboratory microscopic examination.

The field laboratory examinations also revealed adhesion problems with the amber epoxy coat. The epoxy layer was also

cracked significantly, likely due to its lack of flexibility compared to the polyurea. Hard, inflexible coatings often crack when applied to softer, more flexible coatings.

Polyurea coatings, in some cases, can be prone to adhesion problems. The coating is supplied in two components, which are mixed immediately before they are expelled from the spray gun (and sometimes immediately after). The components begin to harden very quickly, usually in less than a minute. In some cases, depending on the temperature of the material, the temperature of the environment, and the distance between the spray gun and the surface being coated, the material starts to harden before it has adequately flowed into the irregularities on the surface, which can lead to poor adhesion of the coating. The laboratory microscopic examination revealed several areas where the coating appeared to have inadequately flowed (keyed) into the underlying surface.

It was not possible to determine whether the material was unusually prone to poor adhesion, or if the poor adhesion was the result of improper cleaning and surface preparation or application errors. Had the applicators applied the coating in a way that was obviously in conflict with the manufacturer's application instructions, the manufacturer's representative likely would have pointed out any errors during the application.

The large volume of water found in the blisters on both the walls and the roof likely came from pinholes in the coating and from the seams. Condensation from the building interior likely traveled through the seams, then under the poorly-adhered coating. Exterior moisture likely also entered from the top, through pinholes, and migrated under the poorly-adhered coating. If the coating had adequate adhesion, water would not have been able to travel under the coating. The blistering is primarily a result of the poor adhesion.

Resolution

The failures of this coating system were too extensive to repair with any reasonable expectation of success. The entire coating system had to be removed and replaced with a flexible acrylic system that had performed adequately on some of the tobacco company's other fumigation buildings. Because the adhesion of much of the epoxy-polyurea-polyurethane coating system was poor, it was relatively easy to remove the system using high-pressure water.

JPCL

Lessons from Coating Water and Wastewater Treatment Structures

By Manuel Najar, PE, V&A Consulting Engineers, Inc., Oakland, CA

Several design factors need to be considered when specifying coatings in water and wastewater facilities, including shop coating versus field coating, or coating existing facilities versus new facilities. This paper will present a number of important design considerations, based on the author's experience, that can avert lining performance problems and inappropriate lining material selection.

Service Environments

This article divides water and wastewater exposure conditions into four service environments: interior atmospheric, exterior atmospheric, exterior buried, and immersed. Once the substrate to be coated can be classified under one or more of the service environments, the specifier can determine the appropriate coating material, surface preparation, and coating application requirements to protect the surfaces.

Exterior atmospheric exposure refers to structures that are in contact with ultraviolet rays. Some coatings tend to degrade on exposure to ultraviolet rays over the years, leading to blistering, chalking, or flaking off. Interior atmospheric exposure refers to indoor structures that may be exposed to high humidity or chemicals, which can create a corrosive environment. Examples include concrete inside of a manhole structure or steel surfaces above the water surface inside a cylindrical tank, as shown in Fig. 1. Figure 2 shows deteriorated concrete inside a primary sedimentation basin that is covered during normal operation.

Fig. 1: Corroded steel water tank walls and roof above the water surface.
Photos courtesy of the author.

Fig. 2: Deteriorated interior atmospheric concrete in an enclosed primary sedimentation tank.

Buried environments refer to structures such as pipes, valves, special fittings, or buried concrete that are susceptible to corrosion from the soil or ground water. Figure 3 shows a polyurethane-coated buried steel pipe. Immersed environments refer to structures that are in contact with water or wastewater intermittently or continuously, such as the steel on a clarifier rake arm, shown in Fig. 4.

Fig. 3: Pump station—buried steel

Fig. 4: Clarifier—immersed steel

Creating a Specification

Before writing a coating specification, the specifier must gather as much information as possible to determine the products best suited for the service environment and the conditions in which the coating will be applied. A good specification will contain the following:

- clearly defined limits of work of a pipe, tank, valve, concrete structure, or floor for new or existing structures;
- location of the coating application, such as a shop, in the field, or both;
- a list of surfaces to be coated and/or surfaces to be protected;
- a description of the level of surface preparation required (i.e., SSPC-SP 10 or SSPC-SP 13);
- stated time restrictions for existing structures that have a limited shut down time; and
- any special application requirements, such as containment system for lead abatement or weld repair plates required after abrasive blasting.

Common Mistakes in Coating Specifications

When referencing surface preparation standards and testing procedures, the specifier must make sure that the appropriate section of the standard or testing instrument is identified. For example, when coating adhesion tests according to ASTM D4541 (for coatings on steel) or D7234 (for coatings on concrete) are required, specifiers may not call out specific instrument types (Type II or Type V) that may lead to inaccurate coating adhesion test results which do not meet the minimum requirements of the specification. Type II is a fixed-alignment instrument that has a maximum pull-off adhesion limit of 1,000 psi (Fig. 5). Type V is a self-aligning instrument that can measure much higher adhesion values (Fig. 6). If a specification for a newly-coated pipe calls for coating adhesion of 2,000 psi, a Type II instrument will not be able to determine whether the specified adhesion value has been met. In contrast, a Type V instrument can measure adhesion values much higher than 1,000 psi and can determine whether the 2,000 psi value has been met.

Fig. 5: Type II gauge has a maximum pull-off adhesion limit of 1,000 psi.

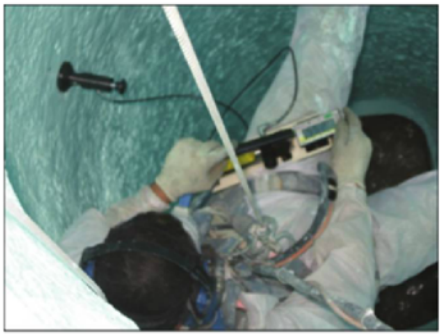


Fig. 6: Type V gauge produces higher pull-off adhesion limit values.

Specifications that rely on surface preparation and coating application "per the manufacturer's recommendations" may also lead to coating failures. Many times, a reference to SSPC-SP 13 is not specific enough because the standard contains several methods. For instance, SSPC-SP 13 contains eight methods of cleaning and abrading concrete surfaces before applying a coating. Therefore, the specifier must determine and clearly state the appropriate surface preparation method and surface profile based on the service environment.

Large municipal water and wastewater projects require careful coordination between equipment specifiers, pipeline designers, and other engineering designers. Several projects have one general painting specification in the Construction Standards

Institute (CSI) format, Section 09 91 00 Painting, that will address protective coatings for valves, gates, piping, motors, masonry, and concrete.[1] The specification for the valves, gates, etc., must have a reference to Section 09 91 00 or have its own surface preparation and coating requirements. When specifiers and engineers fail to coordinate their efforts during the planning phases, premature coating failures occur due to poor surface preparation, or the incorrect coating system is applied. References to Section 09 91 00 can be made in paragraphs labeled "Related Work Specified Elsewhere" in each specification.

(There are several formats for coating specifications, but most municipal construction projects use the CSI 09 91 00 format in contract documents so that contractors can search bids according to the numbered sections. Every section has a Part 1–General, Part 2–Products, and Part 3–Execution. Some might have Part 4–Payment.)

When large pieces of equipment are being manufactured thousands of miles from the project site, the specifier should consider this factor when preparing the coating specification. One to six months may lapse between the prime coat application in the shop and the finish coat that is applied in the field. Most epoxy coating manufacturers allow a 30- to 90-day recoat window. However, the finish coat may not adhere well if the prime coat is glossy, as shown in Fig. 7, or if the surface has conta-

Fig. 7: Finish coat at bolted connection has delaminated on a clarifier.

Fig. 8: Prime coat and welds are sweep blasted on a water tank.

minants. It is highly recommended that the prime coat be abraded before the finish coat is applied, as shown in Fig. 8.

Suggestions for the Bidding Process

As specifiers, we must consider that prospective bidders will create estimates based on the information available at that time. Owners and specifiers must perform their due diligence to provide the following:

- confirm that the existing coatings to be removed have been tested for lead and other hazardous heavy metals;
- quantify the amount of structural steel that requires replacement after abrasive blasting;
- estimate the required amount of concrete resurfacing, crack repair, or reinforcing steel repair and create a separate bid item for these repair tasks; and
- perform a condition assessment of a structure and include photos and access information to all bidders if the surface to be coated is not visible during job walks.

Coating Application Tips

After coating application has begun, the owners and specifiers are still responsible and must ensure that the coating is applied according to the specifications. Owners should invest in a third party coating inspector who has been trained through SSPC's Protective Coatings Inspector (PCI) program or NACE's Coating Inspector Program (CIP). For large water and wastewater projects, the cost of having a coatings inspector is a small fraction of the total project cost. For example, a new 1-million gallon welded steel ground storage tank may have a construction cost of $800,000, of which the protective coatings cost is approximately $300,000. For such a big investment in protective coatings, it is highly recommended to retain a coatings inspector to ensure that the coatings are applied according to the specification requirements. If a coatings inspector cannot be retained for shop coating applications, the shop should be required to submit its own internal quality control coatings inspection report to the owner.

If 100% solids coatings are being applied with plural-component pumps, coating applicators must submit equipment model numbers and specifications to ensure that proper heating, mixing, and pumping ratios meet the coating manufacturer's requirements. Some coating products require heating one component to 150 F (65.5 C) before it is mixed with another component. Certain plural component pumps are not designed to maintain that temperature. The use of incorrect equipment may cause the coating to not cure adequately, disbond from the substrate, or bubble on the surface.

Conclusion

As more capital funds are being invested in infrastructure throughout the United States, it is imperative that specifiers, owners, and coating applicators work together to produce successful coating projects.

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1. Construction Specification Institute (CSI) Titles and Numbering Format April 2012.

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Manuel Najar is a senior project engineer at V&A Consulting Engineers, Inc. He graduated with a BS in chemical engineering from University of California at Berkeley and is a registered chemical engineer in California. He is a NACE Level 2 Coatings Inspector and has written coating specifications for several water and wastewater structures.

Cargo Tank Coatings— A Stressful Environment

By Trevor Parry, Coating Consultant, and Bill Woods, Marinspec Associates Ltd.

Marine cargo tank coatings come under a variety of stresses during their service lifetime. If the stresses are not considered at the design and development stages, they can lead to premature failure and costly replacement. This article identifies these stresses and considers how they relate to coating failure. Illustrations of typical coating failures are also included.

Cargo Tank Coatings

Cargo tank coatings (CTCs) come in a number of generic types, such as alkali zinc silicate, ethyl zinc silicate, epoxy novolac (phenolic), epoxy amine, epoxy amine adduct, and polyurethane.

All currently available CTCs can be divided into two broad classifications: organic and inorganic. Alkali zinc silicates (waterborne zinc silicates) and ethyl zinc silicates (solvent-borne zinc silicates) are both completely inorganic after application and curing. All the other CTCs are organic when applied, and remain so when fully cured. This distinction is simple but important because both classes behave differently when subjected to different stresses.

To understand more clearly how stresses can affect coatings, coatings specifiers and end users need to understand the fundamental differences in morphology and curing mechanisms of inorganic and organic CTCs.

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Editor's Note: This article is part of the Top Thinker Award series published in *JPCL* in 2012 and 2013. Trevor Parry is one of 24 recipients of *JPCL*'s 2012 Top Thinkers: The Clive Hare Honors, given for significant contributions to the protective coatings industry over the past decade. The award is named for Clive Hare, a 20-year contributor to *JPCL* who shared his encyclopedic knowledge of coatings in many forums. Professional profiles of all of the award winners, as well as an article by Clive Hare, were published in a supplement to the August 2012 *JPCL*.

Inorganic Zinc Silicates

Waterborne (alkali) zinc silicates cure initially by the evaporation of water from the wet film into the surrounding atmosphere. Solventborne (alkyl) zinc silicates cure initially by absorbing water from the surrounding atmosphere into the film.

Although the actual curing mechanisms are complex and different, the end result in both cases is the formation of a cross linked, three-dimensional matrix of zinc-oxygen-silica. General industry consensus is that at the steel surface, the hydrated zinc-silica matrix reacts with ferrous ions, and the reaction creates a chemical bond to the steel. The bond provides the coating with a high level of adhesion and high resistance to undercutting.

High concentrations of metallic zinc dust, above the CPVC (Critical Pigment Volume Concentration), are used in the formulations to achieve adequate film formation. Hence, the zinc particles are not fully coated with binder, and the voids between the particles are not fully filled with binder. The resulting film is porous. At this stage in the film formation, in the places where there is no binder, there is contact among the zinc particles themselves as well as between the zinc particles and the steel surface. This contact ensures good corrosion prevention properties, which are initially galvanic. Then, another set of reactions occurs, this time involving moisture and carbon dioxide from the atmosphere. The porosity decreases over time because of these reactions in the matrix. They form zinc corrosion products that plug the pores, making the film denser and less permeable. At this point, the corrosion protection mechanism becomes increasingly barrier in nature.

Organic Cargo Tank Coatings

By contrast, organic CTCs are bound together much differently. All the particles of pigment and extenders in these dry films are completely encapsulated by the binding resin(s). To facilitate spray application, which is the most commonly-used method, organic solvents are usually needed to reduce the viscosity. Other additives are included in the formulation to improve properties such as storage stability and sag resistance. No reaction occurs between the binding resin(s) and the pigments. Adhesion to the steel surface, unlike adhesion of zinc silicates, is considered to be predominantly mechanical.

The stresses that may occur during the lifetime of a CTC are listed below and discussed in the order in which they are likely to occur.

1. Drying and initial curing stresses
2. Post-curing stresses
3. Operational stresses
    - Cargo cycling
    - Cargo absorption and desorption
    - Cargo interaction
    - Tank cleaning
    - Water absorption and desorption
    - Temperature changes

Drying and Initial Curing Stresses

When they cure, both waterborne (alkali) and solventborne (alkyl) zinc silicates form rigid networks. Application of overly thick films creates stresses in the film that cause it to crack. The cracking resembles the appearance of a dried up riverbed, hence the commonly used term, "mudcracking" (Fig. 1). The margin of error between satisfactory and excessive thickness is quite small. Applicators must be careful to avoid

Fig. 1: Mudcracking
Figures courtesy of the authors

excessive film thickness. If mudcracking does occur, the only solution is re-blasting the surface to completely remove the paint and re-apply it—a time-consuming and expensive remedial measure. (It should be noted that a few centimeters of cracks at fillet welds are fairly common and would not in practice require re-blasting.)

By contrast, organic coatings have much more forgiving application characteristics. For some systems, individual layers can be applied at more than twice the thickness that is specified without showing any immediate visible problems. Indeed, many manufacturers allow for the extra thickness in their coating specifications. Internal stress at this early stage is primarily related to evaporation of solvents and other volatile additives, followed by shrinkage during the curing reaction. Even if areas of unacceptably high thickness are identified in individual coats of the system, the excess coating thickness can be removed by local treatment of the affected area without resorting to total re-blasting.

Post-Curing Stresses

Most zinc silicate coatings do not need to be post-cured after application and initial curing. All that is required is to ensure that the coating is washed with either fresh or salt water (according to the manufacturer's requirements), and the coating is ready for full operational use.

However, the same is not the case for organic CTCs. Generally, a post-curing operation is required for coating systems on chemical tankers. And for many organic coatings, such a process is mandatory if the full chemical resistance of the coating is to be realized.

Organic CTCs used in the transport of less aggressive cargoes such as clean petroleum products (CPPs) are not and cannot be post-cured, so they are resistant to fewer cargoes.

Post-curing involves raising the temperature of the coating to a specified level and maintaining that temperature for a specified time. The temperature can be as high as 90 C or as low as 50 C, and the time can be as long as 14 days or as short as 3 hours, depending on the coating and the manufacturer. The process removes residual solvent, enabling and driving further chemical reactions in the coating. These reactions lead to further cross-linking and shrinkage. The result is a coating that is highly cross-linked, very chemical resistant, but very rigid, and can be highly stressed.

To achieve a satisfactory post-cure, coatings applicators have tried many methods, such as

- hot air circulation;
- circulation/stowage of hot fresh water, or salt water; and
- circulation/stowage of a suitable hot cargo.

All of the above methods have met with varying degrees of success or failure. The inherent difficulty in all of these methods is ensuring that all coated surfaces reach the specified temperature for the specified time. Steel temperatures can be recorded with thermocouples, connected to data loggers placed in adjacent ballast or cargo tanks. Due to the impracticality of recording the temperature on all areas in a tank, a degree of uncertainty would remain.

There are means by which the state of cure of a CTC on a vessel can be measured using samples of the coating taken from panels placed in the tanks at the time of coating application and subsequent post-curing. Even this approach does not guarantee that all areas have reached the same degree of cure. Other considerations should also be taken into account, such as the overly thick areas mentioned earlier. How do these areas behave under such post-curing regimes? Figures 2, 3 and 4 illustrate some typical locations where thick paint films are likely and what may happen to them during or after post curing operations. We should also be concerned about other locations on the vessel. For example, what effect does post-curing of the CTCs have on coatings in adjacent ballast tanks (side tanks, and double bottoms) and on the main deck? All of the coatings in these locations will also be placed under considerable stress during the post-curing operation.

Operational Stresses

Operational stresses are created during the normal operation of the vessel. These stresses are described below.

Impact of Cargoes, Cargo Resistance, and Cargo Cycling

The resistance of a CTC to a cargo is related to chemical compatibility, which is the interaction or lack of interaction between the CTC and the cargo.

Because of their inorganic nature and inertness to many neutral cargoes, zinc silicate coatings tend to display excellent resistance to organic cargoes. Included among these cargoes are many low molecular weight and aggressive products such as methanol, and chlorinated hydrocarbons such as ethylene dichloride (EDC). However, zinc silicate coatings have the inherent problem of containing zinc, which is a reactive amphoteric metal. Therefore, it is not resistant to acidic or alkaline cargoes outside a pH range of 5.5 to 10 (depending on cargo and coating supplier).

With organic coatings, the binder can be chemically attacked by incompatible or unsuitable cargoes, such as palm fatty acid distillate (PFAD) and other vegetable acid oils in a pure epoxy-coated cargo tank. (Cargo compatibility varies among different manufacturers' products, and the cargo resistance list should be consulted.) Chemical attack (by PFAD and vegetable acid oils) usually results in detachment of the paint film, and, more often than not, will be accompanied by severe wrinkling of the detached film. Figures 5 and 6 illustrate these typical symptoms.

Figs. 2–4 (left to right): Potential crack locations


Figs. 5 (top) and 6: Poor resistance to cargo

Absorption and Desorption of Cargoes

Inorganic zinc coatings freely absorb and release many volatile cargoes without showing any signs of swelling or contraction. This characteristic is due to their inorganic nature and their initial open porous structure. Unfortunately, they will absorb “oil-like” cargoes also, which do not desorb easily, resulting in potential cleaning and contamination issues.

Organic coatings are different. Even though an organic coating may be classified as “resistant” to a particular cargo, the coating may still absorb a certain amount of the cargo, depending on the its nature, its length of stowage, and the stowage temperature. The absorption and desorption process can result in softening and a degree of, but not necessarily full, recovery of the paint film, which is clearly a stressful and potentially damaging condition. This cycle of absorption and desorption can also result in cargo interaction and subsequent cargo contamination if not managed properly. Figure 7 shows the varying absorption/desorption profiles of four coatings of the same generic type during the stowage and after unloading of an absorbing cargo (EDC). This difference in absorption, desorption and retention properties also occurs, often to a greater extent, in other generic types of organic CTCs.

Table 1 illustrates the increase in dry film thickness of various types of CTCs at maximum absorption of a range of cargoes. Different generic types of coating absorb the same cargoes to different degrees. The degree if absorption is reflected in the swelling of the coating, detectable by an increase in film thickness.

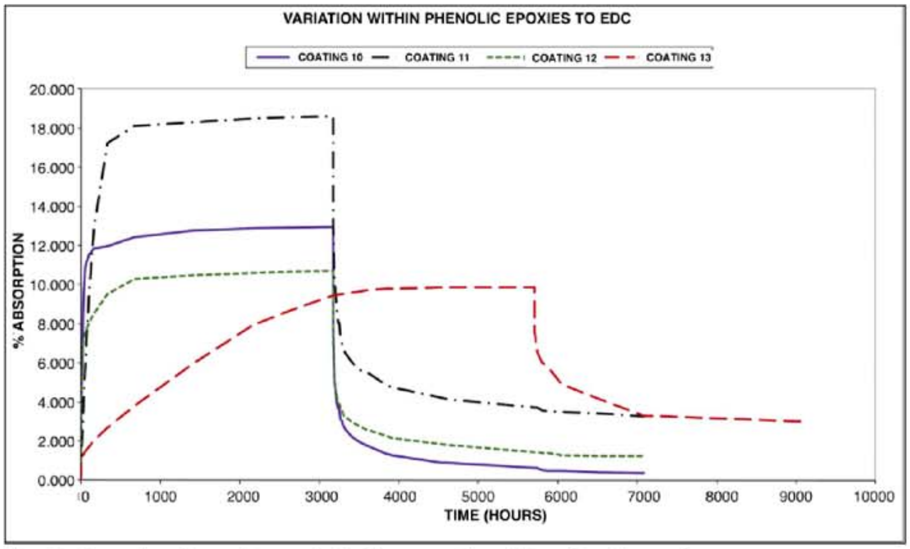

Fig. 7: Absorption, desorption, and retention properties of four phenolic epoxies

Cargo Interaction

Many cargoes may be carried without affecting the coating, even though the cargo may

Table 1: Increase in Paint Film Thickness at Maximum Absorption

Cargo name	Coating	Average % increase in Thickness
Benzene	1	12.5
Benzene	2	11.2
Benzene	3	5.2
Xylene	1	17.2
Xylene	2	11.2
Xylene	3	3.8
Styrene	1	16.6
Styrene	2	10.6
Styrene	3	2.7
Butyl Acetate	1	16.75
Butyl Acetate	2	12.5
Butyl Acetate	3	1.5
Methyl Isobutyl Ketone	1	14.75
Methyl Isobutyl Ketone	2	8.5
Methyl Isobutyl Ketone	3	1.5
Vinyl Acetate Monomer	1	14.9
Vinyl Acetate Monomer	2	9.3
Vinyl Acetate Monomer	3	12.7

Coating 1 – Polyurethane; Coating 2 – Epoxy Isocyanate; Coating 3 – Epoxy Phenolic

Fig. 8: Unbroken blisters

have been absorbed to some extent. If one cargo is followed by a different cargo that is acceptable for the existing coating and is also absorbed, the cargoes have the potential to react with each other to produce a harmful environment within or behind the coating. A typical example would be the reaction of an absorbed halogenated cargo or an ester cargo with a subsequent water-based cargo or with water from a tank cleaning

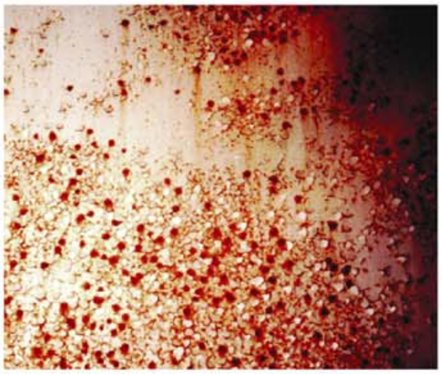

Fig. 9: Cracked/detached blisters

operation. The consequence of these reactions is usually blistering of the coating, which will be followed eventually by cracking and detachment of the blisters (Figs. 8 and 9).

Tank Cleaning

Tank cleaning in all its forms has the potential to place significant stress on the CTC, particularly when cleaning temperatures are as high as 85 C.

For inorganic zinc silicate coatings, the cleaning chemicals must not be too acidic or alkaline, particularly if they are to be used neat or in a concentrated solution for spot cleaning. Zinc silicates are generally unaffected by hot or cold water washing in the short term, although dissolution of zinc does occur over time, with the rate depending on the frequency of the operation and the operation itself.

Organic coatings are again different. They are generally satisfactory for short-term contact with both acidic and alkaline concentrated cleaning chemicals used for spot cleaning at ambient temperatures. But compared to zinc silicates, organic CTCs are more affected by regular hot tank cleaning episodes. Organic CTCs absorb water, some CTCs more than others, and this absorption creates internal stresses in the paint film. It is also accepted that fresh water tends to be absorbed more quickly than seawater. Figure 10 shows the varying water absorption and desorption characteristics of three coating systems of the same generic type. It is of interest to see that one of the coatings (green) continues to absorb water after two of them (blue and red) have reached equilibrium in long-term exposure. Note, however, how quickly all the coatings absorb water during the early stages of exposure, as would be the case in tank cleaning operations.

Temperature Changes

Temperature changes impose stress on the coating system and influence the absorption and desorption of water and cargoes. The

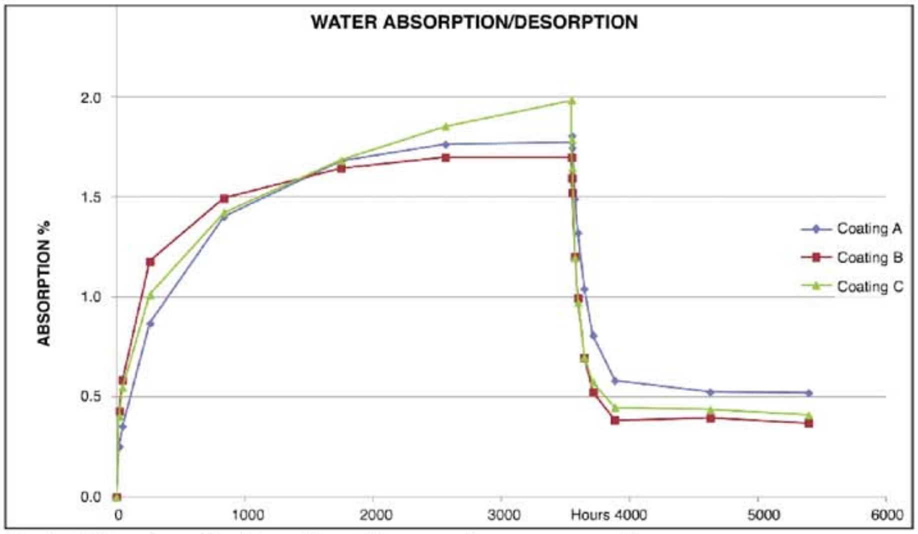

Fig. 10: Water absorption/desorption of three generic pure epoxy coatings

temperature effects are from a variety of sources, such as cargo temperature, sunlight on deckhead plating and subsequent cooling at night, hot cargoes in adjacent tanks, and hot tank cleaning. (Note that some cargoes are heated to facilitate loading and unloading, some are carried hot, and others are carried at ambient temperature.) Temperature changes affect organic CTCs to a greater extent than zinc silicates.

Summary

We have attempted to highlight just how hostile the environment inside a cargo tank of a chemical tanker can be to the coating applied to it and some of the failure symptoms that can result. Apart from the stresses applied during the normal structural movement of the vessel, we have to add the cumulative impact of post-curing stress, and operational stresses.

Of those operational stresses, repeated episodes of hot tank cleaning interspersed with the cyclic carriage of a wide range of cargoes at varying temperatures cause the coating to swell and contract continually while at the same time absorbing and desorbing water, and/or cargo. The coating system has to be very resilient—maintaining good adhesion and cohesion, protecting the substrate from corrosion, and remaining as a continuous film for a number of years.

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Given the very aggressive conditions of the cargo tank, it is not surprising that premature failures do sometimes occur.

These difficult conditions set challenges for both the formulators and users of CTCs. The coating manufacturers must recognize all the stresses that occur in practice and accommodate for them in the formulation and testing of CTCs. Owners and operators must also recognize the stresses, and minimize them by careful selection and considerate stowage of cargoes, to reduce the need and impact of tank cleaning, particularly at elevated temperatures. **JPCL**

Trevor Parry, CSci, CChem, FRSC, MICorr., is an independent coatings consultant who recently retired from full-time work after over 40 years in the industry. A chemist by training, Parry worked for Scientific and Technical Services Ltd. from 1971-2010, eventually becoming Technical Director and owner of the company. He has been a key figure in both domestic and international standardization work, as well as a leader in investigating and solving marine coating problems and failures. Parry now works with clients (mainly marine) on a selective basis, evaluating coating failures and providing advice. He is a recipient of *JPCL*'s Top Thinker: The Clive Hare Honors 2012 award, and a *JPCL* Editor's Award winner.

Bill Woods is a co-founder and associate at MarinSpec Associates, Ltd., a consulting group in the U.K. that specializes in the cleaning and coating of cargo tanks. Involved in the development of marine and cargo tank coatings since 1964, Woods served as General Technical Manager at Camrex Chugoku Ltd.; European Business Development Manager for Newbuildings at Courtalds Coatings (now International Paints); Marine Coatings Consultant at Milbros Shipping AS; and an independent consultant, before forming MarinSpec in 2003. Woods is also a former chair of the British Coatings Federation and a founding member of the Marine Coatings Forum.

Polyurea coatings are suitable for a number of high-performance applications, including railcar interiors, petrochemical storage tank interiors, and secondary containment. Photos: iStock

Formulating Polyureas: History and Advances

By Kevin A. Buck, Huntsman

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

The concept of polyurea spray elastomer technology was introduced more than 20 years ago. This new application was based on the reaction of an isocyanate component with an amine blend to produce a high-performance elastomer system. Since this original work, a number of advances in both the chemistry and application equipment for polyureas have enabled polyurea elastomer coatings to compete with (and often displace) their traditional counterparts in high-performance applications.

Chemistry Differences

Urethane coatings are derived from the reaction of an isocyanate component with a formulated resin blend. Depending on the composition of the resin blend, the coating can be classified into one of three categories:

- polyurethane,
- polyurea, and
- hybrid polyurethane/polyurea.

Common among these catagories is the isocyanate component. The isocyanate can take on a number of characteristics, such as aromatic, aliphatic, or a blend of the two. It may also contain monomeric isomers, polymeric isomers, an isocyanate quasi-pre-polymer, or a pre-polymer. The pre-polymer or quasi-pre-polymer can be made of an amine-terminated polymer resin or a hydroxyl-terminated polymer resin. Although the difference in the technology is primarily in the resin component, additives such as pigments, fillers, solvents, and adhesion promoters can be introduced to all of the coatings.

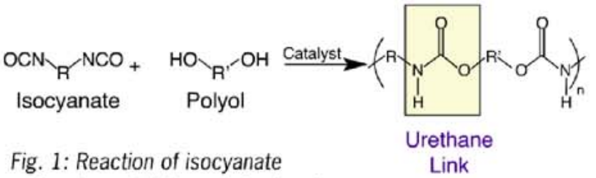


Fig. 1: Reaction of isocyanate and resin containing only hydroxyls results in polyurethane.
Figures 1–6 courtesy of Huntsman

Polyurethane Coatings

A purely polyurethane coating is the result of a reaction between an isocyanate component and a resin blend made with only hydroxyl-containing resins (Fig. 1). The final coating will contain no intentional urea groups. A polyurethane system will probably contain one or more catalysts and may need additives, such as moisture scavengers and anti-foam agents.

Polyurea Coatings

A polyurea coating is the result of a one-step reaction between an isocyanate component and a resin blend component (Fig. 2). The resin blend must be made up of amine-terminated polymer resins, and/or amine-terminated chain extenders and should not have any

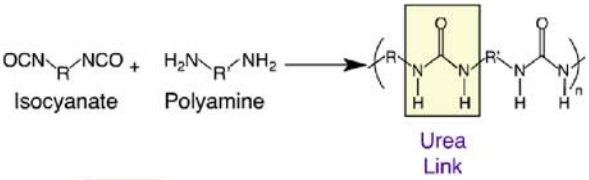


Fig. 2: Reaction of isocyanate and resin containing amine-terminated polymer resins or chain extenders results in polyurea.

intentional hydroxyl moieties. Any hydroxyls are the result of incomplete conversion to the amine-terminated polymer resin.

Hybrid Polyurethane/Polyurea Coatings

A polyurethane/polyurea hybrid coating has a composition that is a combination of the two above-mentioned coating systems. The isocyanate component can be the same as either the polyurea or the polyurethane system. The resin blend may be a blend of amine-terminated and hydroxyl-terminated polymer resins and/or chain extenders. To bring the reactivity of the hydroxyl-containing resins to the same level of reactivity as the amine-terminated resins, the addition of one or more catalysts may be necessary (Fig. 3).

Advantages of Polyurea

Polyurea elastomer coatings offer many advantages over traditional alternative chemistries. These advantages may include the following.

- Fast cure: Polyurea can be sprayed on sloped surfaces without drip or run formation. Foot traffic can resume on coatings applied to horizontal surfaces within 30 seconds.
- Relative insensitivity to moisture and temperature during application: Little effect is encountered on adhesion or coating performance due to weather variations (e.g., high humidity, temperature, and residual moisture).
- 100% solids: Two-component, one-coat systems can be sprayed or poured at 1:1 volume ratio, which eliminates the need for multi-coat applications.
- Excellent physical properties: These include tensile strength, tear strength, elongation, and thermal stability.
- Formulation flexibility: The chemistry can be adjusted to produce soft or hard elastomers. Also, pigments, fibers, and fillers can be added to further differentiate the end product.

Resin Components	Polyurea	Hybrid		Polyurethane
Primary	Polyether Amine	Polyether Amine	Polyether Polyol	Polyether Polyol
Extender	Aromatic or Aliphatic Diamine	Glycol	Aromatic or Aliphatic Diamine	Glycol
Catalysts	None	Possibly	Yes	Yes

Fig. 3: Components of polyurea, hybrid, and polyurethane resins

Equipment

Since the catalyst-free isocyanate/amine reaction is normally rapid and proceeds to completion within a few seconds, working times ("gel times") are generally less than 10 seconds. Because of this fast reaction, the coating requires specialized high-pressure and high-temperature application equipment. Specifically, two-component spray machines equipped with impingement mixing have proven an efficient and adequate option for sufficient blending and rapid dispensing of the polyurea raw materials. It is chiefly this equipment that allows polyurea technology to venture outside of the realm of reaction injection molding (RIM).

Having the capability of heating the components before mixing is a key requirement of the spray equipment. Heating of the materials before spraying helps to reduce the viscosity, thus improving the mix, flow, and leveling of the applied material. These enhanced properties will lead to significant improvement in the performance and appearance of the coating. For polyurea elastomer coatings, the normal mix ratio of the components is 1:1 by volume (usually 1.1 to 1.2:1 by weight), correlating to an isocyanate index of 1.05:1.

Applications

By selection of the appropriate isocyanate component and amine blend, a variety of end properties and applications are possible. Slower reacting systems may be used for a variety of sealant and caulking applications. However, because the formulations can be varied, polyurea elastomer systems are well-suited for application to areas such as pipeline, secondary containment, synthetic stucco, concrete, railcars, tank interiors, various structures requiring waterproofing, and floor joints or seams. In addition, polyurea continues to be evaluated for use in numerous niche applications requiring high-performance coatings that allow equipment to be returned to service nearly immediately.

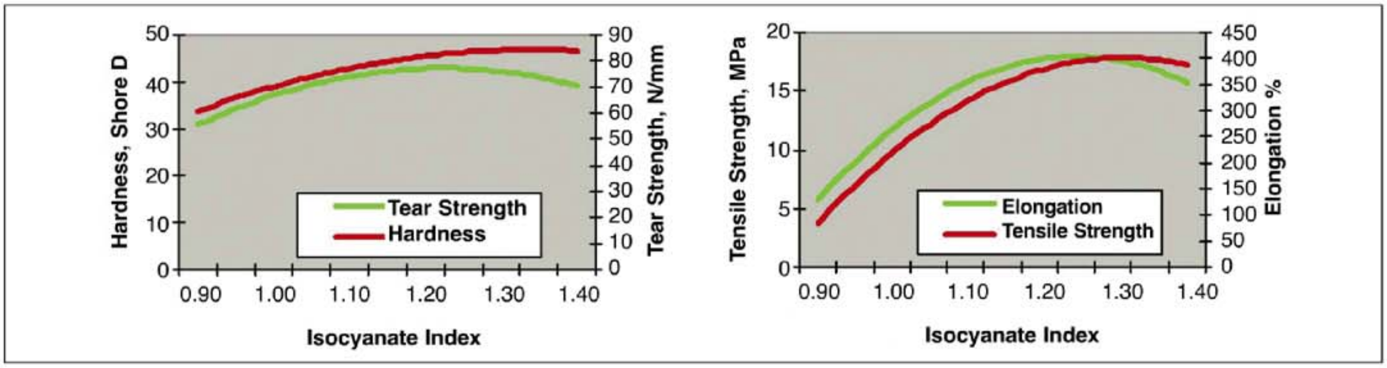
Polyurea elastomer coatings exhibit excellent adhesion to clean substrates such as concrete, wood, asphalt, and fresh blasted steel. However, as with other rapid cure coatings, the rapid cure may limit surface wetting and penetration, leading to decreased mechanical bonding. For this reason, end users are cautioned to test the adhesion of any material on target substrates to assess bonding of the coating. In certain cases, surface primers and adhesion promoters may be necessary. In addition, because the polyurea film exhibits strong physical properties and remains intact as it is pulled from the substrate's surface, greater adhesion may be necessary for specific applications.

Physical Properties

Since a wide range of polyurea elastomer coatings are possible, ranging from soft rubbers to hard elastomers, a variety of physical properties are achievable. It is strongly recommended that both polyurea applicators and customers thoroughly evaluate potential material selection before commercial application to ensure suitability in the intended service.

Figures 4 and 5 (p. 44) provide typical physical properties for hardness, tear strength, tensile strength, and elongation. These properties have been obtained from sample films produced in controlled laboratory conditions. Optimal performance is obtained with an isocyanate index in the range of 1.05 to 1.20.

Actual in-field performance will be heavily dependent on the skill and ability of the applicators. The applicators need to have formal training in the application, operation, and maintenance of the plural-component application equipment, along with formal training in both material handling and proper safety procedures.



Figs. 4 (left) and 5 (right): Hardness and tear strength according to isocyanate index (left); tensile and elongation strength according to isocyanate index (right).

Recent Developments

Although polyurea elastomer coatings have been applied for a number of years, there have not been any concise standards or specifications established. As a result, SSPC: The Society for Protective Coatings initiated work in this area, beginning with performance-based standards, such as SSPC-PS 28.01, "Two-Coat Zinc-Rich Polyurethane Primer/Aliphatic Polyurea Topcoat System," as well as SSPC-Paint 43, "Direct-to-Metal Aliphatic Polyurea Coating, Performanced-Based."

Most recently, SSPC-PA 14 was published. This is specific to the "Application of Thick Film Polyurea and Polyurethane Coatings to Concrete and Steel Using Plural-Component Equipment." This standard focuses on the field application of polyurea, polyurethane, and polyurea/polyurethane hybrid coatings with a thickness greater than 20 mils. It brings together, as a reference, standards from a number of industry groups, including ASTM International, SSPC, NACE International, and the International Concrete Repair Institute, to present a comprehensive reference document.

Safety Considerations for Handling and Using Polyurea

Before undertaking any spray work, the applicator should be thoroughly familiar with the safe operation of the equipment and should follow all instructions and safety precautions provided by the manufacturer of the equipment. Particular care should be taken so that the spray nozzle is never directed toward any-

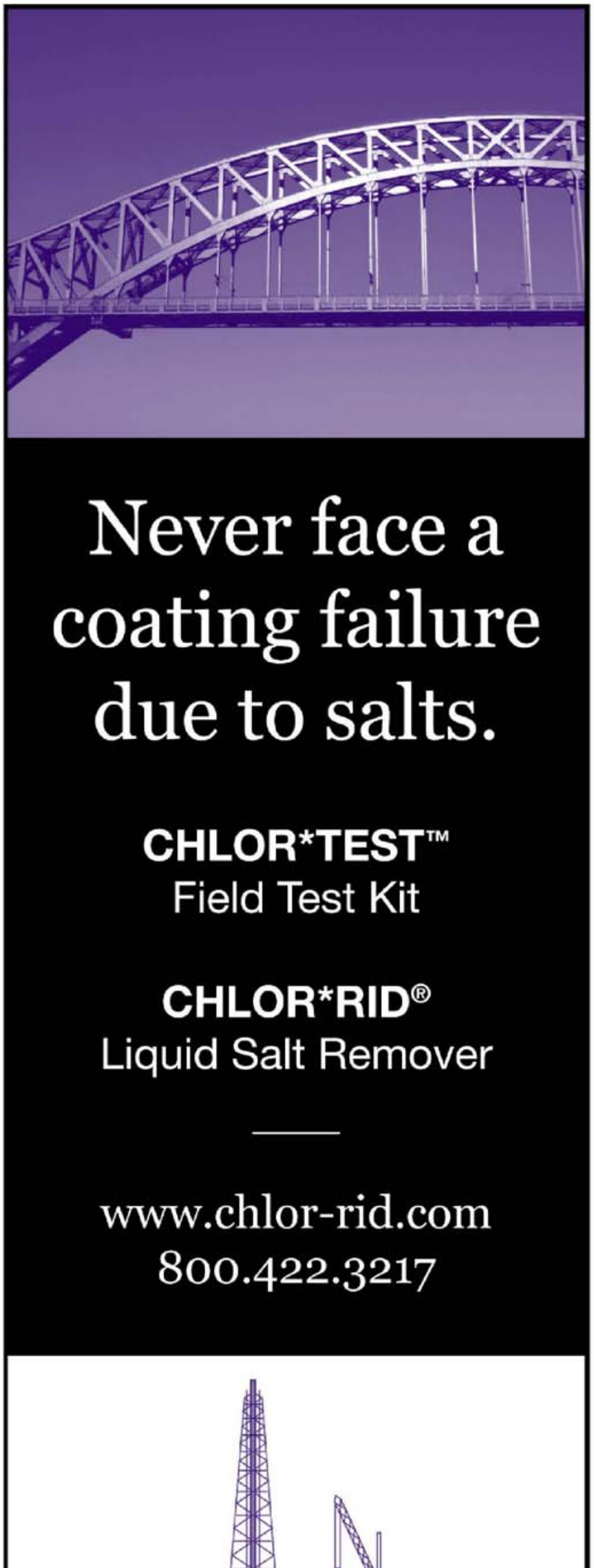


Fig. 6: Applicators must take appropriate measures to protect themselves while spraying polyurea.

one's face or body during operation.

Under normal equipment operating conditions, the isocyanate component and the resin component of the polyurea elastomer coating react almost instantaneously so that there is no excess of either isocyanate or amine exiting the spray nozzle. However, even under ideal operating conditions, very small amounts of un-reacted material may be present as an aerosol or vapor. Before handling or using any component of a polyurea elastomer coating or engaging in polyurea spray work, the applicator should review the Manufacturer's Safety Data Sheet (MSDS) for both the isocyanate component and the resin component for recommendations for appropriate respiratory and dermal protection measures when handling, using, or spraying the company's product (Fig. 6).

Additional information will be available from the manufacturers about safe handling of the different components and should be consulted as well. To minimize any risk due to exposure to chemicals used or the particulate matter created in polyurea spray applications, spraying should be done only in well-ventilated locations (either outdoors or indoors with mechanical fans), or in a properly ventilated spray booth. Applicators should wear the appropriate personal protective clothing and equipment.

Conclusion

While polyurea elastomer coatings offer properties not found in other systems and often may be desirable for particular jobs, they are not recommended for all applications. Applied correctly, and with the proper equipment, polyurea elastomer coatings can provide superior features suited to industrial maintenance, including chemical resistance and physical strength.

Kevin Buck is the Marketing Manager for Huntsman Polyurethanes' Adhesives, Coatings, and Elastomers (ACE) Group in the Americas. With 20 years of experience in the polyurethanes industry, including both technical and commercial positions, he has spent the past decade focused on the coatings, adhesives, sealants, and elastomers markets. He is an active member of the Polyurea Development Association (PDA), the International Concrete Repair Institute (ICRI), and SSPC: The Society for Protective Coatings. **JPCL**

Developments in Waterborne Thermal Insulation Coatings

By Sudhir Achar and Leo J. Procopio, The Dow Chemical Company

The inadvertent transfer of thermal energy in the form of heat leads to a variety of issues in industrial settings. Issues include heat loss from processing equipment and piping, increased energy usage, worker injuries from contact with hot substrates, and associated costs. The traditional insulation methods to combat these issues include use of materials such as fiberglass and polyurethane foam; however, thick layers of insulation can often hide severe maintenance problems such as corrosion under insulation (CUI).

An alternative to traditional insulation is the use of thin-film thermal insulation coatings based on waterborne acrylic and epoxy resins. This article describes our efforts to better understand the polymer design and formulation parameters for these thin-film waterborne thermal insulation coatings. Their potential use in thermal insulation will be described through test results on thermal conductivity, safe-touch properties, and corrosion performance in multi-layer systems that can be applied by traditional methods. Both one-component waterborne acrylic and two-component waterborne epoxy resins and coating formulations have been evaluated and compared to commercial insulation coatings. The use of two types of low thermal conductivity fillers, hollow glass microspheres and silica aerogel, is also described.

Editor's Note: This article is based on a paper the authors presented at SSPC 2013, held January 14 to 17 in San Antonio, TX. The original paper is published in the conference *Proceedings* (sspc.org).

How Heat Transfers

Heat transfers between materials by one or more of three main processes: conduction, convection, and radiation. Heat moves through a solid by conduction, and the rate of the conduction depends on the chemical nature and structure of the solid. Some solids, like extruded polystyrene foam, are designed to inhibit conduction, while others, like copper, are highly conductive and allow heat to pass freely. Convection is the transfer of heat by the movement of a fluid, such as a liquid or gas. Heat can also be emitted by an object through radiation in the form of electromagnetic waves such as infrared light. Radiation of heat leads to the familiar warming sensation experienced when we near a fire or hot wood stove.

Thermal conductivity (k) is the rate at which heat flows through a material between points at different temperatures, and is measured in units of watts per meter per degree Kelvin (W/mK). Heat flux (Q), or the rate at which heat energy is transferred through a given surface (units of W/m^2), is most often determined by measuring a temperature difference over a piece of material with known thermal conductivity. For a material to exhibit thermal insulative properties, it must have very low thermal conductivity. Table 1 gives thermal conductivity values at room temperature of some common materials.

Types of Thermal Insulation for Industrial Plants

Thermal insulation found in most industrial plant operations is used on reaction vessels, pipelines (e.g., steam or chilled water), transfer pipes, heat exchangers, storage tanks, and other equipment. Traditional materials in these settings include calcium silicate,[1] expanded perlite,[2] cellular glass,[3] organic foams (e.g., polyurethane, polyisocyanurate, elastomeric, phenolic, polystyrene),[4] and man-made mineral fibers (e.g., fiberglass).[4]

To maintain its effectiveness and to prevent corrosion issues, insulation typically requires a separate moisture barrier or jacketing to keep out water. Insulated surfaces for carbon steel operating above 149 C (300 F) and below -4 C (25 F) are generally thought to not present major corrosion issues. However, for equipment operating between these temperatures, significant corrosion can occur underneath the insulation. The traditional insulation materials create a significant barrier to inspecting the steel surface. CUI can result in equipment failures, production losses, and increased costs.[5] Corrosion occurs when moisture comes into contact with steel surfaces underneath the insulation. CUI can go undetected because the damage is not visible until the insulation is removed.

Opposite page: Photo courtesy of the Dow Chemical Company

Table 1: Thermal Conductivity of Common Materials

Material	Thermal conductivity, k (W/ mK)
Air	0.02
Aluminum	237
Calcium silicate	0.05
Carbon steel (max 0.5% C)	54
Concrete (lightweight)	0.1–0.3
Copper	385
Expanded polystyrene foam	0.03
Glass (borosilicate glass)	1.14
Hollow glass spheres	0.030
Polyurethane foam	0.03
Rock wool	0.04
Silica aerogel	0.004–0.03
Stainless steel (austenitic, type 304)	15
Water	0.6
Wood (Eastern white pine, oven dry)	0.09

The maintenance costs resulting from CUI have led to enhanced interest in better coating and insulating material systems and the development of functional, liquid-applied thermal insulation coatings. Replacing thick jackets of insulation with a relatively thin, liquid-applied coating with thermal insulation properties has several advantages, including greater ease of application, through traditional methods; application to surfaces with complex geometries; and prevention of CUI through easier inspection for corrosion of metal surfaces. The insulation coating becomes part of the overall coating system, and it can be used with primers and topcoats to provide a system with good durability and corrosion resistance.

Thermal insulation coatings also must protect workers against burns from contact with very hot surfaces. Human skin is very sensitive to temperature within a narrow range. Burn injuries depend on three primary factors: 1) surface temperature of the object being touched, 2) thermal conductivity of the surface, and 3) contact time with the surface. Metals such as steel or aluminum have much higher thermal conductivities than other construction materials, such as wood or concrete (Table 1). The higher thermal conductivity translates into more thermal energy being transferred from the substrate to the skin. Thermal insulation coatings with low thermal conductivities can therefore help protect workers by lowering the surface temperature and slowing down the transfer of thermal energy from the surface to human skin.[6-7]

The current dominant insulation technology is one-component waterborne acrylics coatings, formulated with low thermal conductivity fillers such as hollow glass or ceramic microspheres, and, more recently, with silica aerogels.[8] The hollow glass microspheres are made from sodium or aluminum borosilicate glass with a small amount of air trapped in the micron-sized void space. The trapped air is "still," which contributes to the low thermal conductivity. The silica aerogel particles are extremely porous, hydrophobically treated silica with an open pore structure. The highly hydrophobic nature of the particles keeps water out of the pore space of silica aerogel. Aerogel silica provides low thermal conductivity because of the "still" air in the very small pores (approximately 20 nm diameter) and very low density.

The liquid-applied insulation coatings are therefore composite materials made of functional fillers bound together with a polymer that provides cohesive strength, adhesion to the substrate, flexibility, and stability to constant high service temperatures. Commercial acrylic-based insulation coatings are recommended for use up to approximately 204 C (400 F). With high pigment volume concentrations (PVC) and low polymer glass transition temperatures (T_g), these coatings can be formulated at low VOC levels and high solids. They can be applied directly to the substrate or over a corrosion-inhibiting primer and then topcoated. The primers provide the corrosion protection in a multi-coat system, and the topcoat provides decorative properties and protection to the insulation coating.

Our efforts to understand and further develop formulation knowledge of thin-film, liquid-applied thermal insulation coatings are described in the remainder of this article.

Experimental

We carried out initial experiments using design of experiments (DOE) methodology to quickly screen and narrow the choice of potential polymer and filler candidates for a low thermal conductivity insulation coating. From these experiments, two waterborne acrylic-styrene latex polymers (EXP-A and EXP-B) and one water-

Sudhir Achar is a Technical Service Specialist at Dow Coating Materials with over 20 years of experience in product development and technical service in pigments, architectural and industrial coatings, UV and E-beam coatings, and epoxy curing agents.

He earned a Master's Degree in Chemistry from Polytechnic University Brooklyn, New York, and he holds two patents in epoxy curing agents and one each in foam control and radiation curable coatings.

Dr. Leo Procopio is a Technical Service Group Leader in the Dow Coating Materials business at The Dow Chemical Company. Procopio earned his Ph.D. in Inorganic Chemistry from the University of Pennsylvania and has spent the last 21 years carrying out exploratory research, new product development, and technical service work in the area of waterborne coatings for the industrial maintenance and industrial metal and wood finishing markets. He is a member of the American Chemical Society, ACA, NACE and SSPC, and currently chairs the SSPC committee C.1.4.c on Waterborne Acrylic Coatings.

borne epoxy resin dispersion (EXP-C) were chosen for further formulation development because of their ability to be formulated at low VOC and high volume solids, and to provide coatings with low thermal conductivity and good corrosion protection. Both acrylics have a hydrophobic backbone, and offer excellent water resistance properties. EXP-A has a T_g of 19 C and EXP-B has a slightly lower T_g of 13 C. The waterborne epoxy dispersion EXP-C is a dispersion of a Type 1 solid epoxy, with a minimum film formation temperature of 13 C and an epoxy equivalent weight of 1050. It was cured with a waterborne polyamine adduct with 50% weight solids and an amine hydrogen equivalent weight of 300.

The three resins were formulated into insulation coatings using the two fillers chosen from the DOE experiments for their ability to give low thermal conductivity values and good coating processing. Commercially available, the fillers included a hollow glass microsphere (GL) and a silica aerogel (AER). Coatings were prepared according to the design in Table 2. The fillers were used as the sole filler as well as in combinations. Formulations based on the epoxy resin EXP-C and containing silica aerogel filler (AER) did not have good processing, with high viscosities or gelling, and were not evaluated further.

Table 2: Coating Identification for Insulation Coatings Evaluated

Polymer Filler	EXP-A WB acrylic	EXP-B WB acrylic	EXP-C WB epoxy
GL @ 75% PVC (hollow glass spheres)	A-1	B-1	C-1
GL @ 50% PVC / AER @ 25% PVC	A-2	B-2	not tested
GL @ 25% PVC / AER @ 50% PVC	A-3	B-3	not tested
AER @ 75% PVC (silica aerogel)	A-4	B-4	not tested

The insulation coatings, prepared using a conventional paint making process, are very high-solids (approximately 70% volume solids), low VOC waterborne coatings. Examples of model formulations are provided in the original paper given at SSPC 2013 (sspc.org).

Experimental insulation coatings based on EXP-A, EXP-B and EXP-C were compared with two commercially available insulation coatings, COM-1 and COM-2. Both of the commercial coatings are reportedly based on waterborne acrylic technology, although the supplier technical literature does not reference specific filler technology.

Coatings were tested for thermal conductivity according to ASTM C518, which describes the method for determining thermal conductivity of a flat specimen at a steady state condition using a flow meter.[9] The thermal conductivity of an uncoated polycarbonate sheet of known thickness is measured. The insulation coatings were applied to the 8-inch x 8-inch clear polycarbonate panels at a dry film thickness (DFT) of approximately 80 mils (2 mm) and cured for seven days at room temperature. The thermal conductivity is determined by measuring the sample thickness, heat flux, and temperature difference across the two plates within the flow meter (Fig. 1). Using the known values of thermal conductivity and thickness for the polycarbonate, the temperatures of the bottom and top plates, the thickness of the coating, and the measured value of heat flux (Q) for the system tested, the thermal conductivity of the coating can be calculated using Fourier's Law of Heat Conduction.

Free films of the coatings at 40 mils' DFT were cast on release paper and tested for tensile and elongation according to ASTM D638. Adhesion was tested according to ASTM D3359 for coatings applied to clean, smooth cold-rolled steel at 25 mils' DFT.

Humidity resistance was evaluated by casting films on clean, smooth cold-rolled steel at 50 mils' DFT, drying for a week at room temperature, and placing the panel in a Cleveland condensation cabinet, according to ASTM D4585. Films were evaluated for blistering and rusting at various exposure times.

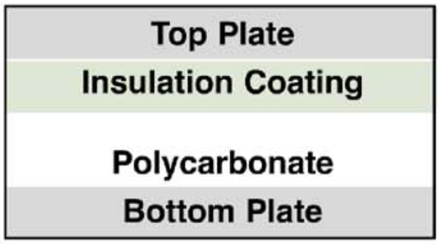


Fig. 1: Schematic diagram of heat flow meter configuration for thermal conductivity testing
Figures courtesy of the authors

Corrosion resistance of systems, including the insulation coatings as a topcoat over an anti-corrosive primer, was tested according to ASTM B117. The primer was an experimental two-component waterborne epoxy formulated with inhibitive pigment. The primer was applied at 3 mils' DFT on smooth cold-rolled steel and cured for seven days at room temperature, then topcoated with 50 mils' DFT of insulation coating and dried for another seven days. Panels were scribed before exposure and rated for blistering and rusting.

The ability of the insulation coating to reduce the surface temperature of hot steel was determined by placing a coated piece of steel on a hot plate and measuring the surface temperature of both uncoated and coated steel with a handheld infrared thermometer. A piece of smooth cold-rolled steel was coated with 75 mils' DFT of the insulation coating and allowed to dry for seven days before testing. Panels were placed directly on a hot plate set to 180 F and allowed to equilibrate. Surface temperature was measured every 10 minutes until it reached an equilibrium value. A side-by-side comparison with an uncoated piece of steel was done in every instance.

Results and Discussion

Table 3 shows the results of thermal conductivity measurements for the various combinations of binder and filler. The main contribution for the low thermal conductivity values is from the functional fillers, which, for the experimental formulations, are either the hollow glass microspheres

Table 3: Results of Thermal Conductivity Measurements

Coating	Polymer	Polymer Type	Hollow glass microsphere (%PVC)	Silica aerogel (%PVC)	Thermal conductivity, k (W/mK)	Thermal conductivity, k (mW/mK)
Uncoated polycarbonate	N/A	N/A	N/A	N/A	0.1649	164.9
COM-1	unknown	acrylic	-	-	0.070	70
COM-2	unknown	acrylic	-	-	0.106	106
A-1	EXP-A	acrylic	75	0	0.080	80
A-2	EXP-A	acrylic	50	25	0.080	80
A-3	EXP-A	acrylic	25	50	0.130	130
A-4	EXP-A	acrylic	0	75	0.120	120
B-1	EXP-B	acrylic	75	0	0.0850	85
B-2	EXP-B	acrylic	50	25	0.0880	88
B-3	EXP-B	acrylic	25	50	0.127	127
B-4	EXP-B	acrylic	0	75	0.104	104
C-1	EXP-C	epoxy	75	0	0.107	107

(GL) or the silica aerogel (AER). The exact type of filler used in the commercial coatings is unknown. The experimental formulations display values from 0.08 to 0.13 W/mK, which are similar to those observed for the commercial coatings COM-1 and COM-2 at 0.07 and 0.11 W/mK, respectively.

Although a low thermal conductivity was achieved with all the experimental formulations, there are differences among formulations containing the same polymer but different filler combinations, even though the PVC is held constant at 75%. For example, in the formulations with acrylic EXP-A, the coating with only hollow glass microspheres (A-1) has the lowest thermal conductivity, while the coating with

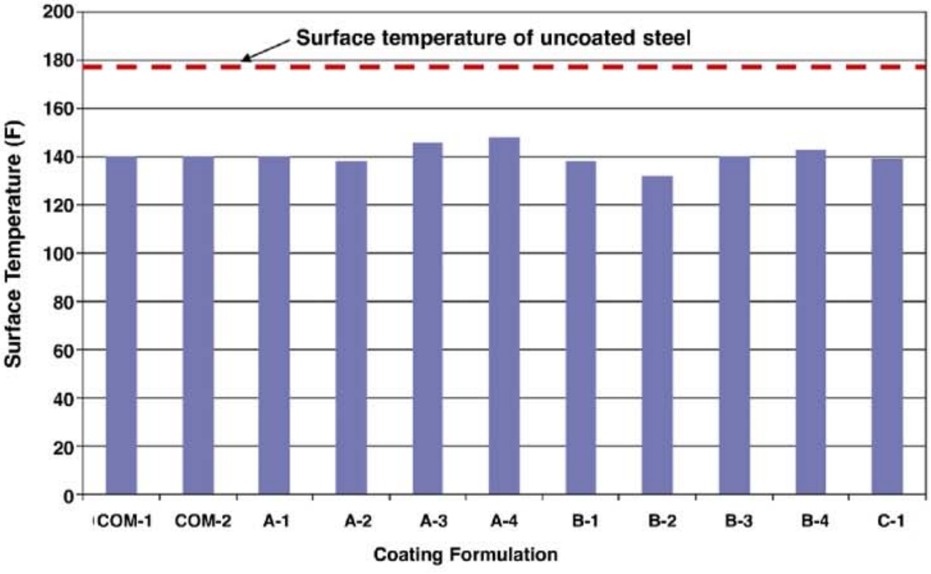


Fig. 2: Surface temperature of insulation coatings at 75 mils' DFT on steel heated to 180 F

only silica aerogel (A-4) has the highest. This result is somewhat surprising because the silica aerogel is a lower density material and should lead to a lower density coating, presumably containing a higher level of still air. The lower density in the wet state is confirmed by measurements of wet density that closely match the calculated values. Although we have not yet confirmed the reason through experiments, we postulate that the difference may be due to the density of the dry film, and we suspect that some polymer intrusion into the open cell pore structure of the silica aerogel may be occurring and displacing air.

The ability of the insulation coatings to provide safe-touch properties was evaluated by measuring the decrease in surface temperature of coated steel compared to uncoated steel. At the film thickness tested, all of the coatings gave a significant decrease in surface temperature (Fig. 2). Most of the coatings gave a surface temperature of 140 F (60 C) or below, which is needed to pass the five-second contact that would result in a first-degree burn.[6-7]

Some differences were noted among the experimental insulation coatings based on filler type, and correlate with the thermal conductivities discussed above. Hollow glass microspheres were more efficient at lowering the surface temperature than the silica aerogel at the same PVC. For example, in coatings made with acrylic polymer EXP-A, coatings A-1 (75% PVC hollow glass microspheres) and A-2 (50% PVC glass microspheres/25% PVC silica aerogel) had surface temperatures of 140 F and 138 F, respectively, compared to coatings A-3 (25% PVC glass spheres/50% silica aerogel) and A-4 (75% PVC silica aerogel) with surface temperatures of 146 F and 148 F. The ability to provide safe-touch properties depends not only on the thermal conductivity and heat flux properties of the coating, but also on the service temperature of the metal surface and film thickness of the coating. At higher metal temperatures, thicker films will be needed to bring surface temperatures down to the required levels for safe-touch protection.

The insulating properties of the coatings are

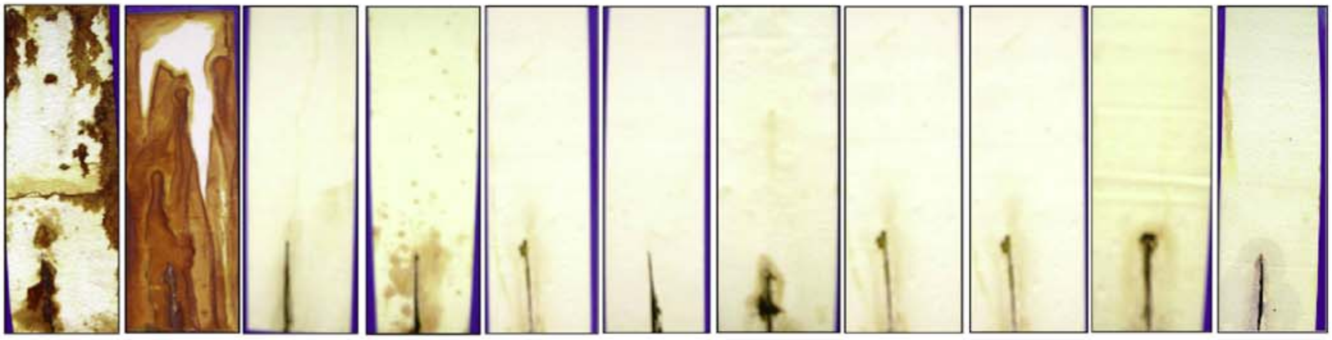
Table 4: Results of Tensile, Elongation, Adhesion, Humidity, and Salt Spray Testing for Insulation Coatings

Coating	Tensile strength (psi)	Elongation at break (%)	Adhesion	1,000-hr Humidity exposure	2,016-hr Salt spray exposure blisters
COM-1	brittle	brittle	5B	no blisters or rust	none
COM-2	169	30	5B	no blisters or rust	none
A-1	185	61	5B	no blisters or rust	none
A-2	196	103	5B	no blisters or rust	none
A-3	204	156	5B	no blisters or rust	none
A-4	173	243	5B	no blisters or rust	none
B-1	113	73	5B	no blisters or rust	none
B-2	137	93	5B		
B-3	182	325	5B	no blisters or rust	none
B-4	182	300	5B	no blisters or rust	none
C-1	brittle	brittle	5B	no blisters or rust	none

largely due to the low thermal conductivity of the functional fillers. The polymer in the insulation coating also contributes to important properties such as adhesion to the substrate, flexibility, and barrier properties (water and corrosion resistance). In some ways, the role of the binder in the highly filled insulation coatings is similar to the role of the binder in highly filled organic zinc-rich primers. The main role is to hold the functional filler particles together in a cohesive film that will adhere to the substrate and withstand the stresses imposed on the coating (e.g., impact, flexing, UV light and water). Table 4 shows results of tensile and elongation measurements, adhesion testing, and barrier properties. Adhesion was measured on a smooth steel substrate, and all of the experimental and commercial coatings performed well, with no failure in crosshatch tape adhesion testing. Elongation measurements on free films demonstrate that all of the experimental acrylic-based coatings performed much better than the commercially available coatings and the epoxy-based coating C-1. COM-1 and C-1were too brittle to prepare a free film to get an accurate measurement, and COM-2 had only 30% elongation. Compared to COM-2, the experimental acrylic coatings had from two to ten times the percent elongation, ranging from 61 to 325% elongation. The type of filler significantly affected percent elongation. In general, higher levels of silica aerogel provided higher percent elongation. The correlation between silica aerogel level and percent elongation is strong for the acrylic-based coatings, and represents a key reason to include this filler in insulation coating formulations. Higher elongation typically translates into improved flexibility, which suggests that coatings containing some silica aerogel will be less prone to cracking when placed under stress. We are currently examining this hypothesis through thermal cycling, impact and flexibility, and exterior exposure testing.

Barrier properties for the coatings were examined through humidity (Cleveland condensation cabinet) and salt spray exposure testing (Table 4 and Fig. 3). The coatings were applied directly to smooth cold-rolled steel for humidity testing, and performed very well after 1,000 hours' exposure to condensation, with no blistering or rusting. Salt spray testing was performed over smooth cold-rolled steel panels that were first

Salt spray results—2,016 hours



Coating Polymer Filler	COM-1 acrylic unknown	COM-2 acrylic unknown	A-1 EXP-A 75% PVC GL	A-2 EXP-A 50% PVC GL/ 25% PVC AER	A-3 EXP-A 25% PVC GL/ 50% PVC AER	A-4 EXP-A 75% PVC AER	B-1 EXP-B 75% PVC GL	B-2 EXP-B 50% PVC GL/ 25% PVC AER	B-3 EXP-B 25% PVC GL/ 50% PVC AER	B-4 EXP-B 75% PVC AER	C-1 EXP-C 75% PVC GL

Fig. 3: Panels coated with insulation coatings, after 2,016 hours of salt spray exposure. Panels were primed with a waterborne epoxy.

primed with 3 mils' DFT of an experimental waterborne epoxy primer and topcoated with 50 mils' DFT of the insulation coatings. Pictures of several salt spray panels after 2,016 hours' exposure are shown in Fig 3. Both commercial coatings performed poorly as part of the coating system, with heavy rusting bleeding through the insulation coatings COM-1 and COM-2. The formulation parameters for the commercial coatings are unknown, but film porosity and water permeability may be higher than the experimental coatings due to choice of polymer and filler type and levels. In general, the experimental coatings performed well in a system over the waterborne epoxy primer, with no blistering and little rust bleed. Only coating A-2 showed appreciable rust spots bleeding through the insulation coating. Additional testing over waterborne acrylic primers showed similar performance, although the systems primed with the waterborne epoxy did slightly better in blister resistance. Although their main function is to provide insulation properties, insulation coatings can add to the corrosion resistance of a coating system due to their barrier properties. The use of hydrophobic acrylic polymers and highly cross-linked waterborne epoxy resins with the proper choice of fillers yields a thick-film coating that helps resist corrosion by preventing water and electrolyte from reaching the steel surface.

Conclusions

Entrapped air between the fibers or cell structure of traditional insulation leads to very low thermal conductivity for those materials. A class of functional fillers, including hollow glass microspheres and silica aerogel, are available for use in coatings and building products, and derive their low thermal conductivity from the presence of air trapped in their small voids and pores. When incorporated into waterborne coatings based on acrylic or epoxy polymers, the functional fillers lead to a new class of insulating materials: waterborne thermal insulation coatings. These insulation coatings offer a number of advantages compared to traditional insulation, including easy spray application, less risk of CUI and easier inspection, simple application to complex geometries, improved personal protection (i.e., safe-touch) properties, and energy savings through their insulating properties.

Excellent elongation properties have been observed with the acrylic insulation coatings, particularly when silica aerogel is included as part of the functional filler. Higher elongation compared to commercially available coatings should translate to better flexibility in situations where it is needed. Finally, the ability of the insulation coating to perform its functional purpose, i.e., insulation, is important, but we have also shown that it can take part in the pro-

tective qualities of the coating system. We have demonstrated that a waterborne system consisting of a waterborne epoxy primer topcoated with a waterborne insulation coating can offer good corrosion resistance properties on steel. For the experimental insulation coatings described in this work, the acrylic and epoxy resins and functional fillers such as silica aerogel are hydrophobic by design, and, with proper formulation, offer a good barrier to water and electrolytes and thus improve the corrosion resistance of the overall system.

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Applicator Training Bulletin

An Introduction to the Deterioration of Concrete

By Randy Nixon, Corrosion Probe, Inc.

You might be wondering why we coat concrete. After all, it feels like a pretty hard substrate. And, in fact, when correctly engineered and constructed, concrete is one of the strongest construction materials available.

But even when it is mixed, poured, and allowed to hydrate (chemically combine with water) properly, concrete alone cannot withstand many exposure environments. Just as properly-applied coatings can help extend the service life of steel, they can also help extend the service life of concrete.

This Bulletin will explain the basic make up of concrete, characteristics of uncoated concrete that make it particularly susceptible to attack in industrial structures, and three of the main mechanisms of concrete deterioration.

Concrete: Make Up and Weak Spots

There are many kinds of concrete, but all are made from the same types of ingredients:

- water (preferably potable water);
- aggregates (such as sand and stones);
- cement (generally a type called Portland cement), which holds the material together when mixed to form a paste with water; and
- additives to give special properties to the concrete (during or after placement).

Fig. 1: Rebar corrosion of a bridge deck soffit
Photos courtesy of Corrosion Probe, Inc.

Properly-engineered concrete hardens into a strong material. In addition, concrete is often placed over wire mesh or over a grid of steel bars called reinforcing steel bars, or rebar, which add tensile strength to the concrete and serve other purposes for the structure being built. Tensile strength relates to the ability of a material to withstand tension without fracturing. If you have ever been on a concrete pier with some of the concrete worn away, you may have seen rebar sticking into the water from the pier. Concrete with rebar is called reinforced concrete.

Despite its strength, concrete has features that can contribute to its deterioration under certain exposure conditions.

First, the cement paste that holds concrete together is made up of substances called alkaline hydrates. Many chemicals and processes easily attack such alkalis. One major alkali in Portland cement paste is calcium hydroxide. We'll read more about this substance later. For now, it's important to know that when the cement paste is attacked, the aggregate is exposed and loosened, and the concrete will eventually deteriorate.

Second, if you looked at the surface of concrete through a magnifying glass, you would probably see that the material is very porous. There are many small passageways or pores within the paste. Water and other substances can get into these pores and attack the paste, the aggregate, or both. In addition, some penetrating substances react with and expand inside the concrete, forcing it to crack from within.

Third, you might remember from the April 1997 Bulletin that steel corrodes when three ingredients are present: moisture, oxygen, and ions such as chlorides. If these three ingredients penetrate reinforced concrete, the rebar itself will corrode, further contributing to the deterioration of the concrete (Fig. 1).

Mechanisms of Concrete Deterioration

We will divide the mechanisms of concrete deterioration into three broad types: chemical, physical, and thermal (heat-related). Each mechanism, or a combination of them, can attack cement paste, aggregate, or rebar.

Chemical Mechanisms

Chemical mechanisms of concrete deterioration begin with a chemical reaction. A chemical substance in the environment comes in contact with a concrete structure, and a reaction occurs between the chemical and the paste. The reaction weakens, dissolves, or otherwise changes the paste, so that the paste can no longer hold the concrete together. Chemicals that attack the cement paste in concrete include acids, alkalis, gases, oils and fats, and sugars. Attack of the paste leaves rebar unprotected and subject to corrosion. Here are some examples.

Acid Attack

Acids occur naturally and as manufactured substances. Naturally-occurring acids are often produced by decaying plants. Manufactured acids include sulfuric, hydrochloric, and nitric acids. Sulfuric acid is also formed under some natural conditions such as in municipal and industrial sewers.

Acid reactions with concrete typically occur in a two-part process. The first phase is an acid-base reaction, which is a chemical reaction. The primary reactants are the acidic solution (liquid) from the exposure environment, and calcium hydroxide and other hydrated compounds from the cement paste. In the reaction, the cement paste dissolves, which weakens the concrete.

The second phase is removal of the calcium hydroxide and other soluble reaction compounds by leaching. Solid and liquid compounds are left after the chemical reaction. The liquid compounds wash away the solid compounds.

Acidic attack is generally indicated by a progressive loss of cement paste, exposing coarse aggregate and, sometimes, exposing and corroding rebar (Fig. 2, p. 63).

Sulfate Attack

Like acids, sulfates are chemical compounds derived from natural sources as well as from manufacturing processes. In nature, sulfates of various metals (such as sodium, magnesium, calcium, and potassium) are found in soils and dissolved in groundwater. Sulfate compounds are also common in chemical manufacturing industries, including

petrochemical processing, oil refining, pulp and paper manufacturing, and metals mining and refining. Sulfates are also found in industrial and municipal wastewater.

Sulfates react with certain ingredients in cement paste and penetrate the concrete. Rather than dissolving the paste, this reaction forms chemical compounds that are larger in volume than the original sulfates and cement paste. This increase in volume produces expansive forces in the concrete. When these forces exceed the tensile strength of the concrete, the concrete cracks and disintegrates (Fig. 3).

Chloride-Induced Deterioration

When concrete is exposed to an external source of chlorides (from various salts), the main mechanism of deterioration is corrosion of the rebar. When concrete is first placed, the steel surface of rebar initially corrodes very slightly; then, a tightly adherent film forms over the steel surface, and corrosion stops. This film protects the steel from further corrosion, as long as the film is not altered. The film provides what is called passive protection. This protection is maintained by the high pH environment created by alkalis in the cement paste.

The destruction of passive protection occurs when moisture, ions (for example, chlorides), and oxygen penetrate the concrete through pores or cracks and reach the steel and corrode it. As the rebar corrodes, expansive forces are set up within the concrete because the rebar's corrosion products take up more space than the uncorroded rebar. When these expanding forces exceed the tensile strength of the concrete, it cracks, allowing further penetration of moisture, chlorides, and oxygen, and ongoing corrosion of the rebar.

The main signs of chloride-related corrosion of rebar are rust bleeding, cracking, and spalling (delamination of the concrete over the rebar). Rebar corrosion is a major problem on concrete bridge decks and other places where salts are present (Fig. 1, p. 60).

Microbiological Attack

Micro-organisms, such as bacteria and tiny marine organisms called mollusks, can cause concrete to deteriorate.

Most bacteria do not attack concrete directly. Rather, concrete deterioration results from the reaction of bacteria with various chemical compounds to which the concrete is exposed. The most common bacterial-related attack of concrete occurs in sewage treatment systems. The chemical formed from the reaction between bacteria and the compounds in sewage is sulfuric

acid. This acid dissolves the cement paste, leaving exposed, loose, coarse aggregate.

Marine rock-boring mollusks found in very warm coastal waters damage concrete structures by boring paths into it. These paths allow chlorides and water to easily penetrate the concrete all the way to the rebar and cause it to corrode. When the rebar corrodes, the corrosion products take up so much space inside the concrete that they force it to crack from within and spall.

Physical Mechanisms

Physical mechanisms of concrete deterioration start with a physical attack from external objects or equipment. Examples include abrasion damage from physical equipment on concrete, erosion damage from solid objects in water flowing over concrete structures, and freeze-thaw damage that occurs when water penetrates concrete and freezes.

Fig. 2: HCl acid attack in petrochemical plant

Fig. 3: Advanced sulfate attack of concrete exposed to high sulfate-bearing water

Fig. 4: Scaling of concrete deck in parking garage due to freeze-thaw cycle

Abrasion Damage to Concrete

Abrasion damage to concrete by wear from physical equipment such as forklifts and dumpster skids is a significant cause of concrete degradation in industrial floors and in concrete pavements for vehicular traffic. The cement paste is typically worn away first, followed by the exposure of and damage to the aggregate. The largest aggregates are often dislodged by continued abrasion after the surrounding paste has been removed.

Erosion Damage to Concrete

Erosion damage to concrete involves physical wear from a liquid having suspended solids in it. When solid particles in flowing water strike a concrete surface, the solids first wear away the cement paste and then the aggregate. Erosion typically leaves a relatively smooth wear pattern in the concrete. When such water is flowing quickly, several inches of concrete can be worn away in a few years, even when suspended solids are not especially large in size.

Another type of erosion, chemical-related erosion, occurs after acid attack. If liquid flow continues after an acid reaction, the liquid may carry away reaction by-products, thus wearing down the concrete. Cavitation is a third type of erosion. It typically occurs when turbulent liquids that contain air bubbles strike concrete and wear it down.

Freeze-Thaw

Freeze-thaw cycles often result in concrete deterioration. The major damage is caused by the freezing phase of the cycle. When water trapped in the pores of the paste freezes and expands, stresses form within the cement paste. When the pressure from the ice exceeds the strength of the paste, the paste fails, and the concrete weakens.

Freezing also causes aggregate failure, especially close to the exposed surface. Cracks and an effect called scaling appear. Scaling is really a series of tiny, connected cracks caused by the freezing. If a thaw occurs and the ice in the cracks melts, the next freeze phase will cause the water to freeze again, and the newly formed ice will pry the cracks further apart.

Freeze-thaw damage is common in parking garages and bridge abutments (Fig. 4).

Thermal Deterioration

Concrete expands and contracts as temperatures rise and fall. When, for example, concrete is subjected to high temperatures during operation and then the source of heat is shut down, concrete surface temperatures are reduced over several hours. This type of thermal expansion and contraction causes some cracking. Factors such as washing down the concrete with cold water during initial shutdown hours magnify the problem.

Another effect of elevated temperature on concrete has to do with the differences in the rate with which rebar and surrounding concrete conduct heat, a property called thermal conductivity. Steel conducts heat much more quickly than concrete. If the temperature of both of the materials is increased significantly and quickly, they will have different rates of thermal expansion. The different rates of expansion will cause cracking. There are also other more complex ways in which sustained elevated temperatures cause concrete to degrade.

Conclusion

In industrial facilities, concrete is often exposed to a combination of chemical, physical, and thermal mechanisms, which may result in rapid deterioration and structural failures. If recurring deterioration or damage is to be avoided, it is important that all the causes of deterioration are well understood.

JPCL

SSPC Annual Report
(January 1, 2012 to December 31, 2012)

PART I: INTRODUCTION

This annual report gives an overview of the activities, plans, and status of SSPC: The Society for Protective Coatings from January 1, 2012 through December 31, 2012. The information enclosed gives the most current figures for all programs.

SSPC had another successful year. We held our conference in Tampa, FL, increased training program delivery, and continued developing and marketing new training programs.

We continue to look at foreign markets as a way to expand SSPC and continue to reinforce our message that the use of protective coatings is the best solution for corrosion control. We have contracted with a consulting firm to help the organization focus on markets that need our training and our members' expertise.

Marketing efforts continue to focus on core SSPC member demographics spread across a broad range of industries and disciplines that use protective coatings.

PART II: ACCOMPLISHMENTS

The acceptance of our Protective Coatings Inspector Course by Bureau Veritas was a major accomplishment in 2012. This is an addition to those who already recognize the course: Lloyds, RINA, and the American Bureau of Shipping. The reason we highlight this is because, to our knowledge, the SSPC inspection course is the only one of the many given that has undergone independent audits by an outside agency. The Florida Board of Professional Engineers approved our entire program for the 2013 conference for Professional Education Units, and the American Institute of Architects approved five sessions at our 2013 conference for continuing education units.

Individual training and certification remain the hallmarks of our association. Last year these two cost centers were 33% of the revenue for SSPC. This year the figure is 37%. From 2011 to 2012, training and certification have increased in revenues by 21.3% as SSPC's courses were requested or specified to meet the needs of the industry in general. New training courses developed in 2012 are noted later in this document. We have also continued to conduct training for all our armed forces, the US Coast Guard, and NASA under the auspices of the University of Akron contract with the Department of Defense Office of Corrosion Policy and Oversight.

SSPC's Protective Coatings Inspector (PCI) Certification was also written into the specifications for the following companies in 2012: ExxonMobil, USA; Chevron Energy Technology Corporation, USA; and RasGas Company, Limited, Qatar. Also, PTT Aromatics and Refining, Thailand, mandated PCI, Abrasive Blast Cleaning (C7), and Airless Spray (C12) in their specifications.

In addition, SSPC signed an agreement with Moody International in China to conduct the SSPC Protective Coating Inspector (PCI) recertification exam. We also established a license agreement in Singapore with IN-SPEC to deliver the SSPC Abrasive Blaster Certification (C7), SSPC Airless Spray Basics Certification (C12), and the Protective Coating Inspector (PCI) recertification exam. We further partnered with the American Society of Materials (ASM) to make SSPC's technical materials available on the ASM International Corrosion Analysis Network.

We made the QP program more user-friendly. QP Contractors can now file their Corrective Action Plans (CAPs) in response to audit findings using an automated, online process. Contractors simply go online, complete the form, and click submit. This new process eliminates paperwork for both the contractor and SSPC.

In October 2012, SSPC launched our Nuclear Coating Contractor Certification Program, SSPC QN-1. This new contractor certification program evaluates the qualifications of industrial coating contractors that perform work in nuclear power plant facilities and shop facilities that coat parts or components for installation in primary containment or other safety- related areas of light water nuclear power plants. This procedure encompasses: field application of protective coatings for corrosion control and decontaminability of concrete, non-ferrous metal and steel surfaces in Service Level I and III areas of nuclear power plant facilities; and, where applicable, shop application of coatings for parts and components to be installed in Service Level I and III areas.

In the area of providing information, SSPC posted headlines on our website relating to government activities that may affect the coatings industry.

We also had 869 technical information inquiries in 2012. We are now finding that many of the coatings technical conversations are taking place on social media outlets such as LinkedIn or Facebook, not on SSPC's Coatings Talk. By participating in these interactions, a user may make use of the outstanding knowledge and expertise of the SSPC membership. Heather Stiner, a chemist and a member of the SSPC staff, is also a superb resource of information for our members, and we invite you to make use of her capabilities.

Another item of note: Again this year SSPC awarded four scholarships to deserving students who are studying in the coatings field. The Board has mandated that this be continued in 2013.

Table 1: Standards and Publications Completed in Year Ending December 2012

NEW

SSPC-Paint 43 Direct-to-Metal Aliphatic Polyurea Coating, Performance-Based – March 2012
SSPC-PA 14 Field Application of Plural Component Polyurea and Polyurethane Thick Film Coatings to Concrete and Steel – September 2012
SSPC-PA 15 Material and Preparation Requirements for Steel Test Panels Used to Evaluate the Performance of Industrial Coatings – September 2012
SSPC-PA 16 Method for Evaluating Scribe Undercutting on Coated Steel Test Panels Following Corrosion Testing – September 2012
SSPC-PA 17 Procedure for Determining Conformance to Steel Profile/Surface Roughness/Peak Count Requirements – September 2012
SSPC-Guide 19 Selection of Protective Coatings for Use Over Galvanized Substrates – November 2012

REVISED

SSPC-Paint 38 Single-Component Moisture-Cure Weatherable Aliphatic Polyurethane Topcoat, Performance-Based – March 2012
SSPC-QP 5 Standard Procedure for Evaluating the Qualifications of Coating and Lining Inspection Companies – May 2012
SSPC-PA 2 Procedure for Determining Compliance to Dry Coating Thickness Requirements – May 2012
SSPC-QP 1 Standard Procedure for Evaluating the Qualifications of Industrial/Marine Painting Contractors (Field Application to Complex Industrial and Marine Structures) – June 2012
SSPC-SP 11 Power Tool Cleaning to Bare Metal – July 2012
SSPC-SP 15 Commercial Grade Power Tool Cleaning – July 2012
SSPC-SP WJ-1/NACE WJ-1 Waterjet Cleaning of Metals – Clean to Bare Substrate – July 2012
SSPC-SP WJ-2/NACE WJ-2 Waterjet Cleaning of Metals – Very Thorough Cleaning – July 2012
SSPC-SP WJ-3/NACE WJ-3 Waterjet Cleaning of Metals – Thorough Cleaning – July 2012
SSPC-SP WJ-4/NACE WJ-4 Waterjet Cleaning of Metals – Light Cleaning – July 2012

PART III: MEMBER PROGRAMS

SSPC is a member-based organization. We are evaluated on how well our programs and services meet the needs of our members and the protective coatings industry.

Standards and Publications

Our core product is our standards. There were six new standards issued and 10 standards revised in 2012. New and updated standards are listed in Table 1.

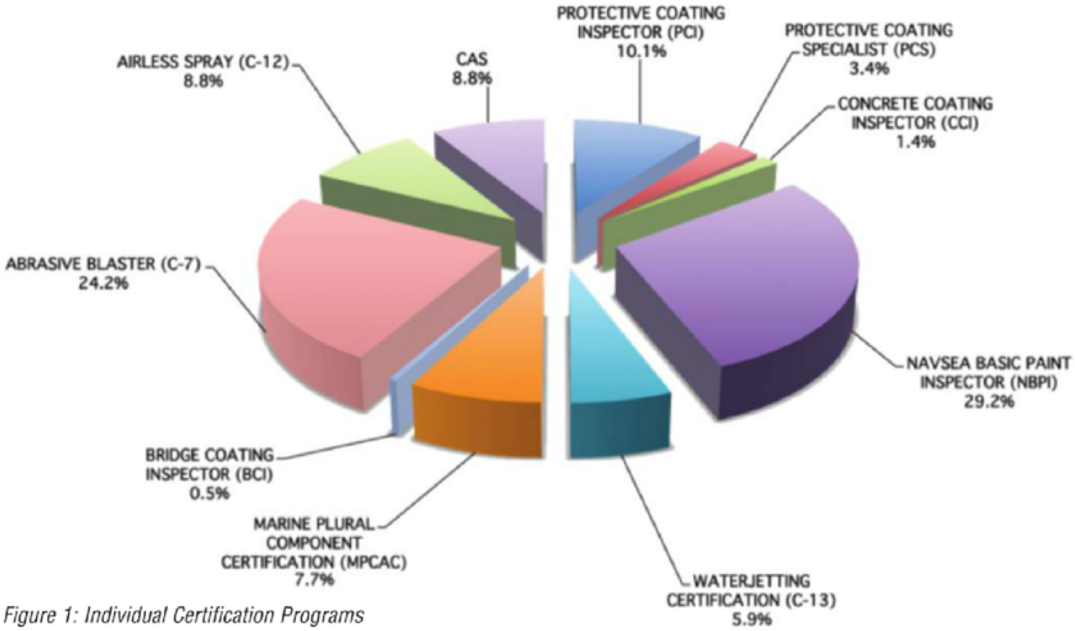


Figure 1: Individual Certification Programs

Certification

The past year saw an increase in the total number of certified contractors. Three hundred twenty-nine contractors, many holding multiple certifications, have achieved certification, an increase of 5.1% over 2011. The past year also saw an increase in the total number of certified coating and lining inspection entities. Nine companies have achieved Coating and Lining Inspection Company Certification.

In the Protective Coatings Specialist Certification (PCS) program, we now have 283 participants certified, an increase of 3.7% from last year. A breakdown of the certification programs is shown in Figure 1. Not listed in the figure are Aerospace Coating Applicator Specialist and Thermal Spray Certifications. They are new certifications and have had few attendees.

Training

SSPC launched four new training programs in 2012. They are: Coating Specification Essentials, Inspection Planning and Documentation, Inspection Instruments Workshop, and Plural Component Application of Polyureas and High Solid Coatings. We also revised two other courses: Bridge Coating Inspector (BCI) and Applicator Train-the-Trainer. We also completed translation of the SSPC C7 Dry Abrasive Blasting course and the SSPC Glossary into Spanish.

In other training news, the SSPC C-1, Fundamentals of Protective Coatings and the C-2, Planning and Specifying Industrial Coatings Projects courses have continued with 164 [+1.8%] students trained this past year. The number of students taking advantage of our online offerings of these courses has decreased to 162 [-8.6%] this year. For Lead Supervisor Competent Person training and refresher courses (C-3 and C-5), 1,985 [+5.4%] students received training. The C-7 Abrasive Blasting course had 371 [-1.9%] personnel trained. Airless Spray (C-12) had 252 [+121%] students trained; WaterJetting (C-13) had 94 [-16.8%]; and Marine Plural Component (C-14) had 72 [-34.5%]. The Applicator Train-the-Trainer course had 44 [+51.7%]. The Quality Control Supervisor course (QCS) had 16 [-79.2%] students trained with another 181 [+9%] taking the course online. Six students attended the Evaluating Common Contract Clauses; nineteen trained in the Navigating 009-32; and 43 in the Basics of Estimating Industrial Coatings Projects.

The Coating Applicator Specialist (CAS) program made strides this year with 87 achieving CAS Level 1 and 730 achieving CAS Level 2 or Level 2 Interim Status. SSPC's Concrete Coating Inspector Certification (CCI) Program had 78 [+77.2%] students. There were 527 [+25.5%] in the

NAVSEA Basic Paint Inspector (NBPI) program, 144 [+23.1%] in the Bridge Coating Inspector (BCI) Program, and 317 [+7.5%] students completing the Protective Coating Inspector (PCI) Program. *In brackets is the percentage increase or decrease from last year.

Webinars

SSPC continued the free webinar program that began in 2010. Nine webinars were given in 2012. This year's attendance was 838. SSPC continues to offer a short online exam for each webinar that provides Recertification Units toward an individual's Protective Coating Specialist (PCS) credential. Eighty-eight individuals took an online webinar exam in 2012. All of the webinars in the 2012 series are archived and can be viewed at PaintSquare.com.

Website

The average number of unique visitors to our site is 16,402 per month, a slight increase from last year. We also acquired six new domain names for possible use in the future.

PART IV: MEMBERSHIP AND ADMINISTRATION

Membership

During the reporting period, SSPC organizational membership (OM) increased to 863, or 5%. Individual membership grew from 9,160 in December 2011 to 9,689 in December 2012, an increase of 5.2%. A breakdown of individual members' demographics is shown in Figure 2; however, it remains nearly the same as the previous year.

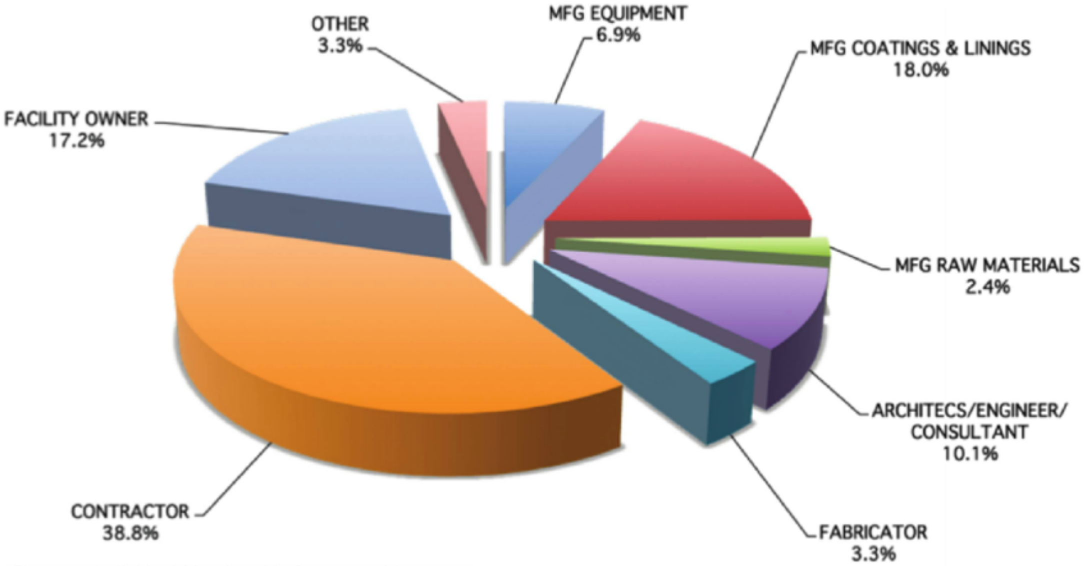


Figure 2: Individual Membership Demographics

Table 2 Board of Governors

NAME	COMPANY	REPRESENTING
Stephen Collins **President**	**Air Products and Chemicals, Inc.** **Thomaston, GA**	**Coating Material Suppliers**
Benjamin S. Fultz **President-Elect**	**Bechtel Corporation** **Houston, TX**	**Facility Owners**
James R. King, Jr. **Vice-President**	**John B. Conomos, Inc** **Bridgeville, PA**	**Coating Contractors**
Robert McMurdy **Immediate Past- President**	**Mohawk Garnet, Inc. Ontario, Canada**	**International Representative and Other Product Suppliers**
Gunnar Ackx	SCICON Worldwide bvba Brugge, Belgium	International Representative and Other Service Providers
Derrick Castle	Kentucky Transportation Cabinet Frankfort, KY	Facility Owners
Garry D. Manous	Atsalis Brothers Painting Warren, MI	Coating Contractors
Victor Pallotta	ARS Recycling Systems, LLC. Lowellville, OH	Other Product Suppliers
Brian Skerry	The Sherwin-Williams Company Cleveland, OH	Coating Material Suppliers
Marty Stamey	The Brock Group Beaumont, TX	Coating Contractors
L. Skip Vernon	CLT, Inc. Tijeras, NM	Other Service Providers
Joseph Walker	Elcometer Rochester Hills, MI	Other Product Suppliers
Gail A. Warner	Huntington Ingalls Industries – Newport News Shipbuilding, Newport News, VA	Facility Owners

* Officers in Bold

Table 3 Revenue Versus Expense (Unaudited and before final adjustments)

REVENUE	FY 12	FY 11
Memberships	$1,038,000	$997,000
Standards and publications	$625,000	$583,000
Conferences	$850,000	$855,000
Certification & training	$4,072,000	$3,591,000
Other *	$941,000	$87,000
Total Revenue	$7,526,000	$6,113,000
EXPENSE	**FY 12**	**FY 11**
Memberships	$812,000	$759,000
Standards and publications	$608,000	$558,000
Conferences	$688,000	$651,000
Certification & Training	$2,679,000	$2,436,000
Other **	$807,000	$760,000
Total Expense	$5,594,000	$5,164,000
Net Surplus (Loss)	$1,932,000	$949,000

* Includes revenue from royalties, interest, and external projects.

** Includes expenses for SSPC chapters, governance, regulatory advocacy, knowledge center, external projects, general administration, and strategic plan implementation.

Table 4 Statement of Financial Position as of 12/31/12 (Unaudited)

	Total All Funds	General Operating Fund	Reserve Fund
Assets - Current Assets			
Cash	$1,278,000	$1,278,000	$5,943,000
Investments	$8,889,000	$2,946,000	
Accounts receivable	$182,000	$182,000	
Inventory	$150,000	$150,000	
Total	$10,499,000	$4,556,000	$5,943,000
Furniture, Fixtures, and Equipment			
Equipment, Leasehold improvements at cost less accumulated depreciation	$407,000 <$364,000>	$407,000 <$364,000>	
Total	$43,000	$43,000	-0-
Other Assets			
Prepaid expenses	$422,000	$422,000	-0-
Total Assets	$10,964,000	$5,021,000	$5,943,000
Current Liabilities			
Accounts payable	$42,000	$42,000	
Accrued expenses	$349,000	$349,000	
Deferred revenue	$1,471,000	$1,471,000	
Total Liabilities	$1,862,000	$1,862,000	-0-
Net Assets - Unrestricted	$9,102,000	$3,159,000	$5,943,000
Total Liabilities and Net Assets	$10,964,000	$5,021,000	$5,943,000

Table 5 Changes in Net Assets (Unaudited)

	Total All Funds	General Operating Fund	Reserve Fund
Unrestricted net assets - December 31, 2011	$7,170,000	$3,298,000	$3,872,000
Change in net assets as a result of current operation	$1,932,000	$1,361,000	$571,000
Transfer from general operating fund to reserve fund		<$1,500,000>	$1,500,000
Unrestricted net assets - December 31, 2012	$9,102,000	$3,159,000	$5,943,000

We are pleased with the progress in increased organizational and individual membership in these uncertain economic times. However, we cannot remain satisfied with the status quo.

Governance

The Board of Governors changed in 2012. The Board welcomed Mr. Vic Pallotta from Advanced Recycling Systems, and Mr. Joe Walker from Elcometer, both representing other product suppliers. The present Board is shown in Table 2.

Administration

Key staff members remained the same. They are: Bill Shoup, Executive Director; Michael Damiano, Director of Product Development; Barbara Fisher, Controller; Mike Kline, Director of Marketing; and Terry Sowers, Director of Member Services.

PART V: FINANCES

We are pleased to report that SSPC again met its financial goals for the FY that ended December 31, 2012. The reserve fund now stands at $5.943M, which would cover about 79% of the 2012 annual operating revenue. SSPC has met its financial goals by increasing operating revenue by $1.413M while only increasing expenses by $430,000. SSPC's investment income increased $902,000 from -$23,000 in 2011 to $879,000 in 2012. The financial details for the last fiscal year and the prior fiscal year are presented in Tables 3 through 5. Those charts demonstrate that SSPC continues to be a financially sound organization and all of our financial indicators and ratios are healthy.

Respectfully Submitted:

Bill Shoup

William L. Shoup, Executive Director

Project Preview

Photos courtesy of Wikimedia Commons

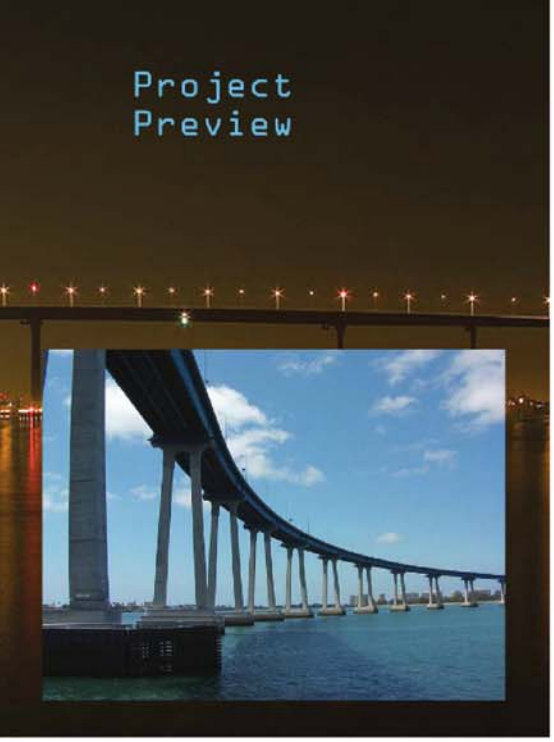
Certified Coatings to Repaint Coronado Bridge

A $2,294,294 contract was awarded by the California Department of Transportation to Certified Coatings Co. (Fairfield, CA), SSPC-QP 1 and -QP 2 certified, to clean and recoat structural steel surfaces on four spans of the San Diego-Coronado Bridge. This 44-year-old, 11,179-foot-long prestressed concrete and steel girder bridge crosses the San Diego Bay, linking the cities of San Diego and Coronado, CA.

The contract includes steam-cleaning or pressure-washing and testing the steel—including rocker bearings, catwalks, and bridge crane rails—for soluble salts, according to SSPC-Guide 15, with as-needed chloride remediation. Corroded surfaces and all crane rail surfaces will then be abrasive blast-cleaned to a Near-White finish (SSPC-SP 10) and coated with an inorganic zinc-rich primer. Finally, all steel will be finished with a two-coat waterborne system. Class I containment according to SSPC-Guide 6 is required to capture the existing lead, cadmium, and zinc-bearing coatings.

Tank, Pump House Coating Project to Tecorp

Tecorp, Inc. (Joliet, IL) won a contract worth $118,333 from the Village of Clarenden Hills, IL, to clean and recoat interior surfaces of a 500,000-gal underground concrete water storage tank, as well the floor of an adjacent pump house and associated metal piping. The contract includes pressure-washing interior tank surfaces at 5,000–10,000 psi, before repairing and recoating the concrete with a two-coat polyurethane system. Interior steel piping will be abrasive blast-cleaned to a Near-White finish (SSPC-SP 10) and recoated with a three-coat, zinc-epoxy system. Lastly, the pump house floor will be hand-tool cleaned and recoated with an epoxy system.



USACE Awards Bridge & Dam Coating Contract

The U.S. Army Corps of Engineers, Tulsa District, has awarded a $2,613,150 contract to Fuel Tank Maintenance Co., LLC (Cookeville, TN), SSPC-QP 1 certified, to rehabilitate the Canton Lake Bridge and four sluice gates over an active spillway at the Canton Dam in Canton, OK. Constructed by USACE in 1948, this 68-foot-tall x 15,140-foot-long dam is currently receiving upgrades as part of a $209 million multiphase safety project.

The contract includes abrasive blast cleaning sluice gate surfaces to a White Metal finish (SSPC-SP 5) and coating the gates with a vinyl coating system. Use of dehumidification equipment is required, as is Class 2A containment according to SSPC-Guide 6 to capture the existing lead-bearing coatings. In addition, 32 hatch frames and covers will be cleaned and recoated with a calcium sulfonate alkyd system. The contract also includes application of a waterproofing protective coating to 3,380 square yards of concrete, as well as repairing 281 square feet of concrete with a fiber-reinforced polymer material.

Project Preview is compiled from Paint BidTracker reports.