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SSPC 2018 STRUCTURE AWARD WINNERS

Seven outstanding projects in the protective coatings field from the past year were honored with SSPC Structure Awards at the SSPC 2018 awards luncheon, held Jan. 15 at the Ernest N. Morial Convention Center in New Orleans.

E. CRONE KNOY AWARD

The E. Crone Knoy Award, recognizing outstanding achievement in industrial or commercial coatings work that demonstrates innovation, durability or utility, went to the Sperry Communications Tower project in the city of Eagan, Minnesota. The 178-foot-tall tower went up in place of a decommissioned water tower that had communication equipment on it, and aesthetics were important as the tower is a landmark for

The Sperry Communications Tower exemplifies both utility and aesthetics. Photo courtesy of Short Elliott Hendrickson (SEH) Inc.

(L-R): SSPC President Brian Skerry and Dan Zienty, SEH Inc. Awards ceremony photos courtesy of SSPC.

the growing city. The tower's tri-tubular superstructure and steel access platforms were hot-dipp galvanized, and the communications equipment is screened by specially manufactured removable panels, which were shop painted with a moisture-cured urethane satin-finish to reflect lighting outward.

The project was carried out for the City of Eagan by contractor STEALTH Concealment Solutions Inc., in conjunction with engineer Short Elliott Hendrickson Inc. and coating supplier The Sherwin-Williams Company.

ERIC S. KLINE AWARD

The Eric S. Kline Award recognizes outstanding achievement in industrial coatings work performed in a fixed shop facility. This year's Kline Award when to the John Greenleaf Whittier Memorial Bridge project, owned by the Massachusetts Department of Transportation.

A new twin-arch structure replaced the previous John Greenleaf Whittier Memorial Bridge. Photo courtesy of PPG Protective and Marine Coatings.

Michael Hewins, Massachusetts DOT–Highway; Ken Allgair, Canam-Bridges; Skerry; and Mark Edwards, PPG Protective and Marine Coatings.

The old Whittier bridge structure was replaced with a new twin-span steel-arch bridge that was metalized and shop-coated with an epoxy-urethane coating system. The coating was undertaken by contractor Canam-Bridges with coatings supplied by PPG Protective and Marine Coatings.

GEORGE CAMPBELL AWARD

The George Campbell Award is given in recognition of a single outstanding achievement in the completion of a difficult or complex industrial coatings project. This year the award was given to two projects.

The Lewis and Clark Bridge project, carried out by contractor Champion Painting Specialty Services Corp. (SSPC-QP 1, QP 2), with materials supplied by Carboline Company, was one recipient. Walsh-Vinci JV served as the general contractor on the project, owned by WVB East End Partners LLC.

The Lewis and Clark Bridge project was awarded because of the tight time line the contractors adhered to and the challenges they overcame to make a Nov. 15 opening date for the span, including outside temperatures dipping to 8 degrees F. Surfaces on the bridge spanning the Ohio River in Louisville, Kentucky were pressure-washed in accordance with SSPC

Extreme temperatures and a tight timeline for completion made the Lewis and Clark Bridge project a challenge. Photo courtesy of PPG Protective and Marine Coatings.

Duane Hough, Champion Specialty Services Corp.; Michael Woodward, Carboline Company; Skerry; and Kevin Bunch, Walsh Construction.

WJ-4, spot power-tool cleaned according to SSPC-SP 3, and coated with zinc, epoxy and urethane systems.

The U.S. 190 Mississippi River Bridge, owned by the Louisiana Department of Transportation, also won a Campbell award. The Liberty Maintenance/Alpha Painting JV carried out the coating job with materials supplied by Sherwin-Williams, under the guidance of engineering firm Modjeski and Masters, superintendent American Bridge Company and consultant KGC Environmental Services.

The 75-year-old bridge in Baton Rouge was chosen due to the challenges of finding pitting and corrosion that in many cases could not be identified

The contractors cleaned and recoated over 3.5 million square feet of surfaces on the U.S. 190 Mississippi River Bridge. Photo courtesy of Modjeski & Masters Inc.

Larry Toups, Modjeski and Masters Inc.; Shawn Wilson, Louisiana Dept. of Transportation and Development; Skerry; Tom Kousisis and Nick Frangos, Liberty-Alhpa JV; Justin Beitzel, KGC Environmental; and Tom Barber, The Sherwin-Williams Company.

until after blasting, and keeping the bridge open to vehicular and rail traffic during the project. Blast support equipment was staged at ground level on each bank of the river and ventilation and abrasive blasting and grit recycling vacuums were piped to the proper location across the truss spans of the bridge. The contractor estimated a total of over 3.5 million square feet of bridge surfaces were cleaned and coated during the project.

MILITARY COATINGS PROJECT AWARD OF EXCELLENCE

The Military Coatings Project Award of Excellence was awarded to the *USS Missouri* Battleship project, undertaken by Pacific Shipyards

The *USS Missouri* Battleship commemorates the defeat of Japan in WWII. Photo courtesy of PPG Protective and Marine Coatings.

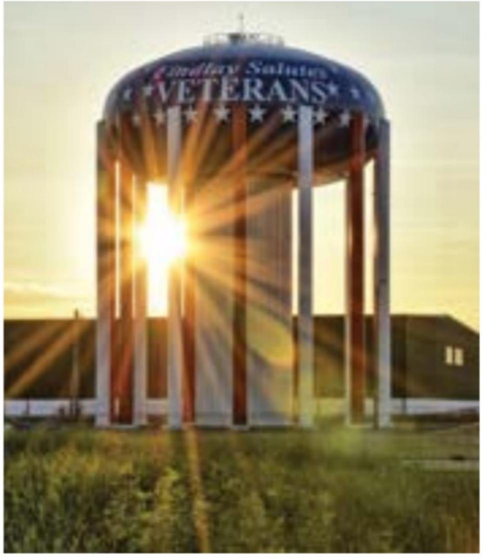
International (SSPC-QP 1, QP 2, QP 3) with coatings from PPG Protective and Marine Coatings, for owner *USS Missouri* Memorial Association Inc.

The "Mighty Mo" was built in 1941, and served until 1992 and is known as the site of the surrender of the Empire of Japan to end World War II. The ship received structural steel repairs and a complete recoating with a zinc primer, epoxy intermediate and siloxane finish. Contractors also recreated replica radar dome structures on the ship, which is part of the Pearl Harbor memorial site in Hawaii.

Mike Branch, PPG Protective and Marine Coatings; Larry Flannigan, Pacific Shipyards; Nick Olvey, PPG Protective and Marine Coatings; and Skerry.

SSPC COATINGS INDUSTRY SPIRIT AWARD

The SSPC Coatings Industry Spirit Award, honoring a coatings project that demonstrates extraordinary service benefiting a community or the industry, went to the North Water Tower project in Findlay, Ohio.



The North Water Tower in Findlay, Ohio is adorned with a tribute to U.S. military veterans. Photo courtesy of The Sherwin-Williams Company.

Brian Thomas, City of Findlay; Gary Collins, UCL Inc.; Jim Clevenger, Dixon Engineering; Skerry; and Doni Riddle, The Sherwin-Williams Company.

Michelle Smay, Smay Trombley Architecture; Skerry; and Glenn Arent, NCP Coatings Inc.

The newly repainted 2-million-gallon toropillar tower designates Findlay as "Flag City U.S.A." with an American flag-themed design that reads, "Findlay Salutes Veterans." The tower was painted by UCL Inc. (SSPC-QP 1, QP 2) with coatings supplied by Sherwin-Williams.

WILLIAM JOHNSON AWARD

The William Johnson Award honors outstanding achievement demonstrating aesthetic merit in industrial coatings work. The award this year went to the St. Joseph North Pier Inner and Outer Lights and Catwalk.

Owned by the City of St. Joseph, Michigan, the St. Joseph North Pier Lighthouse was built in 1907. The city took ownership from the Coast Guard in 2008, with the expectation that it would be restored and opened to the public. NCP Coatings Inc. supplied a four-coat system — a zinc-rich primer, two formulas of epoxy primer and a two-component polysiloxane topcoat developed with the U.S. Naval Research Laboratory. The coating job was undertaken by Mihm Enterprises with architect Smay Trombley Architecture.

The 100-plus-year-old St. Joseph North Pier and Lighthouse was topcoated with a novel two-coat polysiloxane developed by the U.S. Naval Research Lab. Photo courtesy of NCP Coatings Inc.

SSPC BOG Nominations Open

SSPC is seeking nominations for the Board of Governors in the category of Facility Owner. There is one position involved in the upcoming election.

The Facility Owner category is defined in the SSPC bylaws as "individuals who are employed by public or private sector owners of assets who are responsible for the maintenance of coatings of heavy or light industrial structures and surfaces."

All nominees must be SSPC members and meet the requirements on page 5 of the SSPC bylaws. Self-nominations are not accepted.

To nominate a candidate, SSPC asks that members submit a brief statement detailing the nominee's qualifications by March 19, 2018, to SSPC, Attn. Bill Worms, Executive Director, 800 Trumbull Drive, Pittsburgh, PA 15205; or worms@sspc.org.

To learn more about the nomination and election process, please read Article IV, Sections 1 through 4 of the SSPC bylaws, which can be accessed at www.sspc.org.

SSPC, *JPCL* Honor Individuals in New Orleans

Some of the most notable figures in the protective coatings industry were honored Jan. 15 at the SSPC 2018 awards luncheon in New Orleans, La., recognizing achievements in the past year and over an entire career.

The **SSPC HONORARY LIFE MEMBER AWARD** was presented to SSPC past president Jeff Theo, of Vulcan Painters Inc. Theo, introduced by Vulcan CEO David Boyd, was SSPC president in 2003 and had served on the board of governors since 1999 prior to holding the presidency. Theo has served actively on more than 30 committees during his decades of service to

Jeff Theo. Photos courtesy of SSPC.

SSPC and, Boyd noted, was pivotal in moving to get his own firm to achieve several SSPC certifications. In a short speech, Theo stressed that SSPC needs volunteers across the industry in addition to its staff; he encouraged everyone in the room to join a regional chapter and write a paper for presentation and publication. "SSPC is my competitive advantage," Theo said in closing, adding, "And we're all tied here," referring to the collective advantage SSPC gives everyone who was in attendance.

(L-R): SSPC President Brian Skerry and Robert Kogler.

The **JOHN D. KEANE AWARD OF MERIT,** named for the organization's executive director from 1957 until 1984, was awarded to Robert A. Kogler, of Rampart LLC. Kogler, also an SSPC past president, is a former head of corrosion protection and coatings research at the Federal Highway Administration. Derrick Castle, the SRC

SSPC Coatings+ 2019 Call for Papers

SSPC is currently accepting abstracts for technical presentations and posters at Coatings+ 2019, SSPC's rebranded annual conference and exhibition.

Coatings+, scheduled for February 11 to 14, 2019 at the Coronado Springs Resort in Orlando, Fla., will offer thought-provoking discussions and solutions to current challenges faced by coatings professionals, including traditional surface preparation, application, coating failures, health and safety, and other coatings-related topics.

Abstracts will be selected by the Education Program Advisory Committee (EPAC) based on originality, quality, relevance to the industry and overall objectives. If the abstract is accepted, the author must both submit a formal paper (5-to-10 page minimum) and register for the conference. Each presenter will receive a complimentary conference registration.

Abstract submissions are due by May 1, with notification of acceptance being issued by June 1 and first draft of the papers due by Aug. 1. To submit, visit www.sspc2019.com.

Committee Chair, in introducing Kogler, noted that his influence in the world of bridges and transportation infrastructure is felt in specifications across the nation to this day. Kogler is now principal at Rampart, where he works as a consultant to the U.S. Navy.

William Medford and Skerry.

The **TECHNICAL ACHIEVEMENT AWARD** was presented to William M. Medford for his contributions to the five-year revision process of the SSPC/AWS/NACE joint standard, as well as his representation of SSPC on the AASTHO-NTSB Task Group 8 on Coatings and his work on SSPC's thermal spray application programs. Medford, of InSpec, is an SSPC past president, and received the Executive Director's Award in 1997. In addition to his work on the SSPC/AWS/NACE standard, he played a pivotal role in the development of the new SSPC-PA 18: Specification for the Application of Thermal Spray Coatings to Steel Bridges.

Mary Roley and Skerry.

The **WOMEN IN COATINGS IMPACT AWARD** went to Mary Roley, technical director, research and development, of Carboline Company. Introduced by Carboline senior vice president of global innovation and technology Dwayne Meyer, Roley was honored for both her achievements in coating development and her commitment to fostering young women's careers in the industry. Over her 30-year career, Roley has been key in the development of ultra-weatherables at Carboline, including a polysiloxane that could be applied over a primer as part of a two-coat system, eliminating the need for a third coat. Meyer noted Roley's competitive flair, explaining that she brings the winning mentality she has as a competitive runner to the workplace: "She always wants to be at the front of the pack."

There were two recipients of the **RICHARD W. DRISKO COATINGS EDUCATION AWARD**. KTA-Tator's Bill Corbett presented the awards to Anthony Kippen, an instructor of eight SSPC courses, who has taught and audited over five continents; and Aaron Williams, who has been key in bringing SSPC training to Malaysia via an agreement with the Institute of Materials, Malaysia.

Anthony Kippen, Skerry and Aaron Williams.

The **SSPC PRESIDENT'S LECTURE SERIES AWARD** went to John Hilton of The Sherwin-Williams Company for his presentation, "Use of Ultra-High Build, Fast Return-to-Service Coatings to Shorten Construction Schedule at Expansion of Norman, Oklahoma, Wastewater Treatment Plant."

The SSPC New England Chapter was given the **OUTSTANDING NORTH AMERICAN CHAPTER AWARD**, while the Panama Chapter received the **OUTSTANDING INTERNATIONAL CHAPTER AWARD**.

JPCL Readers' Choice Awards

Also honored at the awards luncheon were the winners of the inaugural *JPCL* Readers' Choice Awards. While in past years, the best *JPCL* articles of the year were chosen by a panel of contributing editors, this year, readers were given the chance to weigh in. The best technical articles, as chosen by the *JPCL* readership, were as follows.

- "When Words Fail: Overlooking Spec Language Produces Poor Results," by Peter Bock.
- "Coating Failure: Disbonding of an Overcoat," by Rob Lanterman.
- "The Effect of Surface Preparation on Coating Performance," by Patrick Cassidy, Paul Slebodnick, James Tagert and James Martin.
- "Moisture Testing and Moisture Surveys: Assessing Concrete Floors for Coating Readiness," by Brian O'Farrell.
- "Common Safety Hazards: Taking a Fresh Look," by Michael Halliwell.
- "Tanks: The What, Where and Why of Coating System Selection," by Kristin Leonard.

"When Size Matters: Determining Efficient Blast Containment Size with Brooklyn Bridge Project Data," by Guerman Vainblatt and Timur Kolchinskiy was also honored by the *JPCL* editors with the *JPCL* Editor's Choice Award.

PAINTSQUARE COMMENTS

In Response to, "Are We Learning from Our Mistakes?"

(Inspector's Corner Blog, Feb. 21)

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In the wake of some recent workplace accidents and tragedies in the industry, inspector and frequent PaintSquare blogger Lee Wilson ponders whether or not coatings professionals are truly taking current regulations and health and safety considerations seriously enough.

Tony John:

"Good read, Lee. As the industry is massive globally, we tend to forget or not hear of the vast majority of accidents or fatalities. Although times have changed over the years and gradually it has become safer as training and awareness has vastly improved, you only have to see various posts on LinkedIn to fully appreciate that a lot still needs to be done to encourage the operator to make his or her safety and well-being a priority."

Glenn Holmstrom:

"Excellent read. We have lost family members and good friends due to exposure to a variety of different hazardous substances and working conditions over the years. Although health and safety [practices] are miles ahead of where we used to be, they are still not where desired. We still see a lot of the same mistakes being made today. Even with greater measures put in place by authorities, companies and HSE teams, it is [up] to individuals to adhere to them."

Lee Wilson:

"Glenn, we have both seen firsthand the consequences of industrial related disease. Yes, there have been significant advances within the industry. However, many countries where mass fabrication is now used by the oil majors are still unregulated!"

Michael Halliwell:

"Lee, great article and you are quite correct — even though we've come a long way, the past can still haunt the present and future. Hopefully we are learning from our mistakes, but it seems like that is not always the case. I have witnessed far too many people — both on jobsites and in comments here on *PaintSquare News* — who 'pooh-pooh' the dangers associated with asbestos, even though it remains the number-one killer via occupational disease in Alberta and numerous other jurisdictions."

Lee Wilson:

"Hi Michael — unfortunately, so true. It's clear that so many of us in the industry have seen the consequences firsthand and many continue to die so unfortunately of occupational related diseases. You are correct that there is still a very relaxed attitude to some safety critical elements within the industry; it can't be denied as the evidence is there in abundance."

Simon Hope:

"Well put together Lee. As you are aware, breathing air standards and their proper implementation are one of my hobby horses. I am fed up with the number of times I sit and lecture people on proper RPE and its use and controls, and it seems to go in one ear and out the other. The problem is that we don't see instant results due to bad practices, but insidious attacks as in the way your father died — very similar to the horrendous deaths that befall others working in similar industries, where the exposure to the hazard was in certain instances was a badge of honor and machismo. Oh, how wrong these poor people were. Education is essential, and the sight of a pair of diseased lungs on a slab during a post-mortem can certainly act a focus. You need to explain the long-term damage and stop the 'it won't happen to me' attitude and beliefs. Keep banging the drum! If we all do and save one person it will be worth it."

PAINTSQUARE NEWS TOP 10

paintsquare.com/news, Feb. 5 to Mar. 4

1. **Judge Rejects Border Wall Challenge**
2. **Construction Begins on CA Border Wall**
3. **Aerospace Firm Fined $194K for Chromium-6 Exposure**
4. **Hyperloop Firm Begins Multi-State Study**
5. **PA Bridge Contractor Sentenced in DBE Fraud**
6. **AkzoNobel Reveals UV-Based Antifouling Tech**
7. **Overpass Collapses in Central Brasilia**
8. **Architect Pressed City to Test Failed Cables**
9. **Sales Up, Profits Down for Jotun in 2017**
10. **Trump Releases Infrastructure Plan Details**

Problem Solving Forum

paintsquare.com/psf

What is the best method for preparing newly galvanized steel to be overcoated with an epoxy system?

Erik Andreassen, CPS:
"Prepare the surface by sweep blasting using a non-metallic abrasive such as garnet. Extreme care should be taken to avoid damaging the surface to be coated. Move the blasting nozzle rapidly just to create a key for the epoxy system."

Michael Beitzel, Modjeski and Masters Inc.:
"The answer depends on the type of galvanizing. Solvent cleaning and a sweep blast with a less aggressive abrasive would be best for hot-dip galvanized steel or fasteners. Solvent cleaning to remove lubricating wax and etching with a phosphoric acid and detergent solution would be best for mechanically galvanized surfaces. Both types of fasteners and the adjacent field should be primed with an organic zinc stripe coat to restore damage from installation."

Alexandre Racine, Drytek TransCanada:
"Clean to SSPC-SP 16 with light abrasive (glass bead), 30-to-40 psi blast pot pressure with a large sweep blast method. Double-check the galvanized thickness before surface prep. Read the epoxy specs for surface profile requirements to make sure it meets the maximum galvanized surface profile. If you need a 2.5-to-3-mil minimum profile, you will end up removing the galvanized surface. Check humidity levels and for white rust on the surface. If [present], wash the surface with proper detergent after the blast. A pre-job meeting is a must to make sure the galvanized surface meets the client requirements (galvanized dropping, over-thickness in corners). ASTM A123 accepts some surface criteria that sometimes don't meet client's expectation."

Frank Rea, GPI:
"All good answers, but one important item has been left out. When it is known that the galvanizing is to be painted, the specifications should be written and the galvanizing shop should be reminded at the pre-project meeting that no quenching or chromate treatment is allowed."

Paint Poll

paintsquare.com/poll


©iStockphoto.com/mARTinDigitalPhotoart

The Pennsylvania DOT is filling plug welds with bolts on 13 bridges in the wake of last year's damage to the Delaware River Turnpike Bridge. Is this good preventive maintenance or is it unnecessary?

Good maintenance — bolts will provide more strength to the otherwise weak spots. **69%**

Unnecessary — not every plug weld represents a weak spot. **20%**

Other. **11%**

Michael Beitzel:
"Good maintenance – removal of the plug weld will eliminate the potential stress raisers or potential different physical characteristics of the weld filler metal. Filling the hole with a bolt is likely only to prevent corrosion of the open hole or misreporting by inspectors as a missing fastener."

Simon Wadsworth:
"The bolt hole should be larger than the original weld to capture the heat-affected zone, and the bolt should be a pre-loaded type to put the hole edge into compression."

Alan Denney:
"You need to see the full details in order to make a judgement on this."

Harman Metzger:
"Agree with Alan Denney – there are many variables. If the engineer of record determines the location is in a critical location, consider ultrasonic and/or radiographic testing to the D1.5 code requirements."

Issues and Challenges of Field Surface Preparation

BY JARED RIGO, HRV CONFORMANCE VERIFICATION ASSOCIATES, INC.

As means and methods diversify and structures types become more complex, an innumerable number of challenges can arise with surface preparation projects in the field. While a large number of these challenges can be anticipated and planned for in advance of the project inception, some often go overlooked. This article will identify three potential issues that arise on nearly every field-based industrial coatings project worldwide: abrasive selection, existing condition assessment and worker access.

Before beginning this conversation, a few disclaimers are in order. First, this is not an attempt to lay blame on any party involved in these projects. Designers, contractors, inspection personnel, asset owners and a number of other entities and individuals all play a pertinent role in the completion of any project. The number one goal is to complete a project efficiently and on schedule while keeping costs — both direct and indirect — down. The goal here is to identify some additional, often unforeseen, concerns that often hinder the successful completion of the objective.

Also, this attempt at outlining some hindrances to field surface preparation is exactly that: an attempt to have an objective discussion of the concerns, not necessarily the solutions. While this discussion addresses issues that permeate nearly every project, no individual project assumptions can be made as every project presents its own unique circumstances. There is no "one-size-fits-all" solution to these issues, but having an honest, up-front dialog prior to the inception of any industrial field painting project, and paying special attention to the nuances and intricacies particular to that individual project, will allow for the best attempt at resolving these issues.

ABRASIVE SELECTION

The large majority of field-based surface preparation projects require abrasive blasting to remove the existing coating, clean the substrate and produce the required surface profile. While specifications differ (sometimes greatly) from project to project, they typically all have a number of clauses that pertain to the selection of abrasives to be utilized on the project — or at least the selection is governed by a certain set of requirements.

Nominally speaking, the following items are usually contained in most project documents. First, there is usually a clause stating something along the lines of, "abrasives must be sized appropriately to produce a dense, angular profile of 1.5-to-3.5 mils." A statement such as this directly pertains to the abrasive selected for the project. Aside from quality workmanship on behalf of the trade worker holding the blast nozzle, the size and type of abrasive has a direct correlation with the profile produced.

All photos courtesy of HRV Conformance Verification Associates Inc.

Second, there is often a statement contained in the project documents that discusses the standard to which the abrasives must be manufactured and cared for. Often-referenced standards include SSPC AB 1 and AB 3 for disposable abrasives and AB 2 for recyclable abrasives. These standards, when specified, often come with a secondary statement about testing for abrasive cleanliness, whether it be by vial test or by conductivity testing.

Finally, it should be noted that some specifications require the contractor to purchase new abrasive (of the recycled type, as disposable abrasive is always purchased new) before beginning of the project. Although this is a rare case, it does help to mitigate the issue we're about to discuss.

One may ask: "How is the selection of abrasives a challenge to field surface preparation projects?" To better answer this question, we will need to play out a typical scenario. While this is just a scenario, it is a pertinent one derived from years of experience with these types of projects and warrants further investigation.

Day one of abrasive blasting begins. The contractor has utilized a recycling machine filled with whichever abrasive they had left from the previous project with perhaps a small amount of new abrasive sprinkled in here and there. Regardless, they have made phenomenal progress cleaning the existing coating from the substrate. After a long and arduous shift for the blasters, it is time to perform inspection of the prepared areas. Usually along with the identification of holidays in the substrate, the surface profile is examined with replica tape and a spring micrometer (or digital profilometer, for that matter). The tests reveal a surface profile that is both dense and angular in nature. While this is easily observed to be within project tolerances, it is quickly noted that the profile has a depth in excess of 4.0-to-4.5 mils. This project requires a maximum depth of 3.5-to-4.0 mils. This requirement is not atypical; nearly all projects specify a ceiling of 3.5-to-4.0 mils. So, what happens next?

The inspector brings up the issue to the contractor, who then makes a statement of some sort claiming that there is nothing that can be done to bring the profile to within project tolerances. It is not feasible, nor cost effective, to purchase new abrasive, and the operators stood as far away from the substrate as possible so as to be productive yet not obliterate the steel, and the profile is still too far above the threshold limits for the project.

At this point in time, on nearly all industrial field blast-cleaning jobs, the asset owner or contractor usually procures a letter from the coatings manufacturer stating that this excessive profile is within the tolerances for the coating to be applied. This letter frequently quells the concerns of the designer and the project proceeds uninhibited by the high profile. However, the project wasn't designed this way. There is a ceiling for a reason. There is a maximum depth of profile that was placed there by design. Yet, on nearly all projects, this limit is often exceeded. Is this actually okay? Hopefully, an informed conversation between

the owner, contractor and designer before the beginning of the project can plan for achieving the objectives within a reasonable time frame, while adhering to the design profile limits that are not to be exceeded.

EXISTING CONDITION ASSESSMENT

A vast majority of structures in the U.S. and around the world often exhibit severely corroded areas. Some of these areas are so badly corroded that they have absolutely no existing coating present and are often structurally deficient. Bearings fall out from under beam ends, top and bottom flange joints are filled with pack rust, holes are blown through the web, once rounded rivets turn to pitted prunes — and the existing condition survey of the structure, usually performed several years prior to project inception, captures very few of these problems.

Replacing the existing structure is often out of the realm of possibility, so rehabilitation becomes a necessity.

Project documents generated for these rehabilitation projects often dictate a few points with regard to surface cleanliness and the existing condition of the structure. Usually, at least for field-based projects, the structure is to be blast-cleaned to an SSPC SP-6/NACE No. 3, "Commercial Blast Cleaning," or an SSPC SP-10/NACE No. 2, "Near-White Metal Blast Cleaning" finish. All of the accessible structure is to be cleaned to the same degree, regardless of the existing condition of the substrate underneath the remaining coating. The standards of surface cleanliness specified dictate that all tightly adherent material (coating, rust and mil-scale) be removed and only a percentage of staining may remain.

Often, there is also a small, obscure, poorly written clause inserted into the specification somewhere that makes vague attempts at discussing caulking, penetrating sealer and steel repairs. The vague ambiguities often associated with these clauses cause innumerable headaches and costly change orders.

So, all of the tightly adherent material is removed. Areas previously identified for additional surface treatment (for example, caulking, penetrating sealer and steel repairs) are handled as specified in the project documents. However, an array of other defects were not addressed during the condition assessment previously performed on the structure. These previously unidentified problem areas are treatedaccording to the poorly written "caulking" section of the specification.

Ideally, all of the exposed surface is cleaned and prepared as required and all of the problem areas were previously identified, bid on by the contractor and remediated as directed. However, this very rarely happens. In the real world, the contractor usually applies additional gallons of penetrating sealer and tube after tube of caulking, trowels on the pit-filler and allows for hours of difficult-to-schedule steel repairs, which require additional surface treatment and are often performed after midcoating and/or topcoating. Someone has to pay for all the extra man-hours, scheduling conflicts and materials associated with the additional work required to remediate all of these supplementary "problem children." These costs are often way beyond those which were expected, and the asset owner can end up doling out hundreds of thousands of dollars in extra pay items.

While the obvious answer to the problem is to perform condition assessments more frequently and more thoroughly, this is often not possible. A number of factors prohibit this, including the size or complexity of the structure, the costs associated with performing the assessments and just the lack of vigilance on the part of the asset owner. Realistically, while there is likely no feasible way to capture all of the detrimental areas on a structure before cleaning and coating it, there should be an up-front, honest discussion before blasting the structure into oblivion and then charging the owner a considerable amount of extra money to apply these additional materials. Awareness of the constant and persistent nature of this issue should allow for owners to better prepare specifications to address the potential for an excessive amount of caulking, penetrating sealer, pit-filler and steel repairs. Remember that each individual project will always possess its own unique set of issues, so there is no singular solution.

WORKER ACCESS

A final, often overlooked concern with regard to field surface preparation is worker access. Laborers, blasters, painters, foremen and inspectors (both QC and QA) all have to access the

structure to perform their respective job duties. When a reviewer sits down to examine and approve a proposed containment/access plan, a number of things are taken into consideration.

The first and primary concern when reviewing the containment is safety. Does the proposed plan abide by regulation with regard to worker safety? Also, is the proposed plan safe for the general public to operate around? Does the containment impose an unbearable load on the existing structure?

Assuming the proposed plan allows for a safe work environment for both the worker and the general public, the second consideration is the impact of the plan on the environment. Often required by the project documents is the use of a guide for design and installation. For example, SSPC-Guide 6 is often implemented to assist in design compliance. Maintaining compliance with environmental regulation takes a close second place behind the safety components of the plan.

A little more explanation is required, however, to discover why this is an issue plaguing industrial field painting projects. The implementation of the plan is simple: install each component as indicated in the approved drawings and begin working. Nonetheless, an often-unasked question remains — how efficiently can a worker access the structure to perform their duties under the approved plan? Is work able to be performed effectively and efficiently from the given method of access?

Oftentimes, the easiest method of installation does not equate to the most efficient form of access. Picks, cables and lifts may be much easier and less time-consuming to install, but can prove to be very cumbersome to work from. More often than not, though, the use of these particular access methods complies with the two main concerns with regard to containment plan review — safety and environmental protection — and are often implemented as a result.

A quality job is more likely to result when efficiencies are maximized. One should tend to consider a little more carefully how effectively a worker can utilize the intended access. Is the operator (or inspector, for that matter) able to see the top of the diaphragm or the back of the bearing? Does the worker have to carry a board to place in between the two bottom flanges of a bay to access the corners of the x-brace? How will the blast operators change shields? Where will they hang their hoses at break time? How do they get up and down? Is the inspector comfortable inspecting from these platforms? How many dozens of times must the picks be slid up and down the cables to perform an inspection of the entire blast? Is one going to hear, "blasting off of picks is frightening and I can't get to that spot because of it"?

A full platform may be more difficult, expensive and time-consuming to install on the structure to be blasted. But if one is to seriously consider the efficiency of work from the platform, maybe the time and expense can be recouped in a hurry. Blasting is simpler when the operator doesn't have to constantly and deliberately consider his or her footing. Inspection is much simpler when the picks don't have to be slid in 5-foot increments along a 200-foot blast area. Touchup blasting and coating application are much simpler and efficient when the manlift doesn't have to be continually maneuvered about to avoid structural elements. Ultimately, a higher-quality job is achieved more expeditiously when the worker doesn't have to strain to see or perform acrobatics to blast a particular area.

Some may view this as an issue that doesn't require immediate attention or serious consideration. However, these types of worker access will continue to be used all over the planet, and complaints will continue to be ushered up at the lack of quality and efficiency. Deadlines will be missed, schedules conflicted, time lost, money lost, material spent and un-reclaimed and, most of all, workers will continue to operate in unsure conditions until this is seriously considered.

CONCLUSION

Quickly considered here are three pertinent issues with regard to surface preparation in the field. Honest, earnest and open discussion of abrasive selection, the existing condition and worker access before a project's inception can help to ensure conformance with project specifications and other documents, save time and money and allow for confident, expeditious working. While each project will present its own unique challenges and solutions, hopefully awareness of the constant and persistent nature of these issues can help to mitigate the loss of time and money on your next industrial painting project.

ABOUT THE AUTHOR

Jared Rigo is coatings operations manager in the construction division of HRV Conformance Verification Associates, Inc. He has nearly 10 years of coatings application experience and quality inspection expertise in structural steel bridge members, tanks and railcars. Rigo is a NACE-certified Coating Inspector (Level 3) and an SSPC-certified Protective Coatings Specialist (PCS), and is a certified trainer for SSPC's C3 and C5 courses. He holds a B.S. in chemistry from Saint Vincent College in Pennsylvania.

Thinking Outside the Containment

BY BRADLEY BOX, INDUSTRIAL CORROSION CONTROL, INC. (ICCI)

Fig. 1: This project involved recoating the interiors and exteriors of two ground storage tanks used by the U.S. Air Force to store water for firefighting. Photos courtesy of ICCI, Inc.

Fig. 2: Although the interior tank coating was considered preventative maintenance, the exterior was prematurely failing due to an adhesion issue.

My company was contracted to perform maintenance painting of the interior linings, and repair and recoat the exteriors of two ground storage tanks used by the U.S. Air Force to store water for firefighting, each 25 feet in diameter and 45 feet tall (Fig. 1). The project had to be completed in a tight time frame with liquidated damages for going over the allotted period of performance.

Although the interior tank coating was considered preventative maintenance, the exterior was prematurely failing due to an adhesion issue (Fig. 2). The existing coating was failing between the primer and intermediate coats most likely due to letting the primer's recoat window lapse prior to applying the intermediate coat.

This particular project was by no means the largest or the most complex that our company had performed this year, but the cost of failure was very high due largely to the unfortunate fact that the tanks were located about 50 feet from the flight line and in between two large hangers at a very active Air Force training base. The customer originally specified a Class IA containment (SSPC-Guide 6, "Containment of Debris") for the exteriors of both tanks — not due to the lead content of the paint, but instead due to concerns about dust making its way onto the airfield or the planes that used it.

The cost associated with building scaffolding and containing the tanks was too great for the small scope of the project, so that gave us the opportunity to propose another solution that would still produce the desired results. We discussed options for the project in-house and decided to use wet abrasive-blasting. As many customers might be, this one was a little doubtful about wet abrasive-blasting — that one could blast with very little dust. They, like many other customers, have been in the industry for decades and have seen blasting without containment cause dusting out other trades, the owner and possibly even the neighbors in the process.

To arrest their concerns, we held a meeting with all parties involved and presented demonstration videos and the analytical data behind the dust-reduction technology that we compiled to show the benefits of using this process. We also presented our containment plan to the USAF Contracting Team, showing that we would still be providing a "secondary" containment tarp (a loose, air-penetrable tarp) around the exterior perimeter of the blasting area.

Fig. 3: A three-coat AWWA-compliant coating system consisting of a zinc-rich primer and two coats of epoxy, plus a stripe coat was used to line the tank interiors.

Aside from reducing dust that affects surrounding workers, wet abrasive-blasting also reduces the environmental footprint of the project by using considerably less blast media which means less is sent to the landfill for disposal.

After seeing our plan of action and the data we received a "conditional OK" to deviate from the IA requirement, based on the approval of our test-patch area using the wet abrasive blasting technology. We then set up and performed an SSPC-SP 6 (WAB)/NACE WAB-6, "Commercial Wet Blast Cleaning" on a test patch to prove that the technology would be effective and keep any potential contaminants within our work area. We blasted the remaining parts of the exterior and applied a four-coat exterior system that included a zinc-rich primer, epoxy, aliphatic polyurethane and a fluoropolymer topcoat that should shine for many years to come.

We simultaneously dry-blasted the interior with coal slag to an SSPC-SP 10/NACE No. 2, "Near-White Blast Cleaning" surface and applied a three-coat AWWA-compliant coating system consisting of a zinc-rich primer and two coats of epoxy, plus a stripe coat (Fig. 3). We used a 20,000 cfm dust collector to be sure that we had more than enough capacity to keep any fugitive emissions from making their way onto the tarmac during blasting. We then created a non-skid surface on the roofs

Fig. 4: Because the tanks were located about 50 feet from the flight line and in between two large hangers at a very active Air Force training base, wet abrasive blasting was chosen to avoid dusting out the facility, the other trades and possibly even the neighbors in the process.

of both tanks and on the ladder rungs by broadcasting sand into the mix of the third coat — a safety asset for servicing the tanks in the future. We used a relatively low-cost option for the non-skid — not what I would suggest for any heavily trafficked area, but it should work well for this purpose. We were able to complete the project with over a third of the time still left on the period of performance and the customer was satisfied (Fig. 4, p. 30).

ABOUT THE AUTHOR

Bradley Box is a graduate of the University of Mississippi with a Bachelor of Business Administration degree in finance. He has been in or around the coatings industry his entire life, growing up in the family business at ICCI. Box has held numerous positions starting as a helper at age 13 and after college in quality control. He later obtained his NACE PEER Review CIP Level-3 certification and became quality control manager. Box has spent the last two years as vice president of business development performing project management, estimating, improving customer and vendor relationships, and working on creating new revenue streams.

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NACE International's annual conference and exhibition, CORROSION 2018, will take place at the Phoenix Convention Center in Phoenix, Arizona, April 15 to 19.

CORROSION 2018 will bring together corrosion engineers, scientists, researchers, technicians, asset owners, inspectors and other professionals for a series of technical symposia, forums, committee meetings, an exhibit hall and other events related to corrosion mitigation and prevention.

The following protective coatings-related sessions may be of interest to industry professionals. All information is current as of press time. For more details, including the complete CORROSION 2018 program, visit www.nacecorrosion.org.

SYMPOSIA

The CORROSION 2018 Symposia comprise formal technical sessions in which authors across the many different sectors of the corrosion industry — including students — present their work or information and ideas derived from current or recently completed research projects.

"COATINGS AND INHIBITORS — RESEARCH IN PROGRESS"

Monday, 9:00 a.m. to 5:00 p.m.

This research in progress (RIP) session will focus on the performance and evolution mechanisms of coatings/inhibitors through chemical or electrochemical (corrosion) aspects, and the interrelationship between composition, processing/technique, microstructural/nanostructural features, and the test environment and coating/inhibitor performance.

"POWER INDUSTRY CORROSION"

Monday, 9:00 a.m. to 3:00 p.m.

This symposium will contain technical papers related to corrosion causes, issues, studies, experiences, and/or management practices, including coatings on steel structures and their related components in the power industry.

"INHIBITORS — VAPOR TRANSPORTED (VCI) AND SURFACE COATED RUST PREVENTIVE (RP)"

Tuesday, 9:00 a.m. to 3:30 p.m.

This symposium will present novel applications, technical advances, test methods, and materials that perform as vapor-transported corrosion inhibitors (VCIs) and/or inhibitor coatings applied to metal surfaces to inhibit corrosion.

"OIL AND GAS COATING TECHNOLOGY"

Tuesday, 9:00 a.m. to 5:15 p.m. (Day 1)

Wednesday, 8:00 to 11:30 a.m. (Day 2)

This symposium will discuss long-life offshore coatings (15-to-25 years of service life); temporary coatings for up to one year of service life; coatings for offshore pitted stainless steel vessels; coating blister mechanisms; corrosion under insulation (CUI) coatings; residual stress in pipeline coatings; soluble salt removal methods; and offshore platform one-coat systems.

"NANOMATERIALS AND CORROSION CHARACTERIZATION METHODS AT THE NANOSCALE"

Wednesday, 8:00 a.m. to 3:00 p.m.

This symposium contains technical papers on nanomaterials and nanoscale characterization methods for understanding corrosion mechanisms and mitigating corrosion, including corrosion-resistant and high-performance coatings.

"PIPELINE INTEGRITY"

Wednesday, 8:00 a.m. to 5:00 p.m.

This symposium describes pipeline integrity management plans and procedures, outlining case histories on nondestructive evaluation (NDE) and inline inspection (ILI), NDE and ILI cutting-edge technology, coatings and cathodic protection, and cross-over industry technology.

FORUMS

Forums gather industry leaders for informal panel discussions and Q-and-A sessions regarding a number of different issues affecting corrosion mitigation professionals.

"COATING TECHNOLOGY & SYSTEMS OF THE U.S. NAVY,"

presented by Cameron Miller, James Martin, Colton Spicer and Jimmy Tagert, U.S. Naval Research Laboratory

Monday, 9:00 a.m. to 12:00 noon

This forum will present an overview of coatings and related technology systems being used or developed by the U.S. Navy for corrosion control and provide the opportunity to interact with commercial industry on common challenges.

"COATING ASSET MANAGEMENT — THE STATE OF THE INDUSTRY," PRESENTED

presented by D. Terry Greenfield, CorroMetrics Services, Inc.

Tuesday, 10:00 a.m. to 12:00 noon

This forum will feature coatings industry professionals who have implemented effective coatings management programs to better protect their assets. Each panel member will speak about how they were able to implement the program, including maintenance philosophies, condition surveys and data management systems.

CORROSIVE CHRONICLES

The Corrosive Chronicles Theater takes place on the exhibit hall floor and features interactive presentations on a variety of corrosion-related topics from industry professionals and NACE staff.

"ARTIFICIAL INTELLIGENCE AND DRONE TECHNOLOGY TAKE-OFF: VISION-BASED AUTOMATED CORROSION DETECTION FROM DRONE IMAGE DATA,"
presented by Michael H. Cohen, Industrial Skyworks Inc. and Dr. Gunho Sohn
Wednesday, 1:30 to 3:00 p.m

This session will introduce a state-of-the-art solution for detecting corrosion, including coating damage of facilities and

EXHIBITORS

The following companies in the CORROSION 2018 exhibit hall may be of interest to coatings professionals. For a complete list, visit the CORROSION 2018 website.

3M 921
A.W. Chesterton Company 560
Abrasives Inc. 460
ACT Test Panels LLC 1726
Advanced Polymer Coatings 1546
Advanced Polymerics Inc. 1765
AirTech Spray Systems 1913
American Society for Nondestructive Testing 219
Arkema Inc. 523
Av-DEC 660
Axalta Coating Systems 1455
BASF 1725
Carboline Company 803
CHLOR*RID International Inc. 1539
Clemco Industries Corp. 1509
Cold Jet, LLC 223
Cortec Corporation 1003
Cygnus Instruments Inc. 646
The Dampney Co. Inc. 847
DeFelsko Corp. 931
Dehumidification Technologies 1607
Denso North America 639
DoD Corrosion Prevention and Control 205
Eckart GmbH 1819
Elcometer 413
Ervin Industries Inc. 1267
Evonik Corp. 1251
Farwest Corrosion Control Company 539
Fischer Technology Inc. 1246
GMA Garnet Group 1638
Greenman-Pedersen, Inc. 943
Harsco Minerals International 1363
Hempel USA 1731
Highland International LLC 1462
Hippo Coatings Company 1850
HoldTight Solutions Inc. 1211
InduMar Products Inc. 444
Intech Services 1605
International Paint 331
IUPAT/FTI 557
Jotun Paints Inc. 1013
KTA-Tator Inc. 502
Laboratory Testing Inc. 328
Mascoat 1702
Milliken Infrastructure 1723
MONTI Tools 511
Montipower Inc. 1318
NCERCAMP University of Akron 1924
NDT Global, LLC 406
NRI Neptune Research Inc. 1631
Park Derochie 859
Pipeline Inspection Company 1431
Platt Brothers & Company 1903
Polyguard Products, Inc. 1115
PPG Industries Inc. 621
Praxair Surface Technologies 1309
Raven Lining Systems 1921
RBW Enterprises Inc. 461
Rema Tip Top North America Inc. 418
Rhino Linings Corp. 1759
Sauereisen 1424
Seal for Life Industries 821
The Sherwin-Williams Company 1039
Southwestern Paint Panels 1744
Specialty Polymer Coatings Inc. 747
Specialty Products Inc. 229
Sponge-Jet LLC 1112
Spraying Systems Co. 1063
Sprayroq Inc. 1846
SSPC 259
Strategic Materials 257
Sulzer Mixpac USA Inc. 555
Superior Products International Inc. 1348
Technofink LLC 548
Temp-Coat Brand Products 1749
Thermo Fisher Scientific 1228
Tinker & Rasor 739
Tnemec Company Inc. 1639
Trenton Corp. 1027
TruQC 1621
W Abrasives 1413
Wasser Coatings 419

infrastructure, using imagery data acquired by a GPS-denied UAV system and adopting a vision-based approach from an artificial intelligence neural network system.

"COATINGS 101,"
presented by Rae Marie Mattis
Wednesday, 10:15 a.m. to 12:00 noon (Part 1); 1:15 to 3:00 p.m. (Part 2)

The NACE International Coatings Council will host the second iteration of its popular Coatings 101 event, geared to those just entering the coatings industry and other individuals who need a working knowledge of coatings. The morning session will feature presentations from a diverse range of industry experts, including the following.

- Bob Murphy (The Sherwin Williams Co.): "Coatings in the Water Industry."
- Todd Weigel (International Paint): "Coatings in the Mining Industry."
- Trevor Neale (TF Warren): "Delivering the Expectation."
- Steve Poncio (Consultant): "Coatings Failure Analysis."

During the afternoon session, the Coatings Council will host an interactive panel discussion that will field questions from the audience on all aspects of coatings. The panel will be comprised of industry experts with over 150 years of combined coatings experience.

***COATINGSPRO* CONTRACTOR AWARDS PROGRAM**
Wednesday, 11:30 a.m. to 1:00 p.m.
CoatingsPro Magazine is again recognizing industry excellence in the application of commercial and industrial high-performance coatings with the second annual Contractor Awards Program. Categories awarded include Commercial Concrete, Commercial Roof, Industrial Concrete, Industrial Steel, Specialty Project, and Contractor/Crew MVP.

"REGULATORY CHALLENGES AND SOME DEVELOPMENTS IN RAIL AND TRANSPORTATION COATINGS TECHNOLOGY,"
presented by Shiwei William Guan, Strathmore — A CSW Industrial Company and Paul Whitehead, Strathmore Products, Inc.
Wednesday, 10:30 to 11:00 a.m.
Increased regulatory requirements on health, safety and the environment have imposed many challenges on protective coating technology in many industrial sectors, including rail and transportation. This presentation will outline some of these challenges and highlight a few new developments by the rail and transportation coating industry.

FEATURE

Step-Change Epoxy Coatings for Pipes, Tanks, Vessels and Railcars

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

In the worldwide oil and gas industry, the application of epoxy phenolic coatings has been a dominant strategy in order to obtain high heat resistance from coatings and mitigate corrosion under insulation (CUI) of both insulated carbon and stainless steel pipes operating up to 392 F (200 C). These coatings, however, are sensitive to over-application, prone to cracking and costly to repair when damaged. Additionally, if applied below 50 F (10 C), epoxy phenolic coatings do not cure properly and can fail prematurely, and when applied close to this temperature, can impact shop heating costs, maintenance schedules and productivity.

The genesis and performance of a step-change epoxy coating for high heat-resistant service and CUI mitigation is investigated in this article. Based on a novel amine epoxy technology platform, this next generation high-temperature coating simplifies coating specifications and is easy to apply on carbon and stainless steel pipe externals for both insulated (CUI) and non-insulated service. Tolerant of over-application and possessing fast and sub-zero curing characteristics, the novel alkylated amine epoxy coating can enhance shop productivity and reduce project costs, thereby eliminating several challenges seen with traditional epoxy phenolic coatings.

This article also describes another step-change epoxy: a novel lining developed for the internals of tanks, pipes, vessels and railcar internals. A high-film-build, rapid-curing, single-leg spray-applied modified polycyclamine-cured epoxy (MPCE), this lining was primarily developed for high-temperature and high-pressure immersion service in harsh oil field services and later for railcar internals.

Aside from its high-temperature-resistant characteristics, the next-step MPCE was formulated to possess a smooth and abrasion-resistant surface with a low coefficient of friction and low surface energy, which markedly improved the flow properties of fluids and cargoes in tanks, pipes, vessels and railcars.

COATINGS FOR HIGH HEAT AND CORROSION UNDER INSULATION (CUI)

Considerable literature exists dealing with numerous facets of the origin and prevention of CUI and the cost consequences of this type of corrosion for asset owners. Hence, a general review of CUI will not be given here and is outside the main thrust of this article. The topic of specialty coatings, however, is germane and does set the stage for the discussion regarding a CUI mitigation strategy using a step change in epoxy coatings technology.

How exactly would this new technology be shown to be a step change for use in CUI mitigation? The answer is to compare and contrast the traditional epoxy phenolic technology with the new alkylated amine epoxy technology from several vantage points. These include examining their respective chemistries, assessing the productivity afforded by, and user friendliness of, both technologies and evaluating how they perform in accelerated laboratory testing.

It should be stated from the outset that there is presently no firm consensus in the court of CUI opinion as to what accelerated laboratory test for coatings would provide meaningful and reproducible data to predict and correlate well with real-world coating performance in complex CUI environments. That said, the protective coatings industry is making great strides to develop such an accelerated test[1,2].

Despite inadequacies, accelerated laboratory test methodologies can distinguish coating performance under select CUI conditions and in cycling between cryogenic and high-temperature regimes[3,4]. Importantly, some of these accelerated coating tests have evidenced good correlations between laboratory test data and real-world coating performance for 10 years[5]. This finding provides confidence and a positive influence for specification authorities and asset owners alike who require high-performance coatings as part of their CUI mitigation strategies.

One such accelerated laboratory test to benchmark and determine the suitability of immersion-grade candidate coatings in CUI prequalification programs is the CUI Cyclic Corrosion Pipe Test (CCCPT). Details of this test and its usefulness for differentiation of coatings have been described elsewhere[3].

A SNAPSHOT OF EPOXY RESINS: STRUCTURE, REACTIVITY AND HEAT RESISTANCE

In order to produce epoxy coatings and linings there are three main types of epoxy resins used to cross-link a variety of curing agents (e.g., amines, polyesters, mercaptans, fatty acids and acrylics). The ensuing cross-link density is envisaged as the distance between the cross-links per unit of length. A high cross-link density will yield high chemical resistance and lower

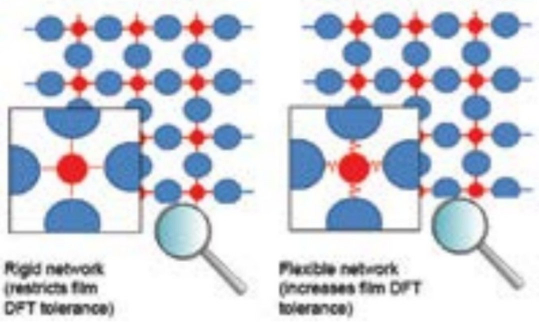

Fig. 1: Epoxy phenolic and alkylated amine networks. Conventional epoxy phenolic (left). Rigid network. Restricts film DFT tolerance. Alkylated amine epoxy (right). Flexible network. Increases film DTF tolerance. Figures courtesy of the authors.

flexibility. Lower cross-link density linings, conversely, yield lower chemical resistance and greater flexibility[6].

All things being equal, the greater the functionality of the epoxy resin, the greater will be the cross-link density of the epoxy coating and the greater the temperature resistance of the coating, say, for a given CUI mitigation service.

Bisphenol A Resins

Bisphenol A resins have the lowest functionality (n = 1.9) of the three classes and are mainly used to produce solvent-based and solvent-free epoxy coatings for less severe environments. They can be co-reacted with high functionality curing agents to produce immersion grade coatings suitable for CUI services at temperatures up to approximately 300 F (149 C).

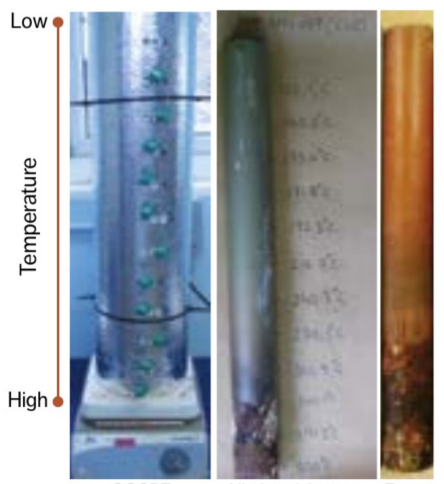

Fig. 2: CUI resistance from CCCPT.

Bisphenol F Resins

Bisphenol F resins have a higher functionality (n = 2.1), are smaller and less viscous, and possess a higher molecular mobility than the Bisphenol A resins. There is a lower steric hindrance of the methylene bridges in Bisphenol F resins compared to the higher steric hindrance from isopropylidene bridges in Bisphenol A resins.

Bisphenol F resins can be co-reacted with high-functionality curing agents to produce greater (a) cross-link density, (b) chemical resistance and (c) temperature resistance of the immersion grade epoxy and range of solvent-free linings. Not surprisingly, epoxy phenolic coatings are the time-proven workhorse for high-heat and CUI mitigation in the temperature range of 39 F (4 C) to 347 F (175 C) for carbon steel and 102 F (40 C) to 347 F for stainless steel. The upper temperature threshold that an epoxy phenolic coating would normally handle for non-insulated structures would be ca 392 F (200 C).

Novolac Resins

These multifunctional and viscous resins (n = 2.5 to 3.4) offer the potential to maximize the chemical and thermal resistance of an epoxy coating when cross-linked with judiciously selected curing agents. The cross-link density, glass transition temperature (Tg), and thermal and chemical resistance of epoxy coatings may follow the rough order of epoxy novolacs are greater than Bisphenol F-based (phenolic) epoxies which are greater than Bisphenol A-based epoxies. However, this is very much an oversimplification[7].

Although epoxy novolacs have high water, chemical and temperature resistance, on the downside their high cross-link densities give rise to epoxy films with increased brittleness and reduced toughness.

While cross-linked densities of epoxy coatings and linings are related to the functionality and molecular length of their epoxy resins, it should be emphasized that the curing agent structure and reactivity also play a pivotal role in the thermal and chemical resistant properties of the film[8,9]. With respect to functionality, the authors have often said "a multi-functional polyamine (curing agent) is to a diamine (curing agent) as a novolac resin (epoxy resin) is to a Bis-A resin (epoxy resin)"[3].

The heat resistance and high Tgs of epoxy linings based on epoxy novolac resins has made them the linings of choice for many oil patch services around the world. Moreover, in the last decade, some of these epoxy novolacs have been formulated with fluorine atom enrichment. The latter provides the film with low surface energy characteristics useful for improved flow over the surface and easier release of unwanted materials and contaminants.

LININGS FOR PIPES, TANKS, VESSELS AND RAILCARS

For decades, thin-film multi-coat novolac epoxies and thick-film single coat novolac epoxies have been used to afford corrosion protection to storage tank interiors, vessels and pipe spools. Service conditions in the oil patch vary considerably and can include high temperatures and pressures, hydrogen sulfide (H_2S) and carbon dioxide (CO_2) acid gases, as well as many types of production fluids. For railcars, aggressive cargoes include molten sulfur, shale oil, caustics, sodium chlorate, potash and plastic pellets.

As in the case of epoxy linings used to mitigate CUI, the structure, reactivity and chemical properties of the aforementioned three epoxy resin types are most important for proper lining design. But in oil field applications, it is largely the curing agent that is the primary determinant of a lining's performance[6].

For the past 20 years, the curing agents used to formulate some of the most temperature- and chemically resistant epoxy linings have been high-functionality polycyclamines, as opposed to the somewhat more chemically resistant, but toxicologically problematic aromatic amines such as methylene dianiline.

Many of the polycyclamine-cured epoxy linings have rapid-cure characteristics and can be applied in single-coat applications. They contain both multi-functional amine curing agents, as well as high-functionality epoxy phenolic or epoxy novolac resins (respectively, n = 2.1 to 2.8).

For railcar internals, the impetus for using the novel single-coat MPCE lining system

Table 1: Conventional Epoxy Phenolic for High Heat and CUI Service.

Temperature	Touch Dry (hours)	Hard Dry (hours)	Min Overcoating (hours)
-5 C (23 F)	NA	NA	NA
10 C (50 F)	8	16	36
15 C (59 F)	7	12	24
25 C (77 F)	6	8	16
40 C (104 F)	3	6	16

Table 2: Alkylated Amine Epoxy for High Heat and CUI Service.

Temperature	Touch Dry (hours)	Hard Dry (hours)	Min Overcoating (hours)
-5 C (23 F)	7	10	14
10 C (50 F)	5	8	10
20 C (68 F)	4	6	7
35 C (95 F)	2	4	4

includes overall productivity with enhanced shop throughput because of the rapid-cure characteristics, minimal time delays, labor savings from the use of single-leg spray equipment, and low VOC emissions from the lining. The latter was hard dry in four hours at ambient temperature or hard dry in two hours if vented for one hour and post cured by baking at 150 F (66 C) for another hour.

STEP CHANGE: ALKYLATED AMINE EPOXY TECHNOLOGY

The differences in the chemistry and network of an epoxy phenolic coating and the step-change alkylated amine epoxy can be pictorialized in the schematic diagram shown in Figure 1 (p. 37).

Protecting process pipes from the ravages of high heat and CUI, epoxy phenolic coatings have an excellent track record and have performed admirably for asset owners worldwide.

From a practical standpoint, the minimum curing temperatures of approximately 50 F (10 C) and long cure times coupled with a sensitivity to overbuild the epoxy phenolic coating negatively impacts fabricators who experience delays in both moving and shipping coated steel pipe from the shop and the field crew erecting the pipe at the jobsite. Time/temperature drying data for a conventional epoxy phenolic coating is presented in Table 1.

In contrast, productivity and logistics issues associated with the use of epoxy phenolics have been overcome with the alkylated amine epoxy. The latter forms a robust film and can be applied at low substrate temperatures, cures at low temperatures and cures rapidly with minimal touch dry and hard dry times as shown in Table 2.

For the coating applicator, the high DFT tolerance of the alkylated amine epoxy reduces the risk of an overly thick film cracking. This is unlike the case for conventional epoxy phenolic coatings which have a propensity to crack at far lower threshold DFT values. Tables 3 (p. 40) and 4 (p. 41) illustrate the tolerances to over-application for an alkylated amine epoxy coating (as a function of temperature) compared to a conventional epoxy phenolic coating.

Aside from the enhanced productivity and ease of use for fabricators and coating contractors, the alkylated amine epoxy was designed with simplicity in mind for engineers and specification authorities in order to reduce the number of coatings on specifications without sacrificing performance.

For process pipes, the alkylated amine epoxy maximum temperature resistance for continuous use is 401 F (205 C) with intermittent use to 446F (230C) and it is used for both insulated and uninsulated carbon and stainless steel operating between -321 F and 401 F (-196 C and 205 C). From testing according to the ISO 20340 protocol, this epoxy exhibits excellent corrosion protection.

Interestingly, for non-insulated process pipes, the alkylated amine epoxy eliminates the temperature and humidity requirements associated with the application of inorganic zinc coatings. This translates to superior coating quality and productivity in all climate conditions.

The CCCPT accelerated laboratory test was used to evaluate the performance of the alkylated amine epoxy for use as a specialty coating for CUI mitigation. A two-coat application of this coating performed well and better than a two-coat application of a conventional epoxy phenolic as shown in Figure 2 (p. 37).

CASE HISTORY

A major fabricator of offshore structures was using multiple coating systems to meet the needs of its coating specification. Systems were required for carbon and stainless steel, insulated and uninsulated service and various operating temperatures.

A two-coat system of alkylated amine epoxy technology (each coat 6 mils [150 microns]) was adopted as a means to help reduce specification complexity. The system was applied to steel abrasive blasted to SSPC-SP 10/NACE No. 2, "Near-White Blast Cleaning" using an airless spray pump with a 19-to-24-thousands-tip range. The specification complexity reduction had numerous benefits: 1) the alkylated amine epoxy technology was very easy to apply compared to conventional products (e.g., inorganic zinc silicate primers require humidity control and epoxy phenolics are sensitive to the applied dry-film thickness); 2) damage repair was straightforward for the alkylated amine epoxy whereas some systems required multiple products; 3) the ability to cure at low temperatures down to 23 F (-5 C) reduced heating costs and 4) the complexity of stock management was eased where

Table 3: Tolerance to DFT Over-Application for a Conventional Epoxy Phenolic.

Conventional Epoxy Phenolic	243 F (120 C)	302 F (150 C)	392 F (200 C)
	1 x 8 mils	1 x 8 mils	1 x 8 mils
	2 x 4 mils	2 x 4 mils	2 x 4 mils
	2 x 6 mils	2 x 6 mils	2 x 6 mils
	2 x 7 mils	2 x 7 mils	2 x 7 mils
	2 x 8 mils	2 x 8 mils	2 x 8 mils
2 x 9 mils DFT	2 x 9 mils	2 x 9 mils	2 x 9 mils
stoved at 392 F (200 C)	2 x 10 mils	2 x 10 mils	2 x 10 mils

Light grey – good, no visible defects. Medium grey – cracking and defects observed around weld only.
Dark grey – cracking and defects observed around face of panel

previously up to 25 different base and curing agents needed to be managed, the alkylated amine epoxy technology reduced this to just four products.

The ease of use and ability to improve productivity of the alkylated amine epoxy technology were both seen as major advantages (Figs. 3 and 4).

STEP CHANGE: MODIFIED POLYCYCLAMINE-CURED EPOXY (MPCE) TECHNOLOGY

Several papers have been published on the accelerated laboratory testing and oil field applications of polycyclamine-cured epoxy linings including the subject low-VOC MPCE lining[10,11].

Before discussing how this technology was recognized as particularly significant for corrosion protection in railcars, it is instructive to briefly review testing the technology by third-party laboratories in the oil and gas industry.

Excellent performance was observed with a single-coat application of MPCE at 16-to-30 mils DFT when tested at elevated temperatures and pressures in simulated oil-patch conditions using Autoclave TM0185 and EIS testing[12,13].

In one published paper the MPCE lining described herein performed best in test among nine solventborne and solvent-free epoxy linings in three test phases, namely aqueous and sweet, sour or shale oil media, and H_2S and CO_2 acid gases at 300 F (149 C) and 250 psi. Table 5 (p. 42) shows the results for three of the relevant linings to the present discussion: MPCE, polycyclamine-cured epoxy and epoxy phenolic[11].

The high-heat resistance of the MPCE lining

Table 4: Tolerance to DFT Over-Application for a Novel Alkylated Amine Epoxy.

Alkylated Amine Epoxy	243 F (120 C)	302 F (150 C)	392 F (200 C)
	1 x 8 mils	1 x 8 mils	1 x 8 mils
	2 x 4 mils	2 x 4 mils	2 x 4 mils
	2 x 5 mils	2 x 5 mils	2 x 5 mils
	2 x 6 mils	2 x 6 mils	2 x 6 mils
	2 x 7 mils	2 x 7 mils	2 x 7 mils
	2 x 8 mils	2 x 8 mils	2 x 8 mils
2 x 12 mils DFT stoved at 392 F (200 C)	2 x 12 mils	2 x 12 mils	2 x 12 mils

No visible defects found in any panel with alkylated amine epoxy.

Fig. 3: Pipe spools coated with alkylated amine epoxy technology.

Fig. 4: Pipe spools coated with alkylated amine epoxy technology.

was confirmed in oil patch immersion service such as tanks, treaters, separators and free water knock-out drums. The results reinforced the judicious decisions of numerous facility owners to protect their assets with this technology and the success garnered in doing so.

Further adhesion test studies by the authors highlighted an effect of the MPCE technology that would also benefit railcar owners, namely the influence of polytetrafluoroethylene (PTFE) pigmentation in the lining. The MPCE lining not only exhibited the best adhesion to steel, as evidenced by the parallel scribe test results seen in Table 5 (p. 42), but also suffered repeated "glue failure" at 600-to-900 psi when subjected to ASTM D4541 adhesion testing[14].

This adhesion study did not suggest an anomaly. On the contrary, the surface of the epoxy lining was enriched with fluorine atoms from PTFE (polytetrafluoroethylene) pigmentation. That meant the lining had a particularly low surface energy, low coefficient of friction and low critical surface tension that was not conducive to the glue affixing a dolly to the lining (Table 6, p. 42). A simple analogy is the anticipated difficulty trying to glue a dolly to a Teflon-coated pan in the vain hope of obtaining meaningful adhesion to the surface, admittedly recognizing that Teflon has a very high thermal resistance and tenacious adhesion to the pan. With no appreciable decomposition even at 500 F (260 C), PTFE is one of the most thermally stable plastic materials and thus does not impair the upper thermal threshold of MPCE at approximately 300 F immersion or 450 F (230 C) in dry conditions.

In practical terms then for railcar owners, the fluorine atoms in PTFE assist the surface slip

Table 5: Post-Autoclave Analysis from Test Program.

Lining	DFT mils (av)	Adhesion (parallel Scribe) Rating				Blistering (ASTM D714)			Impedance Log Z @ 0.1 Hz			
		Pre-test	Water	HC	Gas	Water	HC	Gas	Pre-test	Water	HC	Gas
Conditions: Test temperature 300 F/149 C, pressure 250 psig Gas phase: 10% H_2S, 10% CO_2, 80% CH4 for 96 hrs Hydrocarbon (HC) phase: Shale Oil, Water phase: 5% NaCl in distilled water												
A	17.8	A	A	A	B	None	None	None	12.23	11.70	11.73	11.75
B	32.5	D	C	D	D	None	None	None	11.56	11.68	11.68	11.71
C	20.9	A	E	E	E	None	None	None	11.63	11.79	11.81	11.80

A is solvent-free modified polycyclamine cured epoxy (MPCE) lining. B is solvent-free polycyclamine cured epoxy lining. C is solvent-free epoxy phenolic lining DFTs were measured for each lining and each phase. Reported DFT average of control panels. HC = hydrocarbon.

Table 6: Critical Surface Tensions of a Variety of Substances.

Substrates	Surface Tension (dynes/cm)
Polytetrafluoroethylene	19
Glass	73
Steel	50
Epoxy resin	47
MPCE (Lining A Table 5)	35
Epoxy Phenolic (Lining C Table 5)	50

Fig. 5: MPCE railcar lining.

properties of the epoxy such that fluids do not readily stick to its surface and release easily during clean-out procedures. The same can be said in practical terms for the water and waste, and oil and gas industries. Here, the thermal resistance and low surface energy of the MPCE affords not only corrosion protection and hydrolytic and thermolytic resistance, but slip resistance, head-loss reduction and power reduction during water or oil conveyance.

CASE HISTORY

During the past three years, a single-coat system of a solvent-free, high-build, modified amine-cured phenolic epoxy was applied at 12-to-18 mils DFT to several hundred railcar interiors used to transport shale oil (Fig. 5).

The specification called for an SSPC-SP 10/NACE No. 2, "Near White Blast Cleaning" blast and a sharp angular profile of 2-to-3 mils[15]. A mixture of steel shot and grit was used as the abrasive media. Spray application of the coating system was accomplished using plural-component spray equipment.

The impetus for the single-coat system was essentially labor savings and low VOC emissions. The labor savings achieved with the fast turnaround, single-coat system was judged to save the fabricator considerable time. The internal lining was deemed to be hard dry in four hours at ambient temperature or hard dry in two hours if vented for one hour and post cured by baking at 150 F (71 C) for another hour.

This project was completed on schedule and all parties pleased. One year later the interior linings of two cars were inspected. The owner, railcar fabricator and linings supplier were very satisfied with the lining performance.

CONCLUSIONS

A step change and novel alkylated amine epoxy has been identified that possesses high-heat resistance for insulated and non-insulated steel structures.

The alkylated amine epoxy is atypical of conventional epoxy phenolic coatings. It has low-temperature and rapid-cure characteristics, is tolerant of DFT over-application, is easy to use for applicators and affords productivity enhancements for fabrication shops.

Another step-change epoxy identified is a modified polycyclamine cured epoxy (MPCE) for internal applications that include tanks, pipes, vessels and railcars.

The MPCE technology provides high-heat resistance and low surface energy suited to easy cleaning and improved flow in all industrial sectors.

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ENHANCING THE UV DURABILITY OF EPOXY COATINGS:

Waterborne Acrylic-Epoxy Hybrid Coatings for Steel

BY HANK BERNACKI, ZHENWEN FU, BINGQUAN LI, DENISE LINDENMUTH AND LEO PROCOPIO, THE DOW CHEMICAL COMPANY

Every resin chemistry used in coatings science has both benefits and disadvantages. For this reason, each generic class of resin excels in certain applications and has weaknesses that preclude its use in other applications. Important features of coatings can include properties such as adhesion, corrosion resistance, chemical and solvent resistance, UV durability or hardness, as well as attributes such as raw material cost, potlife, volatile organic compound (VOC) content, flammability, and other environmental, health and safety concerns such as toxicity. Finding a coating with the best balance of these properties and attributes for each end-use application is often complicated by the weaknesses inherent to each specific chemistry.

Epoxy chemistry is widely used within coatings science because of its excellent balance of performance and cost. In two-component (2K) coatings, epoxy resins are cross-linked with a co-reactant such as an amine-functional hardener. The resulting film has a high cross-link density, which leads to excellent barrier and resistance properties. As a generic class, epoxy coatings are widely known for their low water permeability, excellent corrosion resistance, high level of chemical and solvent resistance, tenacious adhesion, and good hardness and resistance to mechanical abrasion[1]. They are used in applications as diverse as pipe coatings, metal primers, concrete floor coatings and tank linings.

In industrial maintenance painting, epoxies are the most widely used generic class of coating and are estimated to make up approximately 35 percent of industrial maintenance coatings used in the United States[2]. They are commonly used as primers or midcoats over steel in atmospheric service and sometimes as direct-to-metal (DTM) finishes. It is in their use as a finish coat, however, where one of the weaknesses of epoxy coatings becomes evident. Due to the high aromatic content of the epoxy resins (and in many cases amine functionality), durability towards ultraviolet (UV) light is poor and leads to breakdown of the epoxy coating when exposed to sunlight. The poor UV durability is manifested in poor gloss and color retention, chalking, and eventually the degradation of film properties such as corrosion resistance.

The most common type of epoxy resins used in coatings are based on the diglycidylethers of bisphenol A (Bis A) and bisphenol F (Bis F) and higher molecular weight resins based on their advancement. The formation of the diglycidylether of bisphenol A (DGEBA) from Bis A and epichlorohydrin is shown in Figure 1 and the process for its advancement into higher molecular weight Bis A epoxy resins is shown in Figure 2. The residual hydroxyl and glycidyl functionalities in epoxy resins are sites for reaction with cross-linkers (also known as hardeners). Cross-linking is essential in building molecular weight in the final coating film and yields properties such as corrosion resistance, hardness and chemical resistance. The excellent adhesion of epoxies is often attributed to the presence of the hydroxyl groups and their chemical inertness is attributed to their aromatic content. However, it is the high level of aromatic ring content in epoxies that results in their poor UV durability. Aliphatic epoxy resins are available, but those resins are more expensive to produce and react more slowly with

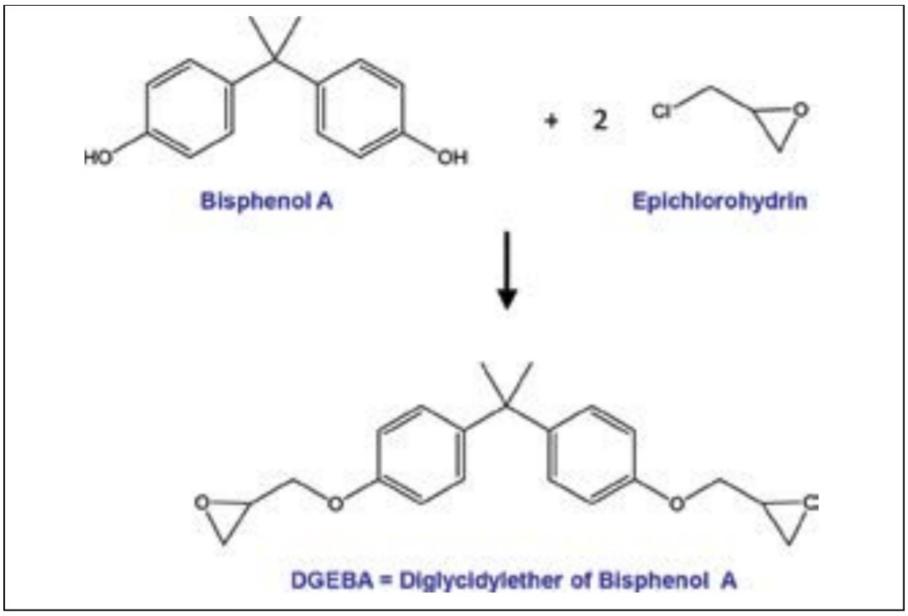


Fig. 1: The formation of DGEBA from Bisphenol A and epichlorohydrin. Figures courtesy of the authors.

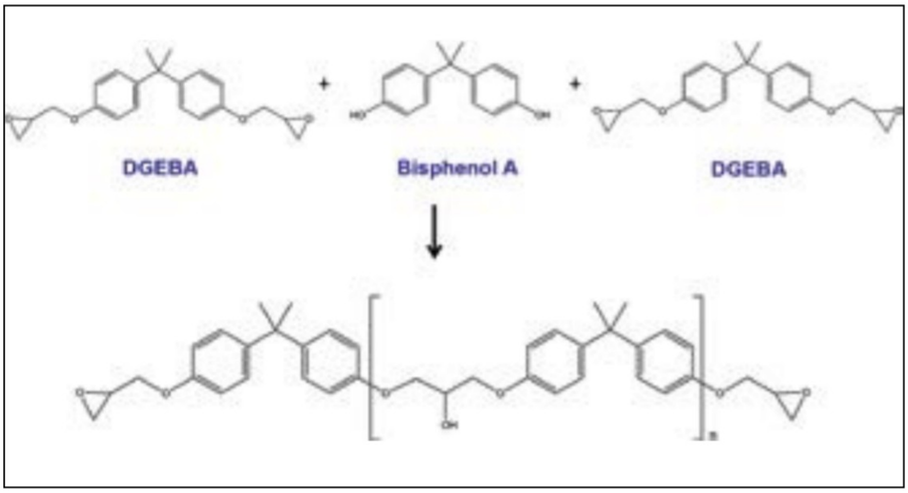


Fig. 2: The advancement of DGEBA into higher molecular weight Bis A epoxy resins.

conventional curing agents than do the more common aromatic epoxies.

Liquid coatings based on epoxy chemistry are available in high solids and solventborne systems, as well as waterborne versions. High-solids epoxy coatings are generally based on low molecular weight epoxy resins, which are necessary to maintain coating viscosities low enough for easy application. Higher molecular weight epoxy resins are generally solids and solvent is necessary to dissolve them to form a liquid coating. One disadvantage of the solventborne versions is higher VOC content. To avoid high VOC content, waterborne epoxies have been developed.

There are three common types of waterborne epoxies used in industrial painting (Fig. 3). The first, referred to here as Type I, is based on taking a low molecular weight, liquid epoxy resin (LER) and dispersing it directly into a waterborne amine hardener. Co-solvents are often added to the LER in order to lower its viscosity, which aids in easier pouring, mixing and dispersing into water. Surfactants can also be added to aid in dispersion, although too much surfactant can lead to water- and corrosion-resistance problems for the coating film. Type I systems typically have a high hardener demand due to the low epoxy equivalent weight (EEW) of LER. The high cross-link density that results can lead to brittleness, poor flexibility and impact resistance. The potlife of Type I systems is often short, in the range of 1-to-2 hours.

The second type of waterborne epoxy system, Type II, is based on a pre-dispersed waterborne epoxy resin mixed with a waterborne amine hardener[3]. The epoxy dispersion in water is made beforehand and typically uses surfactants and mechanical shear to form a stable dispersion. The pre-dispersed epoxy can be either an LER or a higher molecular weight solid epoxy resin (SER) with a higher EEW and lower hardener demand. A benefit of using a pre-dispersed epoxy in a Type II system is its lower viscosity and easier mixing compared to using an LER in the Type I systems. One drawback is

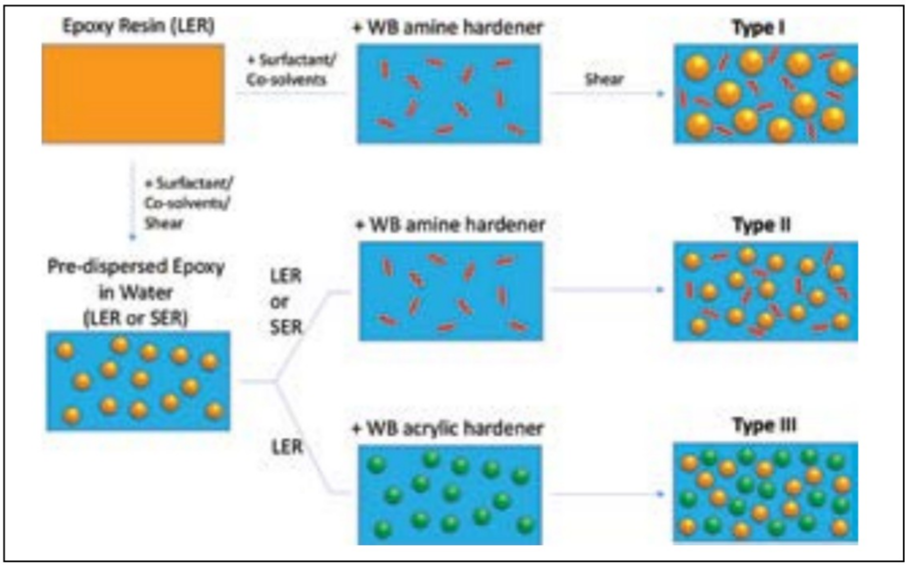


Fig. 3: Types of waterborne epoxy coatings.

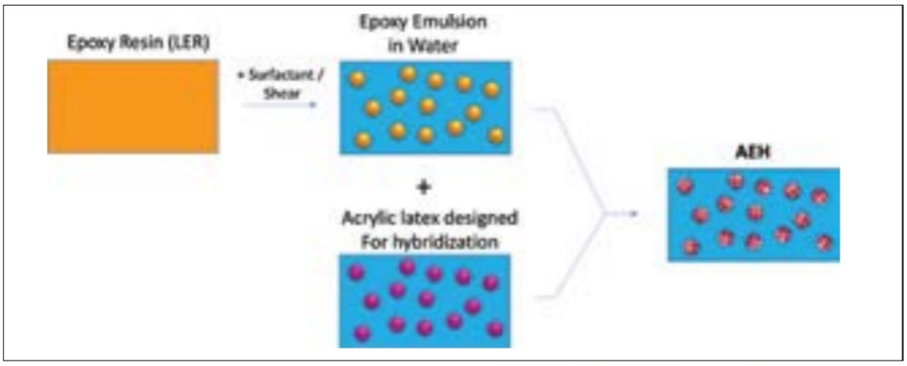
often higher cost because the epoxy is being dispersed ahead of time rather than during the mixing of the 2K coating. When an SER is utilized, cross-link density is lower and flexibility is improved. Drying speed is increased because the high molecular weight SER can give more lacquer-like dry behavior as compared to lower molecular weight LER, which relies on chemical curing to give dry-to-touch properties. The potlife of a Type II coating is typically in the range of 2-to-4 hours.

The third waterborne system using epoxy chemistry is based on a pre-dispersed waterborne epoxy resin and a carboxylic acid-functional acrylic latex hardener[4]. This system is described as a Type III in Figure 3 (p. 45). The reaction between the epoxy resin and the carboxylic acid functionality on the acrylic is fairly slow compared to the epoxy/amine reaction. Due to the slow reaction, full cross-linking and property development can take from several days up to a couple of weeks. The slow reaction is beneficial for the potlife, however, and Type III systems usually have 8-to-24 hours of usable potlife after mixing. The epoxy resin in a Type III system is typically a pre-dispersed LER. On a solids basis, acrylic is usually 70-to-80 percent of the total resin, which means Type III coatings dry rapidly, with the lacquer-like dry typical of an acrylic latex. The high level of acrylic in the final film also facilitates improved UV durability versus Type I and II systems, in essence diluting the less durable epoxy with a more durable acrylic. However, overall cross-link density and chemical/solvent resistance properties of the Type III system is lower compared to the Type I and Type II systems, as is metal adhesion and corrosion resistance.

The challenge with epoxy chemistry is maintaining all of the excellent coating properties such as adhesion, corrosion resistance and chemical/solvent resistance while improving upon its weaknesses such as flexibility, potlife and UV durability. The Type III acrylic/epoxy systems improve upon UV durability, but with slow cure speed and property development. This article describes a new acrylic-epoxy hybrid polymer technology for 2K waterborne coatings that addresses these issues.

ACRYLIC-EPOXY HYBRID TECHNOLOGY

A key challenge in coatings science can be postulated as follows: How do we combine the advantages of two different coating chemistries into a single system and bypass their weaknesses? One method that has been used in the past in coatings science and is getting more attention today is the concept of hybrids, combining two different polymer technologies into a single coating layer. One example of a hybrid that has been used successfully in the past is silicone alkyds, using silicone technology to improve the durability of alkyds. In the industrial maintenance market today, polysiloxanes and fluorourethanes are getting



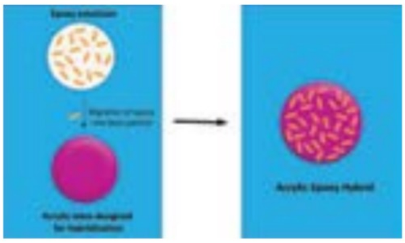


Fig. 4 (Above): Synthetic process for preparation of an acrylic-epoxy hybrid (AEH) polymer.

Fig: 5 (Right): Detailed view of epoxy transporting into the acrylic latex particle to form the AEH polymer.

increased attention. One type of polysiloxane coating combines the benefits of silicone technology with those of epoxy chemistry to give highly durable solventborne topcoats[5]. Fluorourethanes improve upon the gloss and color retention of 2K polyurethanes by incorporating the extreme durability brought by fluoropolymers[6].

As discussed previously, epoxy coatings have many desirable properties, but often lack in certain other ones such as flexibility and durability. Acrylics, on the other hand, are known for their flexibility and UV durability, but lack in corrosion and chemical/solvent resistance compared to epoxies. An acrylic-epoxy hybrid (AEH) technology described here combines the adhesion and corrosion resistance of epoxies with the durability and flexibility of acrylics in a new type of 2K waterborne coating[7].

The AEH polymer can be depicted as an acrylic latex polymer that acts as a carrier for low molecular weight epoxy resin molecules. The synthesis of the AEH polymer is done by first preparing an acrylic latex, and then introducing an aqueous emulsion of low molecular weight epoxy resin to the latex (Fig. 4). The latex is made via a typical emulsion polymerization process, but the acrylic polymer is specifically designed so that it does not react with the epoxy resin to cause gelation of the system. Once added, discrete epoxy domains slowly disappear as epoxy molecules are transported across the aqueous phase and diffuse into the latex particles (Fig. 5). The result is an acrylic latex that has been swollen with epoxy resin to form the AEH latex particle. The AEH polymer is the first component of the 2K cross-linked coating.

Many variables can be adjusted in the preparation of the AEH polymer to control the final coating properties. The acrylic polymer can be varied using all of the tools available in a typical emulsion polymerization, including monomer composition, glass transition temperature (Tg), molecular weight, particle size and morphology. The type and level of epoxy resin can also be varied. Examples of AEH polymers have been prepared with Bis A and Bis F epoxy resins, novolac epoxies, aliphatic

Table 1: Comparison of Gloss White DTM Finishes.

Coating	AEH	Commercial No. 1	Commercial No. 2	Commercial No. 3	Commercial No. 4
Type	WB AEH/ amine	SB epoxy/ amine	SB epoxy/ amine	SB epoxy/ amine	SB epoxy/ amine
VOC (g/L)	100	<250	<250	<200	<340
% Vol Solids	38	72	72	77	63
Dry Time Measurements					
Wet film thickness (µm)	150	75	75	75	75/150
Set to Touch (hours)	0.25	1.5	0.25	2.75	0.2/0.4
Tack Free (hours)	1	4	2.5	5.25	1.75/3.25
Dry Hard (hours)	5.5	6.5	5.25	7.5	4.5/6.5
Dry Through (hours)	>12	9	>12	10.25	>12/10.25
Viscosity (KU)	72	>141	123	102	129
Gloss (60 degrees)	83	37	94	54	55
Potlife	3-4 hours	Not determined. Initial viscosity too high.	4-5 hours	1-2 hours	2-3 hours
Mandrel bend (1/8 in.)	Pass (1/8 in.)	Pass (1/8 in.)	Fail (1/2 in.)	Pass (1/8 in.)	Marginal Pass (1/8 in.)
Konig hardness (sec.)					
1 day	7.0	11.4	11.9	9.5	8.5
7 day	16.7	17.6	42.0	14.3	49.1
14 day	24.4	24.4	54.1	18.6	78.5

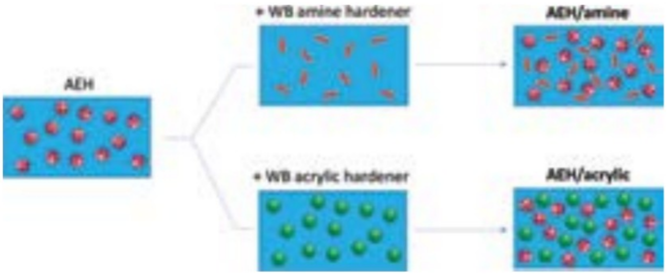


Fig. 6: Possible 2K waterborne coatings based on AEH polymers.

epoxies and combinations of them.

Because the acrylic-epoxy hybrid is epoxy-functional, traditional hardeners for epoxy chemistry are utilized as the cross-linkers in 2K coatings and can also be varied to produce a range of performance capabilities. For example, the second component in the 2K-AEH system can be a waterborne amine hardener or an acid-functional acrylic (Fig. 6). Examples of properties available for protective coatings on steel with the 2K-AEH/amine and AEH/acrylic systems will be described later along with comparisons to traditional solventborne epoxy coatings.

COMPARISON OF AEH TECHNOLOGY WITH SOLVENTBORNE EPOXIES

The examples described here will be gloss direct-to-metal (DTM) coatings. In this type of application, such as exterior coatings for chemical storage tanks or rail tank cars, the poor UV durability of traditional epoxy systems results in chalking and poor gloss and color retention after a relatively short service life. Aesthetic durability is improved considerably with the waterborne 2K AEH coating compared to solventborne epoxies typically used in these applications. This study compares a gloss white DTM coating based on an AEH polymer (AEH-1) cross-linked with a waterborne amine hardener (AH-1). Hybrid polymer AEH-1 has 52-percent solids and an EEW of 613 g/equivalent on a solids basis. Part A of the 2K coating was a pigmented formulation based on AEH-1, with TiO_2 as the only pigment at 15 percent PVC (pigment volume concentration). Due to the high Tg of the acrylic phase of AEH-1, a low level of coalescing solvent was used and VOC of the final coating was 100 g/L. One advantage of the AEH technology is that a high Tg acrylic phase can be

Fig. 7: Salt spray panels after 1,000 hours of exposure to ASTM B117.

utilized but overall VOC content is still quite low, because the imbibed epoxy resin effectively lowers the minimum film formation temperature (MFFT) of the acrylic. The Tg of the acrylic latex used to prepare AEH-1 is over 50 C, but the MFFT of AEH-1 is below 15 C due to the high loading of epoxy. Part B of the 2K coating was a traditional waterborne amine hardener and the epoxy was used in a small stoichiometric excess (a stoichiometric ratio of epoxy to active amine hydrogen of 1.03-to-1).

The 2K waterborne AEH coating was compared to several commercial 2K solventborne epoxies recommended for DTM finishes (Table 1, p. 48). All of the commercial epoxy coatings were supplied at high-volume solids and VOC levels, with the lowest VOC content reported as under 200 g/L. Films were applied at approximately 5 mils dry-film thickness (DFT) over metal panels and evaluated for corrosion resistance, adhesion, UV durability (gloss retention) and flexibility.

Dry times were measured with a dry-time recorder according to ASTM D5895, “Standard Test Methods for Evaluating Drying or Curing During Film Formation of Organic Coatings Using Mechanical Recorders.” It is obvious that the waterborne AEH coating has a much faster set-to-touch and tack-free dry time compared to all of the commercial solventborne epoxies. The structure of the AEH latex allows it to give a fast lacquer-like dry much like a conventional acrylic latex, even before the epoxy/amine reaction is complete. The commercial controls, however, rely on chemical curing of the epoxy/amine to increase film hardness over time. The dry-hard and dry-through times of the AEH and commercial controls are similar.

Coatings based on AEH technology tend to have relatively long potlives compared to Type I and Type II waterborne epoxy coatings. Shown in Figures 5 (p. 48) and 6 (p. 49), in the wet state of the mixed 2K coating, the epoxy molecules are within the latex particle and are effectively separated from the hardener. The gloss white DTM based on AEH-1 had a potlife between three and four hours, measured as the time at which viscosity begins to increase rapidly. The solventborne epoxy/amine coatings all had shorter potlifes, except for Commercial No. 2. Potlives in the range of 4-to-8 hours are typical with the AEH technology and closer to the potlife observed in Type III systems.

Flexibility was measured by bending 1-inch-wide strips of coated panels over mandrels of varying diameters. The AEH system and two of the solventborne epoxies passed at the smallest mandrel diameter of ⅛-inch. Commercial No. 2 failed even at ½-inch and Commercial No. 4 had some slight failure at ⅛-inch. Flexibility results are in line with hardness development shown

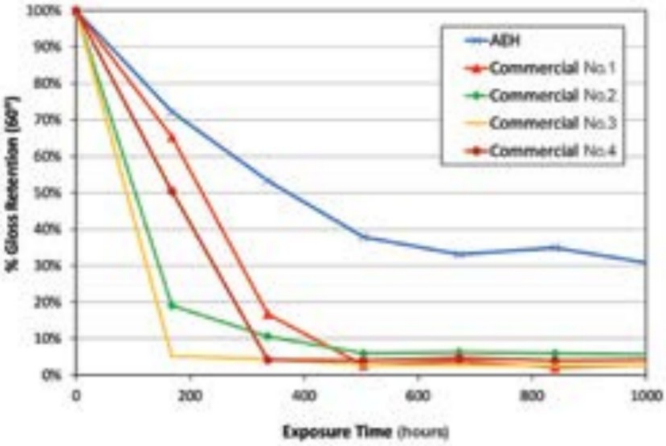


Fig. 8: Gloss retention on accelerated UV-A exposure of 2K gloss white DTM coatings.

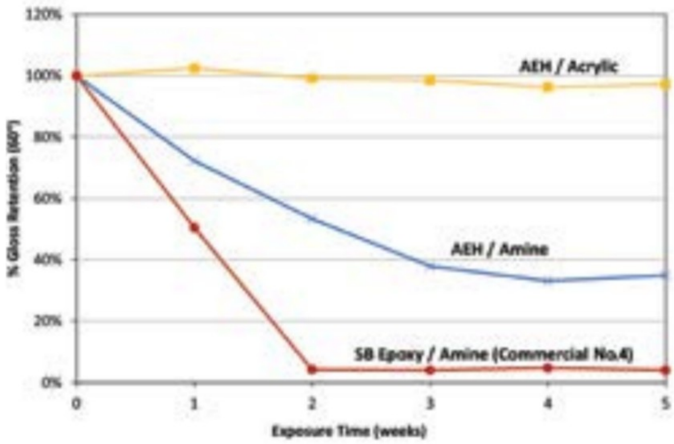


Fig. 9: Gloss retention of 2K gloss white DTM coatings comparing AEH/acrylic, AEH/amine and SB epoxy/amine systems.

in Table 1 (p. 48), where both Commercial No. 2 and No. 4 develop greater hardness compared to the other three systems.

Adhesion and corrosion resistance were also evaluated for coatings applied to steel panels. Coatings were applied at a 5 mil DFT over abrasive-blasted, hot-rolled steel (cleaned to SSPC-SP 5/NACE No. 1, "White Metal Blast Cleaning") and cured for 14 days prior to evaluation. Adhesion was measured by the crosshatch tape method of ASTM D3359, "Standard Test Methods for Rating Adhesion by Tape Test." Wet adhesion was measured after five hours of exposure to water mist in a fog box. All systems had excellent dry and wet adhesion with ratings of 5B. Corrosion resistance was evaluated by salt spray (ASTM B117, "Standard Practice for Operating Salt Spray [Fog] Apparatus"). Figure 7 (p. 49) shows the panels after 1,000 hours of exposure. The AEH coating performed better than two of the solventborne epoxies (Commercial No. 1 and No. 3) and comparably to the other commercial coatings. The excellent corrosion resistance after 1,000 hours of exposure included exceptional adhesion at the scribe, even when scraped with a metal spatula in attempts to lift the film.

UV durability was evaluated using accelerated UV exposure in a weathering cabinet according to ASTM D4587, "Standard Practice for Fluorescent UV-Condensation Exposures of Paint and Related Coatings." Coatings were applied to treated aluminum panels and dried for 14 days prior to exposure. Evaluation with UVA-340 bulbs was carried out using a cycle of eight hours of light exposure (panel temperature 60 C) and four hours of condensation (panel temperature 50 C). Initial gloss values are shown in Table 1 and results of gloss retention versus exposure time are plotted in Figure 8 (p. 51).

Under UV-A exposure, the solventborne controls lose all gloss after 400-to-500 hours. Although not perfect, the AEH/amine system performs significantly better than the solventborne epoxy/amine systems. The main reason for better UV durability with the AEH/amine system is that a large portion of the final film is acrylic polymer, which is much more durable and resistant to degradation by light than an amine-cross-linked epoxy. By diluting the less durable epoxy with acrylic, the gloss retention is improved in a similar manner to how Type III waterborne acrylic/epoxies achieve better gloss retention.

Further improvements in UV durability of the AEH system are possible when replacing the amine hardener with a carboxylic-acid functional acrylic latex. To demonstrate this point, a 2K gloss white DTM was formulated using AEH-1 in Part A and an acid-functional latex (AC-1) in Part B. In this case, TiO_2 pigmentation was included in the Part B formula. The VOC content of the mixed 2K AEH/acrylic coating was 100 g/L, the same as the AEH/amine system described previously. Because the AEH/acrylic coating has an even higher percentage of acrylic in the final film, durability is further enhanced compared to the AEH/amine system. Figure 9 (p. 51) compares the gloss retention of the AEH/acrylic, AEH/amine and solventborne epoxy/amine (Commercial No. 4) coatings under accelerated UV-A exposure out to five weeks (840 hrs). The AEH/acrylic coating has negligible gloss loss at the end of the test and nearly 100-percent retention.

CONCLUSIONS

Epoxy chemistry is prevalent throughout coatings science and is utilized heavily for industrial maintenance coatings for steel and concrete. Epoxy coatings have many excellent properties, such as adhesion, corrosion resistance and hardness. However, both solventborne epoxies and lower-VOC waterborne analogs have deficiencies such as brittleness, short potlives and most notably, poor durability towards UV light. Due to their poor weathering characteristics, epoxies tend to chalk, yellow and lose gloss quickly when exposed to sunlight. A hybrid technology has been described that maintains the best qualities of epoxy chemistry, while improving upon some of its weaknesses such as flexibility and UV durability. The hybrid technology joins acrylic and epoxy chemistries into a single waterborne offering that can then be formulated into 2K waterborne coatings for steel and concrete. The AEH represents a new method for supplying epoxy resin into a mixed 2K coating. The epoxy resin is hosted in acrylic latex particles and becomes available for cross-linking with a hardener after water begins to leave the film and particle coalescence starts. The AEH system is versatile in that either acid-functional acrylic or amine hardeners can be used. The result is a coating technology with a unique balance of properties, including long potlife, excellent corrosion resistance, good flexibility, and excellent UV durability and weatherability.

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JPCL

Getting Down to Earth With Elevated Work Platforms

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If you've spent any amount of time on a construction site, there are two pieces of equipment that you are bound to see: the lowly, but ever present, skid-steer loader (or "Bobcat") and an elevating work platform (EWP). This article will look at EWPs and how to use them safely.

EWPs come in many different variants including scissor lifts, boom lifts, push-around units (i.e., for changing lights in a warehouse area) and those mounted on vehicles (like those used by utility companies). In construction, the former two are the most common. The scissor lift makes use of an expanding scissor mechanism to lift the platform vertically above the powered, movable base. Some scissor lifts have options to extend the platform or rotate it, but this is all generally done directly above the base. These lifts often have a capacity of 500 pounds, but some can have a much greater capacity depending on their intended use and what terrain they're made for. Scissor lifts are most commonly found in on-road or relatively flat environments.

Likewise, boom lifts have movable, powered bases that are generally equipped for off-road use. However, the platform is supported on a straight or articulating boom that can be rotated in a full circle around a central axis, raised, lowered, set at an angle, swung side-to-side and extended telescopically far beyond the base. Because the platform can extend some distance from the base, these units are typically limited to a maximum capacity of 500 pounds and have limits to the slope that the base can be on to prevent the entire lift from tipping over.

Information from the International Powered Access Federation (data from 2013 to 2016) indicates a consistent 65-to-70 fatalities each year associated with EWPs. The most common causes of these fatalities include: falls from height, electrocution, entrapment and overturning. So, what can be done to mitigate some of the risks associated with lifts?

Before anyone on a jobsite even thinks about climbing into the basket of a lift, there are two critical pieces of training to go through. The first is fall-arrest or fall-protection training and the second is EWP training. Fall-protection training teaches you the basics you need to know to safely and effectively use the gear that will keep you from falling from heights. Although lifts are equipped with railings that create a basket for the worker, it doesn't matter whether the worker is standing on top of a water tower or in the basket of a lift 30 feet in the air — a fall from height is a potentially fatal occurrence. Beyond taking a fall, using fall protection properly will also provide a level of protection against being ejected from the EWP platform if you misjudge the terrain. Even a small bump can have big effect when moving a long boom lift.

> **Planning is bringing the future into the present so that you can do something about it now.**
> — Alan Lakein

The second piece of training is EWP training. Although a lift may look straightforward, there is a lot that goes into operating one safely. Do you know how to carry out the proper pre-use checks and visual inspection? What are the limits of the equipment? What sort of planning goes into successfully using a lift? The answers to these questions can be crucial when it comes to preventing injury due to an equipment failure, being able to get back to the ground in the event you are no longer in the lift basket or even helping to prevent toppling the EWP.

With these two pieces of training, and by using proper procedures and personal protective equipment, a worker should be able to greatly reduce the possibility of injury from falls from height and overturning. But, what about the other two potentially fatal occurrences with EWPs: electrocution and entrapment?

Fall-arrest training, personal protective equipment and learning what toggle or joystick actions cause which movements on an EWP will not prevent a worker from getting into trouble. There are many hazards that are somewhat unique to using an EWP and can be easy to miss without proper job planning. Designers often put hazardous items, such as electrical lines and piping, at height to prevent people on the ground from contacting them (known as vertical separation). Vertical separation is often reflective of the magnitude of the hazard, with greater hazards moved higher so that they are farther out of reach. However, with an EWP, the protection of vertical separation can quickly disappear as the worker raises the platform, even reaching the extreme where the worker is above the hazard (and possibly unable to see it through the platform).

Contact with an electrical service, whether directly by the worker or indirectly through the EWP, can also be fatal. Unfortunately, electrocution is also possible without contact, as at higher voltages, electricity can jump or arc when the air is not able to provide adequate insulation. The arcing of high-voltage power to an EWP can be just as lethal to the worker as direct contact with the power source.

The final hazard is entrapment. For many workers, this hazard is overlooked as they are working on the outside of a structure, building or ship ... and after all, it's hard to get stuck in such a way that you cannot get down when working outside. EWPs are mobile — they can be moved so that you can get stuck and cannot be readily maneuvered to easily get unstuck. It is certainly a problem, but one might ask, how is getting stuck up in an EWP a potentially fatal hazard? An EMP can be moved in such a way that the worker is caught in an unforeseen or accidental pinch point. A moment's inattention when moving an EWP can lead to a worker being crushed between a stationary object and the safety cage of the platform.

> **For the best return on your money, pour your purse into your head.**
> **— Benjamin Franklin**

So how do we, as workers, avoid getting into serious trouble using EWPs? As discussed, the first step is getting the training you need before you get into the basket or onto the platform. Without appropriate training, you won't have any idea about the EWP hazards you face or what you need (to do or make use of) to mitigate those hazards.

The next step is to plan your job — you not only need to plan for the job itself, but also for what could go wrong. The foremost question to ask during planning is, "What happens if ... ?" Ask "What hazards are there in the work area?" "Are there electrical or other lines?" "Are there structures that could make maneuvering difficult or lead to entrapment?" "What is the right personal protective equipment to use with the EWP?" "Is there a basket watch to get you back to the ground if you fall off the lift and are dangling by your fall-arrest system?" "Does the basket watch know what to do to get you down?"

> **Nothing spells trouble like two drunk cowboys with a rocket launcher.**
> **— C. J. Box**

Boom lifts are not light — is the ground strong enough to support the weight? Is the terrain rough and if so, how will you access the work area with the lift? What happens if there is a crushing type of entrapment incident with the lift? What is the emergency response plan if there is an incident, especially one at height? These and many more questions should be asked, answered, and more importantly, acted upon before any work is done using an EWP.

Once at the site, you need to make sure that the equipment is as ready to go as you are. This means carrying out the full safety checks and inspection as mandated by the manufacturer of the EWP. Full range-of-motion checks and inspections take time but can identify mechanical issues that have the potential for major consequences. After all, no worker wants to be 50 feet in the air and have a boom lock up or buckle because of an issue that should have been spotted during the safety check. Of course, the worker must be ready to go, too — mentally and physically able to carry out the work. To someone relatively new to working on an EWP, the sway of a boom lift at 30 feet can be disconcerting while the sway of a 100-foot lift might be terrifying. Similarly, a little bit of nausea on solid ground is uncomfortable, but bouncing around at the end of a boom lift can make it far more miserable and lead to poor choices.

The last part of using EWPs safely is to be focused on the work and actually work the plan. You've planned for the hazards for the job, so don't create new ones. If something changes, take a moment to stop and think about how that might alter the potential for hazards. It's better to take a couple minutes to come "down to earth" and review the changes than to dive right into an incident.

EWPs are a valuable tool at the work site and allow access to areas that we could otherwise not readily reach. However, they also come with their fair share of hazards that must be assessed and addressed for safe use. Invest the time in training and planning to avoid potentially fatal hazards associated with EWPs.

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500 lbs.

The typical maximum capacity of a boom lift style elevated work platform.
See page 55.

35%

The percentage of epoxies used in industrial maintenance painting — the most widely used generic class of coating.
See page 44.

50 F

The temperature below which applied epoxy phenolic coatings will not cure properly.
See page 36.

3

Considerations that affect field surface preparation projects – abrasive selection, existing condition assessment and worker access – that are discussed in this month's Focus On column.
See page 22.

20,000 cfm

The capacity of the dust collector used on this tank project to keep any fugitive emissions from making their way onto the nearby tarmac during blasting.
See page 28.

7

The number of coating projects presented with SSPC Structure Awards at the SSPC 2018 annual awards luncheon on Jan. 15 in New Orleans.
See page 4.