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Efficient Blast-Cleaning: Back to Basics

BY MICHAEL DAMIANO, SENIOR TECHNICAL ADVISOR, SSPC

Dry-nozzle abrasive blast-cleaning is one of the predominant methods of surface preparation in the industrial painting industry. When done correctly, the process cleans and profiles the surface more quickly than other methods of surface preparation.

Of course, dry abrasive blast-cleaning is not always feasible and, on some projects, not permitted by the facility owner for various reasons such as the proximity to machinery, other trade personnel, noise concerns or other reasons. However, when permitted, blast-cleaning is a preferred method by industrial painting contractors in almost every case.

The question is: Is blast cleaning always conducted as efficiently and as cost effectively as possible? This article explores the "basics" of dry-nozzle blast-cleaning—primarily of metals—as a refresher on the principles of fundamentally sound abrasive blast-cleaning.

Please note that although blast-cleaning creates several safety and health hazards related to working with high-pressure equipment and removing "old" coatings that might contain toxic dust, this article only briefly mentions safety and health issues encountered. For example, when using oil-lubricated compressors for breathing air, be sure to monitor for carbon monoxide. Because of the intense friction created, ground blast pots and lengthy air piping and use static-dissipating blast hoses. Ensure that pressures don't exceed equipment ratings. Always consult applicable OSHA regulations, safe equipment operating procedures, project-specific compliance programs and safety data sheets for abrasives used when planning any blast-cleaning project.

The basic blasting process involves a source of compressed air (the compressor) to move the air in sufficient volume to a vessel (blast pot) that adds (by metering) stored abrasive to the incoming air and then pushes the air and abrasive mix to the blaster through a blast hose for the blaster to clean and profile the surface.

PHOTOS COURTESY OF SSPC

AIR SUPPLY

For effective blasting, it is essential to have plenty of air. The compressor must have the capacity to compress the air to the pressure (measured in psi or bar units) needed at the nozzle and to supply enough air (measured in cubic feet per meter) for the blaster's air-fed helmet. This is true especially in the field, where the same compressor is often used for breathing air, as well as "work air," for the nozzle at the needed pressure and other equipment, such as air-powered paint pumps or conventional pots, pneumatic power tools and air dryers, and pneumatic remote controls (such as a Deadman switch).

The blaster should check nozzle pressure in the field daily to make sure it produces the correct pressure—about 90–110 psi for blast-cleaning carbon steel, or even higher when using steel abrasive. Conversely, blast pressure should be reduced when cleaning galvanized and nonferrous metal. Checking the nozzle pressure only takes a few minutes. For shop or depot units, one can install pressure gauges at the blast pot, so one knows what the pressure going into the blast room is, if it is nearby.

Having sufficient air supply is critical—and so is the quality of the air. The SSPC/NACE joint blast-cleaning standards require air to be clean and dry. Moisture-contaminated air can cause abrasive clogs and contaminate the surface being blasted. Keeping the air dry can be accomplished by using air dryers, after coolers and oil and moisture separators. Place compressor inlets away from contamination sources, such as vehicle or equipment exhaust. Air can be checked daily

using a simple, quick blotter test (according to ASTM D4285) to make sure it is clean and dry before beginning production blasting.

One major blasting equipment manufacturer recommends that the smallest internal diameter of the air outlet from the compressor should be at least four times the size of the nozzle the blaster is going to use. So, if the blaster is using No. 6 nozzles, the bull line ID should be at least 1.5 inches. Remember, too, when setting up the job and making calculations, that the outside diameter is not the same as the ID. Longer hose lengths will require even more air than the four times recommended above.

EQUIPMENT, VALVES AND FITTINGS

To get the best production rate on every job, use compatible and properly sized equipment and fittings, and avoid restrictions in the system that propel the air from the compressor to the nozzle. Each 1-lb. drop in air pressure reduces production by 1.5%. With regard to fittings, a 90-degree elbow results in a 3-psi pressure loss. Reduce pressure losses as much as possible. Be sure, too, to allow a reserve of 25–50% air above what will be needed for the equipment, air lines, valves, fittings and blast hose.

Use the right size equipment for the job at hand. Use a small machine for a small job and a large machine for a bigger job. Conversely, don't use a big machine for a small job or a small machine for a large job, which would require your crew to stop and fill the machine at short intervals. For a larger job, it is possible to have abrasive pre-loaded into a hopper to save time. Your goal is to get as much production out of the system as possible.

Select an abrasive that is designed for the work at hand. Size is a critical component, along with pressure at the nozzle and stand-off distance, in determining profile depth. Test blast a witness panel to make sure that the abrasive can get the surface cleaned in a timely manner and create the specified profile. If recycling metallic abrasive, have sufficient abrasive on-hand to keep the abrasive "work" mix where it needs to be to maintain specified profile creation and cleaning and to avoid unnecessary down time. It's a balancing act to get the surface cleaned to standard in the shortest time possible while obtaining the specified profile. Creating an out-of-spec profile can lead to costly rework. Also, be sure to adjust your metering valve each shift to make sure your blasters are getting the leanest amount of abrasive that gets the job done.

Air flows best when traveling through straight, unrestricted lines, so use the shortest blast hose length you need to reach the work area and limit bends in the line. Use a correctly sized and best-quality blast hose made specifically for abrasive blasting. If blasters need a whip hose to access certain work areas, try to keep the whip hoses as short as possible to limit production loss. Blast hoses should be inspected before the beginning of each shift to make sure they are not wearing out. Check couplings, too, to make sure they are tight, and check nozzle gaskets for wear.

PROJECT PLANNING

Careful planning to meet the specification usually leads to good performance. Obtain the equipment, abrasive type and size that will allow you to get optimum production in the shortest time. The abrasive that you have in the shop that you may prefer to use may not always be the best abrasive for a specific job. The equipment you own many not be adequately sized to do the job at hand. Work with your abrasive and equipment suppliers to make the best plan for the project. Read the specification carefully, plan and prepare and do witness panel testing ahead of time to verify that the equipment and materials you are going to use will get the job done as quickly and efficiently as possible, and to spec.

TRAINING

Having all of the right equipment means little if you don't train and qualify your blast crew. Trained blasters are more likely to understand why they are doing what they are doing, and why the system has been set up for a certain job. Trained blasters will also become well-versed in the industry standards in order to realize, for example, that there is a difference in cost for the contractor to blast to a Near White finish (SSPC-SP 10/NACE No. 2) when only a Commercial blast (SSPC-SP 6/NACE No. 3) is specified.

CONCLUSION

In summary, employ basic fundamentals for productive and efficient blast cleaning. Consult with your equipment and material suppliers for suggestions on how to best set up a particular job for optimum production and successful completion as each project brings with it special conditions that may require expert advice on what equipment and abrasive to use. JPCL

SAVE THE DATE

DoD CorrCon 2021

COURTESY OF SSPC

SSPC: The Society for Protective Coatings and the U.S. Department of Defense's Corrosion Policy and Oversight Office are pleased to announce that the 2021 DoD-Allied Nations Technical Corrosion Conference has been scheduled for Aug. 9–12, 2021 at El Conquistador Tucson, a Hilton Resort, in Tucson, Arizona.

Administered biennially, the conference is a critical event that fosters an efficient and effective collaborative environment to not only better understand the impact of corrosion on DoD equipment and infrastructure, but also to jointly work toward practical prevention and control solutions. This effort brings together a diverse spectrum of technical expertise and knowledge representing government, industry, academia and international corrosion partners. Attendance ranges between 500 and 700, with participants representing essentially every field related to corrosion prevention and control, including basic and applied research, maintenance and sustainment, research and development, practitioners and manufacturers, and the DoD acquisition workforce.

SSPC has administered this event since 2017, after being awarded the event contract from the DoD Corrosion Policy and Oversight Office in 2016. The CorrCon technical program is led by a different military branch each year, and the U.S. Navy will be the 2021 technical lead. Along with a robust technical program, conference programming includes a general session with leading military officials, an awards ceremony, a co-located exhibit hall and networking lunches, as well as an engaging offsite technical tour with a partnering military base.

The call for papers will be opening soon, so be sure to mark your calendars if you are interested in participating in the CorrCon 2021 technical program. Registration, exhibiting and sponsorship information are also forthcoming.

For questions related to the conference, please reach out to Nicole Lourette, SSPC Events Manager, at lourette@sspc.org or 412-281-2331, ext. 2204. Learn more at sspc.org/dodcorrcon.

2021 STRUCTURE AWARDS NOMINATIONS OPEN

SSPC has announced that it is now accepting nominations for its 2021 Structure Awards, which recognize teams of contractors, designers, coating manufacturers and end users for excellence on protective coatings projects. The awards are presented each year during the Annual Awards Luncheon at SSPC's Coatings+ conference. Coatings+ 2021 is slated for Feb. 1–4, 2021, in Phoenix.

Nominations can be submitted for painting projects on all types of structures, including but not limited to bridges, storage tanks, concrete structures and industrial or commercial facilities. The different Structure Awards include:

- **The William Johnson Award** for outstanding achievement demonstrating aesthetic merit in industrial or commercial coatings work;
- **The Charles G. Munger Award** for the outstanding industrial or commercial coatings project demonstrating longevity of the original coating; the structure may have had spot repairs or overcoating with the original coating still intact;
- **The E. Crone Knoy Award** for outstanding achievement in industrial or commercial coatings work that demonstrates innovation, excellence in craftsmanship or the use of state-of-the-art techniques or products to creatively solve problems or provide long-term service;
- **The Eric S. Kline Award** for outstanding achievement in industrial coatings work performed in a fixed shop facility; the project can be repair work or new construction;
- **The George Campbell Award** for outstanding achievement in the completion of a difficult or complex industrial or commercial coatings project;
- **The Industry Spirit Award** for extraordinary service benefiting a community or the industry; and
- **The Military Coatings Award of Excellence** for exceptional coatings work performed on U.S. military ships, structures or facilities.

With the exception of the Charles G. Munger, Coatings Industry Spirit and Military Coatings Project awards, work on the structure must have been completed between July 1, 2019, and June 30, 2020. A representative of the structure owner must be willing to attend the Coatings+ 2021 Awards Luncheon to receive the award. Award-winning projects will also be recapped in JPCL feature articles throughout 2021.

More information on the awards, as well as a downloadable awards nomination form, can be found at sspc.org/coatings-2021. Completed nomination forms and high-resolution project photos can be submitted via email at structures@sspc.org. JPCL

A New Kind of Virtual Event

Technology Publishing Co., publisher of JPCL, is pleased to announce a new virtual networking event and tradeshow for the protective and commercial coatings industries.

PaintSquare Connect will take place online Nov. 10–12, and will replace the in-person Contractor Connect and Commercial Contractor Connect events, which were scheduled to take place Nov. 3–6 and Oct. 19–22, respectively, in Palm Coast, Florida. The in-person events were canceled in light of the COVID-19 pandemic.

"We had extensive feedback from contractors, facility owners and manufacturers before developing this event, so we know the specific kind of educational information and business interaction they need to keep our industry moving forward," said Brion Palmer, CEO of TPC. "We've combined the best of our in-person event offerings with our digital platforms to build a virtual experience that's right for the times."

PaintSquare Connect will combine unique attributes of TPC's "Connect" events with the comprehensive capabilities of the digital world to produce a unique virtual conference and tradeshow. The event program will offer an extensive curriculum, private meetings and group networking capabilities.

The curriculum will feature webinars, product demo videos, panel discussions, roundtable sessions, keynote speeches and more. The curriculum will be presented in concurrent tracks on topics that will include Protective & Marine Coatings, Commercial Coatings, Equipment and Surface Preparation. PaintSquare Connect will also feature product pavilions featuring interactive company booths, along with a passport participation program—replete with prizes and drawings.

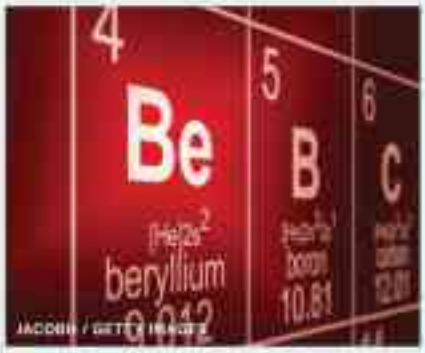
Delegates can participate in individual sessions in real-time during the two-day event, and all content will be accessible in archived format post event for six months. One registration gets you access to all content, product pavilions and the networking activities. Qualified attendees will receive a registration bag, and a print program will be mailed to delegates in advance.

Mark your calendars: PaintSquare Connect Nov. 10–12

For information on registration, sponsorship and more, visit paintsquare.com/psc and check out the ad on pgs. 4–5 of this issue.

PAINTSQUARE CONNECT

Beryllium Rule for General Industry Finalized



The U.S. Department of Labor has issued its Final Beryllium Standard for General Industry. While no major changes are reported in the rule, the DOL did include changes that it says are designed to "clarify the standard and simplify or improve compliance."

A new beryllium rule was published in January 2017 after years in development, authored primarily by OSHA, the United Steelworkers union and Materion Brush (the country's largest supplier of beryllium alloys). In general industry, beryllium alloys are used as an aerospace material, in nuclear reactors and in some medical applications, as well as for other specialized uses.

The rule reduced the eight-hour permissible exposure limit for airborne beryllium from 2.0 micrograms per cubic meter to 0.2 micrograms per cubic meter, a limit that applies to all industries. It also established a short-term exposure limit of 2.0 micrograms per cubic meter over a 15-minute sampling period.

While the rulemaking proposal that was published previous to the actual rule did not apply to the construction and maritime industries, OSHA in the end decided to publish a set of three new beryllium rules, with similar provisions, applying to construction, maritime and general industry.

SSPC, NACE Announce Committees, Monthly Town Halls

On July 24, SSPC: The Society for Protective Coatings and NACE International, The Corrosion Society announced the formation of 13 ad-hoc integration teams to begin combination efforts of the two organizations. This comes after SSPC and NACE announced earlier in the month that they have entered into a definitive agreement to combine.

According to SSPC and NACE, each team is focused on a different area of the associations' operations and services. The teams were reportedly appointed by the SSPC-NACE Steering Committee and consist of members and staff from both organizations.

"We are entering a very exciting and challenging period of this process for the SSPC and NACE community," said Tim Bieri, President of NACE International. "There are many details the ad-hoc teams have to work through before we can move to the next phase of combining; we are focused on retaining the best of both organizations while ensuring we take into consideration all of the feedback we have received from our members worldwide."

The teams are reportedly working with McKinley Advisors, which was brought on at the beginning of the merger talks to serve as a guiding entity for the discussions, in addition to advising the organizations through considerations related to strategic, financial and cultural barriers, among others.

The teams are as follows:

Transition Team – will consider and approve plans and recommendations made by the other integrations teams as well as discuss other topics as they arise;

Accreditation Team – will develop accreditation recommendations for review/approval;

Brand Team – will develop NewOrg's brand and visual identity;

Certification Team – will develop certification recommendations for review and approval;

Chapters/Sections Team – will develop recommendations for consolidating chapters/sections and establishing communities for NewOrg stakeholders;

Conferences and Events Team – will develop conference and events recommendations for review and approval;

Education Team – will develop education recommendations for review and approval;

Finance and Accounting Team – will develop a plan for integrating accounting structures and a financial strategy for NewOrg;

Governance Team – will review and provide feedback on governing documents and support strategic planning and research;

IT Infrastructure Activities Team – will develop IT infrastructure recommendations for review and approval;

Pre-Professional Activities Team – will develop pre-professional activities recommendations for review and approval;

Publications Team – will develop publications recommendations for review and approval; and

Standards Team – will develop recommendations for the standards development process and multi-year transition plan for existing standards.

SSPC and NACE noted that additional teams and focuses could be added as the transition progresses, and information from the teams will be highlighted in upcoming joint town hall meetings that are slated to be held every month through December. The first of these NACE-SSPC Town Halls took place as a Zoom meeting on Aug. 5; for information on future town halls, be sure to check sspc.org and nace.org for updates.

For those industries, the rule applies when materials being used contain greater than 0.1% beryllium by weight (1,000 ppm). However, employers using materials with a lesser beryllium content are exempt only "if the employer has objective data demonstrating that employee exposure to beryllium will remain below the action level of 0.1 µg/m3, as an eight-hour time weighted average, under any foreseeable conditions."

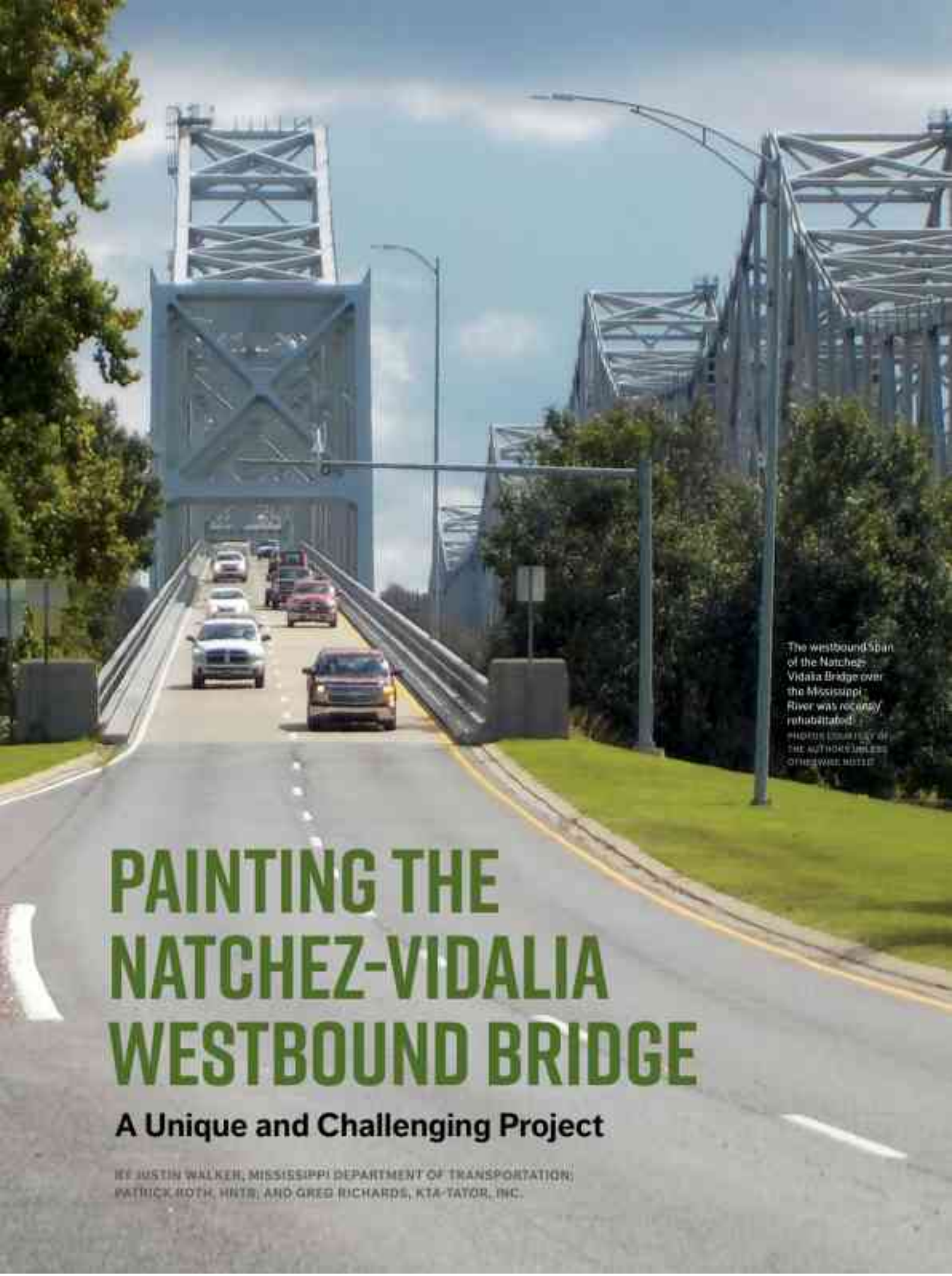
At the time, support material to the proposed rule change said that OSHA included construction and maritime based on data of above-action-level exposures related to abrasive blasting. The Department went so far as to single out coal and copper slags, which has been a point of contention in the industry.

An organization representing some suppliers of blasting abrasives, the Abrasive Blasting Manufacturers Alliance, argued during the original rulemaking process, and again after the publication of the rule, that there have historically been no cases of chronic beryllium disease known to have resulted from exposure via abrasive blasting.

The months and years that followed saw several revisions to the rule, primarily to the standards of the construction and shipyards industries.

In its latest press release, the DOL pointed out that many facets of the General Industry rule have been enforced for a while, saying, "OSHA has been enforcing most of the provisions for general industry since Dec. 12, 2018. The agency began enforcing the provisions for change rooms and showers on March 11, 2019, and engineering controls on March 10, 2020."

The compliance date of this final standard is Sept. 14, and the standard will affect approximately 50,500 workers employed in general industry and is estimated to yield minor net cost savings to employers, the Department added.



The westbound span of the Natchez-Vidalia Bridge over the Mississippi River was recently rehabilitated.

PHOTOS COURTESY OF THE AUTHORS UNLESS OTHERWISE NOTED

PAINTING THE NATCHEZ-VIDALIA WESTBOUND BRIDGE

A Unique and Challenging Project

BY JUSTIN WALKER, MISSISSIPPI DEPARTMENT OF TRANSPORTATION; PATRICK ROTH, HNTB; AND GREG RICHARDS, KTA-TATOR, INC.

The Natchez-Vidalia Westbound Bridge is a 4,205-foot-long through-truss structure that was built in 1940 and carries U.S. 84 westbound over the Mississippi River from Natchez, Mississippi, to Vidalia, Louisiana. The westbound portion is just one of a pair of twin bridges spanning the river.

The westbound bridge was recently repainted as part of one of the largest bridge rehabilitation contracts that the Mississippi DOT has ever awarded. The project involved the removal and replacement of all existing coatings in conjunction with replacing six pins and links in the through-truss sections. This was the first attempt to complete all of this work in a single project.

This article discusses the project coordination and partnering process initiated by the contractor between all parties to realize a full one-year closure for completion. Schedule coordination was imperative as certain areas on the bridge were closed to all construction activities, including vehicles during the pin replacement process, when the bridge was locked down with no movement allowed in those areas. The surface preparation and painting revolved around the pin replacement activities, and weekly coordination was crucial. The project also involved constant communication between the contractor and the QA inspectors to meet the schedule.

BACKGROUND

In the mid-1990s, after finding pin cover plates missing, MDOT and its consulting engineering firm inspected the pins and determined that several had shifted. The consulting engineer developed plans and MDOT promptly let a project to press the pins back to the original locations. However, the project was canceled after numerous failed bid attempts, and MDOT elected to monitor the pins. In 2012, it was determined that the pins were continuing to move, requiring significant repair or replacement.

With the size and complexity of the bridge and pins, MDOT requested that the Federal Highway Administration poll other state DOTs to determine if a pin

Original containment before starting pin replacement

In addition to cleaning and repainting work, the project included extensive pin replacements throughout the bridge.

replacement of this magnitude had ever been completed, and no such project was found. The consulting engineer also contacted several railroad agencies and was able to obtain guidance.

Because a pin replacement project of this size had not been conducted on a vehicular bridge, a preliminary project was developed and let in 2014 to replace only two of the pins, and that project proved to be highly successful. During the process, the paint system was evaluated and determined to be in a failed condition.

With the bridge being a major east-west route for both general traffic and commerce, MDOT and the Louisiana Department of Transportation and Development (LADOTD) decided that the remaining pins and paint system should be replaced. In 2017, a project that would close the bridge for one year to expedite the paint and pin replacements was let and awarded.

DESIGN CONSIDERATIONS

Pre-project design considerations began with looking at the successful replacement of the two pins and links in 2014, with the added difficulties of scheduling the painting and replacement operations so they would not interfere with one another.

When the bridge joints are "locked down" for the pin replacement operation, the bridge is in a vulnerable position because the joints cannot expand and contract as they were designed. Because the contractor was required to limit the time between when the temporary restraints supported the bridge and the new links were installed, a 96-hour time frame was established to complete each pin replacement. Temperature, wind and high-water levels were also considered when deciding when to "lock down" joints for replacement. The contractor was not permitted to engage temporary restraints when the forecasted 10-day temperature fluctuation was greater than 40 degrees, when the forecasted wind speed was expected to exceed 30 mph, or when an unusual high-water event was occurring or expected.

Strain gauges were installed on multiple truss members and the post-tensioning bars to ensure that the temporary restraints were properly transferring the load off the pin and link, as well as to evaluate any unforeseen losses in the restraints. The splice plates were also instrumented to evaluate stresses once the pins were removed. Because the temporary restraints would change the boundary conditions of the bridge to fixed (adding additional load in the truss and forcing the piers to flex), the piers were inspected prior to and after locking each joint. The initial inspection of the piers revealed numerous cracks, as expected for a mildly reinforced pier at 75 years of age. No crack growth was observed in the post-inspection.

The pre-project design considerations for the painting operations included developing an anticipated schedule of events centered around the pin replacement operations. MDOT had to consider how to prepare the surface and which coating system to use once the pin was removed on the interior of the casing. The MDOT standard, Special Provision 907-845-2, "Coating of Existing Structural Steel," was referenced. Throughout the partnering process, project revisions were made that will be discussed later.

SUBMITTAL REQUIREMENTS AND AWARD CONSIDERATIONS

MDOT advertised a Request for Qualification to short-list qualified teams. The painting and structural contractors were required to submit their statements of qualification to perform the work. The following categories were graded for each team:

- Experience and qualifications of key personnel;

Safe bridge access was provided for painting, pin replacements and subsequent inspections.

- The team approach to management of a contract; and
- Past performance on similar projects.

The "pin and link" replacement contractor was required to submit for MDOT Director of Structures approval, which details procedures and outlines means and methods for pin and link replacement operations, with consideration to the painting operations. The submittal included use of temporary restraints, staging of equipment on the bridge, schedule, sequence of construction and more.

Painting submittals included a contract QC plan per the SSPC-QP 1 requirements and a site-specific work plan. Environmental, health and safety plans were required to address pollution control, waste management and waste disposal. The containment plans were the most critical, as they had to accommodate the lockdown periods during the pin removal and replacement process. All parties reviewed the plan to ensure that it would not do any damage to the structure during the process. Other factors like ventilation, wind loading and verifying the containment was constructed to the requirements of the plans were carefully analyzed.

ACCESS AND CONTAINMENT SYSTEM

All coating operations, equipment and containment were not permitted to interfere

with or slow down the pin and link replacement operations. A "no load zone" was set up for each corresponding link replacement location. Only approved link replacement equipment was allowed in the "no load zone." Painting operations and equipment were not allowed in the "no load zone" from the time the post-tensioning bars were engaged until the new pins and links were installed; the length of the "no load zone" was up to 40% of the length of the truss. The contractor was also required to prepare a contingency plan addressing natural weather events such as tropical storms and unusually high river elevations, including the removal and reinstallation of the containment system.

The contractor had a 24-hour window from when the old link was removed to when the new pins and links were installed to set up containment and abrasive blast and paint the area inside the truss, which would become inaccessible once the new links were installed.

The specification required SSPC-SP 10/NACE No. 2, "Near White Metal Blast Cleaning," and application of a single coat of inorganic zinc in these areas. The original plans called for a full three-coat system; however, once the decision was made to reinstall the pin after a 24-hour period (for safety), the decision to use a single coat of IOZ was made.

MAINTENANCE OF TRAFFIC

U.S. 84 is a major east-west route for both general and local traffic and commerce, with a detour length of nearly 200 miles when closed. During the 2014 project, traffic was detoured head-to-head on the adjacent bridge while the contractor was replacing the pins, and this traffic plan proved to be effective.

The same approach was used in 2017 by establishing crossovers at each end of the bridge and putting traffic head-to-head on the adjacent bridge. However, the closure duration was only one year. Oversized traffic was required to schedule a police escort to use both lanes of the eastbound bridge or detour. This proved to be successful with the local traffic easily navigating the closure. LADOTD, MDOT, the City of Vidalia and the City of Natchez worked together to inform the traveling public and commercial haulers of the closure. The agenda for all partnering meetings included MDOT issues. Reps from both the City of Natchez and the City of Vidalia attended these meetings, which proved to be quite useful in solving traffic flow issues.

SURFACE PREPARATION AND COATING OPERATIONS

As previously mentioned, the specification required "Near White Metal Blast Cleaning" and a surface profile that met the coating

manufacturer's recommendation of 2–4 mils. Early on, the surface profile depth was an issue, and the contractor changed grit size to conform to the specification. Due to frequent weather events in the area, the contractor decided to remove all existing coatings, then go back and re-blast to achieve the SSPC-SP 10 requirements before requesting a QA inspection. The QA inspector conducted preliminary inspections during lunches and breaks and advised the contractor QC inspector of missed/non-compliant areas, which helped the project schedule and avoided long inspections before primer application.

During the initial primer application, the contractor applied a thin "hold-coat." However, this process led to missed areas and subsequent rusting, and was eliminated. Instead, the primer was applied within the specified range of 3–5 mils. There was also concern over excessive film-build around the rivets, so the stripe coat of primer was eliminated. Thorough QC and QA inspections were performed to ensure complete coverage of the primer. While time-consuming, the team considered this important and all agreed that it was worthwhile.

The epoxy intermediate coat was applied at 5–10 mils. QA and QC inspection personnel performed the stripe coat inspection at the time of application to enhance productivity. Missed areas were also corrected. After drying, the dry-film thickness measurements and visual inspection reverted to the normal QA/QC process.

The topcoat was an aliphatic polyurethane applied at 3–6 mils. The final inspections entailed checking all areas for DFT, visual appearance and coverage, which was challenging at the pin replacement locations. The team delayed final inspections in these areas as some damage was noted each time. Access had to be reestablished for final inspections, which proved to be difficult. The team tried a drone inspection on the outside faces, but it did not work well due to the sheer number of visual defects noted. Different access was provided to verify DFT and visual inspection and to complete the final repairs.

PIN REPLACEMENT

As part of the contract plans, the contractor was required to submit a detailed sequence of construction demonstrating means and methods for removing the pins and links. The contract plans also provided a suggested sequence of construction that the contractor adopted with minor modifications.

A temporary bypass that locks the joint from moving in all directions was developed to remove the pins and links. It was important for the temporary bypass to have internal redundancy plus alternate load paths to mitigate the risk of any one component compromising the bridge when the pins and links were removed. A series of bypasses were used to lock the joint, while the pier was expected to flex under thermal loads.

Only one pin and link location was permitted to be locked down and replaced at a time. The following steps were employed for the pin and link replacement operations.

Step 1 - Tension Diagonal Bypass: The diagonal bypass bars were tensioned to remove the load in the existing truss diagonal member, link and pin. Stressing operations were conducted in increments and member stresses were observed to ensure that the bypass was functioning as anticipated. Although the entire load would not be released until the pins were removed, it was preferred to minimize the load in the existing link to avoid the pins from binding and prevent sudden movement resulting from pin removal.

Step 2 - Tension Upper Longitudinal Restraint: Both the upstream truss and the downstream truss upper longitudinal restraints were tensioned to prevent the joint from moving longitudinally. The upper longitudinal restraints were designed for a 60-degree temperature drop, but stressed to accommodate a 40-degree temperature drop based on the 10-day weather forecast.

Step 3 - Weld Templates and Field Drill Splice Plate: Once the bridge was locked from moving, the splice plate templates were welded together and used to field-drill the splice plates. Field-drilling and splice plate installation were challenging due to the 100-plus A490 bolts per gusset face, but was completed with minimal incidents.

Step 4 - Install Top Strut Plates: The two top struts were connected to provide lateral

Thanks to coordination from all parties involved, the project was successfully completed during the one-year closure period.

additional rigidity in the event there were any unexpected lateral forces when the link was removed.

Step 5 - Install Lower Longitudinal Restraints: Shims were installed between the two false chord members and post-tensioned together to ensure continuous bearing between members.

Step 6 - Remove Pins: Because of the difficulty in previous attempts to reset the pins in 1997, the contractor elected to cut the pins with a diamond-studded wire saw. After cutting the pins, minimal change in force was observed in the links. No movement was observed in either joint during removal of the pins.

Step 7 - Line Bore Gusset Plates: The contractor line bored a 10 ½-inch to 10 ¾-inch hole through the existing gusset plates to ensure that the new pins would bear properly and fit.

Step 8 - Install New Pins: Once the final hole dimensions and centerlines were measured, the dimensions were sent to the fabricator and the new pins and links were turned down to their final dimensions and delivered to the bridge.

The new pins and links were able to be installed with minimal difficulty.

Step 9 - Remove Temporary Restraints: After the new pins were installed, the temporary restraints were disengaged, and load was transferred to the new pins and links.

PARTNERING FOR THE BEST PROJECT

With a project of this size, complexity and cost, it is critical that all parties communicate. The partnering process helped keep the project on schedule and helped avoid complications that would jeopardize the overall project. Also, because the project was a "one-of-a-kind" (other than the previous 2014 project, which did not include full removal and replacement of the existing coatings), an error could result in a bridge closure or a catastrophic collapse.

Despite all the risks and unknowns of the pin replacement process, the two-agency and five-firm team attributes preparation and communication as the keys to a well-run, successful project. Collectively, team members worked to add years of service life to the bridge. Though coordinating activities between two state agencies and multiple contractors is often a challenge, this project was different. The process went smoothly, and the project team gave a lot of feedback. Many of the contractor's suggestions were considered and applied, particularly on issues such as thermal movement or monitoring as well as sequence of construction between pin and link replacement and painting operations.

The contractor who was awarded the contract introduced an informal partnering process that benefited the entire project. The process was based on trust and an open, honest attitude in which all participants involved with the project recognized both common and individual objectives and worked to achieve those objectives through communication and cooperation.

The partnering process produced several outcomes that aided in completing a quality project on time and on budget. For example, decisions about the QA/QC inspection process for the painting were made that led to some side-by-side inspections, which accelerated the coating operations. Problems and challenges encountered were discussed to create workable solutions that did not impact the quality of the job.

CONCLUSION

The project went very well from MDOT's prospective. In addition to the coordination and communication, other factors that proved critical included the successful completion of the previous "test" project, good contingency planning and having on-site structural engineers conducting the inspection of the pin replacements, along with an extremely experienced paint inspection firm.

One major lesson learned was the ability to adapt to changes and conditions discovered in the field. Though each pin and link panel point was similar, they were also very different and behaved differently. The pin and link replacement operations at each location had a different challenge arise that had to be overcome.

The amount of pre-planning, including open meetings with all bidders to discuss the project requirements, was also critical to the successful completion. The informal partnering meetings were a complete success to solve issues that arose during the project. The critical review of all submittals, shop drawings and containment plans in a timely manner kept the project on budget and on schedule. **JPCL**

ABOUT THE AUTHORS

Justin Walker is the Director of Structures, State Bridge Engineer at the Mississippi Department of Transportation. He joined MDOT in 1997 as a bridge design engineer and has since served as design team leader, design section engineer and Deputy Director of Structures–Assistant State Bridge Engineer. He is a member of the Mississippi Engineering Society and the Structural Engineering Association of Mississippi and is the Vice Chairman of T17 Welding AASHTO Subcommittee on Bridges and Structures. He is also currently the MDOT voting member of the AASHTO Subcommittee on Bridges and Structures. Walker is a graduate of Co-Lin Community College and Mississippi State University, where he holds a bachelor's degree in civil engineering.

Patrick Roth is a Structural and Project Engineer and Bridge Inspection Team Leader with HNTB. He has more than 12 years of experience as a civil and structural engineer and bridge inspector in the New York City and Louisiana areas. He holds a bachelor's degree in civil engineering from Louisiana State University and is a registered Professional Engineer in Louisiana, Mississippi, New York and Texas.

Greg Richards is the Southern Area Manager for KTA-Tator, Inc., where he has been employed for more than 20 years. He manages projects in Florida, Georgia, Alabama, South Carolina, Texas and Tennessee involving bridges and other industrial structures. Richards is an SSPC-certified Protective Coatings Specialist, Bridge Coating Inspector (Level II), Protective Coatings Inspector (Level 2) and a C-3 Supervisor/Competent Person for Deleading of Industrial Structures, as well as a NACE-certified Coating Inspector (Level 3). He also serves as an instructor for SSPC's BCI course, as well as NACE courses.

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SSPC The Society for Protective Coatings

2020 STRUCTURE AWARDS SERIES

The annual SSPC Structure Awards recognize the work of teams of contractors, designers, end users and coating manufacturers for excellence on protective coatings projects. The 2020 Structure Awards were presented Feb. 3 during the annual awards luncheon at SSPC Coatings+ 2020 in Long Beach, California. This series will run throughout 2020 and profile each award-winning project in detail.

IN THIS ISSUE:
City of Celina, Mesa del Sol and Valley Crest Water Tanks

Coatings Industry Spirit Award

CELINA TANK

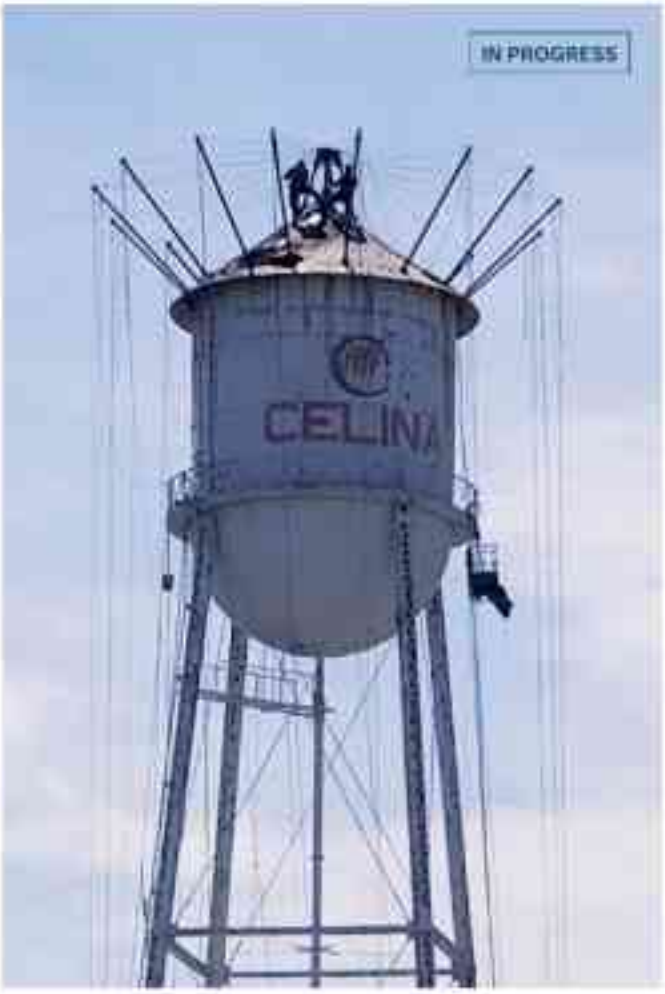
CELINA TANK PROJECT AT A GLANCE
Structure Owner: City of Celina, Texas
Contractor/Applicator: Viking Industrial Painting
Coating Material Supplier: Tnemec Company, Inc.
Coating Distributor: The Barry Group LLC
Engineer: Dunham Engineering, Inc.

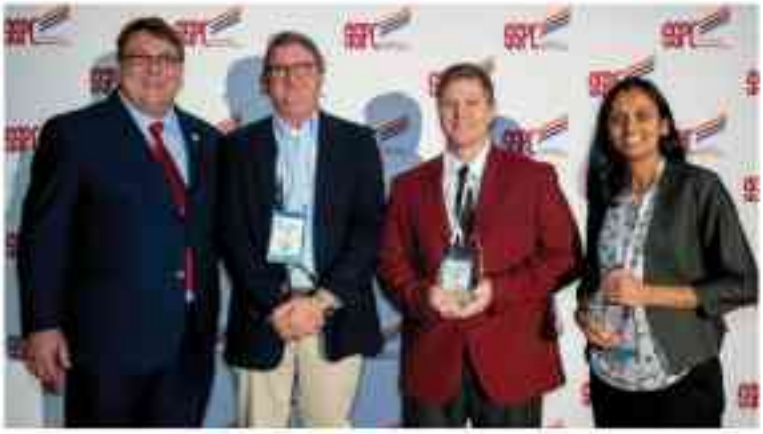
The 2020 Coatings Industry Spirit Award, which recognizes extraordinary service benefiting a community or the industry, went to the City of Celina Elevated Water Tank project, a 95-year-old, 75,000-gallon tank that had been exhibiting deterioration high above the town for decades.

There are few icons that define a rural town's—or a bigger city's—roots more than the elevated water tower, and keeping such a landmark standing and aesthetically pleasing is often important to its community. Bringing the tank back to life was especially important for the City of Celina, which has seen a fast-growing population rise in recent years.

The Celina tank was built in 1925 and had received minimal maintenance since, including an unsatisfactory overcoating job in the 1990s. The owners elected

Repainting work transformed one of the City of Celina's aging water tanks (above and left) into a fresh-looking local landmark (facing page). The tank was originally built in 1925 and had received minimal maintenance since. PHOTOS COURTESY OF DUNHAM ENGINEERING INC.





Pictured, from left: Joe Walker, President, SSPC; Pat Barry, Barry Group LLC; Wesley Oatman, Dunham Engineering Inc.; and Swapna Konda, City of Celina.
COURTESY OF SSPC

A containment system (above) was set up to complete coating work on the tank.

The finished tank (right, top and middle) is now a mark of pride for the city.

for a full blast and recoat, complete with application of the city's logo, to give the tank a new look as the city grows into its future.

The tank was removed from the water system during the project. As the existing coatings tested positively for heavy metals, a Class 2A containment system had to be built around the tank structure during surface preparation and coating work. The exterior of the tank was abrasive blast-cleaned with copper slag abrasive, and the coatings and logo design were applied with a fluoropolymer finish.

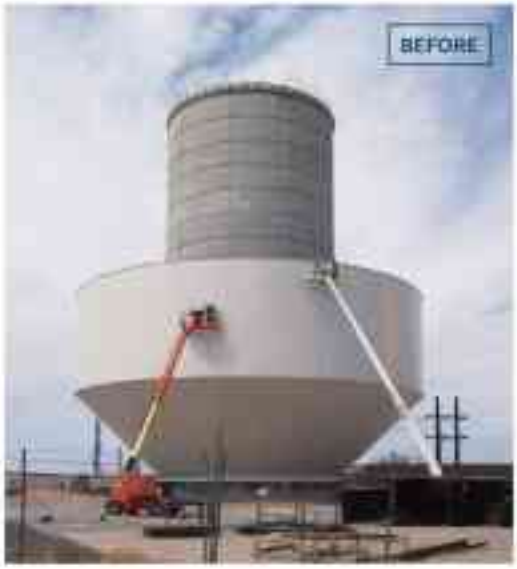
The finished tank now stands as a mark of pride, representing Celina with its new painted logo that is expected to withstand UV light degradation and provide long-term gloss and color retention with good resistance to abrasion and chalking. This water tower is an example of coatings providing more than just protection, but also adding aesthetic value to a structure.

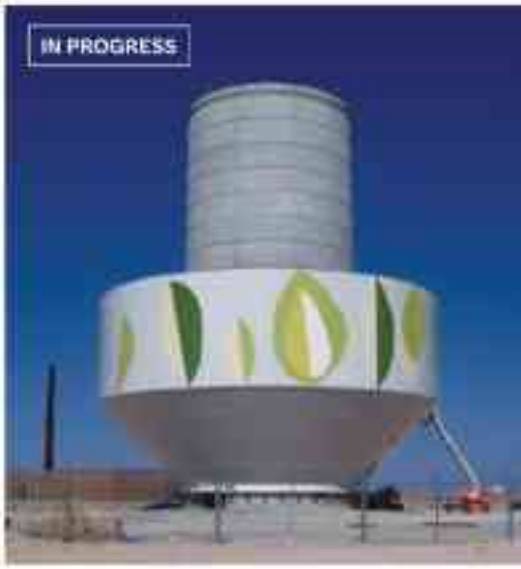
SSPC 2020 STRUCTURE AWARDS SERIES

Charles G. Munger Award

MESA DEL SOL TANK

MESA DEL SOL TANK PROJECT AT A GLANCE
Structure Owner: Albuquerque Bernalillo County Water Utility Authority
Contractor/Applicator: Landmark Structures
Coating Material Supplier: Sherwin-Williams Protective & Marine
Engineer: Bohannon Huston, Inc.





The 2 MG, 175-foot-tall Mesa Del Sol elevated tank (right) is a composite-style tank with added aesthetic features. The welded steel tank was constructed at ground level (below, left) to make coating operations safer and easier. Contractors free-hand applied the leaf design to the tank's exterior (below, right). When it was finished, the tank was raised to the top of the concrete tower. PHOTOS COURTESY OF SHERWIN-WILLIAMS PROTECTIVE & MARINE

The Charles G. Munger Award acknowledges a structure that demonstrates longevity of the original coating. The structure may have had spot repairs or overcoating with the original coating still intact. This year's Munger Award-winning project involved painting the 2 million-gallon Mesa del Sol elevated water tank in Albuquerque, New Mexico.

In 2007, the owners were planning to construct a composite-style tank, with a reinforced concrete pedestal with a welded steel water tank on top. Composite-style tanks can allow for less maintenance than other traditional elevated tank styles, as the concrete stem means less steel to clean and coat over the course of a tank's life cycle.

However, the tank owner wanted a colorful logo displayed on the exterior of the steel tank, and selected a native white oak tree pattern to be free-hand painted. The owners knew that traditional urethane coatings available at the time would lose color and gloss quickly in the intense New Mexico sun, and the tank would likely need to be recoated in less than 10 years. Instead, the owner selected a new high-solids, low-VOC fluoropolymer urethane coating for the tank design, which would extend the tank's maintenance cycle for up to 25 years, according to the coatings manufacturer.

Today, 12 years after the initial coating and nearly halfway through the expected 25-year service life of the exterior coating, the Mesa Del Sol tank is still as shiny as it was when it was first coated, showing no flat spots or down-glossing that would indicate a loss of film thickness. Based on the tank's current condition, the owner is likely to realize an even longer service life.

The steel tank was erected and welded together around the concrete pedestal structure at ground level and coated prior to raising the entire tank and securing it at the top of the 175-foot-tall pedestal. Constructing and coating the tank at ground level not only minimizes the need for elaborate containment processes but is also safer and easier for applicators who can work from manlifts only 50 feet off the ground.

Before application of the fluoropolymer, the tank exterior received a shop-applied sacrificial pre-construction zinc-rich primer. After the tank was constructed in July 2008, applicators sprayed a field primer coat of zinc primer and an intermediate coat of a polyester-modified

aliphatic acrylic polyurethane at 2–4 mils DFT. Finally, applicators painted the leafy pattern of green, brown, yellow and white shades using the fluoropolymer applied at 2–4 mils DFT, followed by an additional clear coat over the design for added protection. The tank interior was also coated with a three-coat zinc-epoxy system, and the lining is reportedly still in excellent condition today.

Pictured, from left: Walker and Bob Murphy (Retired), Sherwin-Williams Protective & Marine. COURTESY OF SSPC

William Johnson Award

VALLEY CREST TANK

VALLEY CREST TANK PROJECT AT A GLANCE
Structure Owner: Golden State Water Company
Contractor/Applicator: Crosno Construction
Coating Material Supplier: Tnemec Company, Inc.
Muralist: Artist Brothers, Peter and Rolf Goetzinger
Designer/Inspector: CSI Services, Inc.

The William Johnson Award is given for outstanding achievement demonstrating aesthetic merit in industrial or commercial coatings work. This year's William Johnson Award went to a tank painting project at the Valley Crest Water Plant in Apple Valley, California.

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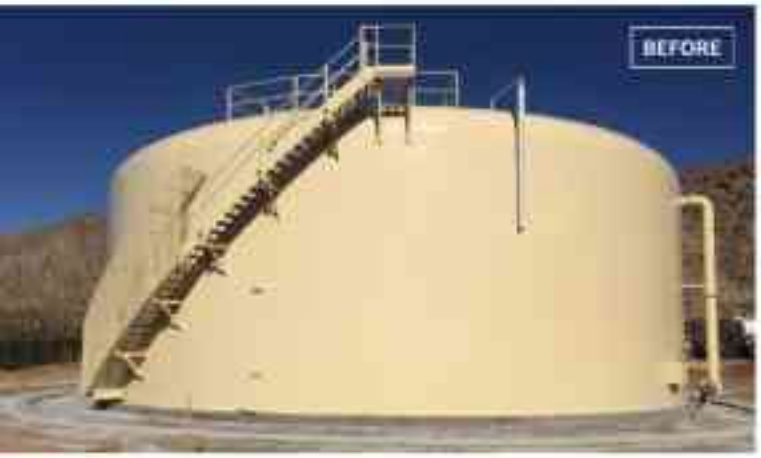

The water tank and adjacent pump house were painted with a rock design (above) by a longtime muralist and water tank artist. The original appearance of the Valley Crest water storage tank (left) brought complaints from the surrounding community.
PHOTOS COURTESY OF THOMEC COMPANY, INC.

In 2015, a ground storage tank was constructed and coated at the Valley Crest Water Plant. However, shortly after its completion, representatives from a nearby church and cemetery started hearing complaints about the structure's bland appearance, and they asked the owners if it was possible to change the look of the tank.

The owners enlisted the help of the contractor, who cleaned and scarified the existing aliphatic acrylic polyurethane coating and applied a new base coat of a low-VOC, low-sheen fluoropolymer typically used as a finish coat. However, the owners took it a step further by enlisting a long-time mural and water tank artist to create a unique finish for the tank.

The rock design was created and painted by the artist, who used the low-VOC fluoropolymer coating in several colors to finish the water tank. The muralist also painted the nearby pump station in a similar motif, utilizing a water-based, low-VOC acrylic polymer coating on the building's concrete exterior.

The repainting project was completed in May 2019. The owners, applicators and surrounding community reportedly are now much happier with the design and its unconventional appearance. In addition to the unique end result, all coatings used during the project met the requirements of the South Coast Air Quality Management District, which has some of the country's most stringent regulations on coatings and air quality. **JPCL**

Pictured, from left: Walker; Beth McDonough, Ben Jimenez and Kirk Phillips, Golden State Water Company; Mitch Scott, Crosno Construction; Patrick Sweeney, CSI Services, Inc.; and Tony Hobbs, Thomec Company, Inc. COURTESY OF SSPC

ANTIFOULING COATINGS: A NEED FOR INNOVATION

STEWART SUTTON / GETTY IMAGES

BY BRUNO RAVEL, ET AL., SAFINAH GROUP

The settlement of marine species on ships' hulls results in economic penalties and could cause environmental damage. The accumulation of biofouling leads to increased hull roughness, which has a direct impact on fuel consumption and consequently the emission of air pollutants from ships, and increased risk of translocating non-native, potentially invasive species.

The most significant financial penalty for the shipping industry is the increase in fuel consumption due to the adverse effects on hydrodynamic performance, as shown in Table 1. Additional maintenance costs arise from biofouling growth in seawater intakes, heat exchangers and other system components. Hull fouling affects the overall ship energy efficiency and therefore ship owners' ability to meet their carbon footprint reduction goals.

The implementation of IMO's 2020 regulation in relation to SOx emissions, which prohibits the use of fuel exceeding 0.5% sulfur unless the vessel is fitted with an approved exhaust gas cleaning system (scrubber), is one of the main challenges the industry faces. Compliance with sulfur limits, whether in the form of scrubber retrofits or the use of alternative fuels, comes at a significant cost. Fuel efficiency is critical for all vessels especially during the transition period that is likely to be characterized by fuel price fluctuation.

Any surface immersed in seawater is covered by a conditioning film within minutes. This is followed by the development of microfouling (slime) and macrofouling (weed and animal fouling) within two to three weeks (Fig. 1). The abundance and richness of fouling organisms depends on

Table 1: Roughness and Fouling Penalties[1]

HULL CONDITION	ADDITIONAL SHAFT POWER TO SUSTAIN SPEED (%)
Freshly applied coating	0
Deteriorated coating or thin slime	9
Heavy slime	19
Small calcareous fouling or macroalgae	33
Medium calcareous fouling	52
Heavy calcareous fouling	84

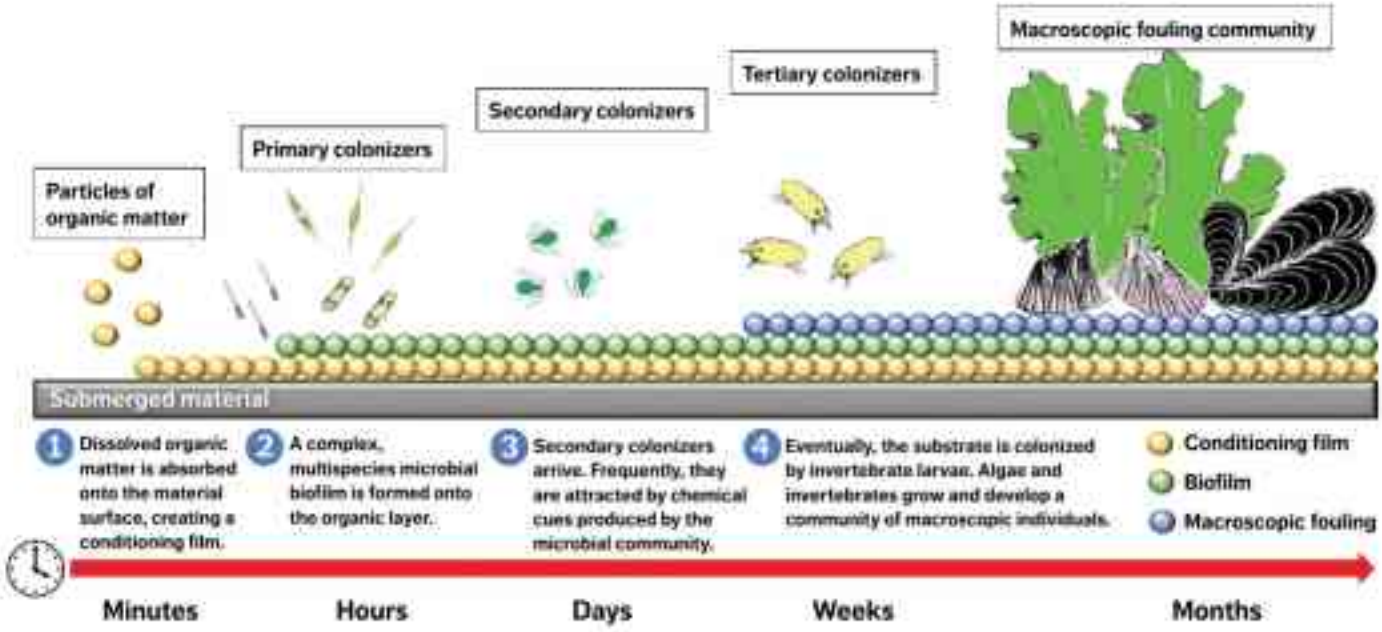

Fig. 1: Biofouling mechanism of immersed surface[2] COURTESY OF PLOS ONE

environmental conditions, such as seawater temperature, salinity, pH and nutrient availability among others (Fig. 2). The tenacity of the fouling to adhere to the hull depends on the ability of the coating to control fouling. Average sea surface temperatures are expected to increase due to climate change, which will likely increase the risk of fouling.

Ineffective fouling control increases the likelihood of transferring non-native, potentially invasive species, thereby posing a risk to biodiversity. The eradication of invasive species is a difficult, time-consuming and expensive process. Minimizing biosecurity threats arising from translocating non-native species is a growing concern for governments and international regulatory bodies worldwide. There are examples of vessels being ordered out of territorial waters due to excessive biofouling that was considered a biosecurity threat. Such occurrences lead to delays and additional costs in terms of demurrage, biofouling management and opportunity costs for the owners and operators.

In an attempt to provide a globally consistent approach to biofouling management, in 2011 IMO MEPC adopted, "Guidelines for the Control and Management of Ships' Biofouling to Minimize the Transfer of Invasive Aquatic Species." These were supplemented by, "Guidance for Minimizing the Transfer of Invasive Aquatic Species as Biofouling Hull Fouling) for Recreational Craft."

As these Guidelines are not yet internationally binding, some regulators have developed national or federal regulations that require evidence of proactive biofouling management strategy to be submitted as per the recommendations in the Guidelines. For example, in the U.S., California requires all vessels to provide an active biofouling management plan or record book as of January 2018, and to submit an Annual Vessel Reporting Form at the first visit of each calendar year. In New Zealand, biofouling management is governed by the Craft Risk Management Standard, according to which all vessels must arrive with a "clean hull." The definition of a clean hull varies according to a vessel's itinerary—for example, a short-stay (<21 days stay) permits a slime layer, gooseneck barnacles and small amounts (<5% cover) of "incidental" fouling.

Maintaining a hull free of biofouling can be challenging and once the ship hull is fouled, the options available to ship owners and operators are limited and can be costly and time consuming, including the following.

In-Water Operations (Cleaning): Proactive in-water cleaning, also referred to as grooming, is a strategy being explored by some operators. However, in-water

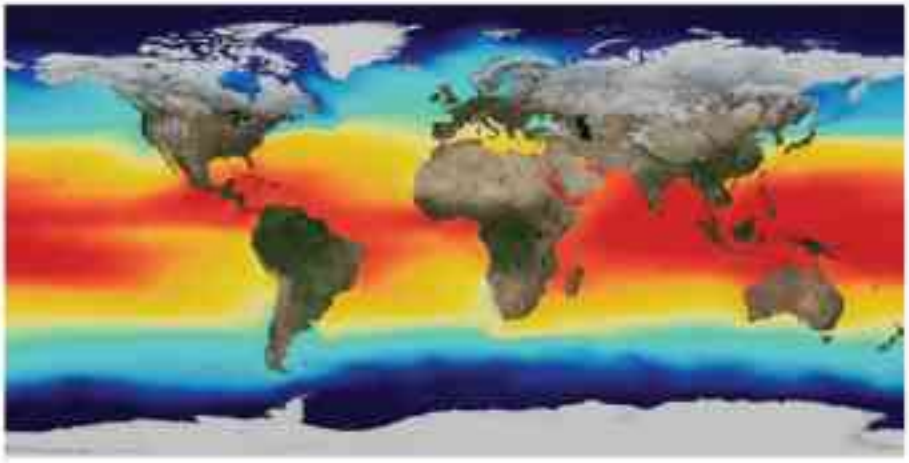

Fig. 2: Global seawater temperature COURTESY OF NASA

operations need to be carefully planned and managed as cleaning frequency and method can have a serious impact on coating performance, longevity and integrity. In-water operations are also under scrutiny from regulators due to concerns regarding chemical contamination from the resulting release of biocides. It is likely that regulators will require data on chemical discharges generated via different types of in-water operations. Restrictions and bans on in-water operations are being introduced in different locations, which poses additional complications for vessel operations and difficulty in complying with biofouling management regulations worldwide.

Repairs in Dry-Dock: The need for a vessel to dry-dock is driven by regulatory requirements and interdocking intervals vary based on age of the vessel and other factors. Repairs involve a high-pressure freshwater wash-down, followed by ultra-high pressure (UHP) waterjetting or abrasive blasting to remove any damaged coatings. Once the full/spot blasting is complete, the anti-corrosive, tie coats and then the fouling control coatings are applied. Removed coatings, fouling and slime and used blasting grit must be treated as hazardous waste. Water used for UHP washing is normally filtered, while spent and empty paint cans have to be collected and treated accordingly.

Taking these factors into account, choosing the appropriate method of fouling control is difficult. When selecting the optimal solution, coating performance is no longer defined by fouling control properties alone. Coatings need to provide reliable and predictable fouling control under a variety of operational conditions while being capable of withstanding potential increasing frequency of in-water operations.

"Optimal coating performance" is a relative term defined and understood in different ways by the various parties involved in the process. Examples of some of the parameters used to define "coating performance" include:

- For ship owners, predictable performance and minimal costs associated with biofouling management and fuel consumption, reduced hull maintenance and emergency cleaning due to restrictions;
- For regulators, a minimal risk of translocating invasive species and contaminating territorial waters, low emission levels; and
- For shipyards/applicators, a simplified coating process to improve productivity, ease of repair, minimal time to immersion in various types of environment (freshwater and seawater), good static performance during outfitting periods. Shipyards tend to be reluctant to modify a coating process to accommodate a new product or process unless it benefits their production activities.

Due to the number of factors affecting coating performance in terms of fouling control, the selection process becomes crucial as the performance and properties of existing products need to be understood and matched to each ship's trading pattern to achieve optimal in-service performance.

BIOCIDE-FREE TECHNOLOGY

Fouling control is achieved using both biocide-free technologies and biocidal coatings. Types of biocide-free technologies currently available include foul-release coatings, hard coatings, ultrasonic technologies and more, and their characteristics are as follows.

Fouling release coatings (FRCs) are typically based on a silicone matrix and are characterized by their low surface energy and elastomeric nature, which prevents fouling attachment. However, FRCs have been prone to slime fouling, which can still have a significant effect on the vessel performance. FRCs are more suitable for high-activity, faster vessels, although recently developed products claim improved performance at lower speeds. The application process for silicone-based coatings can also be challenging due to the need for masking and use of dedicated application equipment, which adds time and cost to the operation. As a result, many shipyards are still reluctant to apply FRCs—particularly at newbuilding.

Recently, a different approach has been adopted, incorporating a biocide into the

FRC formulation. This approach is claimed to reduce the problems associated with slime attachment and provide improved performance under extended static periods.

Hard coatings are typically based on epoxy and vinyl ester technologies and contain no biocides and foul relatively quickly. Due to their good mechanical properties, they can be subjected to regular in-water operations (cleaning or grooming) without damaging the integrity of the coating. These coatings offer good abrasion resistance and are suitable for cold climates and navigation in ice-prone water passages. However, due to regional and local restrictions and bans, planning and executing regular in-water cleaning operations can be challenging for vessels not operating on a fixed route.

Other biocide-free technologies include the use of ultrasonic technologies, UV lights and hull aeration. Despite promising results in some cases, alternative technologies vary in level of readiness with challenges related to scaling up, maintenance and additional power requirements. In addition, some of the technologies may not be suitable for the entirety of the underwater hull.

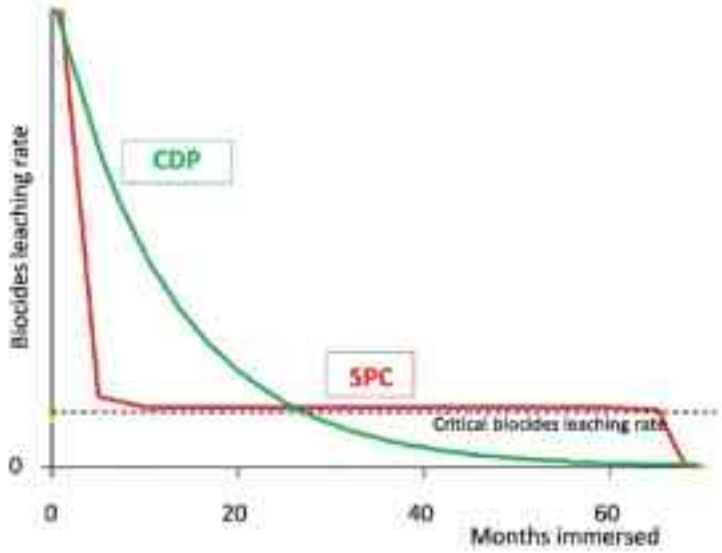

Fig 3: Biocide release rate in SPC and CDP antifoulings COURTESY OF THE AUTHOR

As overcoming such challenges takes time and continuous R&D efforts, liquid coatings and especially biocidal coatings are likely to continue to dominate this market and to be

the preferred fouling prevention solution for the foreseeable future.

BIOCIDES

Biocides in antifouling coatings prevent the attachment of different types of fouling (animal, weed and slime) on the underwater hull. In order to be effective across the entire range of fouling organisms, a combination of biocides is generally used.

A typical biocide package comprises a blend of an inorganic biocide (cuprous oxide) and one or more booster biocides (organic and/or organometallic) in order to be effective across a spectrum of target organisms. Seawater salinity, temperature and pH are some of the factors that can influence the effectiveness of the biocide combinations.

Over the years, environmental concerns on the use of cuprous oxide has led researchers to investigate its reduction or replacement in antifouling coatings. In some locations, regulators have set copper release rate limits as part of the registration process for coatings. For example, in California the maximum allowed copper leach rate for recreational boat products is 9.5 ug/cm2 per day. In Washington, a ban on the use of copper-based antifouling on recreational vessels is being discussed.

The selection of the booster biocide is critical as it will dictate the efficacy of the antifouling coatings against slime and weed fouling. Some booster biocides have also been found to have some effect against barnacles, which can lead to potential reduction in the amount of cuprous oxide used in the formulation.

Ideally, the biocide would be developed specifically for the antifouling market. However, many of the biocides in current use have been developed for other markets such as the agricultural industry and have then found additional uses in antifouling coatings.

BIOCIDAL COATINGS

In very general terms, a biocidal coating comprises a soluble, or partially soluble, resin system containing a mixture of biocides effective against a broad range of fouling organisms. Biocidal coatings primarily differ by the resin system used, also referred to as "delivery mechanism," and the level and type of biocides. The solubility of the resin system and the efficacy of the biocides used are the key parameters determining the overall performance of the coating.

Biocidal antifouling coatings are the most widely used technology for fouling control. They are generally quite effective against fouling but the perfect coating has yet to be formulated. Current products would benefit from improved antifouling performance over extended static periods.

The two oldest types of biocidal coatings are Controlled Depletion Polymers (CDPs) and Self-Polishing Copolymers (SPCs). A comparison of their biocide release rates is shown in Figure 3. More recently, hybrid systems have been introduced. These are effectively a blend of CDP and SPC technologies.

CDPs utilize a combination of soluble resin (typically rosin) and an insoluble resin. Varying the ratio of soluble to insoluble material allows adjustment of the rate of dissolution and hence the rate of release of biocide. This enables the antifouling coating to be tailored to the trading pattern of the ship. Once in water, the soluble resin begins to dissolve and the biocide leaches out into the surrounding seawater, leaving a depleted zone (insoluble resin) at the surface. This is called the leach layer. The thickness of the leach layer increases over time slowing the biocide release to a point where it is no longer as effective at preventing fouling. This point is reached typically after three years.

The most common SPC binder systems are based on copper acrylate, zinc acrylate, silyl acrylate or silyl methacrylate. These resin systems dissolve or "polish" in a controlled manner via a chemical reaction with the seawater, maintaining a leach layer of a constant thickness. This results in a controlled biocide release rate and predictable fouling control performance. As with CDPs, careful selection of the SPC resin and associated biocide package enables fine tuning of the system to match the fouling control requirements of ships. Selecting the right

product results in long-term fouling prevention of up to 5 to 7.5 years in some cases.

Hybrid antifoulings are carefully formulated blends of CDP and SPC technologies, balancing ultimate performance against costs.

New developments in booster biocides will expand the range of options open to the formulator and aid in the development of antifouling coatings with predictable performance. However, few new biocides have been recently commercialized due to the overall costs and time frame involved with registration and proof of performance.

REGISTERING AN ANTIFOULING FORMULATION

New biocides and any antifouling coating containing them must go through the registration process. Both existing and new biocidal active substances must be registered—typically by the manufacturer—in locations where biocidal products (antifouling paints) are to be used. The extensive regulatory dossier requirements are costly, however, and there is a lack of uniformity between countries.

Once granted, registration is reviewed on a regular basis. In Europe, the review/renewal of biocides is governed by the Biocidal Products Regulation and it varies from 5 to 10 years depending on the type of approval gained. Active substances that are not classed as a candidate for substitution are approved for up to 10 years, and active substances that are classed as candidates for substitution are approved for up to 7 years (or 5 years when they meet one or more exclusion criteria).

Biocidal active substances (copper oxide and booster biocides) are under regulatory pressure, and some may not be renewed in the future, may be restricted, or approved on a shorter timeframe if they meet one of the following exclusion criteria:

- Carcinogens, mutagens and reprotoxic substances categories 1A or 1B according to the Classifying, Labeling and Packaging regulation;
- Persistent, bioaccumulative and toxic substances;
- Endocrine disruptors; and
- Very persistent and very bioaccumulative substances.

The range of biocidal active substances available to the formulators to develop new antifouling paint is therefore highly likely to decrease in the future.

In the same way as biocides, antifouling coatings must be registered where they are intended to be used. In this instance, registration is normally carried by the paint manufacturer. Paint manufacturers are unlikely to undertake the expense of paint registration without either a performance, environmental or cost benefit or a need to substitute a biocidal active substance no longer approved or available.

To demonstrate the antifouling performance and convince shipowners and operators, the antifouling paint must be tested in different environmental conditions over a significant period (typically >3 years) on multiple test patches and full vessel applications. The timeframe and extent of testing will depend on whether it is a new development or a modification of a current product. The regulatory cost for paint manufacturers can vary greatly depending on the active substance approval timeframe obtained (5 years to 10 years).

PROMISING INNOVATION

Both the coatings industry and the biocide industry have been working on innovative approaches to optimize the controlled delivery of biocidal substances. One of these approaches—encapsulation technology—is a promising innovation for the controlled release of biocides, to maximize paint performance whilst managing the risk to man and the environment.

Encapsulation technology can offer:

- A more linear and predictable biocide release rate between drydock intervals;
- Lower and controlled release rates that deliver more environmentally sustainable marine antifouling paints while providing full performance against target organisms;

- Reduction in the bioavailability of hazardous substances in the antifouling paints to provide safer products during storage, handling and spraying application; or
- Improved overall environmental and human risk assessments at product authorization level, making encapsulated technology a more regulatory sustainable solution for the industry.

CONCLUSIONS

Shipowners and operators are under increasing pressure to control costs and to comply with emissions to air and sea. As part of this compliance, they must rely on fouling control based on biocide-free or biocidal coatings, compliant with national and international regulations.

While foul-release systems continue to perform effectively only in certain sectors and come with associated complex application requirements, biocidal options are likely to remain dominant in the market for the short- to medium-term.

With the available range of registered biocides potentially reducing year by year, paint companies need access to new biocides to develop new and more predictable underwater hull coatings. Shipowners can assist with this by working closely with the paint suppliers to help bring to market new, innovative and more sustainable fouling control solutions.

Against this background, there is a clear need for continual innovation to ensure that new environmentally friendly materials are available that will enable the development of new products for the marine industry. **JPCL**

ABOUT THE AUTHOR

Bruno Ravel is a coatings consultant with Safinah Group, which provides independent support to the marine, energy, infrastructure and yacht industries, primarily in paint and coating issues, as well as engineering and design for shipbuilding, ship repair and conversion projects worldwide. Ravel has a background in formulation and polymer chemistry and has extensive knowledge in coatings products chemistries.

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CALENDAR

SEPTEMBER 2020

SSPC COURSES: *Course information available at sspc.org*

Sept. 5–6	C7 Abrasive Blast, Portsmouth, VA
Sept. 7–11	CCI Conc Ctg Insp, Manchester, UK
Sept. 9–10	C7 Abrasive Blast, Theodore, AL
Sept. 9–11	C2 Plan/Spec, Hammond, IN
Sept. 11–12	C12 Spray App, Theodore, AL
Sept. 12	PCS Prot Ctgs Spclst, Hammond, IN
Sept. 14–15	C7 Abrasive Blast, Suffolk, VA
Sept. 14–16	Aerospace Maint, Pittsburgh
Sept. 14–17	C3 Lead Pt Removal, Warren, MI
Sept. 14–18	Coast Guard Basic Pt Insp, San Diego
Sept. 14–18	NBPI NAVSEA Basic Pt Insp, Virginia Beach, VA; San Diego
Sept. 14–18	C1 Fundamentals, Grand Rapids, MI
Sept. 14–20	PCI Prot Ctgs Insp, Santa Fe Springs, CA
Sept. 16	CAS Refresher, Jacksonville, FL
Sept. 16–17	C12 Spray App, Suffolk, VA
Sept. 17–18	CAS Ctg App Spclst, Jacksonville, FL
Sept. 18	CAS Refresher, Chesapeake, VA
Sept. 18	C5 Lead Pt Refresher, Warren, MI
Sept. 19–20	CAS Ctg App Spclst, Chesapeake, VA
Sept. 21	CAS Refresher, Portland, OR
Sept. 21–22	C7 Abrasive Blast, La Porte, TX
Sept. 21–23	C7 Abrasive Blast, San Diego
Sept. 21–25	CCI Conc Ctgs Insp, Tempe, AZ
Sept. 21–26	BCI Bridge Ctgs Insp, Warren, MI
Sept. 22–23	CAS Ctg App Spclst, Portland, OR
Sept. 24–26	C12 Spray App, San Diego
Sept. 28–Oct. 1	Aerospace Eng, Pittsburgh
Sept. 28–Oct. 2	PCI Prot Ctgs Insp, San Diego
Sept. 28–Oct. 4	PCI Prot Ctgs Insp, Yogyakarta, Indonesia

CONFERENCES & MEETINGS

Sept. 7–11	Virtual EUROCORR 2020, eurocorr.org
Sept. 14–16	IBTTA Virtual Annual Mtg/Exhibition, ibtta.org
Sept. 29	NACE Nonmetallics Virtual Seminar, nace.org