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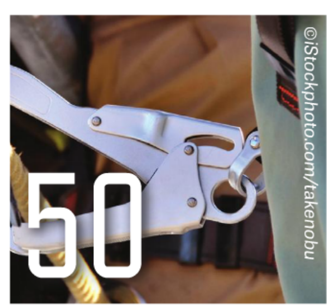
FEATURES



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Polysiloxanes and the U.S. Navy

Polysiloxane Application Issues

A polysiloxane coating is often referred to as a hybrid protective coating. Developed in the 1990s, these coatings are typically low-VOC, rapid-curing products with no isocyanates. Designed to protect substrates for extended periods of time before maintenance and refurbishment, polysiloxanes are also noted for excellent gloss retention and good thermal properties as well as resistance to abrasion and the sun's ultraviolet rays.

Checkerboard appearance of a Navy surface ship topside due to a difference in color between an aged and fresh coat of 2K polysiloxane. Photo courtesy of Naval Research Lab.

As part of a two-coat alternative to a three-coat system, polysiloxanes can be applied over galvanizing, organic and inorganic zinc, and epoxies. Spray, brush or roller application methods may be used.

Early versions of polysiloxanes were extremely brittle, which led to adhesion delamination. More recent formulations remain sensitive to ambient conditions, moisture and mix ratios. Poor adhesion may result from improper application and cure or a poor formulation. Polysiloxane failures are generally isolated instead of large in scale. Surface cleanliness can play a significant role in failures since the coating is not surface-tolerant. This article will explain how the U.S. Navy has recently dealt with some of these issues.

Polysiloxane Use in the U.S. Navy

Background

For more than 50 years, silicone alkyds were the standard topside coatings applied on surface ships. Silicone alkyds were certainly an improvement over previous topside coatings and they got the job done. They are application-friendly in that they do not require mixing of separate components, have long pot lives and are able to cure under a wide range of conditions.

The service members responsible for maintaining U.S. ships, known as "Ships' Force," also used silicone alkyds for overcoating. Ships were typically docked every three-to-five years and repainted. In one case cited by the U.S. Navy, a 49-year-old ship had 41 coats of paint on some areas, which dramatically increased the ship's weight and operating cost.

Lower solar absorption (LSA) silicone alkyds introduced in the late 1990s were also commonly used for topcoating. These coatings became popular because of their ability to reduce ships' heat loads, especially in hot climates, which in turn, reduces a ship's energy consumption when its air conditioning system is operational.

While relatively inexpensive and easy to apply as single-component materials, LSA colors tend to fade within two-to-three years, in some cases shifting to a gray-pink tint or leaving a pronounced checkerboard appearance in touchup areas. The same vessel, if overcoated over multiple sequenced days, can develop a significant shading appearance at the daily demarcation lines. This became a concern because the haze gray color is critical to conceal Navy ships in the marine environment.

Polysiloxanes (MIL-PRF-24635, Type V & VI)

In recent years, the U.S. Navy has sought to improve the quality and extend the service life of the topside coatings it uses to protect freeboards, islands and other important areas of surface ships such as destroyers, cruisers and aircraft carriers. Chief among the concerns for fleet topside coatings are color stability, durability, heat load and service life.

In order to overcome the tendency of silicone alkyds toward rapid color fading, along with issues related to slow cure times, insufficient hardness and chemical resistance, and a high rate of shrinkage, the Navy has begun to introduce polysiloxanes for topside maintenance.

Silicone alkyds are still approved for shipboard use, but polysiloxane use is growing. These coatings provide better color stability and a harder surface that is easier to clean. This reduces the need to overcoat and cover stains and running rust. Instead, both aesthetics and the ship's efficiency are improved through the use of specific power-wash cleaning procedures, which are less expensive and require less skill to implement. When cleaning polysiloxanes, "Ships' Force" follow detailed procedures developed by the Navy Corrosion Control Assistance Team (CCAT) and use a kit developed by the Naval Research Laboratory. CCAT has also developed procedures for overcoating and repairing polysiloxanes as appropriate. However, the primary goal today is to encourage "Ships' Force" to clean the polysiloxane rather than overcoat it as they did with silicone alkyds in the past — the idea being that the fleet can clean the ship regularly, much like a car is washed, instead of constantly repainting it like a house.

While polysiloxanes provide better protection properties than silicone alkyds, they are typically two-component systems with specific requirements for mix ratios (four parts to one) and application. Their limited pot life of two-to-four hours requires that they be applied quickly to ensure proper curing and drying. NRL studies currently underway are evaluating the feasibility of one-component polysiloxane materials.

Because polysiloxanes are not as surface-tolerant as alkyds, the surface must be clean — free of chalking or dust — and dry before overcoating. The Navy will allow polysiloxanes to be used to overcoat silicone alkyds but will not allow overcoating of polysiloxanes with silicone alkyd.

The Navy expects the extended service offered by polysiloxanes to offset initial higher installation costs and improve the overall performance of topside ship coatings.

Sources

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3. "NRL's Single-Component (1K) Polysiloxane Topside Coating for Navy Surface Ships," by Dr. Erick B Iezzi, James Martin, James Tagert, John Wegand and Paul Slebodnick, U.S. NRL, Center for Corrosion Science and Engineering

For questions about this article or for more information about polysiloxanes, contact Joe Berish, corporate certification manager, or Heather Stiner, manager of technical services, SSPC. Berish has been with SSPC since 2013 and can be reached at berish@sspc.org or 412-281-2331, ext. 2235. Heather Stiner is SSPC's Manager of Technical Services. She has been with SSPC for 10 years and can be reached at stiner@sspc.org or 412-281-2331, ext. 2224.

Houston Coating Society to Hold Annual Painters Competition

The Coating Society of the Houston Area is looking for teams of three (foreman, craftsman and helper) to show off their painting skills in the Society's 26th annual Painters Competition.

This free event will take place on April 16 from 7:30 a.m. to 3:30 p.m., at Valu Industrial Services, 6914 East Freeway, Baytown, Texas 77521. Attendees are invited to bring their families for some all-day "tailgating" fun, including games, face painting, door prizes, hot dogs, burgers and more.

The Painters Competition will begin at 9:00 a.m. First place can win up to $900 and free registration for an SSPC or NACE International training course. Items such as paint, panels and air will be supplied; the teams and/or their sponsors will supply the rest of the equipment needed.

For more information on the Competition, visit coatingsocietyofhouston.org. To register your team, contact Bob Yates, 281-470-9120, or Ernie McDaniel, 713-252-1479. For information on tailgating and other events, contact Steve Ubernosky, 713-384-9180, or Pete Mitchell, 713-301-0354. For door prizes and other donations, contact Manny Nerios, 713-828-9382.

The Coating Society of the Houston Area strives to promote education and best practices in corrosion control and to expand the knowledge and proper use of protective coatings to mitigate the effects of corrosion in industry, according to the Society's website. Today, the members of the Coating Society include persons and companies doing business in Southeast Texas and Southwest Louisiana that are involved in corrosion prevention and control. Membership consists of facility owners, coating applicators, coating inspectors, coating manufacturers, coating equipment suppliers and other related services.

Soucek Receives Coatings Recognition

Dr. Mark Soucek of the University of Akron (UA) Department of Polymer Engineering has been named recipient of the esteemed 2016 Roy W. Tess Award in Coatings, the Division of Polymeric Materials: Science and Engineering (PMSE) of the American Chemical Society announced Feb. 16.

The annual Tess Award in Coatings recognizes outstanding individual achievement and noteworthy contribution to coatings science, technology and engineering and reinforces PMSE's long-standing and continuing support and dedication to excellence in the coatings field.


Dr. Mark Soucek

Soucek began his career as a student at North Dakota State University at Fargo in 1993, and he joined the UA Department of Polymer Engineering as an associate professor in 2001. Now a professor at the school, Soucek has published more than 150 peer-reviewed pieces and has filed 15 U.S. patents and pending patent applications.

Soucek has a long history collaborating with the U.S. Air Force to replace chromium primers and coatings on steel and aluminum substrates for corrosion protection utilizing inorganic/organic hybrid coatings. He is also a recognized leader in drying oil technologies, particularly bio-based feedstocks. Soucek has been at the head of the renaissance of alkyd technology, even organizing and editing a special issue of *Progress in Organic Coatings* devoted to the subject. His most significant contribution to coatings science and technology is his work on environmentally benign coatings based on non-petroleum feedstocks. This contribution has involved extensive work with the industry to develop green technologies.

Soucek is also recognized as a leading authority in reactive diluent technology, in which VOCs are replaced with bio-based liquids that dissolve the polymeric binder and participate in film formation by reactive cross-linking. Most recently, Soucek has worked on isocyanate-free technology using cyclic carbonates and acrylic cross-linkable,

Hempel Begins CEO Transition Period

Henrik Andersen

Global protective coatings supplier Hempel has announced that its incoming chief executive officer has officially come on board.

Henrik Andersen joined Hempel A/S on March 1, the company said in a statement, in line with plans for him to succeed Pierre-Yves Jullien as CEO. Jullien will continue as CEO of Hempel, a Copenhagen-based supplier of protective coatings to the decorative, protective, marine, container and yacht markets, until March 29.

During the transition period, Andersen will continue to learn more about the company. The company stated that one of Andersen's primary tasks as its new leader will be ensuring that Hempel reaches the goals described in the company 2020 strategy, Journey to Excellence. The strategy is meant to enhance Hempel's position as one of the leading global coating manufacturers. It sets aggressive growth goals for its products: quadrupling its decorative portfolio; doubling the protective portfolio; and ramping up its marine products with the objective (as stated above) of becoming one of the world's top 10 coating suppliers by the end of this year.

"I am looking forward to converting the strategy into actions together with all of Hempel's employees," Andersen said. "We are part of an exciting and competitive global industry, which requires that we work together in relation to our possibilities as well as our challenges."

Andersen was named as the company's new CEO in September, following a search instituted earlier in 2015 after Jullien announced his retirement plans after 40 years with Hempel, 10 of which he served as CEO. Andersen comes to Hempel after working at ISS, one of the world´s largest facility services providers, since 2000. As a member of ISS's executive board, he was named group CFO in 2011 and became group COO, EMA in 2013. He was recently appointed global group COO, and before returning to Copenhagen, Andersen was CFO of ISS UK, a company with 43,000 employees. He was later named its CEO and served in that capacity for three years.

Prior to that, Andersen, who has a Master of Law degree from the University of Aarhus and a diploma in International Finance from the Business School of Aarhus, was with Jyske Bank for more than 10 years. He is also a member of the Non-Executive Board of Directors of Vestas.

cycloaliphatic epoxides as replacements for bisphenol-A in food-contactable coatings.

Soucek's contributions have been well recognized by the coatings community over the years, including a *JPCL* Editors' Award from SSPC for his paper on self-stratified coatings in 2014. He has contributed to the coatings community through service on the technical committee of Federation of Societies for Coatings Technology (FSCT) and presented many short courses at ICE-FSCT. He also served three years as technical chair for the Cleveland Coatings Society (CCS) and has served as president, vice-president and treasurer of CCS.

Soucek will receive the Tess Award from Dr. Qinghuang Lin, chair of the PMSE division, in August during the 252nd National Meeting of the American Chemical Society in Boston.

SSPC's Heather Stiner to Speak at PDA Conference

Heather Stiner, a protective coatings professional with SSPC, will speak at the 2016 Polyurea Development Association (PDA) Annual Conference, "Polyurea's Path to the Future," held April 18 to 20 at the Hilton Orange County in Costa Mesa, Calif.

Stiner will give her presentation, "A Coating is Only as Good as its Surface Preparation," on Tuesday, April 19 from 8:20 to 9:00 a.m.

Preparing a surface for subsequent application of a coating system is the most critical (and typically the most expensive) step in an industrial coatings project. Whether the surface is plastic, glass, wood, concrete, masonry, aluminum, carbon steel or stainless steel, surface preparation (cleaning and roughening the surface) remains a key factor in determining the ultimate service life of the applied system. In general terms, the better the surface preparation, the longer the life of the coating system. However, not all surfaces, service environments (immersion, atmospheric or chemical) or coating systems demand the same degree of surface preparation. Stiner will discuss how these different factors affect surface preparation across an array of different painting projects.

This year's PDA Conference features a focus on education and the correct application of polyurea, the association says. Sessions are geared toward formulators, applicators and distributors with topics that include the state of the industry, innovative coatings projects and new formulas and processes. For more information on the 2016 PDA Annual Conference, visit pda-online.org/conference.

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Photo courtesy of AkzoNobel

AkzoNobel to Buy BASF Unit for $531M *(Feb. 18)*

In a shift of the global performance coatings landscape, global paint and coatings giant AkzoNobel has agreed to buy BASF's industrial coatings business for €475 million ($531 million), the companies announced Feb. 17.

"This proposed acquisition will strengthen our position in the important coil coatings market and fits well with our existing business," AkzoNobel CEO Ton Büchner said in a statement.

The acquisition includes technologies, patents and trademarks in addition to the transfer of two BASF manufacturing plants — one in Deeside, England, and the other in Vanderbijlpark, South Africa.

The planned transaction — subject to required consultations and regulatory approvals — is expected to close by the end of 2016, the companies reported.

BASF's industrial coatings business supplies products for a number of end uses, including coil, furniture foil and panel coatings, as well as coatings for wind energy plants, general industry and commercial transport, according to the Ludwigshafen, Germany-based company

The business generated sales of approximately €300 million ($333 million) in 2015. Industry experts have said the unit lacks the scale needed to compete effectively in the future, according to Reuters.

"We have successfully developed our global industrial coatings business over the last years with a clear focus on attractive market segments," Markus Kamieth, president of BASF's Coatings division, said in a statement. "To further develop the business, we see positive growth prospects under the umbrella of AkzoNobel, which is a leading global player in industrial coatings."

Amsterdam-based AkzoNobel reported industrial coatings segment sales of around €780 million (about $884 million), or 14 percent of the company's performance coatings sales of €5.59 billion ($6.33 billion) in 2014.

With this transaction, BASF says it will be able to strengthen its focus on its core automotive OEM and automotive refinish coatings businesses as well as its decorative paints segment in Brazil, Kamieth added. BASF's automotive coatings businesses account for 77 percent of its €3 billion ($3.3 billion) business. The two companies announced they were weighing the deal Feb. 11, putting industry speculation to rest.

PSN TOP 10 *(as of Feb. 29)*

1. AkzoNobel Eyes a BASF Coatings Segment
2. Hempel to Shed Blome International
3. AkzoNobel Reports Record FY2015
4. 'Cement Ship' Cracks Under Pressure
5. 'America's Flagship' May Sail Again
6. PPG Launches $7.8M Coatings R&D Hub
7. DOL Cites Steelmaker for Retaliation
8. $6.5B in Losses Lead to Steep BP Layoffs
9. Firms Owe $1.33M in DBE Bridge Scheme
10. O'Hare Lands $1.3B Infrastructure Deal

WHAT'S GOT US TALKING

(PaintSquare News *Weekly Poll, Jan. 31-Feb. 6)*

Would you recommend a career in coatings for your son or daughter?

Yes 53% No 47%

STUMPER OF THE MONTH

(PSN Daily Quiz, Feb. 9)

According to NIOSH, the hierarchy of hazard controls considers which one of the following to be the least desirable?

a. Engineering controls
b. Personal protective equipment
c. Elimination
d. Administrative controls

Answer: Personal protective equipment.
The NIOSH Engineering Controls Program Portfolio gives an overview of the entire program.

On Non-Conforming Coatings and an Inspector's Responsibility

SOME SPECIFICATIONS MAY HAVE REQUIREMENTS THAT THE INSPECTOR MAY KNOW TO BE EXTRANEOUS OR MAY BE MORE RESTRICTIVE THAN NECESSARY TO OBTAIN A QUALITY COATING APPLICATION. WHAT IS THE ETHICAL RESPONSIBILITY OF THE INSPECTOR TO REJECT NON-CONFORMING COATINGS THAT THEY KNOW WILL PERFORM AS INTENDED, PARTICULARLY WHERE ATTEMPTED REPAIRS MAY DEGRADE THE COATING SYSTEM?

Ivan Lasa
Florida Department of Transportation
It is the responsibility of the inspector to verify that the coating is applied as per contract. It would be unethical to make a decision to accept a non-conforming product. In such cases the ethical responsibility rests on the applicator to request acceptance from the owner. The opinion of the inspector may be included as part of the request.

Stephen Bothello
Jotun UAE Ltd.
The coating inspector should be aware and be absolutely clear about his responsibility and authority. The pre-job conference, where the client's representatives, contractor's representatives and applicator's representatives are present, is a right forum to seek clarification about this or reinforce the dos and don'ts of the inspector's job. The main project documents, that is, specification from client, method statement from contractor/applicator and Inspection Test Plan/Protocol (ITP), should be absolutely clear in this regard. If the specification, work procedures or acceptance criteria within the ITP are not complied with, the inspector's most ethical responsibility is to raise an observation report or, in the case of serious violations, a non-conformance report (NCR). If a non-conforming coating has been used, it is, of course, non-compliant with the job specification; hence, an NCR needs to be issued. NCRs have provisions for the applicator and supplier to respond within a reasonable time limit, explaining why a non-complying coating was applied and describing any corrective or preventive actions. Though for an inspector it may be good to know that the non-complying coating may perform as intended, it is only ethical to reject, report and document the non-conformance and leave it to the applicator/supplier to explain, and for the other competent authorities of the project to agree/disagree on final acceptance or rejection of the applied non-conforming coating.

Warren Brand
Chicago Coatings Group
We ran into this exact situation yesterday. A large pump housing, around the size of a large refrigerator, needed to be painted internally ASAP. Our client called and asked if we could get an inspector onsite ASAP. As we put things into motion, I asked for a copy of the product data sheet (there was no specification). The internal environment of this pump housing contained water (condensation) at between 100 and 150 F. The housing was already deeply pitted on the inside due to the original paint peeling off. The housing was made by one of the largest manufacturers in the world (a household name) — highly sophisticated, one would think. The product data sheet, in part, indicated that the material was surface-tolerant (didn't even need to abrasive blast!) and that it could be used on the exterior of a ship, but not below the water line! The last page of the document clearly indicated that for immersion service (which this clearly was), a completely different product was recommended. I was stunned. I raised this red flag to the owner (even though we were hired only to inspect) because it was the ethically correct and kind thing to do. We ended up with an email chain of about a dozen individuals, including some of the top people from the OEM. Then, I heard the words that OEMs use to defend uneducated, improper coating selections, "We've been using this material with no problem for more than 20 years." At the end of the day, I felt my job was to provide my opinion, supported by objective, independent, verifiable data, and then let the client make the decision, which is exactly what happened.

John Kern
VCI
In your original statement [Warren], you indicate there was no specification for the contractor to work to, so my question is, who specified the coating system? As a result of no specification, did the contractor submit to the owner an application and or an ITP? Since neither is indicated, then the "hired" inspector's job is to report the initial conditions as found to the entity that hired him. He does have the right to interject to this

entity his findings such as "the wrong application" for the product in his report and support this finding per the PDS. It is his responsibility only to observe and report to the entity that hired him and then let the owner make a final decision on the use of the coating system. This should have been accomplished during the pre-job conference and documented by the coating contractor.

We as inspectors often find this situation due to the failure of the owner or applicator not performing due diligence in job specifications. In these cases we can only document what we find during the inspection service and report to the appropriate entity. If it is a bad spec, report it to the person you were hired by to perform the service. By reporting it to the other party, you may become liable for the application process. Again, it is our responsibility to document and report the observations and let the contractor or owner make the final decision. If we are working for the contractor and we report to them, then it becomes the contractor's responsibility to report to the owner if he sees fit to do so. If it still becomes a bad spec, so be it, as in your stated case. Inspect, document and report — that is your responsibility!

Karen Fischer
Amstar of Western New York, Inc.
Coating inspector training (SSPC or NACE) indicates that the inspector neither writes the specifications, nor is allowed to change them, no matter how they are written. The inspector's job is to enforce the specifications (observe and record compliance). It is up to the contractor to address any conflict or unnecessary requirements in a specification with the owner or designer of the specification. An inspector can voice an opinion on the matter or inform the owner (either verbally or in writing) that enforcing the specification may result in a failure, but it is not within the job description of most inspectors

to change the specification or allow anything other than what is called for. As a NACE-certified inspector, I would inform the owner in writing of a conflict I saw in a specification and that it may result in a coating performance failure, so that I have my backside covered.

Warren Brand
Chicago Coatings Group
I've had these conversations before and have always found myself in the minority. And, I'm very comfortable there. There is a simple, overarching principle that I follow: What is the right thing to do? I simply am not wired to sit back and "observe, document and report" while something is going wrong. I think this is particularly ironic since my first job was as a daily newspaper reporter where that was all that I did. When people talk of their "ethical" responsibilities as a coatings inspector, I believe they are misusing the word ethical. Ethics relate to moral values, which, in my mind, override pretty much everything else. What I think these folks mean is "obligation" or, perhaps, "authority." But it is certainly not ethical to watch a coating application go wrong and simply sit back and take notes. It may be their job; it may be their obligation; they may even have the authority; but no, it is certainly not ethical behavior. We, as coating inspectors and professionals need to rethink our role. Yes, of course, our first job as an inspector on-site is to observe and document. However, if we see that 100 tons of the wrong-sized blast grit has been delivered, it's our ethical responsibility to let people know, even if it's not necessarily our role.

I was talking to an inspector working on a bridge project this past summer. He called me, exasperated, asking my advice about a situation where the specification called for a blast profile of between 2.0 and 3.0 mils (or something like that). The blast ended up being between 3.0 and 4.0 mils. The coating consulting firm adamantly refused the blast, saying it was out of spec. The inspector took it upon himself to contact the coating manufacturer, who submitted a letter saying the 1.0 mil difference was acceptable. But the consulting firm refused to budge. The profile was out of spec — and that was that. The job stopped. The blast rusted. Expenses piled up for no technical justification whatsoever. The firm may have been acting "responsibly" or perhaps within their "authority," but how can that type of blind adherence to a specification ever be considered ethical?

Charles Harvilicz
Huntington-Ingalls, Newport News Shipbuilding
The inspector has two obligations. One is contractual and the other is ethical or moral. He should carry out the first, and inform the owners of what he knows about the performance of the coatings system with less stringent requirements to take care of the other.

M. Halliwell
Thurber Engineering Ltd.
From the consulting side, we're there to look out for our client's interests. If an issue arises, there is an obligation to bring it to the attention of the client, inform them of the situation and options, then let them make an informed decision as to what happens going forward. If I see something not up to spec, I'm going to talk with the client (and hopefully the other stakeholders), saying, "things aren't meeting spec, but based on past experience what was done should perform sufficiently. Repairs may cause more harm than good. You need to make the decision because you'll live with the consequences, but my opinion is ... "

HOW TO PARTNER WITH YOUR INSURANCE BROKER

By Deidre Dunkin, Dunkin & Bush, Inc.

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As business owners, we are often told to rely on the experts when it comes to matters such as insurance. I generally agree with reliance on others in a specialized area such as insurance. However, it is important to keep in mind that your business may also be specialized and, as a result, your insurance expert may need to be educated about your business to determine what insurance coverage best fits your business. Additionally, each business owner has a different appetite for risk, and the decision to self-insure different categories of risk is best made when one has all applicable lines of coverage on the table and can see the whole of available coverage, as well as any gaps.

By increasing your own awareness and educating yourself, you can partner with your broker, asking the relevant questions, knowing where common gaps lie and using real-life examples to see how various coverages relate to your own operations. We will take a virtual tour of three distinctly different jobsite operations and observe where our risk may lie and learn what type of coverage may insure that risk, while placing our focus on the top one or two areas that may be commonly missed or overlooked.

Blast and Paint Facility

We have arrived at your fully-enclosed blast and paint facility where you typically run multiple shifts blasting and painting your customers' assets such as piping, pipe spools, plates, structural steel members, components and vessels. The operational work sequence at this facility is quite simple — it begins with receipt of your customers' assets via a third-party carrier typically hired by your customer. The assets are unloaded from the truck, staged and at some point moved through the production phase, landing as a finished product and finally packed for transport. Lastly, they are loaded and secured on a third-party common carrier to be returned to your customer.

One of the material risks associated with this operation is that, aside from transport by the third-party carrier, you continuously have your customers' assets in your care, custody and control. Mitigation of this financial risk should that asset be damaged or destroyed under your watch occurs through bailee's insurance. Subject to the exclusions of your policy, you can generally set a large limit per occurrence per location that covers all property of your customer at that location and under your care, custody and control. This is a policy, should it apply, that you should review often, because the assets your customers send you can be very expensive to replace (even before you perform your scope of work). Ensure that you have assessed the average values of those assets while remembering that at any one time, each project is either yet to be started or is incomplete. Also keep in mind as you perform different types of projects or your contract values increase that you can bump those limits so long as you remain proactive and keep it on your radar. Lastly, if you plan to transport those finished products to your customer, you may need to have specialized insurance or ensure that the carrier has appropriate coverage. Do not forget to ask for the certificates of insurance from any common carriers you hire and examine their limits of liability to ensure that if those assets fall off the truck, you have been proactive and they have the policies in place to fulfill their obligation.

Bridge Project

Now, let's head to the bridge project where you have been contracted to perform a scope of work. You have several subcontractors on this project and you are contracted directly with the public entity who owns the bridge. One of your subcontractors is an engineering firm that designed a very intricate access solution in order for your employees and other subcontractors to perform various scopes of work. The applicable drawings required a stamp by a professional engineer to be submitted and accepted by the owner. In the middle of the project, it is determined that the engineer was negligent in its design, which has resulted in cost overruns and schedule delays for you and one of your subcontractors. Do you carry professional liability coverage? Suppose the damages constitute direct damages (cost to re-engineer and dismantle/rebuild the access solution) and an economic loss. If the damages are greater than the policy limits carried by the subcontractor that performed the professional services that you paid for, and you do not carry the coverage yourself as well, then you likely do not have a favorable situation on your hands.

If you carry professional liability coverage, there is likely a remedy (subject to your policy exclusions) that can help greatly mitigate the downside of such negligence. Such coverage is sometimes referred to as subgap coverage or contractor's protective coverage. Essentially it can cover the gap in coverage between those losses and the limits carried by your subcontractor. It can also compensate you for the cost overruns and schedule delays. Should there be a third-party claim against you due to the negligence of your subcontractor, the subgap coverage may apply to that claim as well. Some policies contain an endorsement for rectification indemnity coverage, which would come into play if you incur actual and necessary costs rectifying a design defect during the project for which you have responsibility for both the design and construction (for example, you hired your structural engineer to design a complex access solution and you had another subcontractor erect it). Essentially, you discover the error, and have the opportunity to mitigate the damages by rectifying the problem early and potentially avoiding a claim. If you carry professional liability insurance, there are multiple opportunities available to you; if you do not, it is a risky proposition to be subcontracting out design services. At the very least, ensure that the professional policy your engineer carries has satisfactory limits.

Customer's Plant

Finally, let's go inside the gates of an industrial plant where you are going to be performing a scope of work on multiple storage tanks. The scopes of work vary, but one tank will be relined and another one requires the use of a very specialized and expensive coating. During the relining, your crew is abrasive blasting inside the tank to remove the old lining when they blow a hole through the tank shell. Upon further inspection you wonder if the tank was structurally sound to begin with, but never brought the issue forward. You tender the claim to your Commercial General Liability (CGL) carrier and it is immediately denied. While your CGL policy is intended to provide coverage for third-party property damage, it likely does not cover you when it is the result of your "own work." In short, any real property you were specifically performing work on at the time the loss was incurred would be excluded and you would be paying for that loss out of your own pocket. Be very aware of how this might apply to your operations and make sure the insurance professionals you hire understand your operations well enough to explain to you how this exclusion would apply to your specific operations so you can create processes to mitigate this risk.

The second tank is going to require you to apply a very specialized and expensive coating. You have the material delivered to the plant shortly before you perform the scope of work and it is currently being stored onsite prior to the application. The day you are to apply the coating, you arrive at the plant and realize that at some point after your last shift, someone vandalized the storage area in which the coating was being stored and the coating is no longer useable. You vaguely remember you had coverage for this type of loss but do not remember assessing the limits before this policy period. This is called an installation floater and is intended to cover all materials, supplies, equipment, machinery and fixtures that you own or for which you are legally liable, that are to be installed by you or at your direction, while the property is in transit to a jobsite, at a temporary location or at the jobsite itself during installation. Review these limits often as it is most common to carry one limit that would apply to any location. During certain projects you may have more costs in the material, such as coatings or insulation, than your average project and most of the limits may be set at an average/prudent limit that might normally cover the large percentage of your projects. Educate your estimators and project managers so they can be aware when they may exceed the limit of liability and then you can assess that risk yourself.

Ultimately, you are the only one who truly knows what type of work your company performs and what risks you as a business owner, and the company, are willing to stomach. Therefore, in order to ensure that your insurance provides coverage in all the areas where you wish to mitigate risk, you must take the time to educate your broker and ask questions to determine where gaps may lie so you can prepare appropriate protocol to otherwise mitigate risk.

About the Author

Deidre Dunkin is the president and co-owner of Dunkin & Bush, Inc., an industrial service provider found-

ed in 1943. A fourth-generation family-owned business, Deidre joined the company in 2000 after a career in public accounting. She is a 2015 recipient of the SSPC Women in Coatings Impact Award and an honorary member of the SSPC Industrial Painting Committee.

LITTLE CLUES THAT REVEAL BIGGER ISSUES

Fig. 1: The tanks in question were a pair of 250-foot-diameter, domed, uninsulated floating roof tanks, which contained and treated a propriety brew of waste water. Photos courtesy of the author.

PERFORATIONS IN TWIN 250-FOOT-DIAMETER TANKS

BY WARREN BRAND
CHICAGO CORROSION GROUP, LLC

The first sign of a problem was an urgent call from a panicked reliability engineer on a chilly, misty October morning. A trickle of weeping waste liquid was making its way down the exterior of a tank at roughly the seven-o'clock position, approximately 6 inches from the 24-inch manhole.

The patient was a 250-foot-diameter, domed, uninsulated floating roof tank, which contained and treated a propriety brew of waste water (Fig. 1). There are two of them — twin tanks — and their modes of failure were virtually identical.

Preparations for inspection were made and a confined-space entry scheduled. The task at hand was to determine the mode(s) of failure so that the tank interiors

Fig. 2 (Top): The concept behind a floating roof is to prevent liquid from evaporating. In this case, the top of the discolored area on the walls indicates the upper limit of the liquid level and how far the roof will travel upward when filled.

Fig. 3 (Bottom left): A side view of the system on a seam revealing the laminate, the seam sealer and the steel weld.

Fig. 4 (Bottom right): At first glance, the floor coating systems appeared to be intact overall, but closer inspection revealed areas that caused concern.

could be either repaired or relined in a manner that would provide long-term durability and reliability.

The owner wanted to know whether the tanks could be put back into service with minimal repairs ASAP or if they needed to be relined or repaired now — which would have been exceedingly costly.

When evaluating assets of this size and complexity, one's mindset is critical to a successful and objective analysis. It's easy to jump to conclusions and time must be taken to thoroughly consider all of the variables associated with the failure.

While a lab and other technical services and equipment are always available, it's wise to employ "Occam's (or Ockham's) razor," the principle of which is to give precedence to the simplest hypothesis. Specifically, it is a problem-solving standard devised by William of Ockham (c. 1287–1347) stating that among competing hypotheses, the one with the fewest assumptions should be selected.

SURFACE CONDITIONS

In this case, there were several completely different environments within the tanks and at least two different coating systems used, which was evident visually and documented on the original specification. The environments of each were as follows.

The Floor: Defined as the floor, chime area and 6 inches up the straight wall (the distance at which the fiberglass laminate system extended).

The Walls: Defined as the straight wall from 6 inches above the floor (where the fiberglass laminate stopped) to the tank top.

The Bottom of the Floating Roof: Defined as the bottom of the floating roof and sides of the roof.

Top Side of the Floating Roof: Defined as the area above the roof and below the dome.

The Floors

The floors were subjected to the presence of sludge as well as turbulence from nozzles trying to keep the solids in suspension, but sludge would inevitably build up on the floors.

The Walls

There were areas of the tank walls which were submerged most of the time and areas above the floating roofs which were submerged when the liquid in the tanks was high and exposed when the liquid in the tanks was lower (Fig. 2). UV degradation was not a serious issue here, as the tanks were domed.

The Bottom of the Floating Roof

The bottoms of the floating roofs were subjected to liquid as well as to any vapors that might occasionally collect.

Top Side of the Floating Roof

If a tank is working properly, the coating on the top of a floating roof would only be subjected to normal atmospheric conditions, and if covered with a dome as these tanks were, UV degradation would not be an issue here either.

VISUAL INSPECTION

The Floors

Upon initial entry, the overall appearance of the existing coating systems was mottled and non-uniform in nature. This is not uncommon, but was an observation worthy of consideration. If a coating system is exposed to liquid, and the coating system is 100-percent compatible with the liquid, then staining or discoloration of the coating system is improbable. When a coating system shows staining (which is fundamentally different from residue which sits on the actual surface of the coating film), it is often an indication that there has been some chemical attack to the coating.

The tank floors were lined with a multicoat, vinyl-ester laminate system with a designed dry-film thickness (DFT) of 75-to-90 mils, although in some areas measured it was even thicker. The lap-welded seams were prepared with a seam sealer prior to coating application. Figure 3 shows a side view of the system on a seam.

At first glance, the floor coating systems appeared to be intact overall (Fig. 4). Upon closer inspection, however, there were areas of the floors causing concern. It was not surprising to see liquid oozing from what appeared to be a compromised area along a seam (Fig. 5, p. 24). It was surprising, however, to see liquid oozing from an area that appeared to be well-adhered, non-compromised coating (Fig. 6, p. 24).

An examination of the tanks' manholes revealed that although constructed of stainless steel, they had been welded into the carbon steel tank walls, likely leading to accelerated corrosion in these areas due to galvanic corrosion (Fig. 7, p. 24).

The Walls

The walls of the tanks had what appeared to be two coats of some type of paint system at a DFT of between 18 and 30 mils. Inspectors chose to test the side of the floating roof below the roof seal because these areas would most likely never have been submerged and could therefore provide more accurate information about the original coating thickness.

Upon further examination, the author discovered liquid underneath the unblistered coating as well. In fact, in almost every case where coating thought to be in good condition was removed, the surface underneath was damp. The liquid had no odor, so was likely not solvent due to solvent entrapment.

Despite this, the unblistered areas still exhibited good adhesion and showed little to no corrosion. In fact, removing this coating typically revealed a

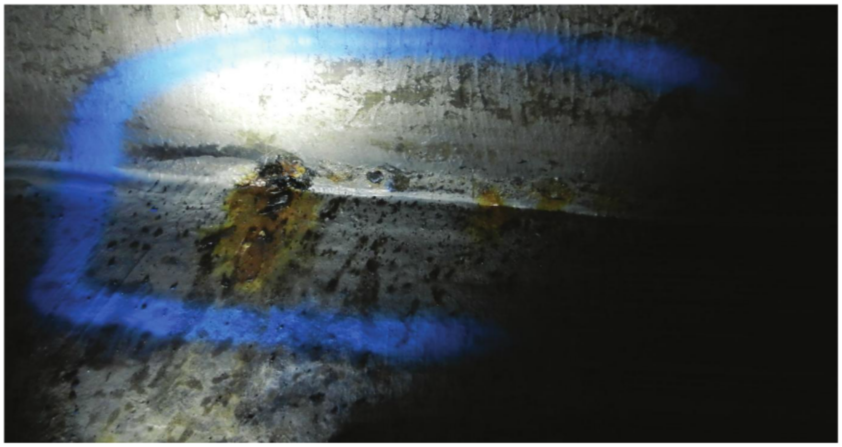


Fig. 5 (Top): Liquid oozing from what appeared to be a compromised area along a seam in the floor.

Fig. 6 (Bottom left): Liquid was also oozing from areas that appeared to be well-adhered, non-compromised coating.

Fig. 7 (Bottom right): An examination of the tanks' manholes revealed that although constructed of stainless steel, they had been welded into the carbon steel tank walls, likely leading to accelerated corrosion in these areas due to galvanic corrosion.

nearly white, abrasive-blasted surface underneath.

There are only two explanations for this phenomenon. First, it is possible that the coating might have softened while immersed in liquid or exposed to vapor, thus reducing its ability to resist permeation and allowing liquid or water vapor to penetrate. Once removed from service, the coating then re-hardened and appeared fully cured but retained the moisture underneath.

It is also possible that the coating system was compromised due to something called the cold wall effect. The cold wall effect exacerbates the tendency of water vapor molecules to penetrate a coating system which is semi-permeable. Picture a cold can of soda on a warm summer day. Vapor molecules (humidity) in the air condense on the surface of the can, turning to liquid water. The cold liquid inside pulls the vapor to the can. The cold wall effect can occur in tanks in cold-weather climates. In tanks such as these, the analog to the humidity on a warm summer day is the warmth of the water, and in this case, the vapor, inside the tank. The cold wall is the cold wall of the tank. Assume that, for example, the weather outside is in the 20s and the water temperature is 110 F. The cold wall of the tank pulls the water vapor molecules from within the tank through the coating to the steel wall. Then, just like that cold can of pop, when the vapor hits the wall, it condenses and turns to water behind the coating system.

The Bottom of the Floating Roof

Initially, the walls appeared to look dirty and discolored (Fig. 8, p. 26). A closer look, however, revealed blisters and delamination. The blisters were intact and when removed, showed no corresponding corrosion underneath. The coatings under the areas of delamination were surprisingly well-adhered and intact (Figs. 9 and 10, p. 26).

Top Side of the Floating Roof

Visual inspection of the top side of the floating roof revealed no areas of concern.

TESTING

Inspectors tested representative areas from each surface of concern: the floors, the walls and the bottom side of the floating roofs.

The floor coating was exceedingly hard and difficult to penetrate and remove. A multitool screwdriver was used to chip away at the weeping holiday. It quickly became apparent that this small drip was just the tip of the iceberg.

As the coating was peeled back, copious amounts of liquid appeared (Fig. 11, p. 27). A hammer and chisel were brought to the site and the coating was removed by positioning the chisel at an angle between the tank floor and base of the coating system and then tapping the hammer.

Concern was now growing that this one area might be endemic to the entire system, but considering the enormity of the floor, the following procedure was selected.

Inspectors elected to hollow test the floors at random locations to identify what sounded like disbonded areas. Since the scope of the analysis was to identify the likely cause of the failure and not necessarily the extent of it, spot random hollow-testing was executed.

When what sounded like a hollow was identified, the coating system was carefully removed from the top layer down to determine the extent and the type of hollow. Instead of using a hammer and chisel to remove the coating, the top layer of the system was scraped down until the substrate was reached in an attempt to determine the location of the failure within the system. With laminate systems in particular, it is possible to find a hollow between coats and within the laminate structure itself, even with the bottom coating layer well-adhered. A cohesive failure (a failure within a single coating layer) was hoped for, as this would indicate that any coating remaining might be protecting the steel. Also, as is sometimes the case when a different material such as a seam sealer is used, areas that sound different can be mistaken for hollow, but sound different only because they're filled with different material.

Random areas which did pass the hollow testing and appeared intact were also removed in the same fashion to serve as control samples.

Coating samples were also removed from the walls and the bottoms of the floating roofs and evaluated for delamination, adhesion issues, blisters and presence of moisture.

GALVANIC CORROSION

In the author's experience, when speaking with various engineers and other industry professionals about galvanic corrosion, sometimes their eyes glaze over. It's often difficult to identify this condition, as it can occur in one area but not in another area that is seemingly identical.

During the initial ultrasonic thickness testing (UTT) inspection, various areas of concern were identified, and spot-abrasive blasting was performed to determine the extent of the metal loss. Figure 12 (p. 27) shows what can only be assumed to be classic galvanic corrosion of the steel bottom in close proximity to a stainless steel nozzle support. Further, as can be seen at the top of the support where the inspector is peeling back the coating with a screwdriver, the coating underneath remains damp.

WHAT DO YOU WANT FIRST — THE GOOD NEWS OR THE BAD NEWS?

The Bad News

Figure 13 (p. 27) shows an area that sounded hollow and when the coating was removed, revealed complete adhesive failure

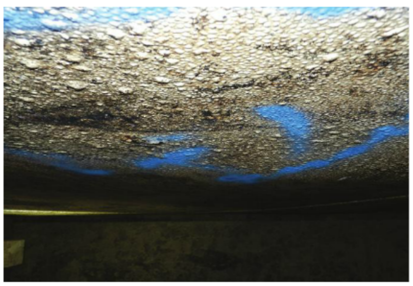


Fig. 8 (Top): At first glance, the walls looked dirty and discolored, but a closer look revealed blisters and delamination.

Figs. 9 (Bottom left) and 10 (Right): The coatings under the areas of delamination were surprisingly well-adhered and intact.

of the coating system from the carbon steel substrate, not the cohesive failure that was hoped for. A number of these areas were identified, the coating was removed and the results were the same — complete adhesion failure with liquid beneath the coating. It was reasonably concluded that wherever there was a hollow, one would find the same type of failure.

Regarding areas which appeared (sounded) well-adhered and looked intact, the results were the same. Figure 14 illustrates just such an area. Oddly, the coating system was well-adhered, as can be seen by the clean margins in front of the author's finger. However, the surface remained damp underneath.

Some of the areas away from the seams, where the coating was removed, appeared well-adhered and dry. However, in every case near a seam, even if the seam looked and sounded intact, liquid was observed. It is likely that this liquid was entering via the holidays and other imperfections and was then flowing under the coating in the channel between the seam and the coating system.

The Good News

Ultrasonic testing (UT) of the steel shell and visual inspections of removed coating showed that there was actually little corrosion taking place. While the coating system was clearly compromised, the data seemed to indicate the overall tank floor was not at immediate risk from corrosion, except in specific areas.

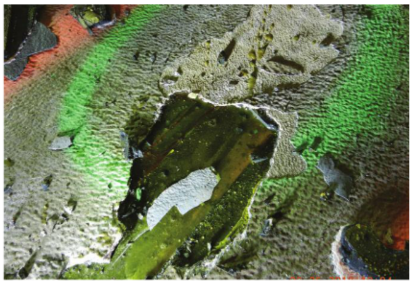
CONCLUSIONS

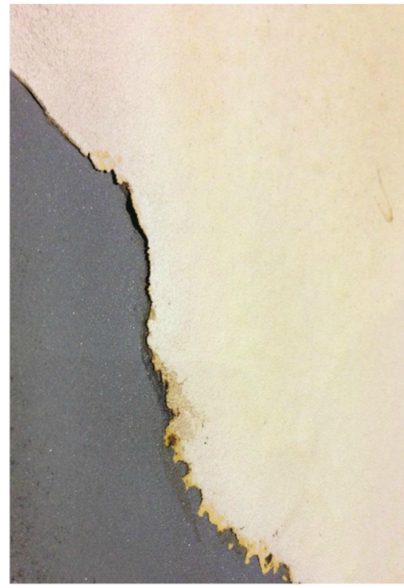
Due to the absence of evidence such as blisters, softening of the coating and obvious chemical attack, it could be concluded that the floor coating material was compatible with the liquid being stored in the tanks, but appeared to have been compromised by liquid entering the system and traveling beneath it. Visual examination of the fibers in the fiberglass laminate, even in areas where liquid was trapped beneath it, appeared to be dry. After observing multiple cases supporting this theory, it was determined that liquid traveled along the lap-welds, underneath the coating system.

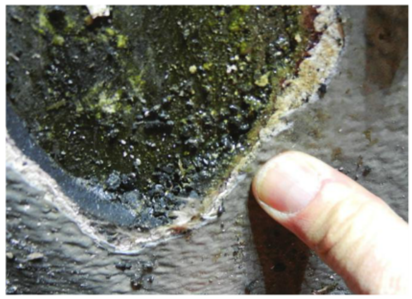
Examination of documentation from the manufacturer indicated that the coating system's final topcoat (applied at 20-to-25 mils) was not designed for tanks larger than 100 feet in diameter.

Due to adjacent dissimilar metals, the perforations near the stainless steel manhole, and the one identified in the floor, were almost certainly due to galvanic corrosion which could be blamed for the initial leaks.

Because the existing coating system was not recommended for tanks exceeding 100 feet in diameter and a tank more than twice that size undoubtedly flexes more, it was concluded that the specific mode of failure was likely due to the coating system. Being very rigid, it had lifted from the tank floor in some areas and as the tank bottom raised and lowered, it cracked. Because flexing would occur at the weakest points in the construction, it was reasonable to assume that those points were the seams, allowing liquid to enter and travel around the lap welds.







However, regardless of the precise mode of failure, it was clear that the coating was compromised and that it would likely continue to deteriorate and disbond over time.

As stated earlier, galvanic corrosion was found to have caused the actual leaks which prompted an inspection in the first place, but in this case, the inspection revealed an overall permeation of moisture, a condition that would likely have led to a much more serious failure if left unattended.

RECOMMENDED SOLUTION

The scope from the owner was to identify the cause of the failure, determine whether the coating system was repairable and if so, how, and also to establish whether or not the tanks would be at risk after they were put back into service.

The recommended course of action was to spot repair all of the areas in the tank bottoms (floors) which exhibited leaking. Because inspectors believed that all of the seams had moisture underneath them but showed no apparent adverse corrosion from that moisture, and because it was paramount to the owner that the tanks were returned to service as soon as possible, a determination was made to leave any areas alone which sounded hollow.

It was also recommended that when the time came to recoat the tank bottoms, that the laminate system be replaced with a non-laminate, much thinner (40-to-60 mil) coating system.

Blasting was recommended as the optimal means of surface preparation as there were so many large areas of exposed steel on the walls that using handtools would be impractical. Technicians also needed to determine if the coating was well-adhered enough to receive an abrasive blast in an effort to tie in paint repairs from the prepared steel onto the cleanly blasted paint system (Fig. 15). It was necessary, as well, to determine what type of margin should be left and if coating repairs should employ a feathered or straight edge.

After the walls were abrasive blasted in all areas where the coating had spontaneously disbonded, new coating was to be applied to the steel and to the feathered edge of the existing coating system.

Any areas believed to be at risk for galvanic corrosion were to be abrasive blasted and coated with systems designed to resist galvanic corrosion, tested as per ASTM G95, "Standard Test Method for Cathodic Disbondment Test of Pipeline Coatings (Attached Cell Method)."

Fig. 11 (Top left): As the coating was peeled back, copious amounts of liquid appeared.

Fig. 12 (Top center): This figure shows galvanic corrosion of the steel bottom in close proximity to a stainless steel nozzle support.

Fig. 13 (Bottom left): This figure shows an area that sounded hollow but when the coating was removed, revealed complete adhesive failure of the coating system from the carbon steel substrate.

Fig. 14 (Bottom center): This figure shows an area which appeared (sounded) well-adhered and looked intact, but revealed liquid beneath the coating.

Fig. 15 (Above right): Technicians needed to determine if the coating was well-adhered enough to receive an abrasive blast in an effort to tie in paint repairs from the prepared steel onto the cleanly blasted paint system.

ALL SILICONES ARE NOT CREATED EQUAL

BY GERALD L. WITUCKI
DOW CORNING CORPORATION

Figures courtesy of the author unless otherwise noted.

For decades, raw materials manufacturers and other members of the silicone industry have promoted silicon-based technologies into markets impacting many aspects of everyday life, including the paint and coatings markets. These materials provide benefits to applications as far-ranging as food processing and medical devices to electronics and hair care, but for some paint formulators, issues relevant to one particular class of silicon-based technologies create reluctance and doubt about the entire chemistry set. Concerns related to the incompatibility of silicones, or the recoatability of paints containing materials broadly described as silicones can impede potential solutions to coatings market demands. But more often, formulators have learned to differentiate silicon-based technologies and recognize the advantages and efficacy of these useful technologies.

In fact, nearly every year for the last three decades, coatings formulators who invest in silicon-based technologies have patented a growing number of inventions citing silicon-based materials as the enabling technology (Fig. 1, p. 30). As of 2103, approximately 10 percent of all U.S. patents issued cite a silicon-based technology (not including silica) in the primary claim of invention. Paint scientists have observed improved thermal, chemical, water and weather resistance, along with flexibility, foam control, wetting and adhesion promotion.

Used as the primary binder in a formulation or as an additive, these technologies impart enhanced performance attributes for high-performance applications, including primers, heat-resistant coatings, industrial maintenance coatings, hygienic coatings, marine coatings, anti-fouling coatings, abrasion-resistant coatings, automotive clear coats and architectural coatings.

Understanding the scope of silicon-based technologies and the differing physical attributes associated with this diverse material set allows a coating formulator to move beyond misconception and gain access to a versatile and robust class of problem-solving technologies. This article will discuss the silicon-based technologies with broad utility in the coating industry: silanes, resins, fluids and copolymers; but let's start with the most notorious: polydimethyl siloxanes.

POLYDIMETHYLSILOXANE (PDMS)

PDMS is a colorless silicon-based polymer used primarily for surface treatment (Fig. 2, p. 30). This class of material is most closely associated with the term silicone. These polymers are linear chains of alternating silicon and oxygen atoms with each silicon atom bearing two covalently bonded methyl ($-CH_3$) groups. Depending on the degree of polymerization (n), PDMS can range from a volatile fluid to a gum-like substance. The use of PDMS is prevalent across many industries including personal care and machine-maintenance lubrication, which ultimately, for factory-applied coatings, may lead to surface contamination and surface defects, such as fish-eyes and craters.

A common remedy to surface contamination is the addition of the offending agent into the paint, thereby equalizing the surface tensions of the surface and the paint. As a result, though often reviled, PDMS is one of the most common remedies to silicone contamination. The active ingredient in many "fish-eye killing" additives is simply low viscosity PDMS. Therein lies a potential area of confusion and the root of many of the concerns associated with silicones.

Low-viscosity PDMS is fairly miscible in organic systems. In fact, silicone fluids (<10 centistokes, or cS) have been found to be reasonable diluents, with a Kauri-butanol rating similar to that of mineral spirits. In the electronics industry, due to low residual deposits, volatile PDMS is used as a cleaning solvent for electronic circuitry. But as the chain length of the PDMS extends, volatility, solubility, recoatability and compatibility with organic resins decreases.

In coatings, PDMS is used to provide wetting, leveling, foam control and gloss, as well as mar resistance and slip angle (coefficient of friction) reduction. Low


Photo courtesy of Dow Corning Corporation

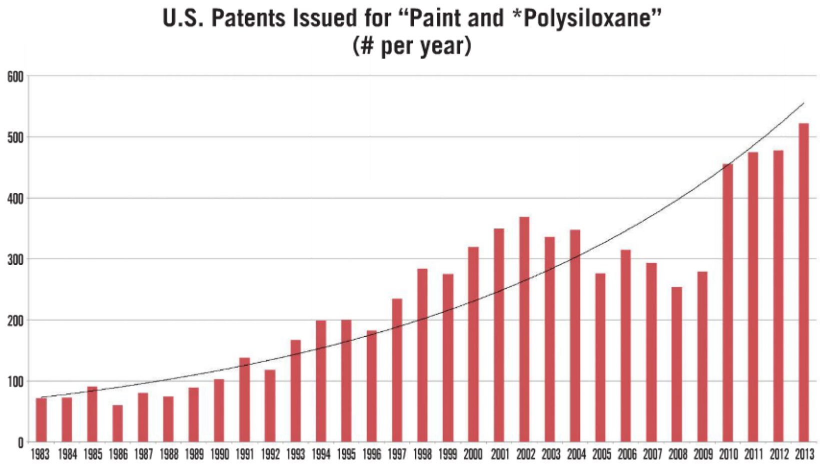


Fig. 1: Nearly every year for the last three decades, coatings formulators who invest in silicon-based technologies have patented a growing number of inventions citing silicon-based materials as the enabling technology.

miscibility and surface energy along with high polymer mobility allow PDMS to migrate to the coating surface, improving wetting or levelling, or providing a desired layer of lubricity, but bearing with it, the unfortunate potential of creating a weak boundary layer on the surface and reducing recoatability and intercoat adhesion. This issue is particularly relevant to high viscosity PDMS.

The effectiveness of PDMS can itself create problems. Used at very low levels (0.05 to 0.1 percent are not uncommon),

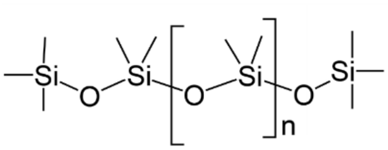


Fig. 2: PDMS is a colorless silicon-based polymer used primarily for surface treatment.

PDMS is a valuable problem solver, but improper dosage can result in well-known surface defects. More is not always better and with PDMS available on the market ranging from less than one centistoke, to greater than 100,000 (cS), with nothing but a viscosity measurement to differentiate, the opportunity for misapplication is high.

$$SiR^{1}_{X(0\text{-}4)}R^{2}_{(4\text{-}x)}$$

Fig. 3: Silanes ($SiR^1_{X(0-4)}R^2_{(4-x)}$) are monomers, containing just one silicon atom.

SILANES

Silanes ($SiR^1_{X(0-4)}R^2_{(4-x)}$) are monomers, containing just one silicon atom (Fig. 3). As monomers, silanes do not possess the characteristic siloxane (-Si-O-Si-) polymer backbone, and as such, cannot be classified as silicones. These materials have viscosities less than water and are often completely miscible in organic polymers, acting as strong polar solvents. Silanes can possess a wide range of substituents, both reactive and non-reactive. Silanes react to form siloxane polymers. The ratio between the reactive (including the hydrolyzable chlorine and alkoxy) and non-reactive (for example alkyl or aryl) groups will determine the crosslink density of the resulting polymer and the associated physical properties.

Inorganic reactive groups include chlorine, alkoxy, hydroxyl and others. These groups react well and provide good adhesion with inorganic substrates such as glass, metals and minerals.

Non-reactive groups include alkyl, phenyl and trifluoropropyl, which provide moisture resistance, organic compatibility and chemical resistance.

Organic reactive groups include epoxy, methacrylate, amino, vinyl, sulfido and others. These groups offer good compatibility and reactivity with organic resins, thereby serving as coupling agents between organic coatings and inorganic substrates. In the paint industry, the most common use of silanes are tetraethoxysilane hydrolyzates, or tetraethylortho silicate (TEOS) for use as a binder in zinc-rich maintenance primers. This application, with required excellent recoatability and adhesion, highlights the distinct differences between silanes and PDMS. As additives into coatings, silanes improve adhesion, filler and pigment incorporation and bulk properties. In applications such as automotive coatings, numerous patents cite the benefits of silanes including controlled hydrophobicity, UV and thermal stability, chemical resistance and corrosion protection.

Also, the inherent weatherability and moisture resistance of alkyl silanes make them suitable for use in water-repellent formulations that meet industry specifications and customer demands for greater protection of wood and masonry substrates, including concrete, sandstone, granite, limestone, marble, brick, tile, wood, gypsum and perlite.

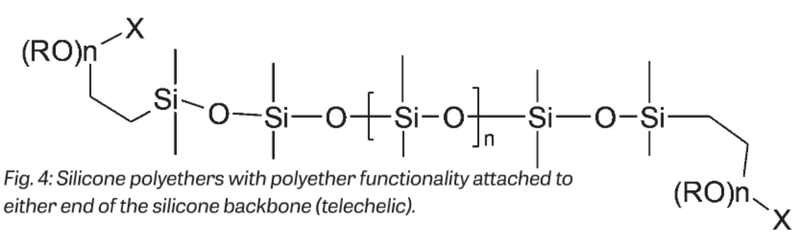


Fig. 4: Silicone polyethers with polyether functionality attached to either end of the silicone backbone (telechelic).

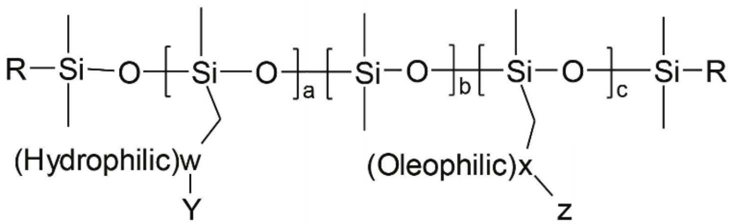


Fig. 5: Silicone polyether with polyether functionality along the polymer chain (pendant or rake).

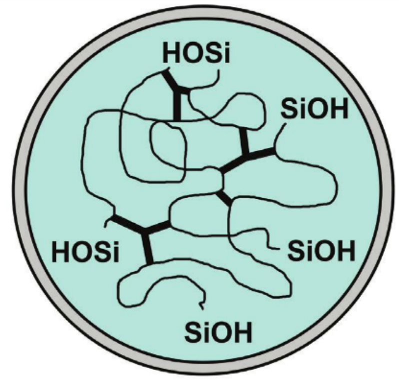


Fig. 7: Silicone elastomers are rubber-like materials (think silicone bathtub caulk) in emulsion (analogous to organic latex) or dried powder form.

POLYORGANOSILOXANE COPOLYMERS

Polyorganosiloxane copolymers possess both the methyl-rich structure of PDMS and a variety of longer alkyl chains and aryl groups which provide compatibility with organic materials and mitigate many of the problems associated with PDMS while providing benefits such as wetting, leveling, gloss, foam control, and slip and mar resistance. They are also used as deaerators for microfoam. Polyorganosiloxane copolymers allow for good recoatability, but depending on the PDMS/organic ratio and the particular resin system, problems of intercoat adhesion could arise. Within the family of polyorganosiloxane copolymers, the largest group is silicone polyethers.

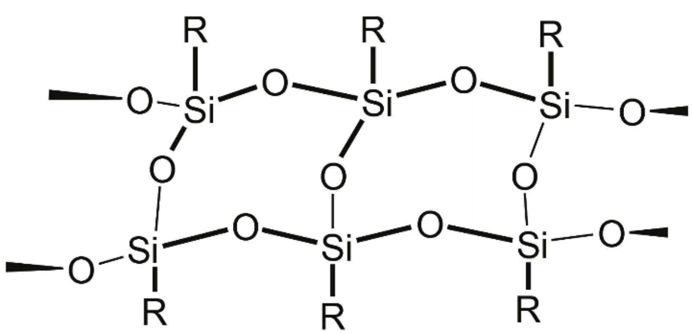


Fig. 6: Silicone resins can be characterized by possessing a high level of crosslinking across polymer chains.

SILICONE POLYETHERS

With polyether functionality attached to either end of the silicone backbone (telechelic) (Fig. 4, p. 30) or along the polymer chain (pendant or rake) (Fig. 5), silicone polyethers are used in coatings where formulators are looking for many of the benefits associated with silicon-based technology, including mar/slip resistance, wetting, leveling and foam control, joined with organic characteristics. The organic portion of the silicone polyether copolymer improves the compatibility of the silicone with organic components, allowing for good incorporation and improving the hand-feel and performance of coating formulations. The wide variety of potential raw materials and the myriad of possible combinations allow this technology to offer application-specific performance.

SILICONE ANTIFOAMS

While some silicone foam control agents are single-component polymers (for example silicone polyethers), most antifoams are compounded mixtures, such as silica reacted with fluids, specifically designed for the coatings industry which requires the delicate balance between foam disruption and defect-free films. These problem solvers are available as neat fluids and emulsions. Variations of silicone antifoams include organic modification of silicone fluid, degree of crosslinking of the silicone fluid and others. By varying the type of silicone used, the degree of crosslinking and the type of silicone, antifoams can be tailored to perform in many different types of coatings, but defects can occur with some antifoam/coating combinations. Owing to the low use levels (0.05 to 1.0 percent), recoatability or intercoat adhesion are rarely issues. Performance is very system-dependent.

SILICONE RESINS

Silicone resins can be characterized by possessing a high level of crosslinking across polymer chains (Fig. 6). A typical silicone resin building block consists of a silicon atom bearing a single organic substituent (R=organic moiety, most commonly methyl or phenyl) and three oxygens shared with adjacent silicon atoms. These units can be homo-polymerized or copolymerized with other siloxane units to provide specific performance attributes.

Silicone resins are cold-blended, reacted with many organic resins, or even used as the sole binder for a wide range of coatings formulations (use level: 15 to 100 percent of resin binder system). They are

$$RSiO_{3/2}^{-}\ Metal^{+}$$

Fig. 8: Siliconates ($RSiO_{3/2}^{-}$ $Metal^{+}$) are reaction products of alkyl alkoxy silanes (for example methyltrimethoxy silane) and metal hydroxides, such as sodium or potassium hydroxide.

primarily used to impart UV and thermal resistance in applications such as exhaust stacks, cookware and lighting fixtures, but improved chemical resistance is often also observed. Silicone resins can be developed with a wide range of physical properties, from soft and flexible to hard and brittle with a range of organic compatibility.

In the uncured state, silicone resins already possess significant levels of crosslinking. These crosslinks improve the thermal, chemical and radiation resistance. In addition, many silicone resins are formulated to contain high levels of aromatic substituents (phenyl) which provide compatibility with organic polymers. With the exception of the pure methyl variants, silicone resins do not cause the defects associated with PDMS. In addition, the crosslinking and compatibility restrict the mobility of the polymer, preventing migration, keeping the silicone within the coating. As a result, silicone resins have minimal impact on recoatability and intercoat adhesion. Unless specifically formulated to do so, silicone resins do not provide release performance. (PDMS fluids are needed.)

SILICONE ELASTOMERS

Silicone elastomers (Fig. 7) are rubber-like materials (think silicone bathtub caulk) in emulsion (analogous to organic latex) or dried powder form. These materials are used in coatings to provide water resistance, mar resistance, and matte, textured finishes. In either form, the elastomer is fully crosslinked as supplied. While initial surfactant compatibility should be evaluated, no free-flowing PDMS exists within the elastomer to migrate from the coating and create subsequent issues.

SILICONATES

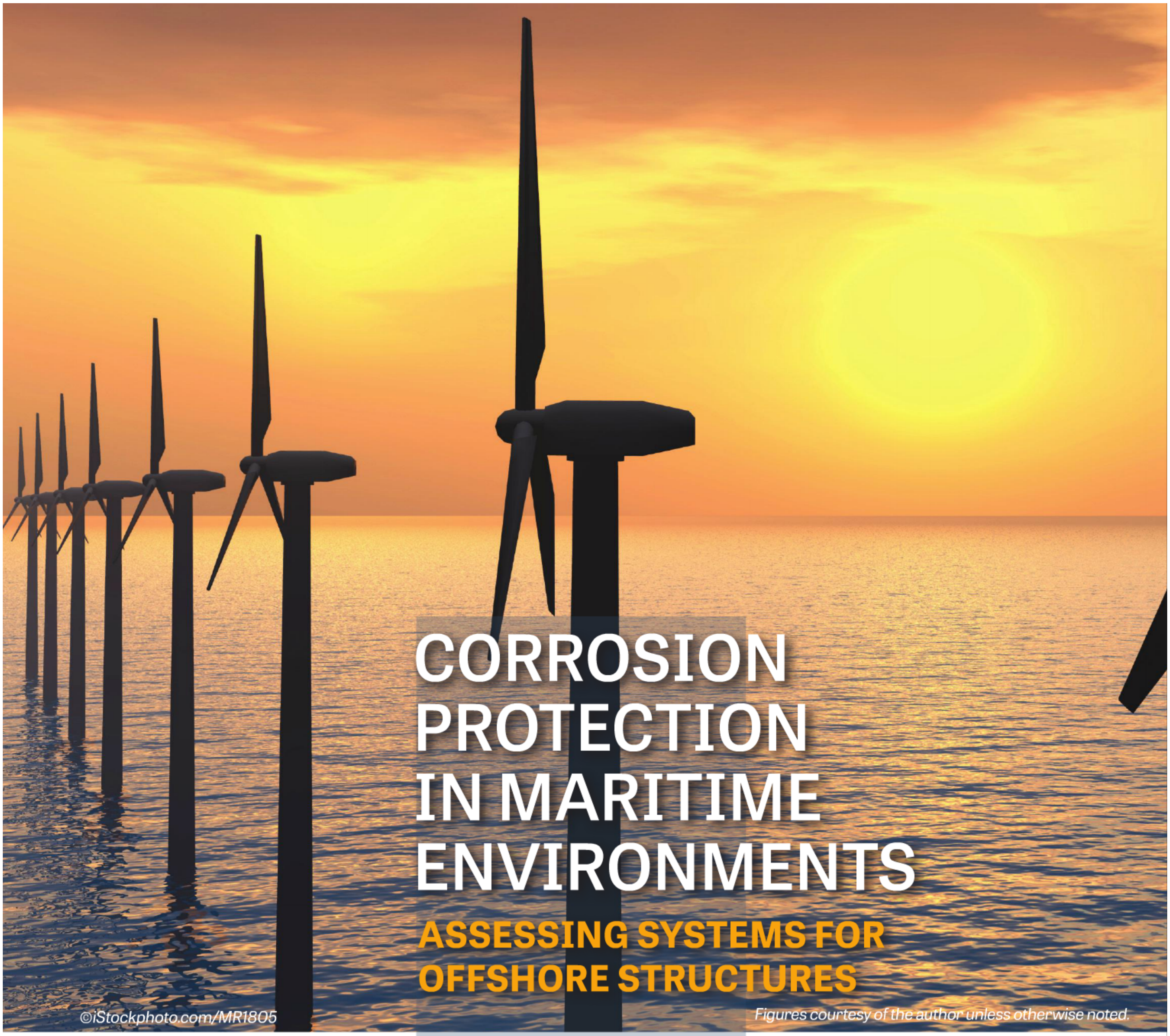
Siliconates ($RSiO_{3/2}^{-}$ $Metal^{+}$) are reaction products of alkyl alkoxy silanes (for example methyltrimethoxy silane) and metal hydroxides, such as sodium or potassium hydroxide (Fig. 8). These are high-pH (11) water-based solutions used as low-VOC, penetrating, water-repellent treatments for damp-proof exterior façade or masonry applications. Similar to silicates, which do not possess alkyl substitution, siliconates exist in monomeric or dimer form until exposed to atmospheric carbon dioxide. Upon application, these materials form water-insoluble silicone resins. Though siliconates might impact substrate wetting by water-based topcoats, the high solubility and subsequent crosslinking provide excellent dispersibility in aqueous resins without the issues associated with PDMS.

CONCLUSION

Silicon-based technologies have advanced coatings innovation by providing many of the performance properties needed in the coatings industry and enabling new coating attributes. Coatings formulators leveraging the traditional benefits provided by silicon-based technology, such as slip and mar resistance, need be aware of the potential issues associated with polydimethylsiloxane (PDMS) materials. While the reputation of PDMS is understandable (but controlled by proper viscosity and dosage selection), other silicon-based technologies are designed to be inherently more compatible, with less propensity to migrate, and eliminate, or at least minimize, the issues surrounding PDMS "silicones."

ABOUT THE AUTHOR

Gerald (Jerry) Witucki, associate coatings scientist at Dow Corning Corporation, has provided technical support and product development of silicone additives and resins for the paint and coatings industries. He has been with the company for over 30 years and has written numerous articles on the use of silicon-based technologies, presented at many industry events, and holds more than 20 patents in the field. Witucki is a graduate of Central Michigan University with an MBA and bachelor's degrees in business administration and chemistry. *JPCL*



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CORROSION PROTECTION IN MARITIME ENVIRONMENTS

ASSESSING SYSTEMS FOR OFFSHORE STRUCTURES

BY GÜNTER BINDER, FEDERAL WATERWAYS ENGINEERING AND RESEARCH INSTITUTE (BAW)

There are currently more than 800 wind generating structures in the Northern Sea and 80 in the Baltic Sea, and more than 20 wind farms, each with a large number of structures and/or towers, will open in the next few years in these areas. In planning for these wind farms, the corrosion protection of the structures to be installed has become a focus of public interest, especially their effect on the environment which is often criticized or feared. There is also a large and immediate task for corrosion specialists to formulate standards in order to protect these steel structures effectively for a period of 25 years under very corrosive conditions.

The German Federal Maritime and Hydrography Agency (BSH) has formulated "minimum requirements" (Mindestanforderungen[1]) which describe the measures to be taken for German offshore wind energy structures concerning their integrity, i.e. ensuring their function and stability, for a lifetime of 25 years. This includes planning, certification, three-step releases and suitability of corrosion protection systems. The BSH will therefore introduce guidelines for corrosion protection for wind farm structures (VGB-BAW-Standard[2]) in 2016. It is important in Germany that corrosion protection measures for wind farms have no adverse impact on the marine environment. This means that while there is a high risk of pollutants entering the maritime environment, virtually no pollution is permitted. Problems can arise because of the release of iron due to corrosion, and aluminum as well other metals from sacrificial anodes, and last but not least, because of solvents and other components typically used as coating materials, for example, isocyanate and bisphenol-A.

factor in order to relate an accurate number of hours in an accelerated test to lifetime in years in real file.

Within a structure erected in a maritime environment (sheet pile walls, oil platforms or wind energy structures), there are generally different zones with different intensities of corrosive attack: bottom or sea floor, immersion and low water zone, tidal and splash zone and last but not least, the atmospheric zone (Fig. 1, p. 36). Therefore, it is necessary to consider different intensities of corrosion in any test procedure to be developed or applied.

Furthermore there is continuous mechanical stress from waves, floating matter and ice movement in winter that can attack coatings, and coatings also commonly suffer from mechanical impact during transport and erection, which can lead to localized damage and coating detachment. The wet, high-salt environment is a constant danger that leads to corrosion, especially in the areas of highest corrosive stress, for example the splash zone. Failure of a coating by osmotic blistering may be caused by condensation of water, and UV-radiation and biological growth are further phenomena that can weaken coatings by deterioration of the binder. Microbial-induced corrosion (MIC) due to bacteria, for example, sulphur-reducing bacteria (SRB), could be hazardous to structures, especially in the low-water zones and the sea floor regions. Then again, in the author's experience, the danger of a corrosive attack by bacteria is only evident with uncoated steel.

Often forgotten is the stress applied to coatings from the electric current produced by a combination of different metals (galvanic cell), as well as by cathodic corrosion protection systems (which should actually prevent any corrosion of the steel). Both circumstances cause an acceleration of the corrosion cell's cathodic reaction and propagation of hydroxyl ions that eventually attack the

Previous tests of binders carried out by Federal Waterways Engineering and Research Institute (BAW) have shown that there are well-formulated materials such as epoxy and polyurethane which show no relevant emission of environmentally hazardous molecules[3]. The calculated large mass of aluminium used for galvanic anodes for cathodic protection[4] can easily be reduced when these anodes are used in combination with coatings or replaced by impressed current systems.

The problem of corrosion of maritime structures should be resolved in the context of all questions concerning the protection of the environment. This article is focused on a number of corrosion test procedures that will be analyzed with regard to their suitability, discerning the excellent corrosion protection systems from the average ones.

DIFFERENT TYPES OF CORROSION STRESSES ON COATINGS IN MARINE ENVIRONMENTS

In prequalification tests, the commonly used standards are generally based on laboratory testing procedures, and it is important to know that these test procedures cannot often determine the true corrosion prevention potential of a coating system. No overall laboratory test exists which considers all the different stresses and includes the appropriate acceleration

Table 1: Stress of Corrosion to Coatings and Selected Test Procedures

Requirements in Nature	Caused by	Test procedures
Resistance to osmosis tests	Steam or fresh water	Water condensation
Resistance to abrasion and impact	Ice, floating matter, impact (ships)	Abrasion test, falling weight test
Resistance to electric current with and without any coating damage	Cath. corr. systems, combination of electrochemical elements by combination of carbon steel and high alloyed steel	Cathodic corrosion protection test under real conditions (potential and time)
Resistance to rusting in general	Water, oxygen, chlorine	Immersion in water and salt fog
Resistance to rusting after degradation due to rough conditions of use and erection	damage to coatings (cuts, delamination) by transport, ice, floating matter, ships	Simulation of rusting conditions
Resistance to biological growth	Bacteria (MIC), sea weeds, mussels	Long term trial (LTT)
Proof of long durability	Time of use	Long term trial (LTT)
Colour	UV-degradation	Long term trials (LTT) or UV- test

coating binder at the steel/primer boundary. Table 1 summarizes the various stresses and equivalent laboratory testing methods. The thesis of this report is that a large part of these individual single stresses can be tested by a combination of long-term trials (LTT) in nature (and was recently proposed by members of the WG 6 of ISO preparing the update of the ISO 12944, "Paints and varnishes — Corrosion protection of steel structures by protective paint systems") in combination with special laboratory test procedures.

DETERMINATION OF LONG-TERM EFFECTS ON COATINGS

The relatively short duration of accelerated laboratory weathering tests (ISO 20340, "Paints and varnishes — Performance requirements for protective paint systems for offshore and related structures," ISO 9227, "Corrosion tests in artificial atmospheres — Salt spray tests" and ISO 11997, "Paints and varnishes — Determination of resistance to cyclic corrosion conditions") may not produce significant deterioration of the coating system as a whole. Therefore, the use of selection criteria to determine best performance is often limited to the post-test determination of underlying rusting at an artificial scribe. With this method, the rusted area may be easily determined and fixed threshold values, i.e. the pass/fail criteria, can be used. Among the remaining difficulties, there is, for example, the difference between rusting, delamination and creep. Then again, coating defects, deterioration of the coating or even rusting of the surface are not always found, or can be differentiated after accelerated testing. These circumstances have forced BAW to carry out LTT in different types of waters and in different zones over a long period of time (five years) to allow corrosion of coated steel to occur, as well as to expose the coated panels to multiple stresses at the same time. According to the Guidelines of Testing of Coatings (RPB[5]) from BAW, the criteria of swelling, brittleness, blistering and rusting are used to calculate a final deterioration number with a maximum of 85, and form a standard/guideline for VBG-BAW[2]. By far, most coating systems show a deterioration number of less than 10 (in LTT 2008-13[6]). This means that no real damage has been observed after five years of exposure. These observations might be explained by the fact that even in LTT in nature, virtually no critical damages comparable to the ones usually caused by impact, abrasion and galvanic action, occurred to the exposed panels.

Variation diagrams are useful tools to detect dependencies between two different series of test results. In previous work some systematic positive correlations between laboratory test and field test results were found[7,8] but mostly by only comparing the immersion zone of LTT with results of aging tests (ISO 20340) or salt spray tests (ISO 9227). Hence, it could be interpreted that in laboratory test procedures, rusting at the scribe does not represent the true corrosive effect in the more relevant zones, like low water, tidal and splash zones. Correlations are seldom seen. Confirmation of the high intensity of corrosion in certain zones is shown in Figure 2 (p. 38). When this fact is accepted, new laboratory tests which include relevant corrosion stresses should be looked for.

RESULTS OF LTT IN NATURE: COMPARISON TO LABORATORY TEST RESULTS

BAW publishes a list of approved coating systems for application on structures

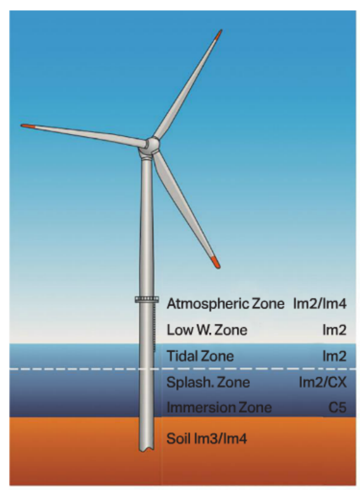


Fig. 1: Corrosion zones of an offshore structure (CX according ISO 9223; Im4 ~ Im2 + CCP according ISO 12944-2; draft 2015).

Table 2: Average Rusting Values at the Scribe After Five Years of Exposure (LTT) for Various Coating Systems

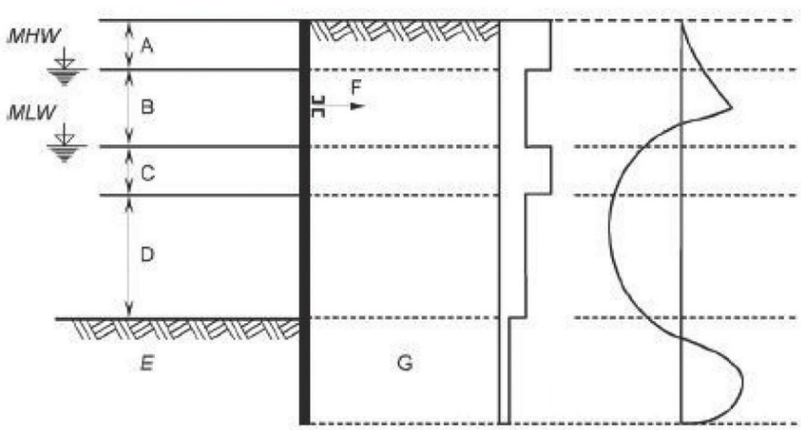
Zone Coating system	Immersion zone (Im2)	Tidal zone (Im2)	Splash zone (C5/Im2)
Zn-rich primer (n=20)	1.4 mm	9.8 mm	4.7 mm
Zn-free. primer (n=7)	1.4 mm	10.4 mm	5.7 mm
Single/two-coat(s) (n=10)	2.3 mm	16.1 mm	22.3 mm
Recommended values1)	2.5 mm	10 mm	6 mm

1) according to [5]

Table 3: Corrosion Rates [µm/h] of Different Standards and Test Results

Testing procedures (threshold values)	Corrosion rates (um/hr)	Zn-rich systems	Single/two-coat systems
	standards	LTT test	LTT test
Salt spray test1) (artificial; 1,440h; 1.0mm)	0.69		
Aging test2) (artificial; 4,200h; 3.0mm)	0.71		
Immersion zone 5) (nature; 43,200h; 2.5mm)	0.06	0.03	0.05
Tidal zone 5) (nature; 43,200h; 10mm)	0.23	0.23	0.37
Splash zone 5) (nature; 43,200h; 6mm)	0.14	0.11	0.52

1) ISO 9772; 2) ISO 20340; 5) RPB [5]; LTT test = long term trial test in nature



a) Vertical zoning of sea water aggressivity
b) Corrosion rate distribution at side
c) Typical bending moment distribution

A Zone of high attack (splash zone)
B Intertidal zone;
C Zone of high attack (Low water zone)
D Permanent immersion zone;
E Buried zone (Water side)
F Anchor;
G Buried zone (Soil side)
MHW Mean high water;
MLW Mean low water

Fig. 2: Corrosion zones according EN 1993-5, Eurocode 3: "Design of steel structures - Part 5: Piling."

in seawater twice a year based on the results of standardized corrosion test procedures in the laboratory[5].

Over the last decade, a trend was observed — an increasing number of corrosion-inhibiting, primer-free coating systems have passed the salt spray test (ISO 9227; 1,440 hours, with rusting less than 1.0 mm). It seems that primers such as zinc-rich can be substituted by these new systems — mainly one- or two-coat systems based on epoxy resins. According to the BAW guidelines[5] an LTT test in nature must follow any accelerated test in order to be fully conforming. After the evaluation of the LTT test results, a huge discrepancy was found — more than half of the approved coating systems did not confirm to the good performance of the laboratory test. This poor result was due to the very high values of rusting seen at the scribe within the tidal and splash zones after the more relevant stresses in the field test (in Kiel, Baltic Sea). Figure 3 (p. 40) shows a test panel with rusting at the scribe after the five-year field test. While in the laboratory test (salt spray test ISO 9227) the panels showed a mean rusting value of less than 1.0 mm (identical to the threshold value in ISO 9772 and BAW[5]), the panel in this figure shows rusting at the scribe of 25 mm after natural exposure. This is far above the required threshold value of 6 mm[5] after natural weathering. In Figure 4 (p. 40), the lower half of the panel has a large rusted area along the scribe while in the upper half corrosion is virtually negligible because of the zinc-rich primer. The calculation of the average rusting values after the five-year exposure in nature gives results which confirm the observation of single-coat systems (Table 2).

The results indicate that in the immersion zone, all the different coating systems show little corrosion at the scribe. In contrast to that, in the tidal zone there is a lot more corrosion and the values allow for a degree of discrimination between systems, as can also be seen in the splash zone. The clear tendency is that coating systems without specially formulated inhibitive primers (single- and two-coat systems) tend to fail in the most corrosive zones in LTT. The explanation of this phenomenon is at first simple: the rusting of the surface along an artificial scribe is prevented by the zinc-rich primer systems. Zinc-rich primers are able to avoid chloride-induced corrosion, and by that, underlying rusting, independent of the generic type of binder of the primer. Their action is twofold: sacrificial as mentioned above; and secondly, binding of OH^- and Cl^- ions, decreasing the primer's "porosity" and increasing its barrier protection.

The calculated corrosion rates (µm/h) of the rusting at the scribe in the previously described test procedures are listed in Table 3, in relation to the threshold values of different standards and guidelines. It can be seen that the salt spray test (ISO 9227) has practically the same corrosion rate value as the aging test (ISO 20340) with the most stress cycles. It is concluded that the threshold value of 3.0 mm is too high a claim and this value should be raised to 4.0 mm.

When the corrosion rates of the different test procedures are compared, one can calculate the acceleration factors, for example, the aging test against the immersion zone in nature: 0.71/0.06 ≈12. The corrosion rates of threshold values of the LTT are always between the very good (zinc-rich systems) and the average systems (single- and two-coat systems) (Table 3).

To check the validity of laboratory test results, a comparison must be made with the results of rusting in LTT in nature. A number of coating pairs (results from two different test procedures) may be checked for any dependencies by a variation diagram[6, 7]. To avoid disadvantages due to application effects, the couples/pairs of the statistical population must be prepared in the same manner. In this way, statistical dependencies can be checked for by calculating a correlation coefficient (r), which shows the confidence level depending on the number of pairs, as presented in Figure 5 (p. 41). The statistical probability that field test results of rusting in the tidal zone and the salt spray test are dependent on each other is higher than 99 percent. Therefore, when one compares the threshold values in the correlation curve, there is a point of intersection at 9 mm (LTT) and 1 mm (salt spray) which is virtually identical to the respective threshold values there. The dependency shown in Figure 5 (p. 41). is the only one found between rusting in laboratory test results (ISO 20340 aging test and ISO 9227 salt spray test) and LTT tests in various zones. It means that both of the common laboratory test procedures are unable to mirror results obtained in the immersion and splash zone in nature. Heavy deterioration at the surface and other signs of damage are not found and are therefore almost negligible in all test series. The generic types of binder don't show any clear influences, although polyurethane (PUR, single pack) shows slightly better results than epoxy coatings.

As a result of these tests and further experiences of protecting hydraulic steel structures in both sea water and the atmosphere, Table 4 (p. 40) presents some proposals of suitable and common coating systems for low water, tidal and splash water zones (Im2/C5, zone 2), according to BAW, as well as proposals for the atmospheric zone (C5/CX; zone 3) which should be introduced for structures in German wind farms in the Northern as well as the Baltic Sea[2].

Table 4: Examples of Recommended Coating Systems in Different Zones

Zone / System-No.	Primer			Intermediate-/Top-Coating			Paint System	
	Binder	Layers/ Coatings (n)	NDFT [µm]	Binder	Layers/ Coatings (n)	NDFT [µm]	Layers/ Coatings (n)	TNDFT [µm]
2/1-3	2K-EP-Zn(R)	1	50	2p-EP + 2p-PUR*	1-3 + 1*	450 + 80*	3	580
2/4	2K-EP-diverse	1	50-100	2p-EP + 2p-PUR*	3 + 1*	400-450 + 80*	5	580
2/8	1K-PUR-Zn(R)	1	50	1p-PUR + 2p-PUR*	3 + 1*	450 + 80*	5	580
3/1-3	2K-EP-Zn(R)	1	50	2p-EP + 2p-PUR*	1-2 + 1*	190 + 80*	3	320
3/5	1K-PUR-Zn(R)	1	50	1p-PUR + 2p-PUR*	2 + 1*	190 + 80*	4	320
3/6	TS	1	80-100	Sealer+2p-EP+2p-PUR*	1 + 2 + 1*	20 + 1840 + 80*	without TS: 4	without TS: 280

Zone 2: low water, water changing and splash water zone (Im2/C5)
Zone 3: atmospheric zone (C5/CX)
* top coating 2p-PUR according RAL 1003; TS = thermal sprayed Zn-alloy

Fig. 4 : Lower half of panel shows single coat system at 600 µm TDFT. Upper half of panel shows Zn-rich system, in atmospheric zone after five years of exposure.

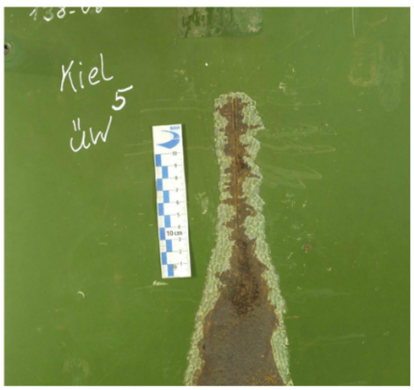


Fig. 3: Significant rusting in splash zone after five years of exposure. (Zn-free system, Norsok A.7).

DISCUSSION AND CONCLUSION

The most critical zones of maritime offshore environments are the tidal zone and the splash zone. Coating systems such as the zinc-free system, A.7 according to NORSOK M 501, do not show good performance in the LTT in nature in these zones, even when they pass the laboratory salt spray test (ISO 9227) or fulfill the 8 mm corrosion at the scribe criterion for repair materials within the aging test according to ISO 20340. This is in agreement with the observations on existing offshore structures. The reason may be that they have no special active layer to prevent rusting at the substrate, as well-formulated primer-based systems do. Also, high adhesion values, for example, are not enough to prevent rusting of the substrate or at the scratch, nor are they ever high enough to prevent osmotic effects which are important for underlying rusting. A statistical calculation showed that zinc-rich primers have an average value of 6.7 MPa in the pull-off test while the two- or one-coat systems show an average value of 7.6 MPa.

Are there any other advantages of primer-free coating systems? To prevent underlying rusting, the coatings must be insensitive to impact and other damage that leads to deterioration of the coating during transport or erection, however single-coat systems are more sensitive to falling weight tests than primer-based coating systems and show significant failure after the test and weathering stress in a salt spray chamber. If a coating system shows signs of damage, there is a high demand for self-protection of the surface against rusting. This can be achieved with specially formulated primer systems as proven in laboratory and LTT tests, as well as on existing structures.

Cathodic protection (CP) by impressed current is a well-known method of protecting structures in seawater against corrosion. For meaningful results, our studies have shown that the cathodic disbondment test (ISO 15711, “Paints and varnishes — Determination of resistance to cathodic disbonding of coatings exposed to sea water”) must be carried out for a duration of 15 months in order to ensure the resistance of coatings to the cathodic protection current generated. At the same time it is advantageous also to measure the current demand because this allows signs of weakness in coatings to be seen when the test panel requires a higher protection current.

Within the immersion zone, the difference of underlying rusting of primer-based systems and single- or two-coat systems is low. Generally very little corrosion will happen there, but at the same time, this is the zone where CP works and this means that due to cathodic polarization, hydroxyl ions are produced by delivering electrons to the cathode in order to protect the steel in sea water. Decades of measurement have shown a constant result: zinc-rich primer based coating systems can bear or withstand hydroxyl attack, and this way disbondment and blistering of the coating can be avoided.

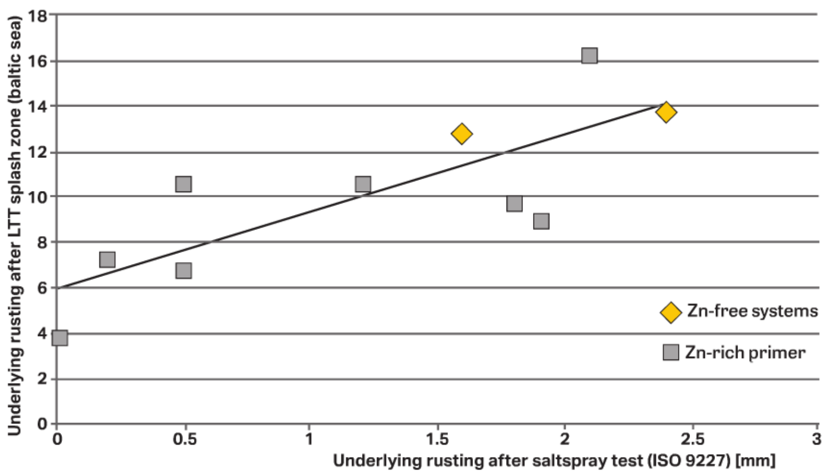


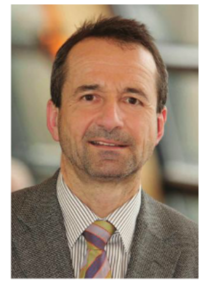
Fig. 5: Long-term trials variation diagram of underlying rusting in water changing zone and salt spray test.

Ultimately the results of a long-time exposure in nature should determine how a system can work in avoiding corrosion under extreme circumstances and conditions on site. Existing laboratory test procedures are useful to a certain extent — for example, as a pre-qualification test for the protection quality of coatings.

Therefore, the threshold values should be aimed at the performance and should not prefer certain systems. For the aging test of ISO 20340 (4,200 hours), a threshold value of 4 mm for rusting at the scribe for all systems of full renewal is recommended while for the salt spray test, 1 mm (1,440 hours, ISO 9227) could be kept as a threshold value. To get an idea of the corrosion rates one can compare the acceleration factor of artificial aging with the rusting in nature. To improve the validity of laboratory test procedures, their results must be compared systematically with the results of realistic testing procedures like LTT in nature. The results of LTT may imply that there is no special need for high-performance pigmented coatings within the immersion zone because of the low through rusting values in general. But, more attention should be paid to the behavior of coatings in combination with the CP electric current in this zone, which induces stress on the coating by the propagation of hydroxyl ions. Here, as well as in the laboratory and field test, special primer systems are available which show good and acceptable results. According to the experiences of BAW (testing of more than 400 systems from suppliers worldwide in the last decades), well-functioning primer systems are available from producers worldwide.

Finally, guidelines for corrosion protection should help to figure out the best systems available by defining proper threshold values in test procedures, although this practice doesn't necessary help with corrosion protection under such difficult conditions as an offshore climate. Laboratory test methods should include further mechanical test procedures such as abrasion and falling weight tests. Contrary to that, pull-off values may show differences in adhesion between the coating layers but are not able to predict the anticorrosive potential of a coating system.

ABOUT THE AUTHOR



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Editor's Note: See PaintSquare.com for additional article content.

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EQUIFINALITY: Specifying Performance

BY TROY FRAEBEL AND TONY IPPOLITI, THE SHERWIN-WILLIAMS COMPANY

Merriam-Webster defines "equifinality" as the property of allowing or having the same effect or result from different events. While the term is typically used in science and business, we need to recognize that there are many different ways to achieve the same end in a coating project, that end being the long-term performance of the coating system and thus, the long-term protection of the asset.

Most coating material specifications have moved away from coating formula-based recipe requirements. Specifying particular products or using qualified product lists (QPLs) are popular, but these methods have their drawbacks. The ideal of specifying materials by performance also has some drawbacks, but there are other aspects of a painting project, for example surface preparation, application and inspection, which can affect long-term performance but may be hampered by overly prescriptive means-and-methods specifications. Qualified and experienced coating contractors know how to apply and achieve successful performance from coating materials and make the materials perform. For the painting portion of a large project or a painting-only project, we can use a balanced equifinality principle — leaving things as open as possible, but restricting where necessary. The contractor's work plan response to the specification is critical to the success of this balanced equifinality principle.

Design/build (D/B) construction contracts are an example of where the contractor's expertise is used to bring in a quality project in a cost-effective, timely manner. It is becoming common for prison, post office, hospital and school projects to be executed in a D/B fashion. In Indiana, for example, one specifier estimates that 35 percent of institutional projects are delivered via D/B. The size, location, number of rooms and functionality/performance are specified, but the design/construction team responds with the details. Comparing the different designs and qualifications of the bidders can be problematic, so multi-step processes, including pre-qualification, are often employed. Unfortunately, many public entities still prohibit D/B contracting.

On the industrial side, we have seen bridge and highway projects executed using the D/B method. Final bridge designs and decisions about the use of concrete or steel construction (weathering steel, galvanizing, or painted steel) are left up to the D/B team. Water and wastewater treatment plants and processes have also used D/B bidding. Ideally, a water storage tank could be specified to last 100 years and hold a million gallons at a certain elevation and pressure, with a certain size piping and head range. Engineers of water storage tanks have recognized equifinality by bidding alternate styles of elevated tanks such as legged, fluted column, spheroid or composite on a project and letting the price and owner decide. Ground storage tanks or reservoirs are also often bid with several options such as welded steel, bolted or concrete. The coating and lining systems on these projects might benefit from a more open performance specification approach.

Performance-based specifications utilizing the balanced equifinality approach are predicated on the development and execution of quality contractor work and inspection plans.

A complication in specifying performance is the inclusion of periodic inspection and maintenance in the long-term life-cycle equation. The life cycle must be taken into consideration during initial funding and bidding; and even more importantly, maintenance and inspection must be funded by the asset owner if the expected long-term performance is going to be achieved.

COATING SELECTION

When SSPC: The Society for Protective Coatings was founded, there were virtually no specifications for paint materials. Military specifications (Mil-Spec) existed and both SSPC and the military wrote formula recipe specifications with minimum composition requirements. Anyone who could read and had a bathtub could make paint. It has since been recognized that this approach led to most materials barely meeting the minimum standard, lack of innovation and no new products. Imagine, for example, that following a recipe for lasagna exactly from the cookbook may work, but the lasagna might not be as tasty as desired. SSPC and the military recognized these limitations and are now producing performance specifications (for example SSPC-Paint 36, Two-Component Weatherable Aliphatic Polyurethane Topcoat, Performance-Based). The military has also recognized the expertise of coating manufacturers and is specifying commercially available products where possible.

Specifying paint performance is ideal under the equifinality principle, but it has drawbacks just like the D/B method mentioned earlier. How should we compare different materials? What are the critical performance criteria for a particular exposure? While side-by-side, accelerated immersion and weathering testing is a good start to comparing different materials, a correlation between this testing and actual long-term performance in a particular environment has yet to be proven. Do we have to wait 30 years to substantiate that a coating or lining system will last that long? If we do, environmental regulations will have likely changed and the established material may no longer be available. We often compromise by looking for performance within a specific generic coating class such as zinc-rich, epoxy or polyurethane but this does not have to be the case.

The American Water Works Association standard, AWWA D102, "Coating Steel Water-Storage Tanks," includes a three-coat, solvent-based epoxy system with a minimum of 12 mils and a 100-percent-solids epoxy system with a minimum of 20 mils. Without empirical testing, one could logically infer that the 20-mil system will outperform the 12-mil system. Further, it is very likely that the 100-percent-solids epoxy system is on par with the 100-percent-solids polyurethane/polyurea system.

Manhole lining is another example where properly installed chemical and hydrogen sulfide (H_2S)-resistant, 100-percent-solids epoxy, polyurethane or polyurea materials might all perform admirably in a wastewater immersion or vapor environment. When conditions limit choices, however, a specifier must restrict when necessary. For instance, the polyurethane/polyurea material may be the only candidate when lining water storage tanks in cold weather or where flexibility is required in a brick manhole.

Performance equal to traditional three-coat zinc/epoxy/polyurethane systems is now often achieved with two-coat zinc/polyaspartic or zinc/polysiloxane technology. One-coat polyaspartic or polysiloxane systems may perform as well as two-coat epoxy/polyurethane systems, especially when the specified level of surface preparation is achieved. However, the ability to spray apply the material can limit the availability of these options.

Moist or green concrete can be successfully topcoated with breathable waterborne epoxy technology or urethane concrete depending on the conditions and contractor preference. High temperature or chemical exposures may limit the material selection to the urethane concrete.

While these examples are not exhaustive, one can see that specifying

Photo courtesy of Pamela Simmons

Photo courtesy of Pamela Simmons

performance using different materials and varying numbers of coats on the same structure and environment type is possible, but the decision-making process can be cumbersome. So, how does one decide?

One approach is to specify a particular product by name and number that is known or anticipated to perform in a certain exposure. While this method may work, it limits competition which may drive up cost and is often prohibited by procurement policies, especially when public entities are involved. Specifying a particular product also puts most of the liability on the specifier if the product does not perform, especially if it is difficult to apply.

Often we see a particular product "or equal" specified. While this approach appears to address the competition concern, it re-introduces the "how to decide" problem. The generic class of coating typically becomes fixed — limited to a particular chemistry when an alternative chemistry may be just as effective to achieve the desired end result. Often compositional and physical properties, and not relevant long-term performance criteria come into play such as volume solids, dry times, volatile organic compound (VOC) content, pigment type and shape, as manufacturers attempt to influence the specifier. Irrelevant performance criteria such as UV-resistance and salt fog resistance (ASTM B117) show up on a water tank lining project. Excessive adhesion or hardness values may cause confusion and varying methods of measuring permeability can frustrate the specifier, who then retreats to the one material listed and the specification in reality becomes sole-sourced and the owner's ability to receive competitive bids is eliminated.

Doing the research up front and developing a QPL maybe the best approach and is customary in many markets including bridge and highway, and oil and gas. The downside is the cost of testing and keeping the QPL up to date. Under the American Association of State Highway and Transportation Officials (AASHTO) National Transportation Product Evaluation Program (NTPEP), paint manufacturers can submit paint materials and systems to one testing agency and the results are available to all state transportation departments for consideration for their respective state or regional QPLs. Often specifiers have to rely on in-house testing by the paint manufacturers and case histories of actual applications to evaluate materials and develop and maintain a QPL. Developing a limited QPL is an example of a balanced equifinality approach and it is much easier than trying to compare products after a project has bid.

While much has been said about the selection and specification of the coating materials, the proper surface preparation and application of the materials is even more critical for achieving long-term performance and optimum life cycle.

SURFACE PREPARATION

The first SSPC surface preparation standard, SSPC-SP 1, "Solvent Cleaning," is performance-based, allowing for "any liquid or vapor ... Examples of solvents include: water, emulsion or alkaline cleaners, and hydrocarbons." The word solvent conjures up thoughts of mineral spirits and strong chemicals like methyl ethyl ketone (MEK) and xylene, while water is the universal solvent. By guiding contractors to the "end-condition of a metal surface from which visible deposits of oil, grease and other visible contaminants have been removed," a specification can be created that does not limit method selection but assures project success. For example, (bio-degradable) detergents and water and/or live steam or pressure washing may clean a surface better than smearing hydrocarbon solvents onto surfaces to be painted. Water or water solutions can more easily and safely be rinsed from surfaces and leave no residue and when waterborne direct-to-metal (DTM) acrylic, alkyd and epoxy primers are specified, hydrocarbon solvents should be explicitly excluded.

SSPC-SP 2 and 3, "Hand and Power Tool Cleaning," respectively, allow for a variety of tools and power sources as long as "all loose mill scale, loose rust, loose paint and other loose detrimental foreign matter" is removed and "cannot be removed by lifting with a dull putty knife." The contractor knows best what will work for him/her and if the area is large enough and conditions allow, SSPC-SP 7/NACE No. 4, "Brush-Off Blast Cleaning" should not be discouraged as it can yield the same end result.

The different degrees of abrasive blast cleaning (SSPC-SP 5/NACE No. 1, "White Metal Blast Cleaning," SSPC-SP 10/NACE No. 2 "Near White Blast Cleaning" and SSPC-SP 6/NACE No. 3, "Commercial Blast Cleaning") are also defined by the end result of being "free of all visible oil, grease, dust, dirt, mill scale, rust, coating, oxides, corrosion products and other foreign matter" with a certain level of acceptable random staining. The required profile range must be specified in addition to the degree of cleanliness. Centrifugal or nozzle blast cleaning, different pressures, nozzle sizes and abrasives, recycled or not, can all yield the same level of cleanliness and profile and the contractor typically knows the best method and abrasive size for a given application or location. Where environmental regulations require or heavy metals are present in the existing paint, it may be necessary to specify containment and recycled abrasives. Specifying particular abrasive type and size and equipment specifics such as pressures and nozzle sizes may render the specifier liable if those means and methods do not achieve the desired cleanliness or profile.

Power tool cleaning in accordance with SSPC-SP 11 or SSPC-SP 15, "Bare Metal" and "Commercial Grade," respectively, can achieve very similar results to abrasive blast cleaning and should be considered especially when small areas need to be prepared in a short period of time. If power tools are acceptable, the choice of which power tools to be used should not be dictated by the specifier; however, both SSPC-SP 11 and SSPC-SP 15 require a minimum profile of 1.0 mil so tools that only polish or burnish should be avoided.

While SSPC-SP 1, "Solvent Cleaning" is required prior to hand, power or abrasive blast cleaning, it only addresses visible contaminants. Non-visible surface contaminants such as soluble salts or other ionic species must be addressed separately in the specification if suspected on the substrate. This might lead one to consider the waterjetting standards (SSPC WJ-1/NACE WJ-1, "Waterjet Cleaning of Metals – Clean to Bare Substrate," SSPC-WJ-2/NACE WJ-2, "Waterjet Cleaning of Metals – Very Thorough Cleaning," SSPC-WJ-3/NACE WJ-3, "Waterjet Cleaning of Metals – Thorough Cleaning" and SSPC-WJ-4/NACE WJ-4, "Waterjet Cleaning of Metals – Light Cleaning") which have several advantages including creating conditions similar to abrasive blast cleaning, removing non-visible contaminants and generating very little waste or dust. Waterjetting will not produce a profile, but the abrasive blast cleaning standards allow for "[o]ther methods of surface preparation (such as wet abrasive blast cleaning) ... by mutual agreement between those responsible for establishing the requirements and those responsible for performing the work." Vapor blast cleaning appears to be effective and greatly reduces the amount of abrasive used. There are considerations about flash rusting and the use of inhibitors which are beyond the scope of this article, but wherever possible specifiers should consider using, or at least allowing, wet cleaning methods as long as the resulting coating application will

Photo courtesy of The Sherwin-Williams Company.

achieve the performance and life cycle desired. Certain high-performance coating materials perform better over slightly rusted clean carbon steel surfaces than over a rust-free contaminated one.

SSPC-SP 13/NACE No. 6, "Surface Preparation of Concrete" allows for a variety of methods as long as the concrete is "free of contaminants, laitance, loosely adhering concrete and dust ..." The International Concrete Repair Institute (ICRI) Guideline No. 310.2R, "Selecting and Specifying Concrete Surface Preparation for Sealers, Coatings, Polymer Overlays and Concrete Repair" lists several methods to achieve a range of concrete surface profiles (CSP 1-to-10). Acid etching, while once a commonly specified method, is seldom specified explicitly because of the presence of curing compounds, and a great variability in procedures would often yield less than the desired profile. Contractors, though, can still use acid etching if they know how to proper apply, rinse and dispose of the water, as long as the proper cleanliness and profile are achieved.

APPLICATION

As with abrasive blast cleaning, spray equipment, pressures and nozzle sizes should be left up to the contractor. While the manufacturer's product data sheet will provide guidance, most equipment decisions can and should be left up to the contractor. Data sheets do include restrictions on air, surface and material temperatures which must be followed, especially when using plural-component equipment to apply 100-percent-solids polyurethane and epoxy materials. Incorrect temperatures or ratios can lead to disasters with application of these materials.

If the finish is acceptable, brush and roller application should not be excluded. Exterior water tank coating systems are usually roller applied to minimize the need for containment and eliminate the risk of overspray while the interior finish coat must be spray-applied to provide a smooth monolithic lining. Manhole lining and resurfacing is another area where a variety of spray, roller and hand trowel application methods are used based on the material, temperature, location of the project and the contractor's expertise and equipment.

In the end, it is long-term performance that is desired and this is typically defined by a certain thickness of a certain material or materials over a certain degree of cleanliness and profile. So if it takes a contractor three roller-applied coats to achieve the thickness that could have been achieved in one spray coat, all is well as long as the coating is adhered and uniformly applied.

INSPECTION

In order to achieve the desired performance, the selected material, surface preparation and application must be inspected and documented. In "Paint Inspection From the Coating Manufacturer's Perspective," presented at SSPC 2015, Fraebel and Snyder explored the various parties (specifiers, third-party inspectors, general contractors, painting contractors, equipment suppliers and coating manufacturers) that are, can and should be involved in the inspection process. Equifinality was alluded to in this paper, pointing out that from a coating manufacturer's perspective, a variety of qualified personnel can perform inspection activities as long as they're completed effectively.

Not only do the participants in the inspection process not allow for much equifinality, but neither do the equipment and methods themselves. Air, surface and material temperatures, relative humidity and dew point can all be measured electronically and automatically recorded by one or multiple gauges or be measured the old-fashioned way with red spirit and spring thermometers and calculated using psychometric tables. ASTM International's D4417, "Standard Test Methods for Field Measurement of Surface Profile of Blast Cleaned Steel" includes three different methods. Dry-film thickness can be measured with sophisticated electronic magnetic and eddy current gauges or simple spring-loaded magnets. In addition to the methods in NACE International's SP0188, "Discontinuity (Holiday) Testing of New Protective Coatings on Conductive Substrates," holidays can also be detected using optically activated pigments (OAP) in accordance with SSPC-TU 11, "Inspection of Fluorescent Coating Systems."

WORK PLANS

If a specifier on a painting project clearly states the expected surface cleanliness, profile and acceptable material or materials and thicknesses, along with other project limitations including timing, access and regulations, then a qualified contractor should be able to respond with a detailed and executable work plan. Overly prescriptive specifications can lead to lack of contractor initiative, absence of new technologies and liability for the specifier and owner.

Work, safety and inspection plans should be prepared and reviewed before the pre-construction meeting and before any work begins. Details about manpower, work hours, the type and quantity of equipment, abrasives, lighting, materials including product data and safety sheets, sequencing and cure times should be included in the work plan. Safety, traffic control and waste disposal are beyond the scope of this article but are equally important to the successful completion of a project. The inspection plan should include who is doing what and when, list the particular equipment to be employed and include a copy of the daily painting inspection report and other documentation to be employed. The inspection plan is critical to the coordination of contractor QC and owner QA on large projects.

LIFE CYCLE AND MAINTENANCE

Life cycle cost including maintenance and periodic inspections are probably the most difficult part of the equation and are often overlooked. As stated earlier, the life cycle must be taken into consideration during initial funding and bidding, and maintenance and inspection must be funded by the asset owner if the expected long-term performance of the coating system is going to be achieved. Periodic inspection, washing and touch-up painting should not be overlooked.

CONCLUSION

Specifying performance using the balanced equifinality approach (leaving things as open as possible while restricting where necessary) in conjunction with a quality, project-specific contractor work and inspection plan will go a long way in achieving the desired life cycle at a reasonable cost. The return on investment (ROI) can be further enhanced by funding and performing periodic inspections and maintenance.

ABOUT THE AUTHOR

Troy E. Fraebel is a project development manager for the protective and marine division of The Sherwin-Williams Company. He has over 25 years of experience in the protective coatings industry including extensive experience in the water, wastewater, bridge, mining and metals, marine, power and petrochemicals markets.

Fraebel is a NACE-Certified Coating Inspector, an SSPC Protective Coatings Specialist and instructor for SSPC's C1, Fundamentals of Protective Coatings and C2, Planning and Specifying Industrial Coatings Projects training courses.

Prior to joining Sherwin-Williams, Fraebel developed the painting quality assurance and maintenance programs for Caldwell Tanks. He was a voting member on the AWWA's D102 tank painting revision task force and spent 13 years with KTA-Tator, Inc.

Fraebel's current professional associations include SSPC, NACE International, ASTM International, AWWA and numerous rural water associations. He holds a B.A. degree from Western Kentucky University and a Master's degree in Education from William Paterson College.

Tony Ippoliti is a multi-market project development manager for the protective and marine coatings division of The Sherwin Williams Company. He began his career with Sherwin-Williams in 1976 and provides project specification and technical resource assistance to facility owners and consulting engineers as part of his association with their global finishes group.

Ippoliti has been a member of SSPC and NACE International for more than 25 years, is an SSPC-Certified Protective

Coatings Specialist (PCS), NACE-Certified Coating Inspector, a Certified Protective Coatings Specialist, a Certified Concrete Inspector and an instructor of SSPC's C1 and C2 training courses. He is also a member of the International Concrete Repair Institute (ICRI), a long-time member of AWWA, a D102 and a 198 tank committee member and an instructor for the Steel Tank Institute. Ippoliti is an affiliate member of the ASCE and WEF. His postgraduate studies include metallurgy and surface coatings at Kent State University.

He has created and presented educational programs for state and local chapters of the Painting and Decorating Contractors of America (PDCA), the Construction Specifications Institute (CSI), SSPC, NACE, ASCE and AWWA. Ippoliti has had input on ASTM, AWWA and SSPC/NACE joint standards-writing committees and regularly hosts educational events for municipalities, industrial facility owners, consulting and engineering firms. He has also contributed editorial to *JPCL, American Painting Contractor, Water & Wastes Digest,* the revised edition of AWWA's "M42 Steel Water Storage Tanks" and provided technical review assistance for SSPC's Generic Coatings and Cleaning and Coating Concrete publications. ***JPCL***


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THE PRINCIPLES OF **WORKING AT HEIGHTS**

BY MINO MUHANAD ALKHAWAM
TRACTEL LTD.

The use of fall protection equipment is very common nowadays but many users do not fully understand the basics of fall protection or how the equipment functions. Safety, in general, depends a lot on the use of common sense and proper due diligence.

It is a fact that we are all exposed to gravity 24/7 and we, humans in general, take little or no protection and precaution against it. The reality is that falls are never expected.

OSHA reports that 4,679 workers died on the job in 2014 and statistics in North America show that falls are dangerous even at low heights. Fall protection seems to be intimidating as there is a selection of equipment, products, systems and components that may be interchangeable. And the efficiency of any safety equipment depends not only on the equipment itself, but also on the user.

Protection against falling from heights actually starts on the ground level. Fall protection programs must be put in place before work starts and should include a rescue plan to get the victim out in case a fall does happen. Additionally, the program and plan must be communicated properly to all the parties and personnel who may be working in the area. Workplace analysis must be done to identify the risks of falling and determine a solution for them.

The Occupational Safety and Health Administration (OSHA) maintains that the hierarchy of fall protection starts with completely eliminating the hazards and risks of falling by engineering them out and away from the workplace. If that is not a reasonable possibility, then preventing falls from happening is to be considered next. If that is also not a suitable solution, then putting in a fall protection program and a rescue plan is a must.

THE DYNAMICS OF A FALL

Gravity pulls everything around the globe to its center. It is a continuous acceleration of 32 feet/second^2. So when a mass (someone) falls, the speed at which the mass travels starts at zero and accelerates. The longer the falling distance is, the faster the speed reached and the greater the amount of energy that will be generated from that fall. The real danger from a fall is not necessarily the distance or the high speed, but rather the amount of energy generated from falling, how it is distributed and where it is dissipated upon impact.

THE A-B-Cs OF FALL PROTECTION

Fall protection is meant to protect workers from the dangers of falling without causing any major injury. Different types of fall protection equipment can be used together to make up a complete system. Some systems are designed to prevent falls from happening (fall prevention systems) while some others are designed to arrest a fall (fall arrest systems). As simple as "A-B-C," any fall protection system needs three main components to function properly:

- Anchor point and/or anchor connector;
- Body harness; and
- Connector or connecting link to connect the anchor point to the body harness.

If the system is missing any of these components, it is not a thorough and safe system. The addition of a rescue plan completes an acceptable fall protection protocol.

Anchor Point and Anchor Connector

It is very important to choose the proper anchor point for a fall protection system, and it has always been a challenge to find that proper point. OSHA requires that a fall protection anchor point must have a minimum tensile strength of 5,000 lbs. (22 kN) per worker attached to it, or it must have twice the maximum arresting force if designed by a professional engineer. To properly choose the anchor point, one must consider the following.

- Strength of the anchor point
- Size of the anchor point
- Height of the anchor point
- Placement and accessibility to the anchor point
- Number of workers to be connected to the anchor point

The anchor point should be easily accessible so that a worker can connect to it before starting the work. It should be located away from any lower obstacles. It is recommended that the anchor point be directly above the worker to reduce any pendulum effect during the fall.

Examples of good anchor points include an I-beam metal structure, residential home main peak trusses and concrete structures over 6 inches thick. Examples of unacceptable anchor points include guard rails, scaffolding, pipes, utility cables and air ducts.

Body Harness

A body harness is a tool that must be chosen properly in reference to the work application. There is no "one harness to do all applications" and no "one size fits all." One should consider the following when choosing a body harness.

- Size of the user
- Number of hours of use
- Environment of the work place
- Nature of work application

Photo courtesy of Trachtel Ltd.

The harness should fit snuggly on the user — not too tight and not too loose. It should be easily adjustable and comfortable to wear. Workers have more of a tendency to wear and regularly use a properly fitting and comfortable harness. Therefore, a better harness selection will result in improved compliance and increased safety on the job.

Connector or Connecting Link

There are many products that fit into this category including lanyards, retractable lifelines, ladder systems, horizontal systems and more. A worker may need more than one connector to properly and safely connect an anchor point to a body harness. The following factors should be considered when choosing a connecting link.

- The height of the anchor point
- The placement of the anchor point
- The environment of the work place
- The nature of the work/application

Non-energy-absorbing lanyards should not be used in fall arrest applications. Energy-absorbing lanyards do have a deceleration distance (sometimes called controlled-fall distance) that should be taken into consideration as part of the potential total falling distance.

Self-retracting lanyards and lifelines have a shorter arresting distance and they allow for easier rescue. However, when using a self-retracting lanyard or lifeline, a balance should be achieved between the horizontal movement away from the anchor point and the vertical distance in case of a fall.

THE RESCUE PLAN

Unfortunately, a rescue plan is not always used as part of a fall protection program, but it is a necessary element. Rescuing a victim after a fall is very time-sensitive. If not rescued quickly, the victim could suffer from suspension trauma or orthostatic intolerance (OI), also known as harness hang syndrome (HHS), and is defined as a condition occurring when the human body is held in an upright position without moving for an extended period of time. It is worth noting also that after a fall, harness webbing straps are tight around the thighs, decreasing blood circulation.

A rescue plan must be put into place in order to start the rescue process while waiting for EMS to arrive. The plan must be communicated and practiced by all rescuers. If any special equipment is to be used in the rescue, then this equipment must be onsite and ready to be used at all times.

Rescue plans in construction should be site-specific and the risk of falling can change from one site to another, so a customized rescue plan should be developed for each work site. In general industrial or manufacturing applications, the work and the risk of falling rarely change. In such cases, a rescue plan can be developed once as part of the overall fall protection program. The plan should be put in place and workers should be well trained in it.

CONCLUSION

In conclusion, protecting workers against falling is of great importance. The use of common sense and due diligence is paramount. We must never neglect the standards, laws and regulations regarding working safely. Understanding falls and analyzing the risks make it easier to find solutions.

Remember, it may take a minute to don a harness, it may take a week to impose a fall protection program, it may take a year to teach a worker to think about safety; but it will take the blink of an eye for someone to fall. And that fall may be the last blink of an eye that person has.

ABOUT THE AUTHOR

Mino Muhanad Alkhawam has been involved with safety products since 2000 and has specialized in height safety and fall protection applications since 2008. He holds a certificate from Concordia University in Montreal as well

as Qualified Safety Sales Professional (QSSP) certification. Alkhawam has been involved in technical work, training, sales and product development for height safety products and since 2013, he has been employed by Tractel in North America as a height safety specialist. ***JPCL***

Indianapolis Welcomes American Coatings Show


Photo courtesy of Indiana Convention Center & Lucas Oil Stadium.

The American Coatings Show and Conference 2016 will take place at the Indiana Convention Center in Indianapolis, Ind., from April 11 to 14.

The Conference, held April 11 to 13, will open with a series of pre-Conference tutorials, followed by two days of information sessions composed of almost 100 presentations pertaining to coatings, adhesives, sealants and construction chemicals. The Show, open April 12 to 14, will showcase almost 500 exhibiting companies from the protective coatings and related industries.

The following list of technical sessions held during the Conference may be of interest to protective coatings professionals and is current as of press time.

For complete information, visit www.american-coatings-show.com.

MONDAY, APRIL 11

8:30 to 10:00 a.m.

"Easy-to-Clean Coatings," by W. Marshall Ming, Georgia Southern University

"Anticorrosive Coatings," by Brian Skerry, The Sherwin-Williams Company

"Waterborne High-Performance Coatings," by Ivan Tyre, Alberdingk Boley; and Lori Boggs, BASF

"Radiation Curing," by Jeffrey Klang, Sartometer

10:30 to 11:00 a.m.

"Polyurethanes," by Mike Jeffries, Covestro

"Sustainable Coatings and Processes," by Jamil Baghdachi, Coatings Research Institute – Eastern Michigan University

2:00 to 5:30 p.m.

2: Additives

3: Functional and Smart Coatings

4: Pigments

TUESDAY, APRIL 12

9:00 a.m. to 12:30 p.m.

6: Polyurethanes I

8: Measuring & Testing

2:00 to 5:30 p.m.

10: Polyurethanes II

11: Direct-to-Metal Coatings

12: Novel Materials

WEDNESDAY, APRIL 13

9:30 to 1:00 p.m.

13: Industrial Coatings

14: Alkyds

15: Biobased Coatings

16: Protective Coatings

EXHIBITORS AT ACS 2016 The following list of American Coatings Show 2016 exhibitors may be of interest to protective coatings professionals and is current as of press time. For a complete exhibitors list, visit the official ACS website.

3M Advanced Materials Division ... 1867
ABRAFATI – Brazilian Ctg. Mfrs. Assoc. ... 1483
ACT Test Panels ... 665
Advanced Composite Materials ... 1987
AGC Chemicals Americas .. 2936
Air Products ... 2240
AkzoNobel ... 2161
Allnex ... 1233
American Coatings Association ... 1789
Arkema, Inc. ... 1031
Ashland ... 1763
Atlas Material Testing Technology, LLC ... 2476
BASF – The Chemical Company ... 1431
Beyond Powder Coatings Ltd. ... 329
Brenntag North America, Inc. ... 1749
BYK Additives & Instruments ECKART ... 2031
Cabot Corporation ... 941
Cardolite ... 1061
Celanese ... 1455
Chromaflo Technologies Corp. ... 1240
Clariant ... 1367
Coatex ... 1031
CoatingsTech Magazine ... 1789
Covestro, LLC ... 2331
Croda ... 1655
DeFelsko Corporation ... 1267
Dow ... 2230
Dow Corning ... 249
DSM Coating Resins ... 208
Durablity + Design ... 568
Eastman Chemical Company ... 1885
Elcometer USA ... 636
ElektroPhysik USA Inc. ... 2277
Elementis Specialties ... 1630
Emerald Performance Materials ... 2755
Evonik ... 2728
Ferro Corporation/ Nubiola ... 861
Fischer Technology ... 2359
Heucotech Ltd./Heubach ... 1955
Hexion, Inc. ... 2348
Huntsman ... 930
Incorez Custom Chemistry ... 1568
JPCL ... 568
King Industries, Inc. ... 2171
Lonza ... 1055
Lubrizol ... 1643
Missouri University of Science & Technology ... 155
Momentive Performance Materials ... 961
Nanovea ... 2773
North Dakota State University – Ctgs & Polymeric Materials ... 154
Nuplex Resins ... 2055
Omnova Solutions ... 1555
Paint & Pintura Magazine .. 2596
PaintCare ... 1784
PaintPAC ... 1787
PaintSquare ... 568
Paul N. Gardner Co., Inc. ... 730
Perstorp Group ... 2855
Q-Lab Corporation ... 2255
Reichhold ... 1931
Ring Specialty Chemicals Inc. ... 2180
SKSHU Paint Co., Ltd. ... 2869
Solvay (formerly Rhodia) .. 1541
Specialty Minerals Inc. ... 2580
Specialty Polymers ... 1977
TIB Chemicals ... 3054
TQC bv ... 1255
Troy Corporation ... 1442
U.S. Silica ... 2554
Univar ... 2649
Vincentz Network ... 1889
Wacker Chemical Corporation ... 1946
The Waterborne Symposium- University of Southern Mississippi ... 156
Worlee-Chemie GmbH ... 2679

SSPC Annual Report

JAN. 1, 2015 TO DEC. 31, 2015

PART I: INTRODUCTION

The SSPC Annual Report provides an overview of the status of SSPC: The Society for Protective Coatings from January 1, 2015 through December 31, 2015. The following information gives the most current figures for all programs.

SSPC experienced another year of growth in both membership and revenue (excluding investment income). Individual membership topped 11,000 for the first time and corporate membership reached a new high of 961, indicating SSPC's continued growth in relevance.

The previous year was also a year of change for the organization as Bill Shoup retired and Bill Worms took over as the organization's new Executive Director. Mr. Shoup was an iconic figure in the industry and at SSPC, and his contributions to the organization were innumerable and greatly appreciated.

In addition to the leadership change, SSPC experienced a location change in 2015. SSPC reinvested in the organization by purchasing a world headquarters building, thus transitioning out of formerly leased office space. The new building doubles the space of the organization's previous location, and it has newly renovated training facilities, as well as ample space for future growth and expansion.

PART II: ACCOMPLISHMENTS

Training and certification experienced solid growth with training being up over 14 percent (see Part III). As previously indicated, both individual and corporate memberships also showed growth, and both reached new highs in 2015 (see Part IV). SSPC also grew in the number of licensees and chapters, and continued growth in 2016 is expected at an even higher rate. One of its new licensees, MPI, has become a strategic partner for SSPC and its joint Trainthepainter program will be a point of focus moving forward. The continued growth in all aspects of SSPC's portfolio indicates the Society's continuing efforts to further expand its relevance and its commitment to better service the industry.

In addition to all of the membership and training expansion, SSPC also expanded its activity in the area of standards. Fifteen existing standards were revised and three new standards were developed last year (see Part III). A number of the revisions and new training programs were for the military, as SSPC continues to work diligently to support our armed forces. SSPC is committed to support our warriors in the field.

Analogous to its standards development, SSPC also focused on improving access to its technical information by launching two new apps. In today's digital world, instant access to information is critical, and SSPC is committed to becoming more accessible and user-friendly in the coming years. In 2015, a new Technology and Communications department was formed within SSPC, and the department's role will be to further develop and refine SSPC's website, social media, and training and communication platforms.

Additional accomplishments within SSPC in 2015 include:

- ISO 17020 accreditation;
- passing of the Protective Coatings Inspector (PCI) Level 2 audit by Lloyd's without any deficiencies;
- approval of the Technical Education Program for Educational Units by the American Institute of Architects (AIA) and Florida Board of Professional Engineers (FBE); and
- a successful, seamless move to SSPC's new world headquarters.

PART III: MEMBER PROGRAMS

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

Standards and Publications

SSPC's core product is standards. There were three new standards issued in 2015, and fifteen standards were revised. The updated standards are listed in Tables 1 and 2 (p. 56).

Training and Individual Certification

Note: The numbers shown in brackets are the percentage increase or decrease from the previous year.

SSPC training programs continue to grow overall. Last year, the Society trained or certified 6,942 students, an increase of 14.4 percent.

SSPC developed four new training programs in 2015: Coast Guard Basic Paint Inspector Course; Mitt Training; Surface Preparation and Paint Application for Shipboard Organizational Level Corrosion Control; and Basics of Nonferrous Surface Preparation. The Protective Coating Specialist Program now has 345 individuals, an increase of 16.5 percent. A breakdown of the Individual Certification Programs is shown in Figure 1 (p. 56).

Surface Preparation and Coating Application Certification Programs

The C-7 Abrasive Blaster Program had 414 [+12.8 percent] students trained. The Aerospace Coating Applicator Specialist Certification Program had only 5 students for a decrease of 50 percent. The Coating Applicator Specialist (CAS) Refresher Course had 152 students [+60 percent] and CAS Level 1 had 131 [+87.1 percent]. The CAS Level 2 Interim had 401 students

[-35.1 percent] and the CAS Level 2 Full had 72 [-20.9 percent] students trained. The Waterjetting Certification Program had 79 [-18.6 percent] students trained and the Marine Plural Component Applicator Certification Program (C-14) had 90 [+4.7 percent] students. Finally, the Thermal Spray Certification Program had 94 [+248 percent] students trained.

Coatings Technology, Management, Lead, Health and Safety Programs

The Applicator Train-the-Trainer course trained 27 [+80 percent] students in 2015. For Lead Supervisor Competent Person Training and Refresher Courses, (C-3 and C-5) a record number of 2,505 [+19.5 percent] students received training. Basics of Estimating had 23 [-33.3 percent], Evaluating Common Contractor had 8 students [-46.7 percent] and Project Management had 17 [-19 percent] students trained. The foundation course for the PCS program, Fundamentals of Protective Coatings (C-1), had 29 [-34.1 percent] students trained.

Inspection Programs

The Bridge Coating Inspector Program had 133 [+25.5 percent] persons trained. The SSPC Concrete Coating Inspection Programs did well with the Concrete Coating Inspector Program training 93 [+97.9 percent] students and the Concrete Coating Inspection Supplement – Determining the Level of Moisture in Concrete had eight [+100 percent] students trained. The NBPI (NAVSEA Basic Paint Inspector) Program had 483 [+57.3 percent] students and Navigating NAVSEA Standard Item 009-32 had 61 [306.7 percent] students trained. The Protective Coating Specialist Certification Program had 1,009 [+10.2 percent] personnel trained for all three levels.

E-Learning Programs

Almost all of the SSPC's E-Learning programs saw an increased number of students enrolled in 2015. Applicator Training Basics had 48 [+29.7 percent]; Basics of Concrete Surface Preparation had 22 [+10 percent]; Basics of Steel Surface Preparation had 81 [+52.8 percent]; and Basics of Non-Ferrous Metal Surface Preparation had 24 [+242.9 percent]. Fundamentals of Protective Coatings (C-1) had 167 [+31.5 percent] and Managing Protective Coatings projects (C-2) had 67 [+48.9 percent]. The PCI Online course had 24 [+71.4 percent] and Marine Coatings had

TABLE 1: STANDARDS AND CONSENSUS DOCUMENTS REVISED IN YEAR ENDING DECEMBER 2015

REVISED
SSPC-AB 1, Mineral and Slag Abrasives
SSPC-AB 2, Cleanliness of Recycled Ferrous Metallic Abrasives
SSPC-AB 4, Recyclable Encapsulated Abrasive Media (in a compressible cellular matrix)
SSPC-QP 8, Standard Procedure for Evaluating the Qualifications of Contracting Firms that Install Polymer Coatings and Surfacings on Concrete and Other Cementitious Substrates
SSPC-QS 1, Standard Procedure for Evaluating a Contractor's Advanced Quality Management System
SSPC-Paint 16, Coal Tar Epoxy Polyamide Black (or Dark Red) Coating
SSPC-Paint 32, Coal Tar Emulsion Coating
SSPC-Paint 33, Coal Tar Mastic Coating, Cold-Applied
SSPC-Paint 39, Two-Component Aliphatic Polyurea Topcoat Fast or Moderate Drying, Performance-Based
SSPC-Paint 42, Epoxy Polyamide/Polyamidoamine Primer, Performance-Based
SSPC-SP 1, Solvent Cleaning
SSPC-Guide 6, Guide for Containing Surface Preparation Debris Generated During Paint Removal
SSPC-Guide 7, Guide to the Disposal of Lead-Contaminated Surface Preparation Debris
SSPC-TU 7, Conducting Ambient Air, Soil, and Water Sampling During Surface Preparation and Paint Disturbance Activities
SSPC-PA 9, Measurement of Dry Organic Coating Thickness on Cememtatious Substrates Using Ultrasonic Gages

TABLE 2: NEW STANDARDS COMPLETED IN YEAR ENDING DECEMBER 2015

COMPLETED
SSPC-TU 12, Ambient-Curing Fluoropolymer Finish Coats Applied to Metal Substrates
SSPC-Guide 21, Guide to Evaluation of Slip and Fall Resistance of Flooring Surfaces
SSPC-Paint 46, Elastomeric, Water-Based, High-Build, Flat Performance-Based Coating for Masonry and Concrete

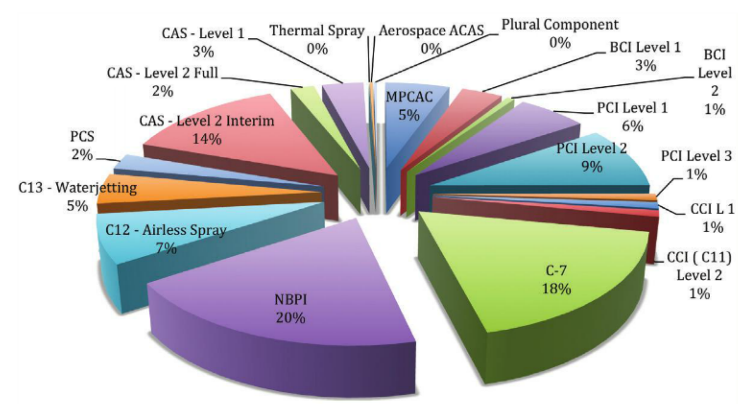

Fig. 1: Individual Certification Programs. All figures courtesy of SSPC.

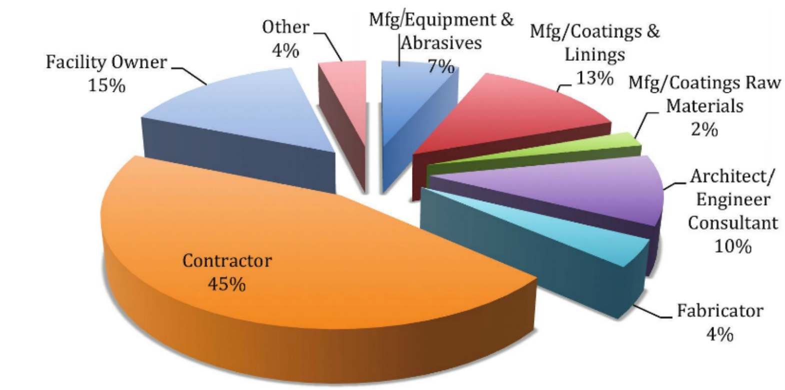

Fig. 2: Individual Membership Demographics.

TABLE 3: BOARD OF GOVERNORS

NAME	COMPANY	REPRESENTING
L. Skip Vernon President	CLT, Inc. Tijeras, NM	Other Service Providers
Gunnar Ackx President-Elect	SCICON Worldwide bvba Brugge, Belgium	International Representative and Other Service Providers
Brian Skerry Vice President	The Sherwin-Williams Company Cleveland, OH	Coating Material Suppliers
James R. King, Jr. Immediate Past-President	John B. Conomos, Inc. Bridgeville, PA	Coating Contractors
Benjamin S. Fultz	Bechtel Corporation Houston, TX	Facility Owners
Jay Kranker	DRYCO, LLC Palm Desert, CA	Other Product Suppliers
Garry D. Manous	Brock Industrial Services New Lenox, IL	Coating Contractors
Ahren Olson	Covestro LLC Pittsburgh, PA	Coating Material Suppliers
Victor Pallotta	ARS Recycling Systems, LLC Lowellville, OH	Other Product Suppliers
Sam Scaturro	Alpine Painting & Sandblasting Contractors, Paterson, NJ	Coating Contractors
Paul Vinik	Florida Department of Transportation Gainesville, FL	Facility Owners
Joseph Walker	Elcometer Rochester Hills, MI	Other Product Suppliers
Joyce Wright	Huntington Ingalls Industries – Newport News Shipbuilding, Newport News, VA	Facility Owners
Robert McMurdy Ex-Officio	Mohawk Garnet, Inc. Ontario, Canada	International Representative and Other Product Suppliers

TABLE 4: REVENUE VERSUS EXPENSE (UNAUDITED AND BEFORE FINAL ADJUSTMENT) (IN $1,000S)

REVENUE (In $1,000s)	FY 15	FY 14
Memberships	$1,089	$1,108
Standards & Publications	$537	$554
Conferences	$1,028	$917
Certification & Training	$4,711	$4,528
Other *	$121	$1,068
Total Revenue	**$7,486**	**$8,175**
EXPENSE	**FY 15**	**FY 14**
Memberships	$976	$924
Standards & Publications	$459	$439
Conferences	$737	$689
Certification & Training	$3,389	$3,182
Other **	$919	$894
Total Expense	**$6,782**	**$6,128**
Net Surplus (Loss)	**$704**	**$2,047**

31 [+106.7 percent] enrolled. Quality Control Supervisor (QCS) with 121 [-27.5 percent] was the only E-Learning course that had a decrease in 2015.

Webinars

The SSPC/*JPCL* Webinar Series will continue in 2015 with 14 webinars being given. Webinar attendance in 2015 reached a high of 2,110, which was a 14.9-percent increase over 2014. SSPC continues to offer a short online exam for each webinar, which is free to members. Each webinar exam provides Recertification Units toward an individual's Protective Coatings Specialist (PCS) certification renewal. A total of 331 individuals took an online webinar exam in 2015. All of the webinars are archived and can be viewed on www.paintsquare.com for a one-year period.

Certification (Company)

The past year saw an increase in the total number of certified (363) contractors. Three hundred sixty-three contractors, many holding multiple certifications, have achieved certification, an increase of 4.6 percent over 2014.

Website

The average number of unique visitors to SSPC's official website, www.sspc.org, is 20,620 per month, a 12.9-percent increase from the previous year.

ISO/U.S. TAGs

SSPC continues to participate in US ISO Technical Advisory Groups (TAGs). The Society is presently involved in the various subcommittees dealing with S.P. & C.A. ISO TC 35, Paint and Varnishes. SSPC is also actively involved in TC 67, Materials, Equipment and Offshore Structures for Petroleum, Petrochemical and Natural Gas Industries. Heather Stiner attended ISO committee meetings this year.

PART IV: MEMBERSHIP AND ADMINISTRATION

Membership

During the reporting period, SSPC organizational membership (OM) increased to 961, an increase of 1.05 percent. Individual membership grew from 10,820 in December 2014 to 11,096 in December 2015, an increase of 2.5 percent. A breakdown of individual members' demographics is shown in Figure 2 (p. 57); however, it remains nearly the same as the previous year. After a slightly flat year in membership, SSPC hopes for additional growth in 2016.

Governance

Table 3 (p. 57) shows a list of the current members of SSPC's Board of Governors. Marty Stamey resigned from the Board in January 2015 because he no longer works for The Brock Group and therefore does not represent the Coating Contractor demographic. Gail Warner retired from Huntington Ingalls Industries–Newport News Shipbuilding in April 2015, and Joyce Wright was appointed to fulfill her unexpired term. Derrick Castle resigned from the Board in August 2015 because he no longer works for the Kentucky Transportation Cabinet and therefore does not represent the Facility Owner demographic. Paul Vinik was appointed to fulfill Castle's unexpired term.

TABLE 5: STATEMENT OF FINANCIAL POSITION AS OF DECEMBER 31, 2015 (UNAUDITED) (IN $1,000S)

	Total All Funds	General Operating Fund	Reserve Fund
Current Assets			
Cash	$210	$210	
Investments	$13,584	$2,177	$11,407
Accounts Receivable	$435	$435	
Inventory	$108	$108	
Total	**$14,337**	**$2,930**	**$11,407**
Furniture, Fixtures and Equipment			
Equipment	$605	$605	
Less Depreciation	($437)	($437)	
Building/Land	$3,058	$3,058	
Net Equipment/Building	$3,226	$3,226	
Total	**$3,226**	**$3,226**	**-0-**
Other Assets			
Prepaid Expenses	$440	$440	-0-
Total Assets	**$18,003**	**$6,596**	**$11,407**
Current Liabilities			
Accounts Payable	$123	$123	
Deferred Revenue	$2,687	$2,687	
Accrued Expenses	$449	$449	
Total Liabilities	**$3,259**	**$3,259**	**-0-**
Net Assets - Unrestricted	**$14,744**	**$3,337**	**$11,407**
Total Liabilities and Net Assets	**$18,003**	**$6,596**	**$11,407**

TABLE 6: CHANGE IN NET ASSETS (UNAUDITED) (IN $1,000S)

	Total All Funds	General Operating Fund	Reserve Fund
Unrestricted Net Assets - December 31, 2014	$14,133	$2,406	$11,727
Transfer from General Operating Fund to Reserve Fund		$155	($155)
Change in Net Assets as a Result of Current Operation	$611	$776	($165)
Unrestricted Net Assets - December 31, 2015	$14,744	$3,337	$11,407

Administration

As previously mentioned, Bill Shoup transitioned out of the organization into retirement and Bill Worms was hired as the new Executive Director. Other key staff members remained the same: Michael Damiano continues as Director of Technical Services, Barbara Fisher remains Director of Administration, Mike Kline transitioned from Director of Marketing to the newly formed role of Director of Technology and Communications and Terry Sowers remains Director of Member Services.

PART V: FINANCES

SSPC is pleased to report that it has again met its financial goals for the fiscal year that ended December 31, 2015. The reserve fund now stands at $11.429 million, which would cover more than one year of the 2015 annual operating revenue. The financial details for the last fiscal year and the prior fiscal year are presented in Tables 4 (p. 57) through 6. These charts demonstrate that SSPC continues to be a financially sound organization and that all its financial indicators and ratios are very healthy.

Respectfully submitted,

William M. Worms
Executive Director, SSPC