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SSPC The Society for Protective Coatings

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SSPC'S QP 1 Program: How the U.S. Navy and State DOTs Benefit

BY KEVIN LARUE AND BREE MCCULLOUGH, SSPC

As chronicled in this column of the September JPCL, SSPC: The Society for Protective Coatings' QP 1 certification was created in 1986 in reaction to the industry's demand for a program that would increase quality performance, worker safety and environmental protection.

Now, QP 1 is an internationally recognized painting-contractor certification program that evaluates the practices of industrial painting contractors in key areas of performance using standards for best practices. These standards are considered the minimum level of service and quality for today's coatings industry.

Project owners that specify QP 1, such as the U.S. Navy and state Departments of Transportation (DOTs), do so because they expect to receive high-quality performance and longer life cycles for their structures from an SSPC-QP 1-certified contractor.

Currently, over 80% of all state DOTs require QP 1 on steel bridge and heavy highway work, and QP 1 is required on all critical coated areas of the U.S. Naval fleet.

Data forecasts predict that in the next seven years, over $8 trillion will be spent on American infrastructure, a vast majority of which will be overseen by state DOTs. Additionally, the U.S. Navy spends approximately $10 billion annually on the preservation of its fleet.

Clearly, critical asset owners such as these, who are investing in their structures so dramatically, want to guarantee the longest life cycle possible. This is what QP 1 is designed to deliver.

The complex nature of coatings systems and the specific surface preparations required in the standard has made the QP 1 guidelines vital to the longevity of applied protective coatings. Because there is a small window of acceptable variance that contractors and workers operate within under QP1, contractors must be precise and accurate in completing their work.

For example, on a recent thermal-spray nonskid application on a U.S. Navy aircraft carrier, the overall dry-film thickness range of the project was specified to be between 70 and 80 mils. This total includes the surface preparation anchor profile (4–10 mils),

MasaoTaira / Getty Images

and the thermal-spray nonskid system, which would be applied in two coats. The first coat included a minimum dry-film thickness of 25 mils and the second application had a minimum dry-film thickness of 45 mils. (For reference, a common credit card is approximately 30 mils thick.) Obviously, the margin for error was razor thin.

In addition to precision and quality performance, QP I also requires contractors to operate in a manner that provides a safe environment for craftworkers. In the case of certified bridge painters, these craftworkers are operating in elevated environments, dealing with altered traffic patterns and handling extreme surface preparation and system application conditions.

QP I ensures that the contractor has safety and quality control programs in place along with a trained and certified workforce through certification programs such as SSPC Coating Application Specialist (CAS), Abrasive Blasting (C7), Spray Application (C12) and more. The work under QP I is being performed in a manner to achieve specified expectations of surface preparation and coating application while protecting the environment.

Project owners that specify QP I appreciate not only the standards, but also the program rules for compliance and SSPC's auditing process. This is what provides the facility owner with the assurance that a quality contractor is performing the work.

QP I's annual audits are designed to reveal any findings and deficiencies the contractor may have that must be addressed and corrected. If there are any major findings or groups of minor findings, they must be addressed within the QP I Corrective Action Plan (CAP) process. The contractor must identify the issue, determine its root cause and provide a plan to correct the action to prevent future findings. This reinforces and helps the contractor improve their performance and meet the expectations and demands of facility owners.

In extreme cases, to protect the integrity of the QP I program, some contractor actions will result in specific Disciplinary Action Criteria (DAC) steps. These steps range from warning letters, probation, suspension and even certification revocation. Many owners have openly stated to SSPC representatives that the CAP and DAC processes are what make the QP program the industry benchmark for certification of the best industrial coating contractors.

As owners continue to invest billions annually into their structures, it is critical to have a quality-assurance program like QP I as a requirement for contractors performing work. QP I not only helps to reduce coating failures, but also helps to provide a more efficient and productive operation for contractors.

Quality performance, safety and longevity are key demands of the industry and expectations of our customers—facility owners and contractors. SSPC-QP I meets those demands, and SSPC will continue its work of maintaining the high level of integrity under which the QP I program operates.

For more information on the QP I program, or to get your company started on the path to certification, visit sspc.org/qp-qpi.

SSPC, NACE Merger Talks Continue

SSPC: The Society for Protective Coatings and NACE International, The Corrosion Society announced on Oct. 21 that discussions were continuing the potential collaborative efforts for the possible merger of the two organizations.

In March, the organizations announced the beginning of merger talks, and on Aug. 6, they announced the mutual decision to bring McKinley Advisors onboard as a guiding entity for the merger discussions. McKinley, serving as an independent third party, was chosen for its established success in advising other organizations through similar talks. McKinley will also advise through considerations related to strategic, financial and cultural barriers, among others.

Most recently, at the reestablished Pittsburgh-based SSPC Steel City Chapter meeting earlier this month, it was announced that a NACE board meeting with the McKinley CEO and two SSPC board members was scheduled for late October in Asheville, North Carolina. The merger task group was also reported to be planning to schedule additional face-to-face meetings later this year or by January 2020.

As reported in an SSPC press release, last month joint staff and members of the leadership task group from both SSPC and NACE reconvened to continue possible merger conversations. The meeting reportedly focused on the research and analysis conducted by McKinley Advisors about the potential challenges the organizations would face regarding blending financial structures, cultures, memberships and other components.

Out of 50 interviews—25 NACE- and 25 SSPC-designated individuals—McKinley reported that leading stakeholder concerns lied with the potential loss of relevance or voice in a larger organization, as well as whether all certifications of both organizations would continue to be recognized and supported.

In addition to the interviews, the task force was asked to focus on developing a model during the meeting that would combine SSPC and NACE with emphasis on corporate and governance structure, aligning key organizational functions, exploring a membership model and value propositions.

"If we merge, we will rely on a joint-member task force to make recommendations around certifications," said SSPC President Joe Walker. "The task force would work under a set of parameters focused on allowing certification holders to be grandfathered in and to then recertify into a continuing certification with no financial burden to do so."

NACE President Terry Greenfield added, "Our members are the lifeblood of our organizations and we agreed that we must work to keep the best of what each organization offers its members. We also agreed that membership tenure of any individuals or corporations will be carried over. And if a member has been involved with both organizations, the longer term of their two memberships would be applied."

While a large portion of the meeting was reported to have been devoted to developing the model for governance, discussions regarding member leadership terms, in addition to leadership roles and responsibility concerns were also brought forward. In McKinley's findings, no substantive hurdles were reported that would threaten the proposed merger and it also added that the current financial model is sufficient, while legal teams from both organizations presented an overview of possible corporate structures.

Moving forward, the organizations have announced that both existing brands will continue to be protected as separate entities in the marketplace and have agreed that the best model will involve a hybrid structure that includes both corporate and individual membership options and combines the best of both organizations' value propositions.

In taking the next steps, the task group plans to complete remaining research into considerations raised during the September meeting and will meet again in early 2020. During the time in-between, bi-monthly task-group calls will continue. All information collected during these meetings will then be shared with members from both organizations.

In the decision to merge SSPC and NACE, the SSPC Board will vote during its first-quarter meeting on Feb. 1, 2020. NACE's Board will vote at its first meeting of the year on March 14, 2020. Members of both organizations will be asked to vote on or around April 1, 2020.

In the meantime, any questions about the merger can be sent to news@sspc.org or cooperation@nace.org.

PPG Reports Consistent Sales for 2019 Q3

PPG released its third-quarter 2019 earnings report on Oct. 17, announcing net sales consistent with the prior year at $3.8 billion, noting that net sales in constant currencies were about 2% higher.

Third-quarter 2019 reported net income from continuing operations was $386 million, down from $369 million last year, while adjusted net income from continuing operations was $396 million, up from $353 million last year.

The Performance Coatings segment third-quarter net sales were about $2.3 billion, 1% higher than the prior year with segment volumes remaining flat, according to the company. Segment income for the third quarter was $380 million, up $49 million, or about 15%, year-over-year. Segment income benefited from higher selling prices, continued cost management and restructuring initiatives.

Within that segment, aerospace coatings sales volumes grew by a high-single-digit percentage in the quarter while net sales for automotive refinish coatings increased by a low-single-digit percentage. Sales in the protective and marine coatings business increased by a mid-single-digit percentage, driven by strong marine coatings sales in Asia and Europe. Year-over-year sales in architectural coatings Americas and Asia Pacific increased slightly, while in the U.S. and Canada, architectural coatings sales grew modestly, led by low-single-digit percentage year-over-year sales growth in the national DIY retail and independent dealer channels.

The Industrial Coatings segment third-quarter net sales were $1.5 billion, down about $15 million, or 1%, versus the prior-year period. Segment income was about $205 million, up nearly $40 million, or about 22%, year-over-year. Within the segment, automotive OEM coatings sales volumes decreased by a high-single-digit percentage year-over-year driven by lower global automotive industry production rates.

monsitj / Getty Images

Sherwin Reports Sales Increase for Q3

The Sherwin-Williams Company released its third-quarter earnings report for 2019 on Oct. 22, announcing an increase in consolidated net sales, diluted net income per share and net sales from stores located in the U.S. and Canada.

Consolidated net sales increased 2.9%, or $136.2 million, for the third quarter, to $4.87 billion, an increase that was attributed to higher paint sales in North American stores as well as selling price increases, though this progress was slightly offset by lack of demand in some markets outside the U.S. as well as unfavorable foreign currency translation. Diluted net income per share increased to $6.16 in comparison with last year's $3.72, and EBITDA increased 11.8% to $919.3 million, equating to 18.9% of sales.

"For the second consecutive quarter, all three operating segments increased segment profit and margin compared to the same period last year," said John G. Morikis, Chairman and Chief Executive Officer for Sherwin-Williams.

For the Americas Group, net sales increased 8.7% to $2.90 billion, which was largely attributed to higher paint sales across end markets in North American stores as well as selling price increases. For stores in the U.S. and Canada open for longer than a year, net sales increased 8.1%. Segment profit also increased $85.9 million to $663.7 million, and profit as a part of net sales increased to 20.6% compared to last year's 20.1%.

Net sales in the Consumer Brands Group, in contrast, saw a 11.9% decrease to $678.5 million, which was largely attributed to comparisons to load-in sales for a 2018 customer program, the divestiture of the Guardsman furniture protection business during last year's third quarter and softer sales in end markets outside North America.

There was also an increase in segment profit, totaling $114.9 million over last year's $83.9 million. Better supply chain efficiency as well as good cost control were named as contributing factors, but these were partially offset by customer program investments. Segment profit as a percent of net external sales increased in the quarter to 16.9%, over last year's 10.9%.

Net sales for the Performance Coatings Group experienced a 0.3% decrease, to $1.29 billion, which was largely attributed to softer sales outside North America and unfavorable currency translation rate changes, though this was partially offset by an increase in selling prices. Currency translation rate changes made Group net sales by take a 1.6% hit, but segment profit increased to $137.4 million from last year's $104.9 million.

For the fourth quarter, Morikis noted that the company anticipates consolidated net sales to increase by a low single-digit percentage.

PAINTSQUARE COMMENTS

NBC Philadelphia

In Response to, "Report: PA Refinery Fire Caused by Corroded Pipe" (PaintSquare News, Oct. 18)

A degraded piece of metal pipe has been named the culprit behind the fire at a Philadelphia crude oil refinery that occurred in June, an incident that was the result of several explosions, generating a blast that could be felt as far as southern New Jersey and Delaware County, Pennsylvania. The U.S. Chemical Safety and Hazard Investigation Board released a 10-page update on the incident in mid-October.

Andrew Piedl:

"'The fireball that resulted from the explosions was captured by a weather satellite in space due to the incident's intense heat' ... Not far from residential neighborhoods, no less. Now why would anyone want to transition to alternative energy sources?"

Thomas Van Hooser:

"I wonder how much the facility saved by skimping on their corrosion control program."

Michael Holliwell:

"Andrew, you can point fingers at almost anything. Tibetan folks have been after the Chinese over pollution from lithium mines, hydroelectric [power] requires copious amounts of concrete and releases massive amounts of CO_2 during manufacture, solar cells require hazardous chemicals to produce (heavy metals, acids, caustics) and can release toxic chemicals (such as cadmium) when broken, and current nuclear technology has a multi-millennium legacy.

Here, where we have numerous refineries and petrochemical plants, there are mandated offsets to keep residential and commercial properties a certain distance away. I'd love to have a magic fix—I'd love to have the current small-scale thorium reactors prove scalable and as efficient en masse—but for right now, we've got to use what we've got.

Thomas, I'd say between the corrosion program and saved downtime, probably nowhere near as much as this incident has cost them."

In Response to, "Boring Company Vegas Tunnel Progresses" (PaintSquare News, Oct. 30)

Earlier this month, construction work on The Boring Company's tunnel for the Las Vegas Convention Center officially entered operation. A tunnel boring machine is also reportedly on-site, as well as other assorted heavy equipment.

Jon Edwards:

"$26 million per mile—like tunneling in NYC. And 155 mph in a 2-mile-long tunnel—better strap yourself in for the acceleration and deceleration. Will be faster than an airliner [or] a DC-3."

Robert Ikenberry:

"If the acceleration is essentially continuous—accelerating for the first half, decelerating for the second half—it shouldn't be too bad. Elevators in super-tall buildings can reach 60 mph and they start and stop in less than ¼-mile. Vertical acceleration is probably easier to tolerate than horizontal, though."

Problem Solving Forum

paintsquare.com/psf

Why would a pull-off adhesion test give a high value (no failure) for a solventless epoxy that later showed poor adhesion in service?

Jon Cavallo, Sponge-Jet Inc.:

"I am assuming that the question has to do with pull-off adhesion tests performed in accordance with ASTM D4541. This standard specifically prohibits cutting of the coating on the periphery of the adhesion 'dolly' unless specifically directed in writing. If you don't cut around the 'dolly' prior to performing the adhesion pull-off test, you may be

PSF cont. on p. 13

PAINT POLL

paintsquare.com/poll

jtpenn / Getty Images

The Mackinac Bridge, located at the Straits of Mackinac in northern Michigan recently received a new paint job with help from a movable scaffolding system. Without this innovative equipment, do you think the project would have been able to reach completion within a year?

Yes. **8%**

No. **88%**

Other. **4%**

PAINTSQUARE NEWS TOP 10

paintsquare.com/news, Oct. 7–Nov. 3

1. **Multiple Casualties at NOLA Hard Rock Collapse**
2. **SSPC, NACE Merger Discussions Continue**
3. **Titanium Dioxide Powder to Get Cancer Warning**
4. **Boring Company Vegas Tunnel Progresses**
5. **Sherwin Reports Sales Increase for Q3**
6. **NTSB Points Blame in FIU Bridge Collapse**
7. **Report: PA Refinery Fire Caused by Corroded Pipe**
8. **Sherwin-Williams Looking for New HQ Location**
9. **FIU Bridge Collapse Documents Released**
10. **NYC's Beleaguered 'Bouncy Bridge' Demolished**

PSF cont. from p. 10

measuring the cohesive film strength of the coating rather than its adhesion to underlying coatings or the substrate. The test may result in an erroneously high number even if the adhesion of the topcoat to the underlying layer or substrate is poor. That is one of the main reasons that knife adhesion testing was standardized (ASTM D6677)."

Ricardo Márceles, Pintuco:

"An adhesion test, in itself, is not decisive to say that the product will work excellently. There are several factors that affect it, such as the roughness profile, the degree of surface preparation and the presence of soluble contaminants. Also consider profile versus thickness ratio, ambient operating conditions to which it will be subjected, thermal extenders and so on. Adhesion values, like the others, are parameters that indicate the probability that the product will behave well ... but also remember that the product continues crossing over time and that cross-linking generates a shrinkage of the coating and this can be subtle or very strong and will depend on temperatures, chemical medium, profile versus thickness and curing speed. If an accelerator is added, for example, this becomes more critical."

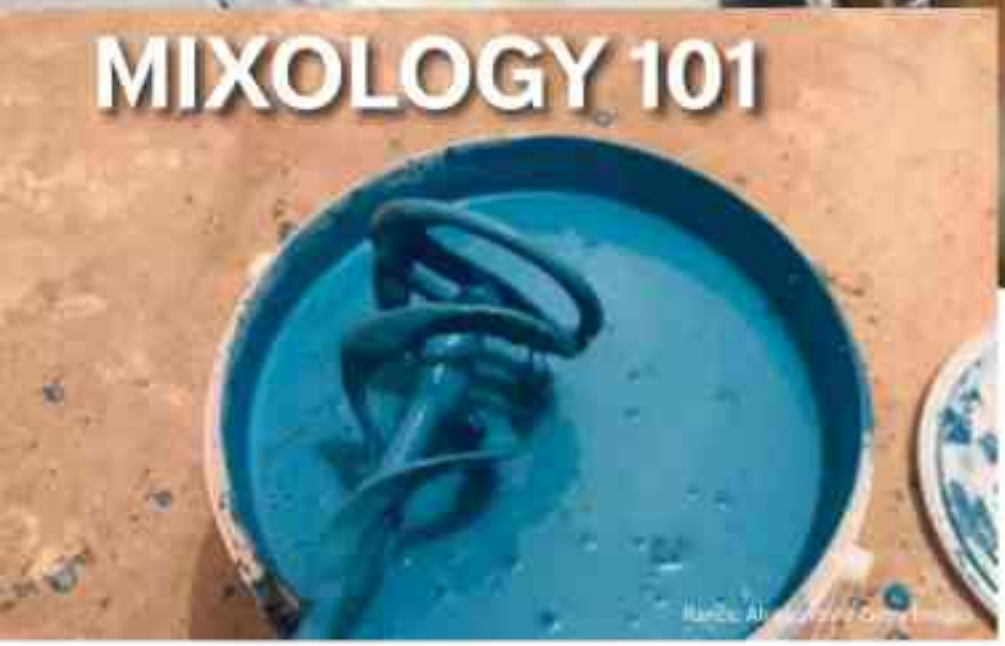
Jeff Longmore, Thin Film Technology, Inc.:

"The coating formulation would play a critical part in premature failure. For example, excessive water-solubles in the resin system or pigmentation invite transport of water through the film to degrade adhesion at a steel substrate. Deviation from correct stoichiometry may also invite water penetration through excess or unbound hydrophilic curing agents."

WHAT YOU NEED TO KNOW

Budko / Getty Images

MIXOLOGY 101



BY TROY FRAEBEL, ABKAELIN, LLC

Have you ever made a fancy cocktail or a special cake from scratch? What is the first thing that you need when doing so? You need a recipe to know what ingredients are required, how to mix them and in what order, and how long it needs to chill or bake.

Mixing paint for an industrial coatings project is no different. The recipe when mixing paint is typically found on the product data sheet (PDS)—and not just any PDS, but the most current one, since manufacturers are often updating PDSs to reflect formula changes or lessons learned. The good news is that it is easy to find the most current PDS online at the product manufacturer's website or linked to an industry association or inspection app. When one sees a trailer full of paint on a jobsite, the PDSs and associated safety data sheets (SDSs) should be hanging nearby.

We can learn the following from the PDS:

- Generic type of the material and its intended uses;
- Shelf life and storage temperatures;
- Mix ratio and mixing instructions;
- Package size;
- Sweat-in (induction time) and pot life at various temperatures;
- Volume-solids and volatile organic compound (VOC) content; and
- Acceptable thinners and percentages.

Let's look at these in more detail.

GENERIC TYPE AND INTENDED USES

If you live in Kentucky, you are probably looking for a bourbon concoction and not a fruity vodka drink. It is similar when choosing the right paint. The coating must fit the setting—in this case, its service environment—and labels can often be misleading.

For example, you know that a two-component epoxy is good for potable water immersion, but purchasing has provided a less expensive one-component pre-catalyzed epoxy. Read the PDS. It probably says that this material is not suitable for immersion, let alone in potable water.

Or, let's say you are installing a floor coating that you have used many times, but this time you are in a food processing plant. Does the floor coating meet the U.S. Department of Agriculture (USDA) standards for such facilities? Again, read the PDS.

Think of it as if you have a new friend on a gluten-free diet. That tried-and-true cake mix that you've always used in the past may not be the best when having this person over for the first time. Read the ingredients before you start mixing up your batter.

SHELF LIFE AND STORAGE TEMPERATURES

If you are not making a cake from scratch, or are using one of those drink mix packages that you bought in New Orleans, you should look

at the expiration date on the box or package before you begin to mix in the other ingredients. The good news is that most food products have expiration dates clearly printed on them. Unfortunately, this is not the case with most paint manufacturers.

On a recent project, this author was excited to see the manufacture and expiration dates printed on a lid of paint to be used. However, that excitement was short-lived, as the next report from the foreman referencing the same manufacturer read, "Yeah, it's got some numbers on the bottom of the can, and I'm not wasting time trying to decipher them."

Shelf lives from three months for a vinyl ester, one year for Part A of an epoxy, two years for Part B for a polyurethane, or indefinite if not opened for an acrylic can be found on the PDS, but actual manufacture and expiration dates are typically not printed on cans or labels. Because you do not want to use a paint material that has expired, you have to deduce the expiration date from the batch number printed on the can and the shelf life printed on the PDS.

Typical information that can be determined from the batch number are year, month, and sometimes day of manufacture, manufacturing plant location, lot and sometimes can number. Unfortunately, each manufacturer uses a different system, so you will need to contact your manufacturer's representative to help you calculate the expiration date.

The good news is that if the owner and specification allow, most manufacturers will extend the expiration date if the material meets certain physical characteristics. Storing paint materials in the temperature range listed on the PDS will also help a material meet and possibly exceed its shelf life.

MIX RATIO, MIXING INSTRUCTIONS AND PACKAGE SIZE

Before you start making a cake or fancy drink, it is a good idea to make sure that you have the right amount of each ingredient, and it is the same with paint. Most paint manufacturers recommend mixing complete kits of two or more component materials. A well-organized mixing station will have complete kits stacked individually to help identify the proper components and to make sure that you have enough of each.

For example, a one-gallon can of Part B epoxy hardener is stacked on each five-gallon pail containing four gallons of epoxy to yield a five-gallon kit (4:1 ratio). Partially filled quart cans of isocyanate are stacked on one-gallon cans of polyurethane resin to yield a one-gallon kit (6:1 ratio). But do not be deceived by the packaging; sometimes, a partially filled five-gallon pail of Part A, combined with one-gallon of Part B, and some zinc dust, does not yield five gallons but only four (2:1 ratio and zinc by weight). By now, this should sound familiar, but it bears repeating over and over: read the PDS.

In addition to storage temperatures, the acceptable range of temperatures for mixing paint material is also listed in the PDS. It is important to measure the paint temperature using a thermometer inserted into the paint material, not just at the surface (for example, do not use a non-contact infrared thermometer). Just like when cooking, you need to know the internal temperature.

As with most cake recipes, it is best to thoroughly mix the liquid ingredients then add the mixed dry ingredients. It is the same for zinc-rich epoxies: mix Parts A and B each separately, then add Part B to Part A, thoroughly mix, then slowly add the dust, then strain. The PDS will indicate how to mix the material and in what order, but if you are ever in doubt, always contact the paint manufacturer.

Another instance to contact the paint manufacturer is when partial kits are allowed and used. This can happen when the mix ratio is simple (such as a 1:1 polyamide epoxy), when high temperatures greatly shorten the pot life, or for other technical or economic reasons (small kits are too expensive or not available). The paint manufacturer should provide written approval for and how-to instruction on mixing partial kits. This typically involves precise measuring or weighting (if using zinc or intumescent coatings). Eyeballing is not acceptable; measuring cups and scales should be used.

WHAT YOU NEED TO KNOW

SWEAT-IN AND POT LIFE

Per SSPC, the induction time (sometimes called sweat-in time) is the time interval that must elapse after mixing the components of multicomponent paint before satisfactory application can begin. This allows the chemical reaction to reach the necessary stage.

Some materials do not require a sweat-in time, but many do. For multicomponent materials, PDSs typically list sweat-in time and pot life at three temperatures (laboratory temperature of 70 or 77 F, and extreme high and low temperatures). Unfortunately, most field projects do not occur exactly at these temperatures. Paint manufacturers typically can provide time extrapolations at temperatures between the extremes.

While sweat-in time is the time you have to wait before serving the drink, pot life is how long it will remain at its best (before all the ice melts). Per SSPC, pot life is the length of time during which a multicomponent coating system can be successfully applied after it's been mixed. Like sweat-in time, pot life is temperature-dependent (greater temperatures reduce both sweat-in time and pot life), so it is critical not to mix more paint than can be used in the anticipated time frame. It is important to note that pot life starts when the paint is mixed, not after the sweat-in time.

Table 1: English Units of Volume Measurement.

128 ounces =	1 Gallon
32 ounces =	1 Quart
16 ounces =	1 Pint
8 ounces =	1 Cup

VOLUME-SOLIDS, VOCS AND THINNERS

Simply put, the volume-solids is the amount of material that will remain after solvent evaporation. Cakes typically increase in volume after baking, while most coatings, unfortunately, lose volume. For example, a waterborne acrylic may have only 35% volume-solids (remaining material after evaporation), while a 100%-solids epoxy has no loss. Therefore, you would have to apply three times the wet-film thickness (WFT) of the acrylic to get the same dry-film thickness (DFT) at the same WFT application of 100%-solids epoxy. You would need to mix three gallons of acrylic versus one gallon of epoxy to get the same thickness.

Also, while watering down a drink may make it appear to go further, thinning does not make the paint go further. Using the previous example, if you needed 3.0 mils WFT of acrylic to get the specified 1.0 mil DFT, and added 30% more water (solvent) to make it "go further," you have actually reduced the volume solids to 27% (35/[100+30]) and would have to apply 3.7 mils WFT to get the specified DFT—otherwise, you short the owner 0.2 mils DFT at 3.0 WFT.

Many solvents are VOCs and are limited due to air-quality regulations. It is critical that if you thin a coating, that it is not thinned to a point where it exceeds the local air-quality regulations or the manufacturer's maximum percentage allowed. PDSs typically report VOCs of the unthinned material. In addition to air quality, ANSI/NSF 61 certification of potable-storage-tank linings can be put in jeopardy if the wrong type or too much thinner is used. Again, refer to the PDS or the paint manufacturer for guidance.

The big question is: why thin a modern coating? Most coatings nowadays are designed and packaged to not require thinning. It would be as if you made a nice dinner dish to go along with your fancy cocktail and special dessert cake, and your sister-in-law doused the dish with salt before tasting it.

Adjustments to the material temperature and the spray gun (if conventional), changing tip size and/or air pressure, or even changing the type of equipment used should be tested before thinning the coating. Remember that thinners are solvents that evaporate, so they do not add to the paint film, and can cost the project money.

If you have to thin, follow the manufacturer's instructions on the PDS as to the type of thinner to use, the maximum quantity and the timing (for example, after the sweat-in time). So how do you measure 10% of three gallons? Is "three glugs" correct? No, you have to actually measure. Just like with partial kits, measuring cups must be used. Be sure to use clean cups with markings that are resistant to the solvent being measured. English units are not as easy to convert to percentages, so Tables 1 and 2 are included for reference.

Table 2: How Many Ounces per Mixed Gallons Based on Percentage.

Gallons	1%	3%	5%	8%	10%	15%	20%	25%
0.5	0.6	2	3	5	6	10	13	16
1	1.3	4	6	10	13	19	26	32
2	2.6	8	13	20	26	38	51	64
3	4	12	19	31	38	58	77	96
4	5	15	26	41	51	77	102	128
5	6	19	32	51	64	96	128	160
10	13	38	64	102	128	192	256	320

CONCLUSION

A successful coatings project depends on many factors, including the proper mixing of coatings. This can be achieved by reading and following the directions from the PDS and coating manufacturer and documenting each step of the process including batch numbers, expiration dates, storage and mixing temperature, sweat-in time and pot life, and any thinners used including type and quantity.

ABOUT THE AUTHOR

Troy Fraebel is the Vice President of Protective Coating Services for ABKaelin, LLC. He has over 30 years of experience in the protective coatings industry and is an SSPC Protective Coatings Specialist, a NACE-certified Coating Inspector (Level III) and an instructor for several SSPC training courses. He holds a B.A. from Western Kentucky University and a Master's degree in education from William Paterson University.

THIS MONTH IN ...

CELEBRATING 1984 35 2019 YEARS

1991

Manufacturers have always sought to develop coatings that can cure in adverse conditions. In the article, "The Canadian Experience: Cold Weather-Curing Coatings," John Witter of Corrosion Service Company Limited uses mining, shipping, petrochemical and bridge projects to highlight the difficulties associated with coating in cold weather and the use of inorganic zinc-rich, vinyl and other novel coating systems for cold-weather service.

2005

The case history article, "Shipyard Takes Softer, Greener Approach to Surface Prep," covered one shipyard's efforts to use "greener" surface prep technologies by employing sponge media

instead of conventional mineral and glass abrasives during blast-cleaning. The shipyard prepared aluminum guards for windshield wiper motors on fishing trawlers using this technology.

2014

The Navy has used non-skid coatings on ship decks for decades. "Gaining Traction: Low VOC and Sprayable Siloxane Nonskid/Nonslip Coating," by Erick Iezzi, James Tagert, James Martin, Paul Slebodnick and John Wegand of the U.S. Naval Research Laboratory presents an NRL-developed siloxane-based nonskid/

nonslip coating that provides enhanced color and profile retention, low VOC content and low viscosity and can be applied using commercial spray equipment.

2017

In "Case Study: Cargo Tank Coating Refurbishment," Alan Walker of Safinah Ltd. compares the recoating of tanks within two sister vessels, offering recommendations to

avoid cost and time overruns on similar projects and suggesting that the cost of employing a coating expert pales in comparison to the cost of a potential coating failure.

Visit paintsquare.com/archive to read more.

FOUL-RELEASE COATINGS: PAST, PRESENT AND FUTURE

Denys Yelmanov / Getty Images

BY RAOUF KATTAN, SAFINAH, UK

Keeping ship hulls free from fouling has traditionally required a biocidal effect produced by any of a number of mechanisms, such as copper compounds alone; copper compounds in combination with a booster biocide of some form; and tributyl tin (TBT) compounds with booster biocides.

In recent years, polishing and smoothing mechanisms have also added to the performance of the antifouling products. The combination of these mechanisms to create self-polishing co-polymers (SPC) has today enabled paint manufacturers to keep vessels free of fouling for up to five years, and, in exceptional cases, longer.

However, the ban on TBT—because of its adverse effects on the environment and concerns about other biocides' environmental impact—has prudent paint companies and ship owners looking for biocide-free alternatives. Several technologies are being offered in the marketplace. Of these technologies, the most commonly used at present is silicone-based. While silicone-based technology for coatings is not new, its use for protecting ships against fouling is a relatively recent phenomenon. Based on the author's experience as a consultant to the marine industry, this article reports on silicone technology, its limitations, its advantages, and its implications for the future of coatings to protect hulls from fouling.

SILICONE TECHNOLOGY: HOW IT WORKS

Silicone technology works by creating a coated surface that has been described as very smooth, nonstick, easy to clean, or having a low surface energy. These terms attempt to address the basic features of a silicone-based coating: The coating makes it difficult for marine growth to attach to the surface; moreover, any attachment made is very weak and can be broken by vessel movement.

Editor's Note: *This year marks the 35th anniversary of the publication of JPCL, the definitive source of technology and information about protective and marine coatings. To celebrate, JPCL will be highlighting archived content, updating previously published technical articles throughout the year and looking back on past practices and technologies.*

This article initially ran in the February 2006 issue and has been updated by the author for publication in this issue.

To differentiate it from antifouling coatings that leach toxins into the environment in one form or another, silicone-based coating technology is referred to as foul-release technology and is considered environmentally friendly. (The environmental advocacy group Greenpeace uses this type of technology on its vessel, the *Rainbow Warrior*.)

Because silicone coatings do not contain biocides, they don't need to be registered under any country's environmental legislation. Without incurring the costs associated with product registration, silicone coatings are relatively inexpensive to bring to market.

The surface created by the application of the silicone-based, foul-release coatings is claimed to be smoother than that of freshly applied SPC-type antifouling coatings. Owners of vessels recently out of dry dock report measurable fuel savings, even when these products have only been applied to the propellers.

LIMITATIONS AND STRENGTHS

Most of the existing foul-release coatings require a vessel to have a threshold speed of about 14–15 knots (kts) with relatively high levels of activity, so silicone technology is not currently suitable for all vessel types.

Despite the often cited 15-knot threshold speed, silicone-based foul-release coatings have been applied on a number of slower and less active vessels (such as tugs) with mixed results, and because of this, application on vessels with speeds below 15 kt must be determined on a case-by-case basis.

In addition to threshold speed, the limitations of silicone-based coatings to date have been reported as follows:

- Cost;
- Potential for cross contamination in the shipyards;
- Difficulty of repair; and
- Low mechanical strength.

Cost has been relatively high, some four to five times higher than the top SPC systems. However, foul-release coatings have a much longer service life than SPC systems. The longer service life, which is in excess of five years, and the fuel savings reported give a relatively short payback period for vessels that achieve speeds above 15 kts. Payback periods as short as three years have been reported.

In addition, prices are set to start to come under downward pressure as more and more paint manufacturers enter the foul-release market.

The problems for new builds have been based on cross contamination (traces of silicone paint on adjacent surfaces cause paint adhesion problems); generally tighter procedures required to properly control application; and poor low temperature capability of some products in the marketplace. But these problems have been overcome either by improved procedures and control or, in extreme cases, the use of a predelivery dry-docking, which can be justified by the reported fuel savings.

The silicone-based systems can be difficult to repair. How do you get paint to stick to a nonstick paint? To address this problem, paint suppliers have developed tie coats for repair. While the repair process is more complex than that for antifoulants, the increased life span of the silicone coating scheme can provide the savings to cover these costs.

Finally, the coatings are soft and therefore susceptible to mechanical and frictional damage from tugs and fenders. Vessels likely to be subjected to mechanical damage are not well-suited to the current generation of foul-release products. This situation has often led to hybrid schemes, such as the use of traditional antifouling coatings around the waterline to give mechanical integrity, and the use of silicone for the rest of the underwater hull.

Frictional damage, particularly alongside in port, has in some instances been eliminated by keeping the fenders wet so that the coating remains slippery, hence preventing damage.

THE PRESENT STATE OF SILICONE TECHNOLOGY IN FOUL-RELEASE COATINGS

Silicone technology is not new. It can be traced back almost 30 years in patent literature. But its use has been a mere trickle until the past two years, when foul-release coatings have passed two milestones:

- Major ship owners are now taking up the use of these products during the dry-docking of large parts of their fleets to help offset higher fuel costs; and
- More major paint companies are offering silicone-based products.

Both of these moves will increase volume sales and generate more competition, placing current prices under pressure. In addition, the author's company understands that a number of technology developments are advanced enough to considerably reduce the threshold speed to 9–10 kts.

Table 1 gives an indication of the potential for foul-release products based on data about the world fleet as it stood at the end of 2003. The table also indicates that some 22% of the world's vessels are eligible for the use of silicone coatings on a 15-kt threshold. Of course, not all vessels capable of 15 kts or above meet the activity criteria. Analyses of the fleets for different speed thresholds indicate considerable changes to this picture. The number of vessels is not a good indicator of coating demand. The true potential for silicone coatings is evident only when the analyses are run using suitable tonnage measurements.

Table 1: World Fleet as of 2003.

Ship Type	Number of vessels with a design speed above 15kts
Liner	4,859
Deep sea	4,270
Deep sea	9,070
Naval	3,916
Total	22,115

What is clear is that the uptake of these products is showing considerable increase as can be seen from data compiled in a survey of major paint companies. There were 107 applications of silicone-based foul-release coatings from their introduction to the market 30 years ago until 2004, while there were 261 total applications as of 2005.

Thus, in the first 30 years of the technology, only 107 vessels were coated, whereas in the first 11 months of 2005 an additional 154 vessels were coated with silicone systems. In addition, almost 200 propellers have been coated, and an increasing number of rudders are being coated where the silicone technology is claimed to show some resistance to the effects of cavitation.

The minimum annual growth in silicone-based coatings declared by one major

paint company has been 100%, with some companies showing 300% growth in sales.

The vessel types that have had these products applied include:

- Container ships;
- Very large crude carriers (VLCCs);
- Ferries;
- Passenger ships;
- Frigates/destroyers;
- Tugboats; and
- Mine counter-measure vessels (MCMV).

Of the ships listed, only one is identified as a newbuild, while the others were reported to be coated during dry-dock.

However, the number of vessels on order that are now being pre-specified with silicone coatings is also showing a marked increase after Daewoo's recent technological breakthrough—construction of the first new building with silicone coatings specified, and since, many new container ships and LNG carriers are now being specified with these coatings.

TO WHERE FROM HERE?

It is tempting to surmise that silicone-based foul-release coatings will provide the answer to all antifouling problems for many years, thus signaling the end of biocide and heavy-metal-based systems. But this conclusion is premature.

Although they are biocide-free, silicone-based coatings are not problem-free. There is some concern over their environmental impact, with some studies already conducted on the leaching of silicone oils.

It is also evident that paint companies are not relying on this one solution for the future: many testing programs for alternatives are under way. In addition, the silicone technology faces a challenge from "hard coatings," which a number of ship owners have applied in trials with mixed results. A number of the alternative technologies will soon undergo testing as part of a major European research project, while other European-funded projects are looking at the potential for nanotechnology engineered surfaces.

The future in the antifouling market was once very predictable, but the demise of TBT and the increase of environmental legislation make the future far less clear.

UPDATE FROM THE AUTHOR

Since writing this article, a number of developments have taken place as a result of performance in service.

The first major change was that threshold speeds for foul-release products continued to be reduced by the suppliers, and at one time speeds as low as 6 kts were being marketed.

However, the issue of slime has increased in importance, and was the first major technical challenge the coatings faced. Its tenacious presence on hulls even at high threshold speeds had a significant adverse effect on vessels—even those with relatively high activity rates, such as container ships, resulting in further developments of the coating systems and a restriction of their market-share growth. In recent years "slime-release" coatings have been developed to overcome this problem.

However, perhaps the most significant development is the introduction of biocides into these products to enhance performance, and in particular, resistance to long static periods.

Products also now need "replenishment" approximately every five years to ensure their continued efficacy, and thus, rather than offering considerably longer life cycles, there is now a regular need to repair them in dry dock. This repair has posed problems as the procedures to ensure a successful repair application (without requiring full removal of the "nonstick" coating) have raised challenges and were not always successful in the early days.

The use of the products on propellers has been almost completely abandoned, with few instances of its application these days, while the resistance of major newbuild yards to use these products has continued, with a few exceptions—LNG vessels, in particular. This reflects the increased process issues and their impact on the productivity of high-volume yards, while lower volume-build yards (such as cruise ship builders) do not face the same degree of productivity issues.

Market share has possibly increased in terms of the number of vessels coated, but more or less held firm in terms of overall market share, which is still less than 10% of the total demand.

Mechanical properties have not significantly improved, but underwater cleaning and grooming issues have generally increased (as they have for all fouling-prevention types as trade patterns and activity levels have generally declined since the economic downturn of 2008).

In the meantime, other technologies have been introduced to improve the performance of self-polishing-type coatings and the emergence of new booster biocides.

The main challenge for the future will be regulatory-driven. In particular, there are concerns about the regulatory impact on existing biocides in use, and increased concerns about hullborne aquatic invasive species that were highlighted in the IMO guidelines of 20[illegible].

These will drive the need for new technology solutions for the underwater hulls in general, and in particular for niche areas, and will also increase pressure on improving performance from underwater hull-cleaning solutions.

Initiatives are already underway to optimize the design of underwater hulls and to monitor the risk of invasive aquatic species.

The challenges the industry faces are likely to increase, and considerable effort is being made to ensure that the industry rises to meet these challenges to control fuel consumption and greenhouse gas emissions.

ABOUT THE AUTHOR

Raouf Kattan is the Principal Consultant and founder of Safinah Ltd., a U.K.-based coating consulting company. He has worked with many leading shipbuilders and owners on coating issues from design to production with a focus on improving productivity in coating processes.

DEVELOPMENT OF A TEST METHOD:
EVALUATING NONSKID PERFORMANCE UNDER THERMAL LOADING

BY COLTON SPICER, CAMERON MILLER, JIMMY TAGERT AND JOHN WEGAND, NAVAL RESEARCH LABORATORY; AND DR. ERICK ALLEY, NAVAL SURFACE WARFARE CENTER

Military performance specification, MIL-PRF-24667, governs the vetting and qualification of nonskid systems for the U.S. Navy[1]. The primary function of a nonskid coating installed on exterior decks of Navy ships is to provide a slip-resistant surface for sailors to safely perform mission-critical operations. Nonskid topcoats are applied over a primer that functions as a corrosion barrier and serves as a bond coat between the nonskid layer and the substrate. The nonskid layer is a composite coating consisting of a polymer matrix into which aggregate particles are dispersed to provide antislip properties. When the current nonskid system was deployed for service in 1971, the primary focus was to develop a nonskid system durable enough to withstand extended periods of atmospheric exposure, as well as mechanical damage from routine ship operations. However, as U.S. Navy technology and innovation has evolved and next-generation weapon systems have been deployed, high-temperature resistance has emerged as a new nonskid requirement for coating manufacturers to consider when selecting raw materials for new formulations. In support of these new requirements, the Naval Research Laboratory (NRL) has developed a new test method for evaluating temperature resistance of these new nonskid formulations.

FIELD OBSERVATIONS

There are several sources of high-temperature exposure on U.S. Navy ships. Some traditional epoxy/amine-based nonskid coatings currently in use have exhibited poor temperature resistance that resulted in premature failure. It is believed that prolonged high-temperature exposure impacts the nonskid coating and substrate in several ways, including discoloration and embrittlement of the nonskid and temporary deformation of the substrate from thermal expansion. The elevated temperatures exceed the degradation temperature for the epoxies and over time, the repeated heating causes the glass-transition temperature to increase, which reduces flexibility. Eventually, the nonskid coating cracks and the increased strain at the nonskid/substrate interface causes the coating to delaminate (Fig. 1).

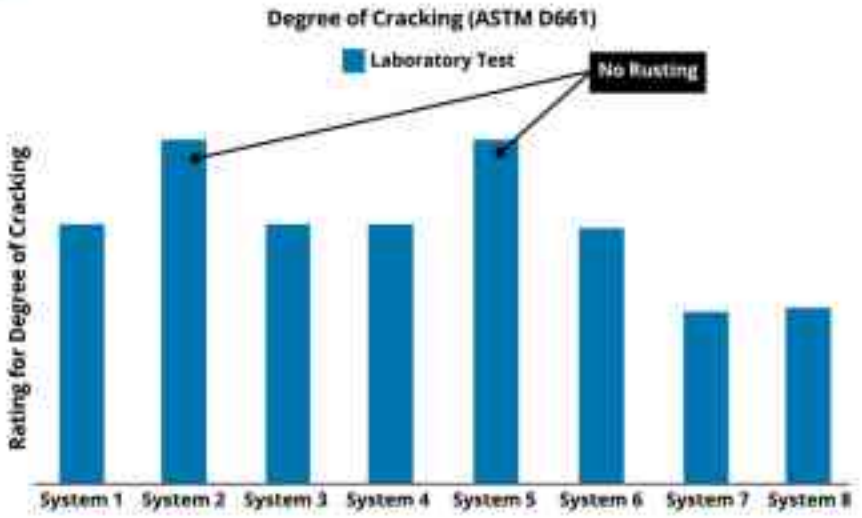


Fig. 5: Nonskid panel ranking after the Nonskid Heat Test.

Fig. 6: (From left) Surface preparation, primer application and nonskid application.

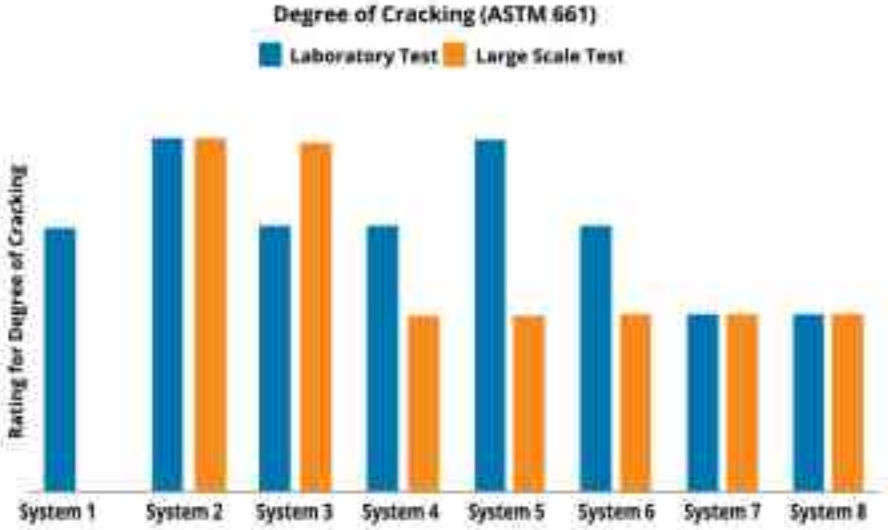


Fig. 7: Nonskid panel ranking comparison of laboratory test to large-scale test.

Discussion and Results

Eight of the most commonly used MIL-PRF-24667 nonskid coatings were selected for testing. These included four high-durability products, two extended-durability products and two cold-cure products. This represented eight of 17 unique nonskid-coating systems (47%) qualified for use. High-yield-strength steel (ASTM A514) test panels (6 inches by 12 inches by ¼ inch) were prepared with steel shot to achieve an SSPC-SP 10/NACE No. 2, "Near-White Metal Blast Cleaning," surface cleanliness with the intent of replicating the steel condition found on U.S. Navy ships[5].

Following surface preparation, the primer and nonskid layers were applied to the specimens in accordance with each manufacturer's product data sheet.

All material candidates were subjected to 10 cycles of the Nonskid Heat Test. One cycle consisted of 72 hours of UV aging, two thermal cycles in the HBT and 48 hours of salt spray. Specimens were evaluated at the end of each cycle to determine if checking or cracking had occurred. The condition of each nonskid coating after 10 cycles of the Nonskid Heat Test is shown in Figure 4 (p. 23). Checking is defined as slight breaks in the film that do not penetrate through the coating, while cracking extends through the full coating thickness. An indication of cracking is rust bleed-through following salt-spray exposure.

Checking and cracking were the primary modes of failure observed throughout the Nonskid Heat Test cycles with no nonskid coating showing signs of adhesion loss or delamination. Specimens were judged on the severity of cracking according to ASTM D661, in which a higher rating represents less cracking[4]. The cold-cure products (Systems 7 and 8) displayed the most cracking and rusting overall. Figure 5 shows the quantitative ranking based on ASTM D661, as well as examples of a passing and failing nonskid coatings.

LARGE-SCALE VALIDATION TESTING

In order to validate the laboratory testing, a large-scale land-based demonstration was performed by constructing four identical 15-by-6-by-4.5-foot mock-deck structures and placing them outdoors beneath a turboshaft engine for high-temperature exposure. The test structures were composed of high-strength, steel-plate, T-beam stiffeners with square tubing around the perimeter. After construction, they were coated with the same nonskid coating systems and application procedures used for laboratory testing. Figure 6 shows an overview of the surface preparation and coating application processes followed for the test plates.

The mock-deck structures remained in test for a duration of one year and were

periodically exposed to thermal cycles from the turboshaft engine. The plates were routinely inspected for nonskid degradation including discoloration, charring, embrittlement, blistering, cracking and delamination. The total number of thermal cycles was different for each plate depending on engine availability and nonskid performance; however, NRL was able to obtain results that were comparable to the laboratory test. In general, the laboratory test results predicted performance in the large-scale testing; however, the primary modes of failure of the nonskid coatings on the large-scale test plates differed from that of the laboratory testing. The result was both cracking and delamination which was thought to be due to the increase in both the number of heat cycles (in some cases over 60) and the heating rate. (Fig. 7).

The primary modes of failure of the nonskid coatings on the large-scale test plates differed from that of the laboratory testing, resulting in both cracking and delamination. This was thought to be due to the increase in both the number of heat cycles (in some cases over 60) and the heating rate. Although the mode of failure differed, the laboratory test results generally predicted performance in the large-scale testing. Systems 2 and 5 performed the best in the Nonskid Heat Test cycle and continued to perform well in the large-scale testing, except that System 5 exhibited cracking localized to areas where excessive hydraulic oil was observed as seen in Figure 8 (p. 26), causing a lower rating. This performance variance identified a gap in current Nonskid Heat Test cycle design as it did not incorporate any chemical-resistance testing.

The high-durability products appeared to perform the best overall. These products, with the exception of System 4, showed no signs of charring, embrittlement, blistering, cracking or delamination. The cold-cure nonskid coatings performed the worst and were actually removed from the test early because of catastrophic failure exhibiting significant delamination on System 7 and large blistering on System 8. Both extended-durability products showed cracking and delamination when probed.

CONCLUSIONS

NRL was able to successfully develop and execute a laboratory scale test method that is able to simulate the unique service environment on U.S. Navy ships. The design of the Nonskid Heat Test cycle captured the most significant exposure elements including mechanical bending strains, high-temperature exposure, saltwater environment and UV aging. Hydrocarbon contamination was identified as a potential addition to these service elements and will be considered in future testing. The results showed that a performance difference does indeed exist within MIL-PRF-24667-approved products and that the chemistries of the various materials behave quite differently when subjected to thermal exposure.

Fig. 11: (From left) High-durability product System 2, extended-durability product System 5 and cold-cure product, System 7.

The following list of observations was made based on the test results:

- Cold-cure products exhibited the most significant cracking, substrate corrosion and delamination during laboratory and large-scale testing;
- Thicker coatings increase the potential for premature failure due to shrinking and bending loads;
- The type and amount of aggregate used in the nonskid formulation can affect nonskid cracking;
- Temperature resistance of the primer coat can affect the corrosion resistance of the nonskid system;
- Analysis suggests that higher glass-transition temperature may improve coating performance; and
- Both laboratory and large-scale testing show that the driving or primary cause of nonskid failure is the combined effect of thermo-mechanical fatigue.

ABOUT THE AUTHORS

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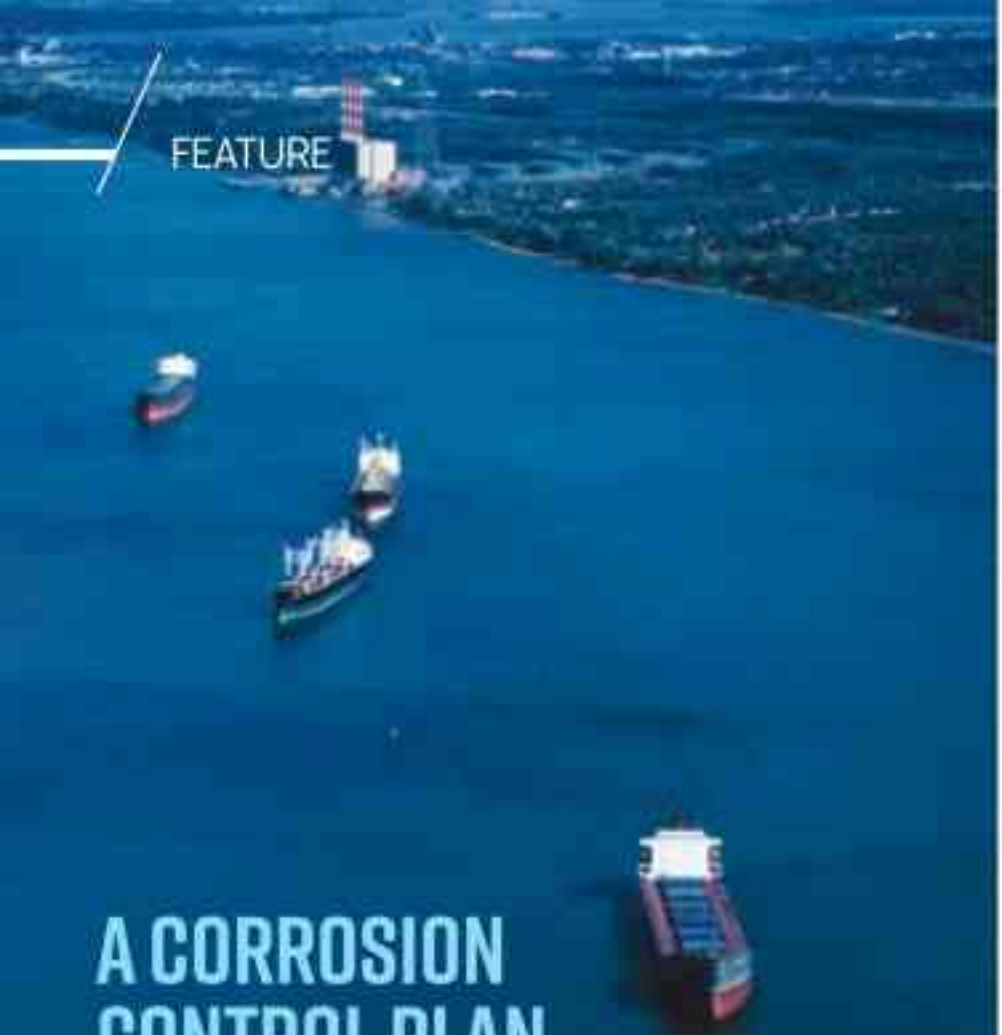
REFERENCES

1. Military Performance Specification (MIL-PRF-24667C), "Coating System Nonskid, for Roll, Spray or Self-Adhering Application," Washington Navy Yard, DC, Naval Sea Systems Command, 2008.
2. Alley, Erick, Ph.D., (NSWCCD, Code 6540, Structures and Composites), "Strains for Topside Coatings," Message to Cameron Miller, August 24, 2012.
3. ASTM International, ASTM G154, "Standard Practice for Operating Fluorescent Light Apparatus for UV Exposure of Nonmetallic Materials, West Conshohocken, PA, 2016.
4. ASTM International, ASTM B117, "Standard Practice for Operating Salt Spray Apparatus, West Conshohocken, PA, 2016.
5. The Society for Protective Coatings (SSPC), SSPC-SP 10/NACE No. 2, "Near-White Metal Blast Cleaning, Pittsburgh, PA, 2007.
6. ASTM International, ASTM D661-93, "Standard Test Method for Evaluating Degree of Cracking of Exterior Paints," West Conshohocken, PA, 2011. ***JPCL***



Heiners Technologies / Getty Images

A CORROSION CONTROL PLAN FOR SAINT LAWRENCE SEAWAY NAVIGATION LOCKS

BY RICK HUNTLEY, KTA-TATOR, INC.; AND DAN BOICH, ST. LAWRENCE SEAWAY MANAGEMENT CORPORATION

The Saint Lawrence Seaway is a series of locks, canals and navigable channels that allow oceangoing vessels to travel from the Great Lakes to the Atlantic Ocean. To facilitate this transport, construction on the St. Lawrence Seaway along the St. Lawrence River began in 1954 and was completed in 1959. The existing gates were installed during that construction.

In Canada, the locks are managed by the St. Lawrence Seaway Management Corporation (SLSMC), while in the United States the locks are managed by the St. Lawrence Seaway Development Corporation (SLSDC).

The SLSMC manages five locks in the Montreal region—Locks 1, 2, 3, 4 and 7. Locks 5 and 6 are managed by the SLSDC in the United States. Additionally, SLSMC manages all of the locks on the Welland Canal in the Niagara region.

THE WELLAND CANAL LOCKS AND GATES

Construction of the current Welland Canal began in 1913 and was completed in 1932, and the Welland Canal gates in existence today are the original gates from the construction completed in 1932.

Fifty of the gates at the locks at the Welland Canal are miter gates consisting of two leaves. All of the miter gates on the Welland Canal are the double-skinned type, meaning that they have solid steel plate on both sides. Several sections on the bottom of each gate are designed to be airtight. These air chambers provide buoyancy to the gate, taking pressure off of the gate hinges and making them easier to operate. The top chambers of the gate are filled with water and are referred to as water chambers.

The Welland Canal is in continuous operation throughout the year except for an approximately 10-week period that typically begins in January and continues through March. During that time, the canal is dewatered to facilitate maintenance. The Montreal section of the St. Lawrence Seaway is on a different dewatering schedule that occurs once every three years for approximately 10 weeks during the winter. As a result, all gate painting must be performed during those periods in the dead of winter.

Similar to any steel structure exposed to exterior and/or immersion environments, the gates managed by SLSMC require periodic maintenance including coating all exterior surfaces and the interior surfaces of the double-skinned miter gates. According to SLSMC documents, the exterior surfaces of the gates in the Montreal section of the St. Lawrence Seaway had not been coated since their original installation in 1959. The interior surfaces of the double-skinned miter gates on the Welland Canal have been coated at various times with most of the interiors coated within the last 15–25 years. The exterior surfaces of the individual gates were coated between 1961 and 1989 with the majority of the gates coated in the 1970s (Fig. 1).

Fig. 1: Miter gates from the Welland Canal with a vinyl coating system. Photos courtesy of KTA-Tator, Inc. unless otherwise noted.

THE STUDY

To facilitate efficient and effective corrosion protection on the existing gates as well as secure the functionality of the Seaway for oceangoing vessels, SLSMC commissioned a study, the goal of which was to develop a program to extend the life of the existing gates on the St. Lawrence Seaway at least until 2059.

Analysis of Existing Coatings

The first step involved reviewing the current condition of the existing coatings. Fortunately, SLSMC had an extensive library of photographs of the interior of the double-skinned gates taken between 2010 and 2014 (Fig. 2). In addition to reviewing the photographs, the interior and exterior surfaces of various gates in the Niagara and Montreal regions were examined firsthand. The interior surfaces of the double-skinned miter gates in the Niagara region were accessed through manholes on the top of the gates. Exterior surfaces were generally visually examined from the top of the lock except for a few where the exteriors were closely examined from a crane basket.

The condition of the coatings in the water chambers and the air chambers varied considerably. The coating on all gate interiors was black and had an appearance similar to that of coal-tar epoxy, although, on a few of the gates, the coating had a checking pattern that is more commonly found with coal-tar enamel than with coal-tar epoxy. The degree of corrosion found in the water chambers was somewhat greater than in the air chambers, although the amount of corrosion on the surfaces was not generally found to be excessive considering the length of time that the coatings had been in constant or intermittent immersion service. Although the air chambers are obviously not in immersion service, it was clear that there was some water intrusion into the chambers and frequent condensation that created a moderately corrosive environment.

The thickness of the coatings within the gate chambers varied considerably, from as low as 160 µm up to 700 µm. The thinnest coatings were found in areas where the topcoat had delaminated, leaving only the primer. There was no noticeable correlation between the thickness of the coating in an area and the amount of corrosion on the surface.

Fig. 2: The interior of a double-skinned miter gate with a coal-tar-epoxy coating system.

The adhesion of the coating was assessed in accordance with ASTM D3359, Method A (X-cut) and was rated 3A or better in most areas, which is considered good for an aged coating.

The condition of the vinyl coatings on the exterior surfaces of the gates in both the Niagara and the Montreal regions were generally in excellent condition, considering the length of time they had been in service (Fig. 3, p. 30). Close access to the exterior surfaces of the gates was limited, and the condition survey was mostly done from the top of the locks. In the Montreal region, the coating systems on the exterior surfaces were the original systems applied in 1959, indicating that the coatings had been in service for almost 60 years (Fig. 4, p. 30). In the Niagara region, the coatings were generally applied in the 1970s, indicating a service life of approximately 40 years. Regardless of extended service lives, many of the gates that were examined had less than 5% corrosion.

Gates in both regions had a black vinyl topcoat. The condition of the coating on the miter gates was often in noticeably better condition on the upstream side than on the downstream side. Unlike the corrosion found on the interior surfaces, the corrosion on the gate surfaces generally appeared in patches found most predominantly on the plate surfaces. Corrosion was less severe on the rivets. On the upstream side of the double-skinned miter gates, the worst corrosion patches were found predominantly in the middle of individual chamber cells between the rivets, although sometimes the corrosion extended to the riveted surfaces (Fig. 5, p. 32). The coating thickness here was between 200 µm and 500 µm and the adhesion was rated good (3A or better) in limited areas of access.

The next step was to estimate the remaining service life of the existing coating system. Because the dewatering process is conducted in winter, a heated enclosure around the gates was necessary to apply coatings on both the interiors and exteriors. Because of the cost of such an enclosure, it was deemed most expedient to recoat both the interior and exterior of double-skinned gates at the same time. Surfaces were prioritized based on the

Fig. 3: Some pitting on the old vinyl system that was mostly intact.

degree of corrosion from greatest to least.

The approximate percentage of corrosion was estimated on each of the gates, with the interiors and exteriors of the double-skinned gates estimated separately. The percentage of coating breakdown within the interiors of the double-skinned miter gates was determined mostly from viewing the nearly 14,000 photographs taken during previous examinations of these surfaces.

There was considerable variation in the condition of the interiors of the double-skinned miter gates. The amount of deterioration ranged from as little as 0.5% up to as much as 20%. The amount of deterioration of the exterior coatings in the Niagara region ranged from 1–20%, while the amount of deterioration on the exterior of the gates in the Montreal region ranged from 2–10% (Fig. 6, p. 32). Based on the percentages of coating deterioration, a table was prepared for SLSMC prioritizing the gates in order of need for coating replacement. Generally, coatings in immersion service are considered to have reached their service life when the percentage of coating breakdown is between 5 and 10%. There were several gates within this category that required recoating within the next 10 years.

SELECTING CORROSION-CONTROL SYSTEMS

Various corrosion control systems were investigated to determine the most efficient and cost-effective method for the lock gates. Coating systems including liquid-applied organic systems and thermal-spray metals were considered separately for the gate exteriors and the interiors of the water and air chambers on the double-skinned miter gates.

Moisture Cured Urethanes

Moisture-cured urethanes (MCUs) have been used for many years on dam and lock gates by the U.S. Army Corps of Engineers and other agencies. The MCU coating system is reported to perform very well in freshwater environments similar to those found on the St. Lawrence Seaway. One of the biggest advantages to moisture-cured urethane systems is that they can be applied in cold, damp conditions—temperatures as low as -7 C with humidity of 99%. The primary restriction is that the surfaces to be coated must be dry. The basic system consists of an MCU zinc-rich primer and two barrier coats formulated with micaceous iron oxide and coal-tar resin. This coating system has a relatively thin film applied at 330–480 µm dry-film thickness. At this thickness range, a service life of approximately 30 years can be expected before maintenance painting is required.

Because this system is composed of three coats, it takes somewhat longer to apply than do one- and two-coat systems such as elastomeric urethanes and 100%-solids epoxies. The recoat window between coats is six hours at 21 C and 12 hours at 10 C. The cure time before immersion service is fairly long—seven days with the use of an accelerator.

Fig. 4: A single-skinned miter gate with a 60-year-old vinyl-coating system.

100%-Solids Epoxy Coatings

The 100% solids epoxy coatings have been known to provide excellent corrosion protection for well over 30 years, generally with only minor maintenance painting required a year or two after installation to touch up pinholes and discontinuities on edges and welds. These coatings were developed in the 1970s in Germany and some of the applications installed at that time are still in service today. The coatings were introduced to the United States in the early 1980s. Many of these installations are still in service after over 30 years.

There are two major advantages of low-VOC or VOC-free formulations. From a performance and application perspective, the lack of solvent prevents the coating from shrinking after application, which in many cases reduces internal stresses and provides greater edge-retentive properties. Additionally, because no solvent is present, the return-to-service time is significantly reduced, although there still is a cure-to-service time period to ensure that the coating has properly cross-linked.

Elastomeric Urethanes

Elastomeric urethanes are 100%-solids products; however, they have a slightly shorter history of successful use compared to their 100%-solids-epoxy counterparts. Elastomeric urethanes have been used in immersion service since the early 1990s and like the epoxy coatings, these applications are still in service. A service life of 25–30 years has been achieved in immersion service and could reasonably be anticipated on hydraulic structures.

The advantages of elastomeric urethanes are that they can be applied at temperatures as low as -32 C and they cure rapidly. The coating is typically dry to the touch in 20 minutes at 21 C (although curing times vary by product) and can be put into service in less than 24 hours. However, because elastomeric urethanes cure so quickly,

plural-component spray application is required, which can create a challenge in limited access areas like those found on the interiors of double-skinned miter gates.

Vinyl Systems

In chemistry, vinyl is a term that refers to chemical linkage ($-CH=CH_2$). Many industrial protective coatings contain that linkage, but generally, industrial vinyl coatings are considered to be combinations of vinyl chloride and vinyl acetate. The most significant advantage of a vinyl coating system is its excellent resistance to water permeation. In fact, prior to the 1980s, vinyl coatings were used extensively in potable water tanks, on bridges and on various other steel structures that were exposed to water, including hydraulic structures.

A large amount of solvent is required to formulate a vinyl coating with a low enough viscosity for application. In most cases, these coatings contain solids of less than 30% but because of the high percentage of solvent, they did not conform to VOC-content limits in the U.S. and Canada, and as a result cannot be used in most applications. However, vinyl coatings can still be used on hydraulic structures.

Thermal-Spray Coatings (Metallizing)

Metallizing is a process where a metal wire or powder is heated to the melting point and the melted particles of metal are then transferred to a surface using compressed air. In the protective coatings industry, thermal spray coatings typically consist of 100% zinc, 100% aluminum, or an alloy of approximately 85% zinc and 15% aluminum. There are advantages and limitations to thermal spray coatings. The biggest advantage is that they provide excellent galvanic protection to steel. The applied coating is hard and has good impact resistance. However, thermal-spray coatings are not surface tolerant and therefore, SSPC-SP 5/NACE No. 1, "White Metal Blast Cleaning" (for immersion service) and an angular 75–100 µm surface profile are required.

PROBABLE COST OF SURFACE PREPARATION AND COATING OPTIONS

A cost analysis was prepared for the various surface preparation and coating material options that involved making several assumptions based upon information provided by SLSMC, consultant expertise, and industry experience. The following assumptions were used in generating these cost opinions:

1. The maximum available working time is 10 weeks during the winter months.
2. The contractor is able to work seven days per week.
3. Because the work will be performed during cold ambient conditions, heating units will be required to control

Fig. 5: The corrosion in the interior spaces was predominantly on rivets and crevices.

temperature and relative humidity for surface preparation and coating application.

4. Toxic metals such as lead and chromium may be present in existing coatings.
5. For gates with interior wet and dry surfaces, the contractor will be permitted to cut additional temporary hatches for access and ventilation, the cost of which was included in the estimates.
6. For gates with timber fenders (lumber used to dampen ship impact), labor costs to remove and reinstall fenders were included in cost estimates. Cost of new fenders and associated new hardware was not included.

Fig. 6: The exterior of a miter gate showing advanced corrosion.

Life-cycle costs of various interior and exterior lock gate candidate coating materials were generated. The purpose of the life-cycle analysis was to determine a candidate's value based not only on initial cost but on future cost as well. For example, an installed coating system may have a very high initial cost, but if this coating system has a life expectancy superior to other candidate systems, an overall cost savings may be realized.

Life-cycle cost was not the only consideration for choosing a corrosion-control system. Environmental impact was also considered, but high VOC content was offset by a long service life and relatively low required thickness. Ease of application in the difficult conditions was also of prime importance. In the end, the two systems with the lowest calculated life-cycle costs were recommended.

It was determined that for the exterior surfaces, a four-coat vinyl system provided the lowest life-cycle cost partially due to its extended service life. For interior surfaces, the lowest life-cycle cost was a moisture-cured urethane system, although the life-cycle cost of the 100%-solids epoxy system was a close second. Moving forward, each year a few gates will undergo complete removal and replacement using the selected coatings.

CONCLUSION

The value of the St. Lawrence Seaway to transportation of cargo cannot be understated. Over 80% of seaway traffic is made up of bulk cargoes such as grain, iron ore, coal, chemicals and oil. Manufactured goods of all kinds, including finished and semi-finished steel products, make up the remainder of seaway cargoes. Ships from more than 50 nations call at Seaway ports in Canada and the U.S.

Since its opening, the St. Lawrence Seaway has moved more than 2.5 billion metric tons of cargo with an estimated value of more than $375 billion. Almost 25% of this cargo travels to and from overseas ports. The SLSMC in Canada and the SLSDC in the U.S. work together to ensure the gates on the locks do not become victim to corrosion and remain operable for decades. Coating-system selection is particularly critical given the time of year and short length of outage when coating work must be executed.

ABOUT THE AUTHORS

Rick Huntley is the Technical Manager of Coatings Consulting and a Senior Coatings Consultant for KTA-Tator, Inc., where he has been employed for over 20 years. He is a NACE-certified Coating Inspector (Level III) and an SSPC-certified Protective Coatings Specialist. Huntley has consulted on major marine and bridge coating projects, condominium and housing-project rehabilitations and parking-garage renovations. He has also conducted coating specification review for highway departments, water districts, A&E firms and various manufacturers. Huntley is a primary instructor for various KTA training courses and holds a B.S. in chemical engineering from Washington State University.

Dan Boich is currently the Continuous Improvement Manager at the St. Lawrence Seaway Management Corporation (SLSMC). He is a Professional Engineer who is proficient at executing and managing Lean Six Sigma Black Belt projects for the Corporation. Boich has spent the last 26 years working in the fields of new product development, mechanical maintenance engineering, asset management and continuous improvement. He previously chaired the Movable Bridge Technical Committee, the Hands-Free Mooring Technical Committee and led large asset-management-related studies for the SLSMC. **JPCL**

THERE'S AN ICEBREAKER IN MY TANK!

Photo courtesy of Enbridge.

BY DR. MIKE O'DONOGHUE AND VIJAY DATTA, MS, INTERNATIONAL PAINT LLC

Well, not exactly. But up to 25 years ago, an icebreaker coating primarily designed for the underwater hulls of ships was installed in the Canadian oil patch on the floors of many 150-foot-diameter aboveground storage tanks (ASTs) (Figs. 1 and 2). Owned and operated by Enbridge, a Calgary, Alberta-based oil-storage company and distributor of over three million barrels of crude oil a day, the tank linings are now decades old and in near-perfect condition.

Why use an icebreaker coating system in the Alberta oil patch? Insight comes from Walter Kresic, Vice President of Enbridge, who two decades ago wanted, among other things, to improve the life-cycle costs of Enbridge's tank linings. According to Kresic, "The corrosion-mitigation systems for tank floors that were used in the early 1980s were fiberglass laminates expected to give over 20 years of service life. The linings were great but took seven–10 days to install, were expensive, and posed certain health, safety and environmental (HSE) issues." Then he heard about an innovative approach using novel epoxy coating technology that could offer equal or better performance than the current fiberglass laminates, be easier and quicker to apply, and have added HSE benefits. The system had a good track record in aqueous immersion service and a raft of test data derived in-house and from third-party independent testing in crude-oil immersion and various chemicals, and thus looked very promising in crude-oil immersion service.

Relevant case histories have long been considered of primary importance for owners' lining selections and specifications, and the advantages of using a judiciously selected high-performance epoxy holding primer beneath a solvent-free epoxy had garnered considerable attention.

With some initial reservation, Enbridge decided to give the two-coat system of solvent-borne epoxy holding primer and icebreaker epoxy for new tanks a go in 1994, and later elected to use it on several other tanks throughout their network.

So, what led to the use of what, at first glance, seems like such a peculiar lining system for floors in crude-oil storage tanks?

The icebreaker coating applied in 1994 was formulated with very good ice- and abrasion-impact resistance but also possessed very good chemical resistance. A special epoxy based on a modified phenalkamine curing agent was selected for the primer in order to provide the necessary surface wetting and good adhesion to steel. Other advantages were that the robust icebreaker epoxy topcoat only required airless spray equipment and had a long pot life, both of which were welcomed by coating applicators.

Interestingly, in the late 1980s and early 1990s, solvent-free epoxy technology largely had long pot lives, was applied using regular airless spray, and was formulated to give good wetting of the steel surface if used in optional single-coat, direct-to-metal (DTM) applications. This contrasts with the current trend of solvent-free epoxies, which have short pot lives, require plural-component-spray equipment to apply, and have rapid-cure and rapid back-to-service features. While single-coat, thick-film, solvent-free epoxy linings have gained acceptance for much touted productivity benefits such as fast turnaround retrofits many such linings provide poorer wetting of the steel surface compared to their solvent-borne counterparts.

THE EPOXY LINING SYSTEM

Originally, the solvent-free epoxy icebreaker coating was applied DTM. However, if the paint crew finished the abrasive blasting before a weekend, or the weather was poor, then they used the solvented epoxy holding primer. This practice morphed into using the holding primer all the time with benefits such as fewer holidays in the two-coat system than in the single-coat DTM film. Hence, for most of the AST floor-lining applications, the system consisted of:

- A 3–5 mil dry-film thickness (DFT), low-temperature-cure, ultra-high-solids (UHS)

modified phenalkamine epoxy holding primer (sometimes the topcoat was applied DTM) (Fig. 3); and

- A 25–35 mil DFT solvent-free epoxy topcoat based on an epoxy novolac resin (Fig. 4, p. 36).

The environment on, and beneath, steel floor plates in oil-storage ASTs is often aggressive because of the corrosive effects of chemicals and biofilms. No wonder tank floors have been known to fail in less than five years. Therefore, each coat of a two-coat lining system, or a DTM system, must be individually resistant to the immersion conditions of the particular ASTs for at least 20 years.

The novel modified phenalkamine epoxy holding primer used in the subject tanks had equal water and crude-oil resistance to its thick film topcoat. Furthermore, it met the most stringent VOC regulations; dried fast, had low-temperature-cure characteristics, and possessed low viscosity and good wetting capabilities while possessing sufficient thixotropy to be readily applied at 3–5 mils DFT. It had a recoatability of at least two days at ambient temperatures and, for safety reasons, had a flash point above 80 F.

Fig. 1: Light reflects off a 25-year-old epoxy lining that protected a 150-foot-diameter tank floor from internal corrosion. Photo courtesy of Enbridge.

LINING SYSTEM APPLICATION AND PROJECT SUCCESS

Commencing in the early 1990s, Alberta-based contractors Unimin and CSI applied the linings in the first and second sets of four out of eight ASTs at the Enbridge Athabasca site, respectively. According to Wayne Duncan, Principal of CSI, "What sticks out most in my mind at that time of transitioning from FRP linings to novel epoxy coating technologies, was the surface preparation. Recycled steel abrasives for surface preparation were also a departure from the norm of single-use abrasives in those days. To ensure that the same or better-quality surface preparation was obtained, we monitored the abrasive mixes for soluble contaminants, ensured the correct working mix of shot/grit and cleaned all abrasive debris from the tank floor prior to coating. We vacuumed the prepared steel and also ran large bar magnets with a specific offset over the surface to ensure no abrasive debris was left behind. These important steps were incorporated into our execution plans as being critical to ensuring the lining application would be successful."

Third-party independent inspection was mandated by Enbridge and provided by NACE-certified inspectors. The tanks were erected in the field. As the steel was covered in mill scale, the floors were blasted to remove this and profile the steel before coating. "All steel floors were prepared according to an SSPC-SP 5/NACE No. 1, 'White Metal Blast Cleaning' standard prior to application of the epoxy holding primer," said Jamie Davis, President of a contracted inspection firm. But what about soluble salts, especially chloride contamination? Taking measurements in those days was limited and there was less concern regarding contamination by soluble salts on new steel.

Common sense, however, did prevail. If the steel did not turn black a short while after abrasive blasting, then it was assumed that there were no chlorides present and the lining application proceeded. Compare this with today's attention to residual chloride levels!

Added Davis, "After we established compliance with the governing specification, the use of a holding primer meant that it was easy to stripe-coat welds and edges, and both see and clean up residual blast media, thereby reducing the chance of holidays occuring in the final coating application."

In 1994, automated-centrifugal-abrasive blasting was used in lieu of air-abrasive (nozzle) blasting on the third AST, which the authors will focus on as illustrative of the lining system performance. An 80% steel shot/20% steel grit mix was used in the environmental blast equipment (EBE) and a 3–4 mil angular profile was obtained.

When the lining in AST 3 was inspected some 25 years later, apart from some small areas of discoloration in the previously buff epoxy topcoat, there was no evidence of blisters, delamination or cracking. The existing lining still retained a glossy finish.

Fig. 2: A leg supporting the floating roof is surrounded by small repairs to the epoxy coating (caused by mechanical damage during the cleaning process) that are marked with pieces of tape. Photo courtesy of Colts Inspection Ltd.

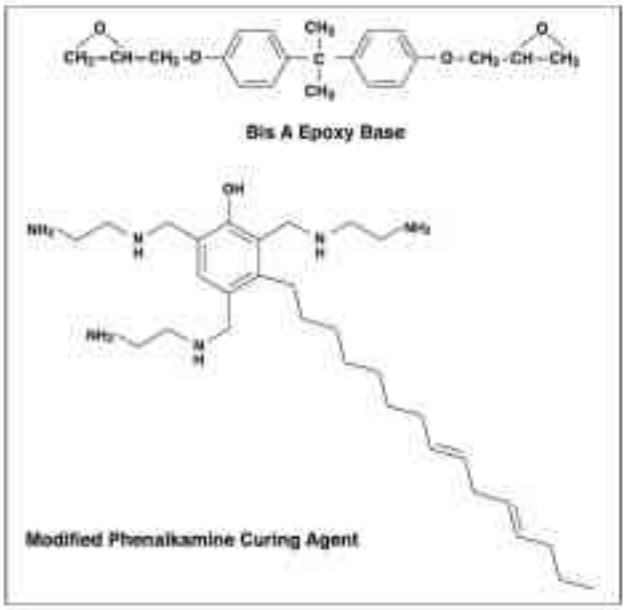


Fig. 3: Solvent-borne epoxy holding primer—the chemical structure of the epoxy base and curing agent.

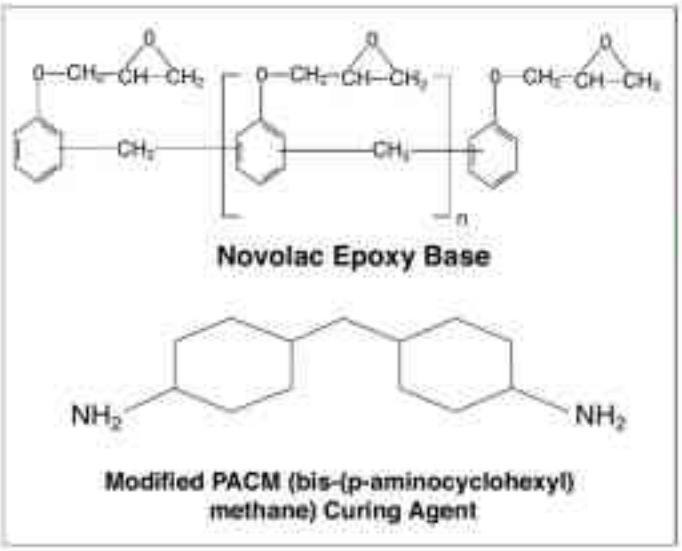


Fig 4: Solvent-free epoxy topcoat—the chemical structure of the epoxy base and curing agent.

"What really amazed me was the tenacity of the liner's adhesion to the steel after years of service. In this tank, the ASTM D4541 pull-offs were all in excess of 2,000 psi," commented Dr. Harry Tsaprailis, Enbridge's current coatings specialist.

Fig 5: Each holiday repair is solvent-washed and abraded prior to a new patch of epoxy coating being applied. Photo courtesy of Enbridge.

Repairs and touch-ups were carried out using a squeegee application of a solvent-free epoxy caulk applied to spot-blasted or power-tool-cleaned damaged areas (Fig. 5).

"New tanks in Canada are [typically] taken out of service after 20 years. With our understanding of the lining performance history and additional similar service assessment results based on other tanks for soil-side corrosion condition, we are able to safely push the inspection to a later date allowing us to reallocate our resources to other maintenance projects," said Jeff Liang, Senior Tank Engineer for Enbridge.

Interestingly, one tank where a DTM solvent-free epoxy was used exhibited over 1,500 holidays that were found after 25 years of service. Many of the holidays were the result of embedded shot and grit. Hence, the lining required extensive repair consisting of abrasive sweeping the DTM solvent-free lining and then applying a full seal coat of a solvent-free polyamine epoxy. Based on the authors'

experience, this procedure could possibly be problematic (although the jury is still out) given that the aged epoxy will be subject to fracturing. Despite initially good dry intercoat adhesion of approximately 2,500 psi, the wet adhesion of the refreshment lining could be impaired and reduced to largely mechanical interlocking. Lastly, there will be no chemical adhesion such as a Lewis acid-Lewis base interaction between the epoxy topcoat and the aged epoxy lining—the latter being 25 years outside of its recoat window. During the next out-of-service interval, Enbridge will open the tank and assess the repaired liner.

In the technical community, concerns have been expressed by some coating practitioners, including the authors, about automated-centrifugal-abrasive blasting possibly not providing the intended level of steel surface preparation and optimum steel condition for the desired epoxy lining performance. While this is an area of current research by both the authors and others, this successful 25-year case history of eight Enbridge AST linings applications has largely dispelled such concerns under the conditions tried.

And all of this brings us back to the notion of an icebreaker in a tank. Patently false of course, but to reiterate, there was an icebreaker lining in many Enbridge tanks with 25 years of failure-free performance with little or no maintenance. Spurred on by his desire to lower life-cycle costs of linings in Enbridge's ASTs, hats off to Walter Kresic for his innovative step 25 years ago and, dare we suggest, to a couple of coating practitioners and a formulator, all with quizzical and maverick minds who came up with the idea of what seemed at the time an apparent absurdity.

ABOUT THE AUTHORS

Mike O'Donoghue is the director of engineering and technical services for AkzoNobel's International brand. He has 37 years of experience in the marine and protective coatings industry.

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ACKNOWLEDGEMENT

This case history is dedicated by the authors and Ron Garrett, formerly of ICI Devoe Coatings, and to Al Lawrence, a former corrosion technologist with Mobil Oil Ltd. for his mentorship in internal linings in the Canadian oil patch and proactive contribution to the protective coatings industry during the 1980s and 1990s. ***JPCL***

BLASTING RESOURCE GUIDE

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SSPC COATINGS+ 2020

Long Beach, CA | Feb. 3–6, 2020

EVENTS & AWARDS

JulianHarel / Getty Images

In addition to the technical program and training and certification offerings, Coatings+ 2020, SSPC's annual conference and exhibition, will feature a full schedule including the annual Awards Luncheon, opening and closing celebrations, networking get-togethers and more.

The year 2020 will also mark SSPC's 70th anniversary, and SSPC hopes attendees will join in the different celebrations planned to take place over the course of the week.

All events will be held at the Long Beach Convention Center unless otherwise noted. For a complete schedule of events, visit sspc.org/event/coatings.

ANNUAL AWARDS LUNCHEON

Monday, Feb. 3, 11:30 a.m.–1:00 p.m.

Each year, Coatings+ attendees are invited to join SSPC President Joe Walker, Executive Director Bill Worms and the Board of Governors to recognize the coatings industry's finest with the following honors.

The **SSPC Honorary Life Member Award** is given for extraordinary contribution and long-term activity on behalf of SSPC. To become an Honorary Life Member, an individual must be nominated by an SSPC Board member and approved by two-thirds of the Board. Only one Honorary Life Membership is awarded each year.

The **John D. Keane Award of Merit**, named after SSPC's executive director from 1957 to 1984, recognizes outstanding leadership and significant contribution to the development of the protective coatings industry and to SSPC.

The **SSPC Coatings Education Award** is given for significant development and dissemination of educational material and technical information related to protective coatings and their application.

The **SSPC Technical Achievement Award** is awarded for outstanding service, leadership and contribution to the SSPC technical committees.

The **Women in Coatings Impact Award**, established in 2014, recognizes women in the coatings industry who have helped create a positive impact on the culture of the industry.

The **President's Lecture Series Award** is presented to papers handpicked by the SSPC President and chosen for the reflection of the coatings industry and profession.

The **SSPC Outstanding Publication Award** is presented annually to the author(s) of the best technical paper or presentation from the SSPC conference or from JPCL that scores the highest in the following categories: clarity of expression and organization; originality of content or presentation; importance to the protective coatings industry; and effectiveness of figures or tables. SSPC selects a panel of judges from SSPC and JPCL to vote on the award.

The **JPCL Readers' Choice Awards**, selected from a field of more than 100 eligible papers from JPCL articles published between May 2018 and July 2019, are voted on by JPCL readers and judged on significance to the industry among other criteria.

The **SSPC Outstanding Chapter Awards** are presented to an Outstanding North America Chapter and an Outstanding International Chapter each year. Chapters are evaluated on their overall operation and the creativity and quality of the events held each year.

The **14th annual SSPC Structure Awards**, recognizing teams of contractors, designers, end users and other personnel for excellence and expertise demonstrated on industrial and commercial coatings projects, will also be presented at the luncheon. The Structure Awards categories include:

- The *William Johnson Award* for a project demonstrating aesthetic merit in industrial coatings work;
- The *E. Crone Knox Award* for commercial coatings work;
- The *Charles G. Munger Award* for a project demonstrating longevity of the original coating;
- The *George Campbell Award* for the completion of a difficult or complex industrial coatings project;
- The *Military Coatings Award of Excellence* for exceptional coatings work performed on U.S. Military ships, structures or facilities;
- The *Eric S. Kline Award* for industrial coatings work performed in a fixed shop facility; and
- The *SSPC Coatings Industry Spirit Award* for

a coatings project that demonstrates extraordinary service benefitting a community or the industry at large.

JPCL will feature Structure Award-winning projects in articles published throughout 2020.

OPEN TOWN HALL FORUM ON THE SSPC-NACE MERGER

Monday, Feb. 3, 2:30–3:30 p.m.

This is your opportunity to voice any comments or concerns over the possibility of combining the two organizations. Additional open forums will be held throughout the week.

CHAPTER BREAKFAST & NETWORKING

Monday, Feb. 3, 8:00–9:00 a.m.

SSPC's influence continues to grow with the establishment of new chapters both in the U.S. and abroad. Chapter members are invited to attend this breakfast at the start of the conference to discuss chapter activities and share ideas for continued chapter growth.

WELCOME RECEPTION

Monday, Feb. 3, 5:30–7:30 p.m.

Sponsored by Carboline Company

SSPC will be celebrating its 70th anniversary in 2020, so join us at the retro beach-themed Welcome Reception for a slice of SSPC birthday cake, and be sure to visit the SSPC booth to see SSPC history throughout the years.

KEYNOTE BREAKFAST

Tuesday, Feb. 4, 8:00–9:30 a.m.

For the second year in a row, the Coatings+ conference will feature a keynote speaker touching on relevant topics in both the coating industry and business as a whole. This year, speaker Erik Qualman will present, "Digital Leadership: The Five Simple Habits of Digital Leaders."

SSPC NBPI INSTRUCTOR MEETING

Tuesday, Feb. 4, 10:30–11:30 a.m.

All SSPC-approved NBPI instructors are encouraged to attend this meeting.

FACILITY OWNERS LUNCH & PEER TECHNICAL DISCUSSION

Tuesday, Feb. 4, 11:30 a.m.–1:00 p.m.

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SSPC invites facility owners to a complimentary lunch to thank them for their commitment to

COATINGS+ Exhibitors

The following is a list of companies planning to showcase their products and services in the Coatings+ 2020 exhibit hall. For questions about exhibiting, please contact Nicole Lourette (lourette@sspc.org).

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Barton International
Bellemare Abrasives & Minerals
Blast One
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Bullard
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DESCO Manufacturing Inc.
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Eagle Industries
ecoFinish LLC
Ecomaterials, Inc.
Elcometer
Element Materials Technology
EnTech Ind.
ErgonArmor
Ervin Industries
Express Chem
Federal Signal Environmental Solutions Group
Fischer Technology, Inc.
Forensic Analytical Consulting Services (FACS)
Gannett Fleming
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GMA Industries
GNP Ceramics, LLC
Graco Inc.
Greener Blast
Groenman-Pedersen, Inc.
Harsco Minerals
Herc Rentals
Hippo Multipower
Hippowrap Containment
HoldTight Solutions, Inc
HRV Conformance Verification Associates Inc.
Induron Protective Coatings
Industrial Vacuum Equipment Corp
International Paint/AkzoNobel
ITW Polymers Sealants North America
IUPAT/ Finishing Trades Institute
J.H. Fletcher & Co.
JPCL
Kennametal
KTA-Tator
Langtry Blast Technologies
LIUNA
MES – Rentals & Supplies
Minerals Research, Inc.
Monarflex by Siplast
Montipower
NACE / NACE Institute
National Equipment Corp. (NECO)
NCERCAMP @ The University of Akron
Nextec, Inc. / ProTex
Novatek Corporation
Nu Way Industrial Waste Management, LLC
Olimag Sand
Opti-Blast, Inc.
Pacific Dust Collectors & Equipment
PaintSquare
Polygon
PPG Protective & Marine
Pro-Tect Plastic & Supply
Rapid Prep
RD Coatings - Dothée S.A.
Ruzhao Garnet LTD
Rust-Oleum
Saint-Gobain
SAFE Systems, Inc.
San-Blast-Ture LLC
Sherwin-Williams
Sonay Q
Sponge-Jet
Spray Foam Systems
Sprayrog, Inc.
SSPC Gulf Coast Chapter
SSPC Pittsburgh Chapter
SSPC Southern California Chapter
SSPC Mexico Chapter
Sulzer Mixpac USA
Tarps Manufacturing
TDI Group
Technofink, LLC
Technology Publishing Co.
Texan Stone LLC
Thermion Inc.
Tinker & Rasor
Titan Tool
Tnemec Company, Inc.
Trelawny SPT Ltd.
Trenton Corporation
TruQC
U.S. Minerals
Van Air Systems
Vector Technologies Ltd.
VersaFlex
Vulkan Blast Shot Technology
The Warehouse Rental & Supply
W Abrasives
Wasser Coatings
Western Technology
WIWA
ZIBO TAA Metal Technology Co., Ltd.

SSPC standards and quality programs for their industrial coating projects. A peer technical discussion session will follow lunch, where facility owners can share their thoughts on best practices and solutions related to industrial coatings, surface preparation, new technologies, asset life-cycle extension and budget efficiencies. An RSVP is appreciated.

STUDENT POSTER SESSION

Tuesday, Feb. 4, 3:00–4:00 p.m.
Wednesday, Feb. 5, 10:00–11:00 a.m.

Bringing more young people into the organization and coatings industry as a whole remains one of SSPC's top goals, and the Student Poster Session provides an annual forum for college students and young professionals to participate in the conference. Posters will be judged by a panel of SSPC members, and prizes will be awarded to the first-, second- and third-place posters. For more information, contact Don Molinari (molinari@sspc.org) or Christine Lajzo (lajzo@sspc.org).

EXHIBIT HALL GRAND OPENING

Tuesday, Feb. 4, 5:00–8:00 p.m.
Sponsored by The Sherwin-Williams Company

Once Joe Walker and SSPC Board members cut the ribbon to the exhibit hall, be among the first to peruse the floor and enjoy complimentary food and drinks. The Coatings+ 2020 exhibit hall will feature a new Activity Zone with games, simulated surfing and a professional headshot station. Visit the booths and get to know members of SSPC's worldwide chapters, including the Mexico chapter, exhibiting for the first time. Also debuting in the hall this year is the Product Demonstration Stage, where exhibitors will showcase and demonstrate new products every 30 minutes during regular exhibit hall hours.

*The Coatings+ 2020 Exhibit Hall is nearly sold out! Limited prime locations remain available for purchase. Please contact Nicole Lourette at lourette@sspc.org or 412-288-6023 for information on exhibiting.

dszc / Getty Images

MEGARUST MID-YEAR FOLLOW-UP

Wednesday, Feb. 5, 8:00 a.m.–12:00 p.m.

This annual follow-up meeting to the MegaRust Naval corrosion conference—held this past May in Portsmouth, Virginia—is designed to continue the discussions on key corrosion issues concerning the Navy, generate questions and talking points for potential presenters at the 2020 conference, and draft the conference theme and agenda. If interested in participating, please email megarust@navalengineers.org.

LUNCH WITH EXHIBITORS

Wednesday, Feb. 5 and Thursday, Feb. 6, 11:30–1:00 p.m.

SSPC and industry sponsors will provide complimentary lunch tickets with your conference registration packet. The outdoor exhibit demonstrations area will also be open during regular exhibit hours.

SSPC APPROVED INSTRUCTOR MEETING

Wednesday, Feb. 5, 12:30–1:30 p.m.

Approved SSPC instructors will meet to discuss initiatives for 2020 and to brainstorm about how to improve SSPC training.

INTERNATIONAL CHAPTER MEETINGS: LATIN AMERICA AND ASIA PACIFIC

Wednesday, Feb. 5, 1:00–2:30 p.m.

SSPC's industry influence continues to grow internationally with the establishment of a number of new chapters around the world. Stop in and listen to what some of SSPC chapters abroad are up to.

JOINT MEETING OF SSPC EDUCATION & INSTRUCTOR COMMITTEES

Wednesday, Feb. 5, 3:00–4:30 p.m.
(Invitation Only)

The committee will discuss recommendations regarding the improvement of educational curriculum and training delivery processes and procedures.

SSPC PROFESSIONAL DEVELOPMENT PANEL

Wednesday, Feb. 5, 3:30–5:00 p.m.
Sponsored by PPG Protective & Marine Coatings

This session, new to Coatings+ 2020, seeks to provide practical advice for both newcomers and industry veterans who are working to shape the future of the coatings industry. It will open with a panel set-up, headlined by the winner of the Women in Coatings Impact Award and a panel consisting of SSPC-certified Protective Coatings Specialists, contractors and engineers, as well as other young professionals and their mentors. After a brief Q & A period, the reception will be followed by a cocktail hour.

CLOSING BLAST

Thursday, Feb. 6, 7:00–9:00 p.m.
Sponsored by LiUNA

Before returning home, gather one last time with your friends both new and old for salsa dancing, salsa eating and a chance to win a Harley Davidson motorcycle! All attendees will receive a raffle ticket in their registration packets and must drop their tickets off at LiUNA's exhibit hall booth to enter. The winner will be picked at the closing party and must be present to collect the prize.


Courtesy of SSPC

SSPC Brazil Chapter Hosts Inaugural SIPRA Conference

The SSPC Brazil Chapter conducted its inaugural technical coatings conference, SIPRA (Seminario Internacional de Pintura e Revestimentos Anticorrosivos), on October 23 in Rio De Janeiro, Brazil.

Over a dozen exhibitors, 31 sponsors and nearly 300 paid attendees were present for this day-long conference. The SIPRA technical agenda covered topics such as general coating systems, coating inspection and corrosion, coating program updates from Brazilian oil-and-gas producer Petrobras and power generation/transmission company Electrobras, and on the uses of polyureas and polyaspartics.

To learn more about the SSPC Brazil Chapter and SIPRA conference, visit sipra.sspc.com.br.


Courtesy of SSPC

SSPC Panama Chapter Conducts Panama Coatings Show

On October 25, the SSPC Panama Chapter conducted its third annual conference, the Panama Coatings Show, in Panama City, Panama.

The 2019 conference had over 250 paid attendees and for the first time was a collaboration with the Universidad Tecnologica de Panama (UTP) School of Civil Engineering and the SSPC UTP Student Chapter.

Featured speakers included SSPC Board of Governors members Robert Cloutier from Bath Iron Works (pictured, fourth from left) and Juan Caballero, MCI, from Naval and Industrial Services (pictured, fifth from left). The technical presentations covered concrete coatings, marine coatings, coating inspection and uses of polyurea coatings.

SSPC LICENSEE NEWS

Gannett Fleming, an engineering firm involved in American infrastructure and environmental solutions for over 100 years, has recently received approval as an authorized licensee from SSPC for the Lead Paint Removal (C3) and Lead Paint Removal Refresher (C5) Programs in the United States.

Sayerlack Mexicana S.A de C.V., a contributor to improving the professional and economic conditions in Mexico, the U.S., Central and South America for over 50 years, also recently received approval from SSPC as an authorized licensee for the Fundamentals of Protective Coatings (C1), Planning & Specifying Industrial Coatings Projects (C2), Concrete Coating Basics (CCB) and Concrete Coating Inspector (CCI) programs in the Mexico.

These training programs provide practical and comprehensive information on protective coatings, as well as the fundamentals of corrosion, hazardous material encounters and the use of coatings as a protective mechanism against corrosion and deterioration of industrial structures. Students will learn how to develop and manage effective coating projects and familiarize themselves with OSHA and EPA regulations.

As with all new SSPC licensees, Gannett Fleming and Sayerlack underwent rigorous reviews of their personnel, organization and procedures to ensure their capability to administer quality SSPC training programs.

"We are excited to come together with these companies, both well known for their contribution to the industries," said Jennifer Merck, SSPC's Director of Training. "We believe they will be able to reach untapped potential in their regions, thus growing the qualified trainee numbers to new heights."

Along with these new licensees, current licensee LiUNA Canadian Tri-Fund has added the Concrete Coating Application Specialist (CCAS) program to its approved courses. This new course from SSPC provides a comprehensive overview and practical hands-on training for coating concrete surfaces that extends to project-specific certification for structural concrete designs. SSPC is excited to have LiUNA to help spread the word of this new course in Canada.

Information on SSPC licensees can be found at sspc.org/firm-licensees. Training and certification status for individuals can be confirmed on the SSPC homepage at sspc.org.

Index to Advertisers

CALENDAR

DECEMBER 2019

SSPC COURSES
Course information available at sspc.org

Dec. 2–5	C3 Lead Paint Removal, Santa Fe Springs, CA
Dec. 2–6	C2 Planning & Specifying Industrial Coatings Projects, Leduc, Alberta
Dec. 2–6	NBPI NAVSEA Basic Paint Inspector, Norfolk, VA; Leduc, Alberta
Dec. 2–6	Ground Vehicle Corrosion, Newington, NH
Dec. 2–6	CCI Concrete Coatings Inspector, Daytona Beach, FL
Dec. 2–6	PCI Protective Coatings Inspector, Pittsburgh, PA; Seattle, WA
Dec. 2–14	PCI, Batam, Indonesia
Dec. 3	Using SSPC PA 2 Effectively, Manchester, UK
Dec. 6	C5 Lead Paint Refresher, Santa Fe Springs, CA
Dec. 7	PCS Protective Coatings Specialist, Leduc, Alberta
Dec. 9–10	C7 Abrasive Blasting, La Porte, TX
Dec. 9–11	Aerospace Maintainer Coating Application, Bakersfield, CA
Dec. 9–13	Ground Vehicle Corrosion/Protective Coatings, Pittsburgh, PA
Dec. 9–13	C2, Irondale, AL
Dec. 9–14	BCI Bridge Coatings Inspector, Newington, NH; Highland, IN
Dec. 9–15	PCI, Warren, MI; Portland, OR; Surrey, BC
Dec. 10–11	Shipboard Surface Prep & Paint Application, National City, CA
Dec. 10–12	CAS Coatings Application Specialist, La Porte, TX; Theodore, AL
Dec. 10–21	PCI, Singapore
Dec. 12–13	ACAS Aerospace Coating Application Specialist, Bakersfield, CA
Dec. 12–13	C12 Spray Application, La Porte, TX; Chesapeake, VA
Dec. 12–13	C6 Power Tool Surface Prep & Paint Application, National City, CA
Dec. 14	PCS, Irondale, AL
Dec. 16–19	Aerospace Engineer Coating Application, Bakersfield, CA

1971

The year when the current MIL-PRF-24667-approved nonskid system was deployed for service.
See page 22.

25 years ago

When an icebreaker system originally designed for ship hulls was tested in aboveground storage tank interiors in the Canadian oil patch.
See page 34.

107

The total number of ships coated with silicone-based foul release coatings since their introduction 30 years ago through 2004; 154 additional vessels were coated in the following year alone.
See page 18.

3

The number of different temperatures—laboratory, extreme low and extreme high—at which sweat-in time and pot life are typically listed in product data sheets for multi-component coating materials.
See page 14.

2059

The target year of service life in a program developed to facilitate efficient and effective corrosion protection on existing gates on St. Lawrence Seaway locks.
See page 28.

17

The number of award categories that will be presented during the annual awards luncheon at Coatings+ 2020 in Long Beach, California, on Feb. 3, 2020.
See page 55.