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The Voice of SSPC: The Society for Protective Coatings

Cover photo courtesy of Xu Huanhui, CYG Changyuan New Materials Company

FEATURES

38 **Fiberglass Reinforced Plastic for Pipelines**

By Xu Huanhui, CYG Changyuan New Materials Company, Shenzhen, China

The author explains how coupled with the appropriate application and quality control initiatives, FRP can effectively protect anticorrosion coatings during trenchless pipeline construction.



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By Nuno Cipriano, Ultrablast Lassarat Ltd., Brazil

This article describes how these combined technologies in newbuilding projects can provide benefits such as a cleaner shipyard, no abrasive material to dispose of, less cost and the ability to carry out simultaneous operations without dependency on ambient conditions.



51 **Replica Tape: Unlocking Hidden Information**

By David Beamish, DeFelsko Corporation

A surface profile is composed of a complex pattern of peaks and valleys. This article explains a developing technology that allows for extraction of useful information from replica tape, beyond just peak height.



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By Robert Ikenberry, California Engineering Contractors, Inc., and Don Schnell, Polygon

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EDITORIAL

(Right, below right): This Lockheed C-130 Hercules aircraft is part of the fleet at the U.S. Air Force's 911th Airlift Wing at the Pittsburgh International Airport. Photos courtesy of the 911th Airlift Wing, Pittsburgh International Airport Reserve Station and SSPC.



Take Pride in All Our Military

SSPC is presently working with the U.S. Air Force to update a training video that airmen who maintain their numerous fighter and cargo aircraft are required to watch. The video is about corrosion and the responsibility that each maintainer and airman has in fighting this menace to the combat readiness of each airframe. We shot video at the 911th Airlift Wing, located at the Pittsburgh International Airport. This Air Force Wing, which is under the U.S. Air Force Reserve Command, has some of the oldest Lockheed C-130 aircraft in the fleet; some of the planes date back to 1978. We received nothing but outstanding support from that unit. Whatever we needed, they would accommodate. Whatever video we were trying to take, they would give us the access, the manpower and the help we needed to make it happen. It is likely that had we gone to another Air Force base, they may have seen this as an intrusion, another distraction, and we would have gotten in their way. They may not have been able to see the big picture: that this video is important to the entire Air Force. The 911th clearly realized the importance of this future training tool to their branch of service.

While I was there for those four days of shooting, I talked with many of the airmen. Their attitude, morale and military discipline were qualities that all of us should be proud of. They were well-led, well-trained and absolutely focused on what needed to get done. Twenty years ago, when I left the military, we referred to the Reserves and the National Guard as "week-end warriors" or "Christmas help." That can no longer be said. Without them, our active forces would be severely restricted in accomplishing their assigned missions. With the conflicts in Iraq and Afghanistan, most of the Guard and Reserve forces



have been deployed as much or more than the active forces. At the 911th, they have eight aircraft in their wing; four of them are deployed overseas right now. While talking with the airmen I was amazed to learn the number of times they had been deployed and the places they have been.

So when you see a serviceman or servicewoman, thank them, slip them five bucks for a cup of coffee and wish them well. Take pride in all our military, because they are one team. Whether it is the active forces, the Reserves or the National Guard, they make up a much larger team: the United States military forces. Unlike the sports teams that we idolize too much, all those in the military, no matter the component or the service, are members of one of the only teams that truly makes a difference.

Bill Shoup

Bill Shoup
Executive Director, SSPC

Webinar Studies Weathering on Florida Bridge Coatings

"Weathering of High-Performance Coatings on Florida Bridges," the latest free webinar in the 2015 SSPC/JPCL Webinar Education Series, will be presented by Paul Vinik of the Florida Department of Transportation on Wednesday, August 19, from 11:00 a.m. to 12:00 noon, EST.

The State of Florida spends millions of dollars each year to mitigate corrosion and paint bridges. Because of tourism's importance to the state's economy, it is important to keep these structures in a condition

that is pleasing to the eye. Meanwhile, the constant sunlight and southern latitude produce a severe environmental effect on polymeric resins. Consequently, many bridges are painted purely for aesthetic purposes.

The Florida Department of Transportation (FDOT) has been evaluating the ability of high-performance coating systems to resist color and gloss degradation. This webinar will present the results of this study, which focuses on aesthetics, not corrosion resistance. The study, conducted at FDOT's environmental test facility in Marathon, Fla., used test panels exposed to xenon arc radiation and outdoor exposure. The



evaluation also has included several high-profile bridges, including the Sunshine Skyway in St. Petersburg and the Hart Bridge in Jacksonville. Multiple coating systems and colors were evaluated. Color and gloss data will be presented for coating systems incorporating fluorourethane and clear coatings with UV inhibitors for finish coats.

Paul Vinik is a state structural material systems engineer with the Florida Department of Transportation



Paul Vinik

and an SSPC Bridge Coating Inspector (BCI) Level 2 instructor. He holds Bachelor of Science and Master of Science degrees in chemical engineering from the University of South Florida. Before joining FDOT, Vinik was a research engineer with James Hardie.

This webinar is sponsored by AGC Chemicals Americas – LUMIFLON. Participants will be eligible to receive credit from SSPC.

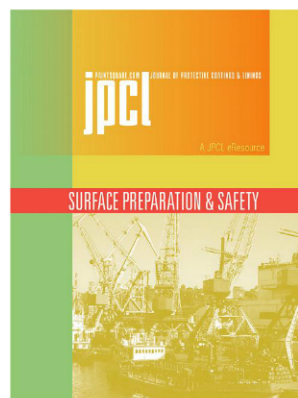
Registration, CEU Credits

This program is part of the SSPC/JPCL Webinar Education Series, which provides continuing education for SSPC re-certifications and technology updates on important topics. SSPC is an accredited training provider for the Florida Board of Professional Engineers (FBPE), and Professional Engineers in Florida may submit SSPC webinar continuing education units to the board. To do so, applicants must download the FBPE CEU form and pass the webinar exam, which costs \$25. Register for this free online presentation at paintsquare.com/webinars.

JPCL eBook Helps Keep Surface Prep Safe

The hard work of surface preparation can be as dangerous as it is important, and some of the risks involved are addressed by a variety of experts in a new resource from JPCL.

Surface Preparation & Safety features seven technical articles from JPCL that examine critical safety practices, considerations and standards in abrasive



blasting, shipyards and related work.

The eBook, available free of charge, is the latest in a series by JPCL publisher Technology Publishing Co. The entire series, as well as other technical materials, is available via free download from the PaintSquare Store, paintsquare.com/store. *Surface Preparation & Safety* includes the following

titles, all of which were previously published in various issues of *JPCL*.

- "Safety Monitoring and Remote Control Systems";
- "OSHA's Proposed Rule for Silica Hits the Streets";
- "Shipyard Regulatory Update";
- "On the Time between Blasting and Priming";
- "Safety Considerations for Abrasive Blasting";
- "Setting Up Air Blasting Equipment"; and
- "Surface Preparation: Adventures in Frustration."

Other titles in the exclusive Technology Publishing Co. series include:

- *Abrasive Blast Cleaning*;
- *Advances in Corrosion Control Technology*;
- *Dehumidification and Other Environmental Controls for Coating Projects*;
- *Selecting the Right Abrasive*; and
- *Ultra-High-Pressure Waterjetting*.

JPCL also offers a free *Buying Guide* eBook series designed to provide general guidance on selecting and specifying coatings, as well as information on sources from which to acquire the appropriate systems.

The entire series, which covers industrial structures from bridges to wastewater plants, is available via free download from the PaintSquare Store.

New PPG Lining Protects with One Coat

PPG Industries has launched Novaguard 810, a one-coat storage tank coating designed for superior resistance to a wide range of chemical and oil products. Suitable for both the lining of new tanks and the refurbishment of existing ones, the solvent-free coating is formulated for rapid curing to enable a fast return to service.

A single coat of Novaguard 810 "typically provides the protection required for storage tanks holding crude oil, petroleum products, solvents and various chemicals," according to PPG's Protective & Marine Coatings business. A smooth, light-colored finish facilitates cleaning and inspection, the company says.

The two-component amine rapid-cure novolac phenolic epoxy coating is suitable for tanks holding crude oil, aliphatic hydrocarbon, refined petroleum products, heavy fuel oil, unleaded gasoline, xylene and higher aromatics, oxygenated fuel and caustic soda, the manufacturer says.

The solvent-free formulation reduces explosion risk and fire hazard and provides dry heat resistance to 120 C (250 F). Hydrocarbon immersion is possible after one day at 20 degrees C (68 F).

Novaguard 810 can be applied in one coat

with a total dry-film thickness of as little as 12 mils (300 microns) and meets Energy Institute (EI) 1541, "Performance requirements for protective coating systems used in aviation fuel storage tanks and piping," according to PPG. The coating cures at temperatures down to 32 F (0 C) with an extended recoat window. Crude oil can be stored at temperatures up to 194 F (90 C).

More information is available at ppgpmc.com.

Axalta Primer Made for Carbon Steel

Axalta Coating Systems LLC has introduced a zinc-rich primer designed to deliver high levels of corrosion resistance to carbon steel substrates.

The latest addition to Axalta's general industrial line, Ganicin 2.8 ZR-U is designed for use in new construction, shipping containers, fabrication, the amusement industry and highly corrosive environments such as Gulf Coast exposures and certain offshore settings.

The polyurethane primer is designed to provide maximum corrosion protection to steel when

used with other Axalta general industrial products. Spray application is recommended, although brush application may be used for small touch-up areas. The primer is not recommended for immersion service or for marginally prepared surfaces.

The three-package, VOC-conforming (2.8 lbs/gal), low-HAPS primer conforms to SSPC-20 Class I definitions for zinc-rich products containing 85 percent zinc in the dry film, the manufacturer says. According to Axalta, the gray-green primer provides excellent adhesion, solvent and chemical resistance, and color and gloss retention.

Axalta plans to introduce several other Ganicin products into the industrial market throughout 2015, including a moisture-cured primer and a zinc-rich epoxy primer.

For more information, visit axalta.us/industrial.



The primer is designed to provide maximum corrosion protection to carbon steel substrates. The photo shows a typical application, not the actual product. © iStockphoto.com/DarioEgidi

THE BUZZ

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"City's Golden Spans Eye a New Color" (July 1)

The City of Pittsburgh is planning to repaint its "Sister Bridges" — the Andy Warhol Bridge, the Rachel Carson Bridge and the Roberto Clemente Bridge — which gives Pittsburghers a chance to either embrace or eschew coatings history. The bridges have been painted yellow (officially, Aztec Gold) since they opened in the 1920s, but now Allegheny County, which owns the bridges, is asking the public to weigh in on new paint colors. In an online poll, officials offer the following choices.



Photo: © iStockphoto.com/Veni

- The Sister Bridges should remain Pittsburgh yellow.
- The Warhol Bridge should be painted silver (gray), and the Carson Bridge should be painted green.
- I don't care if the bridges stay Pittsburgh yellow, but they should all be the same color.
- Why are you limiting us to just three colors?

As of Tuesday, June 30, after nearly 12,000 votes had been cast, Pittsburgh yellow was the runaway favorite, with over 83 percent of the votes.

STUMPER OF THE MONTH (June 22)

What generic coating type is most likely to be found on the faying surfaces of slip-critical joints?

- A. Inorganic zinc
- B. Polyurethane
- C. Acrylic
- D. None of these

Answer: Inorganic zinc. Inorganic zinc-rich coatings can have the appropriate coefficient of friction to maintain slip-critical joints of steel structures in a static state.

PSN TOP 10 (as of July 7)

1. SSPC Names New Executive Director
2. 4 PennDOT Inspectors Sentenced
3. Bridge Inspector Drowns in High River
4. PPG to Acquire Industrial Coating Maker
5. Water Tank Worker Killed in Fall
6. PA Bridge Collapses During Repair
7. Mayfly Swarms Plague PA Bridge
8. Sherwin-Williams Superfund Cleanup Set
9. Man Dies Collecting Copper at Job Site
10. Painter Injured in Water Tower Fall

WHAT'S GOT US TALKING

"Specifications: Does Anyone Still Care?" (June 18)

Coatings consultant Warren Brand's recent blog addressed some of the failures that can occur when painting specifications aren't properly administered and when the parties involved aren't educated on the many different aspects involved in a painting project.

Michael Halliwell: "It just makes me wonder: where has the quality and pride in workmanship gone? I can understand the overwhelmed (more folks being asked to do more with less) and complacency/indifference, as well as a bit of the 'it's just a job' mentality in this age of short term, part-time workers....I know there are great painters and coaters out there, but it is too bad that it is becoming less the art and science that it once was and more 'just a job' than ever."

Matthew Burkett: "Driven by the almighty dollar, compromises and the attitude of 'she'll be right' are the order of the day. Unless the end client, the contractor who does the bid, and the painter/blaster doing the work are educated, then there is not much hope."

William Feliciano: "Unfortunately, in today's day and age many projects must be completed in a rushed, 'due yesterday' kind of way. Time is indeed money, but when you want a coating to perform as intended for many years, investing the required minutes or hours for proper dry or cure shouldn't be asking too much. Way too often this is not the case."

On Stripe Coating

WHEN AND WHY WOULD I NEED TO STRIPE COAT IF I AM USING AN EDGE-RETENTION PRIMER?

Trinidad Diaz

Keppel Prince Engineering

Stripe coating is still important in order to gain proper DFTs in those hard-to-reach areas.

Alfredo Claussen

Instituto Mexicano del Petróleo

First of all, why do edges need to be treated differently? When a coating undergoes polymerization, a contraction is experienced and this results in a certain level of residual stress which develops inside the coating which, coupled with the stress concentration at the edges, facilitates the initiation of microscopic cracks. One of the initial contributions to stress concentrations that lead to crack development is a reduced coating thickness at the edges, because of the wet coat retracting due to surface tension in the still liquid coating. Polymerization then literally pulls the coating as it dries, setting in the high-stress concentration that gives origin to minute tears and cracks.

Other places where cracks develop are crevices, non-ground welds and interior angles in structural profiles. The best way to avoid those cracks is to get a large radius, at least 1/8-inch or 1/4-inch preferably, but this can be expensive or cumbersome. Therefore, the proper application of a stripe coat is the most practical solution and almost mandatory if one wants the system to endure a long time. What paint and coating manufacturers call edge-retention is based on formulations and additives that tend to reduce wet pull and chemical shrinking, but stripe coating is more effective in real life, if properly done.

There is special equipment available, designed and sold for easy application of the proper width of stripe coats, avoiding the usual material waste that results from trying to employ conventional equipment to apply the relatively narrow stripe. This equipment includes either roller or brush applicators fed from small and very

practical cartridges that use static mixer nozzles that guarantees the proper mixing ratios. I wrote a technical paper about residual stresses in coatings and ways to solve this problem titled, "Fenómeno de Generación de Esfuerzos Residuales en Recubrimientos Anticorrosivos" for Academia.edu (available at <http://bit.ly/1BgOpCC>). I know it is in Spanish, but you can see the photos of the special equipment and some diagrams that you will find to be self-explanatory.

Adan Cabeltes

Mega Paint and Coating Corp.

It is the human factor. Whether the coating retains on edges or not, we still have to make sure we do it right.

Michael Beitzel

Modjeski & Masters Inc.

Stripe coating should be employed particularly when spray painting a structure. In addition to providing adequate coating thickness to edges, the other primary benefit of stripe coating is to work paint into the seams between components or discontinuities or crevices in welds. For this reason, striping of seams, welds and fasteners should always



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precede application of the first full coat of paint as seams and crevices tend to be bridged or missed during spray application. Striping should also always be applied by brush to work coating into the seams and to mechanically remove any residual dust from surface preparation efforts which typically cling or are trapped in these seams after blow-down operations and could cause poor bonding to the surface if coating is just spray applied. Rollers can be used for striping edges and can be applied before or after the first full coat. This step is necessary even if edge-retentive coatings are applied. They will have improved edge covering, but they will always have lower thickness and afford less protection than the adjacent flat surface. Striping also helps ensure that areas with difficult access for spray application are properly coated. Some will argue that striping prior to application of the full first coat



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will jeopardize the quality of the surface preparation and want to "save the blast" by spraying first. What happens then is these difficult-to-access areas are left uncoated and will rust back until they are striped at some point after the full coat has dried. This is likely the reason these areas are typically the first areas to break down even though they are the most critical in protecting the structural connections from fastener or weld deterioration and from the development of pack rust between member components.

Mihael Deaton
Hilly Tech Services

If you look at any job that is breaking down, notice where it's breaking down (normally all of the areas that should have been striped). In plain English, if you want a paint job to last any length of time, stripe coat before you spray every coat...period!

Carlos Augusto
Correia Petrobras

For a reliable paint scheme, it is advisable to grind all edges with at least one grinder pass. For a two-coat, anticorrosive paint scheme, two stripe coats are usually specified. Even when using an edge-retentive paint, the stripe coat cannot be waived, if we want to guarantee a reliable paint scheme. The difference in this case is that only one stripe coat will be applied with the edge-retentive paint, between the first and the second full coats. In this scheme, the first coat can be a usual anticorrosive paint, but the second must be the edge-retention type. In brief, the stripe coat is always necessary and should be applied by brush. What will vary is the number of stripe coats, depending on the anticorrosive paint type. This approach has been used in cargo and ballast tanks of oil carriers with success.

Problem Solving Forum questions and answers are published in *JPCL* and *JPCL's* sister publication, *PaintSquare News*, a daily electronic newsletter. To subscribe, go to paintsquare.com/subscribe.

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RAW MATERIALS UPDATE

INTERNATIONAL PRESENCE AT WORLD'S LARGEST COATINGS SHOW

By Brian Goldie, *JPCL*

The European Coatings Show was again held in Nuremberg, Germany from May 21 to 23, and according to the organizers this was the largest show so far, with 1,024 exhibitors from 42 countries and approximately 28,500 trade visitors representing nearly 110 nationalities.

The associated European Coatings Congress had around 700 participants again from 42 countries; 144 presentations were given by prestigious speakers from academia and industry and concentrated on the production of

high-quality coatings, paints, sealants, construction chemicals and adhesives. The products at the show and the papers presented at the congress were focused on the requirements of modern coatings: functional, safe, environmentally friendly and sustainable. This article gives an overview of some of the main products exhibited, and presentations given that are of relevance to our industry, meeting these requirements. The information reported in this article was supplied by the companies. *JPCL* does not endorse any products

mentioned and no effort was made by *JPCL* to verify any claims.

Sustainability and Green Products

The common themes among the exhibitors were sustainability, renewable resources and green products.

According to Clariant, sustainability is an important part of their business strategy and they announced their EcoTain sustainability excellence label at the show. This label is used to clearly identify products offering sustainability performance, the company says. Clariant

RAW MATERIALS UPDATE

worked with a 3rd party consultant, the Collaborating Centre on Sustainable Consumption and Production (CSCP), to create a 36-point check list against which products could be screened. The products awarded this label so far include pigments, additives, dispersing agents, surfactants and halogen-free flame retardants.

BASF invited its customers to take a closer look at more sustainable formulations. They now offer more than 500 raw materials for paints, coatings and the construction industry in Europe, which according to the company, can contribute significantly to sustainable development in the value chain. These include pigments, resins and additives.

According to BASF, the biggest challenge within the industrial metal coatings industry today is providing environmentally sustainable products

which offer similar coating properties compared to established systems. For paints that protect metal against corrosion they offer water-based resin types including Acronal PRO, acrylic-modified emulsions for anticorrosion primers, and metal coatings, which according to the company, are one step closer to the replacement of solvent-based systems. They also offer high-performance corrosion protection, as well as being environmentally friendly with lower solvent demand, the company maintains. Joncryl RC, surfactant-free acrylic-modified emulsions, are fast drying 1K coatings with good corrosion and humidity resistance, according to the company.

With the aim of increasing the durability of coatings, improving indoor air quality or reducing energy and resources in formulations and production

processes, BASF offers its customers in the architectural coatings and construction industry, a broad portfolio of more sustainable solutions to meet the economic, environmental and social needs along the value chain. This covers dispersions, pigments, pigment preparations and additives. According to BASF, these products make façades resistant against weathering, fading and dirt pick-up, improve indoor air quality and reduce the resources needed for the production of high-performance formulations. Advanced construction raw materials enable the cost- and resource-efficient, health-friendly production, application and use of building materials, the company says.

Sustainability was also being promoted by Dow, who highlighted the latest developments in their HYDROTECH

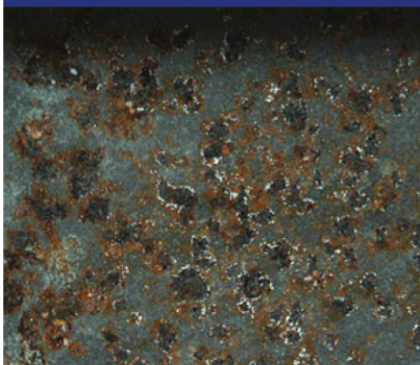


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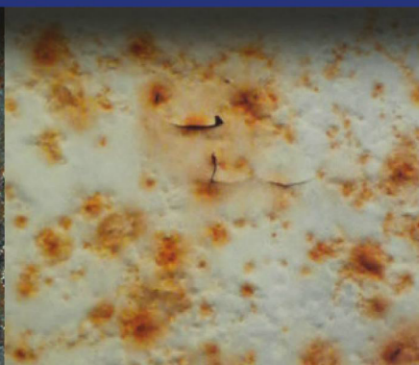
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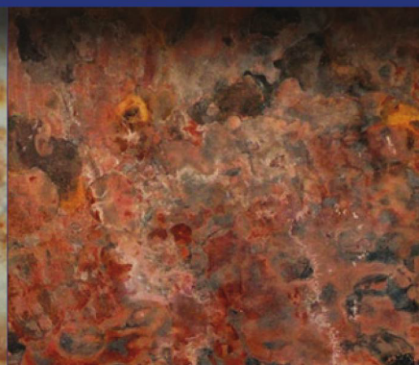
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Technology, offering improved open time, flow and leveling, and gloss; as well as new film-forming binders for solvent-free paints, according to the company. Said to offer formaldehyde abatement technology to improve indoor air quality, Dow also featured their FORMASHIELD Technology.

Dow Coating Materials introduced their Paraloid Edge Technology, which eliminates isocyanate and can offer short cure times and long pot life for solventborne 2K polyurethane coatings, the company says. According to Chuck Martz, global business director for industrial coatings, "Choosing between longer pot life and faster cure time is an ongoing challenge of 2K polyurethane coating formulations that results in a trade-off on one or both of these key properties. With this new technology, formulators and applicators don't have to sacrifice cure speed to extend pot life, or vice versa." The new solvent-borne offering has ambient curing, and also features application and cost efficiency and an improved environmental, health and safety profile by being isocyanate- and formaldehyde-free, according to the company.

For agriculture construction equipment (ACE) applications, the novel technology can be used in direct-to-metal (DTM) formulations or over primer in pigmented topcoats. According to the company, because it only requires ambient curing, it can allow faster throughput for the original equipment manufacturer (OEM) and longer pot life can reduce the OEM's material waste. It can also be used as a clear or pigmented topcoat for steel structures, tanks, railcars, offshore oil and gas pipelines, and more, the company maintains.


Specific products from a variety of producers, with environmentally friendly/green credentials included those from Bayer MaterialScience, who introduced a bio-based hardener for polyurethane coatings, based on

pentamethylene diisocyanate (PDI), in which 70 percent of the carbon content is biomass-based. The starting product is starch from forage corn, a feed and industrial crop that is not intended for human consumption and therefore does not compete directly with food production. When reacted with

existing polyols from renewable raw materials, it enables polyurethanes to be made from entirely bio-based components. The product, Desamodur eco N7300, has equivalent hardness, processing and resistance to weathering and chemicals, to conventional petrochemical-based hardeners, and better

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Photo: NürnbergMesse

compatibility with coating formulations, the company says.

According to Dr. Gesa Behnken, global head of new technologies, business unit: coatings, adhesives, specialties at Bayer MaterialScience, the suppliers of the PDI precursor are working on the next generation of biomass source (cellulose or bio-waste), which is already being used to produce bio-ethanol.

Hardeners

New hardeners/crosslinkers were also exhibited by Hexion, BayerMaterialScience, Evonik, Air Products and Huntsman.

Hexion (formerly Momentive Specialty Chemicals Inc.) announced two new types of acrylic polyol dispersions based on Cardura glycidyl ester, that provide improved resin use, easier processing and greater stability compared to

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solvent-borne formulations for high solids and waterborne polyurethanes, according to the company.

BayerMaterialScience exhibited several new hardeners for polyurethanes. In new branding of its polyaspartic technology, PASQUICK is Desmodur E 2863 XP, which due to its low viscosity can be used to produce flexible, solvent-free floor coatings, according to the company. A current challenge within industrial coatings is the formulation of low viscosity, waterborne coatings, without sacrificing productivity or properties. This can be met with the new isocyanate hardener, Desmodur N 3580, the company says.

Evonik has launched a range of crosslinkers to improve the scratch resistance of clear coats. The new family is called Vestanat EP-M, which combines the benefits of silane chemistry and polyurethanes, according to the company.

Air Products had two new Amicure epoxy curing agents (IC-221 and IC-321) for fast curing, low emission floor coatings, the company maintains.

Huntsman has launched a new amine curing agent, Jeffamine D-205, a low amine hydrogen equivalent weight polyetherdiamine with slower curing speed than conventional polyetheramines. According to the company, this is suitable where longer potlife, low viscosity and high Tg are required.

Resins

New binders/resins were highlighted by several companies. Hexion unveiled a new epoxy resin dispersion that can help close the cost/performance gap between waterborne and solvent-borne industrial coatings, the company maintains. The new resin, EPI-RES 7520-WD-52 can aid corrosion resistance and substrate adhesion comparable to that obtained with solvent-borne epoxy coatings used in transportation and industrial application and has a shelf-life of over 12 months longer than many other waterborne dispersions, the company says.

Perstorp introduced a range of lactide copolymer polyols derived from renewable lactic acid, for high performance polyurethanes. Depending on the grade, they have up to 50 percent renewable content, according to the company. These Capa lactides are low viscosity high molecular weight (MW) liquid polyols.

German resin company, Robert Kraemer GmbH, has extended the range of its Rokrapol polyester polyols with several 'green' binders based on up to 100 percent renewable resources.

One of the latest resins from Omnova Solution is Pliotec HD12, a unique water-based composition, based on the

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company's proprietary "hydrophobic dispersion technology." According to the company, this resin has very low water permeability characteristics and can be used to protect metal surfaces from the elements. It adheres to both ferrous and nonferrous metals and is suitable for use on a variety of commercial, industrial and residential DTM applications, according to the company.

Evonik has launched a new generation of flooring resins which it maintains are environmentally friendly, fast setting and odorless, making them especially well-suited for application to sensitive areas. The Degadur 4U series has all the qualities of conventional methylmethacrylate systems, but overcomes the limitations associated with flammability, as well as being environmentally friendly and fast setting, according to the company. They contain, in part, bio-based components.

New ambient curing silicone resins

for high-temperature coatings were also exhibited by Evonik. The company maintains that its Silkophen AC 900 and AC 1000 provide long-term heat resistance and early chemical resistance properties, are flexible during heating and cooling down, and have very low VOC content. Also new from Evonik are silicic acid esters used in anticorrosion coatings and zinc dust paints. Evonik maintains that the esters possess excellent weather, chemical and extreme temperature resistance.

Vertellus Specialties Inc. showcased its 100%-solids castor oil based polyols, as cost-effective diluents that lower VOCs and increase solids in 2K solvent-borne polyurethanes.

Wacker exhibited new silane-terminated polyethers which have a high density of crosslinkable silyl groups, providing a very tight crosslinked network that

is strong but elastic, so says the company. GENIOSIL XT 50 can be used to produce crack-bridging liquid waterproofing systems with tensile strengths up to 9 N/mm² and tear strengths of up to 50 N/mm, the company maintains.

Michelman displayed its new "ProHere" family of waterbased binders which can offer corrosion and chemical resistance, mechanical strength and adhesion, according to the company.

Additives

There were many additives designed for both waterborne and solvent-based coatings including, two new superwetting surfactants, Dynol 960 and 980 from Air Products. According to the company, these were designed for high-performance waterborne coatings in order to improve flow and leveling on difficult-to-wet surfaces such as nonferrous metals.

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More environmentally friendly anticorrosive pigments were highlighted by Nubiola, such as the Nubirox 300 series of zinc and label-free corrosion-inhibiting pigments based on calcium strontium phosphate. According to the supplier, these are ideal for high-gloss waterborne DTM coatings.

Construction Chemicals

Raw materials for the construction industry are now part of the European Coatings Show, and BASF showcased a wide range of products here, including dispersions and additives for waterproofing applications, as well as sealants and flooring adhesives which can contribute significantly to sustainability along the whole value chain, according to the company. The Acronal range of acrylic-based products, such as 5442 dispersion intended for high-performance waterproofing applications, and 6257 intended for flat roof coatings were among several exhibited this year.

Dow was also promoting a range of raw materials for the construction industry, showcasing their APEO-free binders for highly flexible cementitious waterproofing, including PRIMAL CM-500, a pure acrylic binder said to be designed to provide high crack-bridging at low temperatures in exterior and interior applications; PRIMAL AS-8012, said to be suitable for two-component waterproofing membranes, flexible coatings, crack-filling systems and ceramic tile adhesives; and specialist product PRIMAL AS-48, a styrene acrylic emulsion polymer said to have high adhesion and high crack-bridging capability designed for water tanks.

The waterborne binder, Primal EC1791 for cool reflective roof coating applications was also highlighted. Also based on APEO-free acrylic technology, this resin is said to impart outstanding exterior durability, UV resistance and long-lasting low temperature flexibility for high crack resistance to lengthen

the life of the roof. It is also said to maintain very good adhesion to difficult substrates such as galvanized sheets and polyurethane foams.

Lubrizol presented its Caboset CA1009, an acrylic-polyurethane hybrid emulsion intended for roofs and building façades which has good elasticity and

tensile strength to protect against cracks and leaks, so says the company.

European Coatings Congress

Presentations at the congress were also heavily orientated toward sustainability and green coating raw materials. The validity of this theme was endorsed by the

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audience in the plenary session where they were asked to register their views on issues currently affecting the industry. When asked what future technology they believed was most important, the majority selected waterborne coatings, and when asked what they felt was the most important innovation, high-performance bio-resins came first, followed by isocyanate-free.

The keynote address by Prof. Dr. Rolf Mülhaupt of the Freiburg Materials Research Centre FMF at the University of Freiburg took a critical look at the term "sustainability." He stressed that 'green'

in the sense of being bio-based, is not enough to claim that a product is sustainable. It is necessary to examine the entire manufacturing process in detail, beginning with growing of the raw plant materials and ensuring no competition with the food chain. In fact, according to Mülhaupt, when considered as a whole group, synthetic polymers could well be clearly superior to biopolymers.

There were 24 sessions in all, covering all aspects of coating formulation and production, with two sessions dedicated to bio-based coatings and waterborne coatings.

The European Coatings award was given to Fred Van Wijk of Nuplex Resins for his congress presentation "New, ultra-fast drying, low VOC, isocyanate-free technology for 2K coating systems." In this presentation, the potential that can be found in using isocyanate-free chemicals as a replacement for conventional 2k topcoats was discussed, with the benefit being the decoupling of pot life and drying time without sacrificing fast curing.

BIO-SOURCED AND RENEWABLE RAW MATERIALS

C. Lefevre, M. Wenkin, M.H. Delvaux, Coatings Research Institute (CoRI)

In the paint market today, the use of bio-based products creates new challenges for paint chemists. There is a limited range of bio-based products that are satisfactory in terms of quality, cost and availability. Furthermore, there is also a lack of information on these products. This article discusses the

actual status regarding the incorporation of already existing bio-based and renewable products in paint formulations. The ecological quality of paint characterized by its environmental impact linked to the life of the products will be discussed, as will the main parameters which influence the ecological quality of a paint.

Background

Historically, there has been an increasing trend in the ratio of renewable to oil-based energy sources used in industrial processes. As shown in Figure 1 (p. 26), prior to the industrial revolution (1760), 100 percent of energy was derived from renewable sources. The percentage

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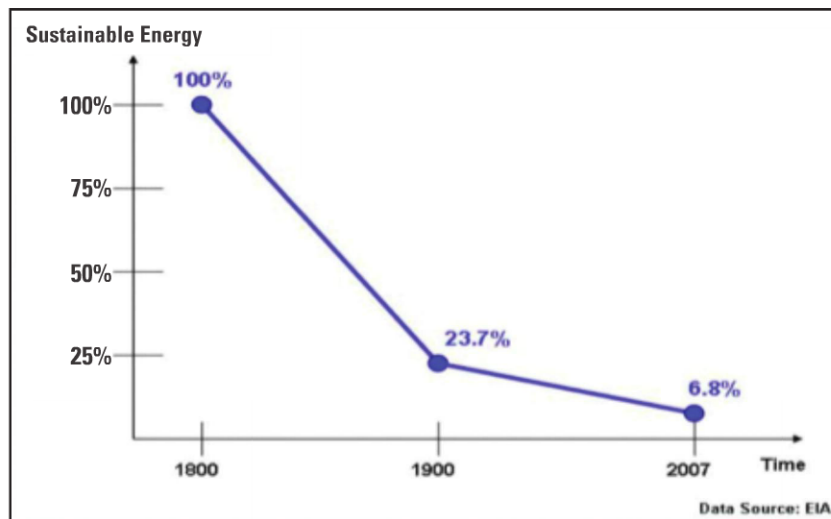


Fig. 1: Percentage of sustainable energy derived from renewable resources over time. Figures courtesy of CoRI.

of sustainable energy or sources declined drastically throughout the 20th century, because unsustainable energy (oil and gas) was used to enable modern activities such as food production, cooking, lighting, transportation and more

Paint industries started using lead and chromium products, and because of this and unsustainable energy use, pollution increased, both in the air and in the soil. In 1990, Paul T. Anastas, Ph.D. and John Warner, Ph. D. published the "12 Principles of Green Chemistry." The intention of this approach was to reduce the environmental impact of both the extraction and production of

raw materials, products, processes and systems. The objective is therefore to develop synthesis methods using and generating products that have minimal toxicological impact on human health and the environment. However, in this approach the chemicals must maintain the functional effectiveness while reducing the toxicity. Increasingly, a raw material must be selected based on its renewable characteristics rather than on the risk of depleting resources. The recent development of legislation impacting the paints sector and the importance of the measures depending on the regulatory push is shown in Figure 2.

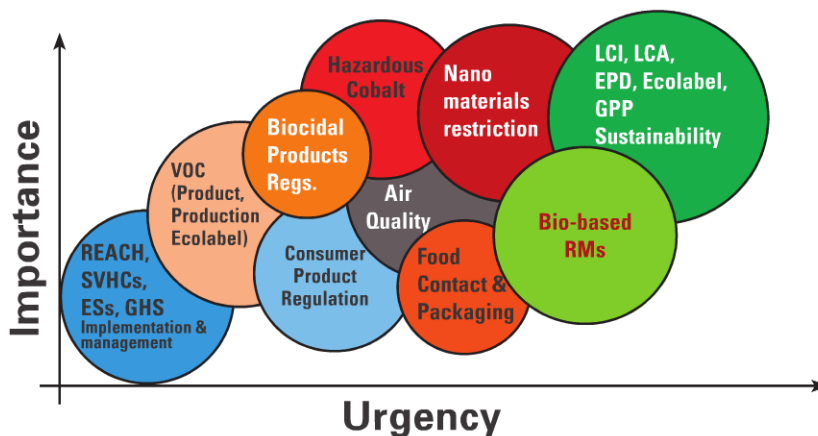


Fig. 2: Importance and urgency of recent regulatory legislation impacting the paints sector.

Current Situation

Currently, paint industries are focused on important topics like: air quality, the replacement of petrochemical products by renewable materials and Life Cycle Assessment (LCA) to anchor the sustainability concept.

Sustainable development is development that meets today's needs without compromising the ability of future generations to meet their own needs. Its objective is to define viable schemes that combine three aspects: ecological, social and economic human activities. It is important to note that there are no "zero impact" products. For a similar service, paint has a lower impact on the environment than other similar products. LCA is a practical tool for assessing environmental impact. It considers impact at all stages of a product from cradle to grave. LCA is regulated by standards (ISO14041, 14042 and 14043).

With regard to industrial coating formulations, in recent years, replacement of solvent-based paints by aqueous paints, high-solids paints, powder paints, or UV or EB curing paints, has been a driver of innovation and a source of many technological developments. As for decorative paints, the reduction of the VOC content in liquid paint (reducing emissions), the use of raw materials produced by more environmentally-friendly processes or the use of bio-based raw materials are also themes behind many developments and innovations.


The European Committee for Standardization (CEN), technical committee 411, is developing standards to support the growth of the bio-based product market by increasing transparency and boosting consumer confidence. According to CEN, a bio-based product is a product derived partially or fully from biomass (EN 16575-2014, "Bio-based products – Vocabulary"). It therefore comes in

whole or in part from renewable raw materials. However, the term "bio-based" does not mean "non-toxic".

Currently, there are major developments of bio-based raw materials for the formulation of paints, and decorative paints in particular, being carried out. These include

binders, solvents, additives and natural pigments derived from minerals or of plant or animal origin such as turmeric, cochineal and walnut stain.

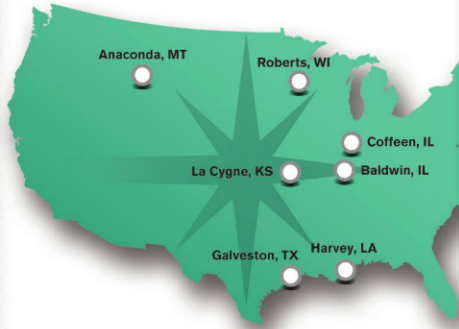
In the bio-based family of binders, there are emulsions made of vegetable oils and alkyd emulsions composed of glycerol, vegetable



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oil and vegetable organic acids and polyurethane products based on polyols derived from modified vegetable oils and casein.

Solvent consumption is still huge in this sector of paints in Europe but nevertheless, there is a lot of research

underway to develop bio-solvents.


As for additives, there are already bio-based surfactants and many developments in progress on this topic. One-hundred-percent bio-based plasticizers are used as alternatives to phthalates and bio-based biocides or

bio-based coalescing agents are also available.

Conclusion

In conclusion, a paint must be selected according to its purpose. Indoor or outdoor paints will have different requirements in terms of performance. The end use for which the paint is intended will also strongly influence the specification. The nature of the substrate, as well as its condition, must not be overlooked when selecting a coating. Critical thinking is essential in this selection. It is also important to look at labels, pictograms and safety data sheets, which are available on request from the supplier.

Finally, the bio-based and renewable raw materials designed to replace what is used today must have the same performance at a comparable cost. The end of the life of a product should also be considered at the start of the selection process in order to prevent, and better manage, waste and packaging. It cannot be assumed that any new raw material can just be dropped into an existing formulation. We must think differently to incorporate renewable or bio-based materials into our pre-existing methods; and in short, innovate. JPCL



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The Straws that Broke the Camel's Back

By Dwight G. Weldon, Weldon Laboratories, Inc.

All figures courtesy of Weldon Laboratories, Inc.

Coating failures are not always caused by one thing. In fact, sometimes there are several factors involved, as this column will demonstrate.

Ductile iron pipes and fittings were supplied to a water treatment plant located in a mid-Atlantic state. The pipe supplier had contracted with a local paint shop to apply one coat of the specified red polyamidoamine epoxy primer. The product data sheet for the primer, as well as the job specification, called for 4 to 6 mils dry film thickness (DFT).

The pipes were primed at various times and were not all shipped in the same order. Furthermore, they generally were not topcoated immediately upon receipt at the water treatment plant. Hence, it was possible that some of the primed pipe could have aged for a few months prior to topcoating, possibly even outdoors. The topcoat was specified to be another polyamidoamine epoxy, at 3 to 6 mils DFT.

While many *JPCL* readers are likely acquainted with amine epoxies and polyamide epoxies, it is possible that the term "polyamidoamine epoxy" may be unfamiliar. In all three cases, the prefix refers to the type of curing agent.

As the name implies, the curing agent for amine-cured epoxies are simply multi-functional amines (an amine contains the $-NH_2$ group). Generally speaking, amine-cured epoxies have short pot lives, crosslink very tightly and have excellent chemical resistance. They also have poor flexibility and tend to blush



Fig. 1: Adhesion test taken at a good location, showing that poor adhesion was much more widespread than initially thought.

under certain environmental conditions. Polyamide curing agents, which have longer pot lives, greater flexibility and blush less, are formed by reacting dimer fatty acids with multi-functional amines.

A polyamidoamine curing agent is formed by reacting simple mono-functional fatty acids (not dimer fatty acids) with a multi-functional amine. The cross-link density of a polyamidoamine epoxy is very much less than that of an amine epoxy, and even less than that of a polyamide epoxy. These coatings have extended pot lives, longer recoat windows and better impact resistance and flexibility than even polyamide epoxies. They are generally less chemically resistant than amine-cured epoxies, and have poorer solvent resistance than polyamide epoxies.

Sometime after the plant was put into service, problems began occurring with delamination of the topcoat from the primer. This resulted in both a site investigation by the coating consultant and laboratory work in an attempt to determine the cause of the failure.

Site Investigation

Most of the problems were occurring in the clarifier room, which contained many different diameters and configurations of pipe. This room was clean but somewhat humid. Some of the pipes were sweating badly, while others were only slightly damp. In addition to visual observations and sample taking, the site visit also involved adhesion testing and

thickness measurements. Because of the humid nature of the environment and condensation on the pipes, it was not possible to do tape adhesion testing. Hence, adhesion was judged by subjective knife probing.

The site investigation showed that there were many pipes that exhibited coating failure. The first pipe examined was a 16-inch-diameter vertical pipe, which had a roughly 3-by-6-inch area where the topcoat had peeled from the red primer. When examined with a field magnifier, the surface of the exposed primer was smooth and clean. Knife probing at the perimeter of the failing area showed that the topcoat had very poor adhesion to the primer, and pieces as large as 0.5-by-1-inch could be easily removed. A non-destructive thickness gage showed that the total topcoat/ primer thickness at this location was 12 to 17.5 mils, and that the primer-only



Fig. 2: Dirt on the backside of poorly adherent topcoat.

thickness was 6 to 7.2 mils. The poor intercoat adhesion on this first pipe was not confined to the perimeter around the area of spontaneous failure. Indeed, knife probing several feet away, in locations

that appeared to be in good condition, also showed very poor intercoat adhesion (Fig. 1, p. 31). Several other pipes were examined, including some that showed no evidence of peeling topcoat. However,

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even on some of the pipes that showed no spontaneous failure, knife probing revealed very poor adhesion of the topcoat to the primer. In every case, the primer was well-adhered to the steel.

Interestingly, while most of the pipes had poor intercoat adhesion, a few were found where the adhesion of the topcoat to the primer was judged to be fair. At these locations, chips of topcoat no bigger than about 1/16-square-inch could be removed with some difficulty.

Two horizontal pipes were found that displayed a distinct pattern of failure. The coating was generally in good condition on the top half, or hemisphere, of the pipes, but much of the topcoat was missing from the bottom half of the pipes. The top half of the pipes was damp, whereas the bottom half was dripping wet.

Laboratory Investigation

As is standard practice, the first step in the laboratory investigation consisted of visual and microscopic observations. Chips of failing paint were taken from several different pipes for examination. The first chip examined from the first failing pipe showed a large amount of dirt on the back of the disbonded topcoat (Fig. 2, p. 32). It also showed that there were two coats of topcoat. The first coat was 4 to 5 mils thick, and the second was 4 to 6 mils thick.

Another chip was examined from a second pipe. While there was little to no dirt on the back of the topcoat, there were slight to heavy amounts of rust and rust staining. A microscopic examination of the cross-section of this chip showed that the rust had been painted over (as opposed to having formed after the paint was applied), as the topcoat had clearly flowed over and around the rust. Once again, two coats of topcoat were present. The first coat was 5 to 7 mils thick, and the second (upper) coat was 2 to 3 mils thick.

A chip from a third failing pipe had no dirt or rust on the back of the failing topcoat. However, there was a faint reddish cast over much of the backside of the



Fig. 3: Reddish residue of chalked primer on the back of poorly adherent topcoat.

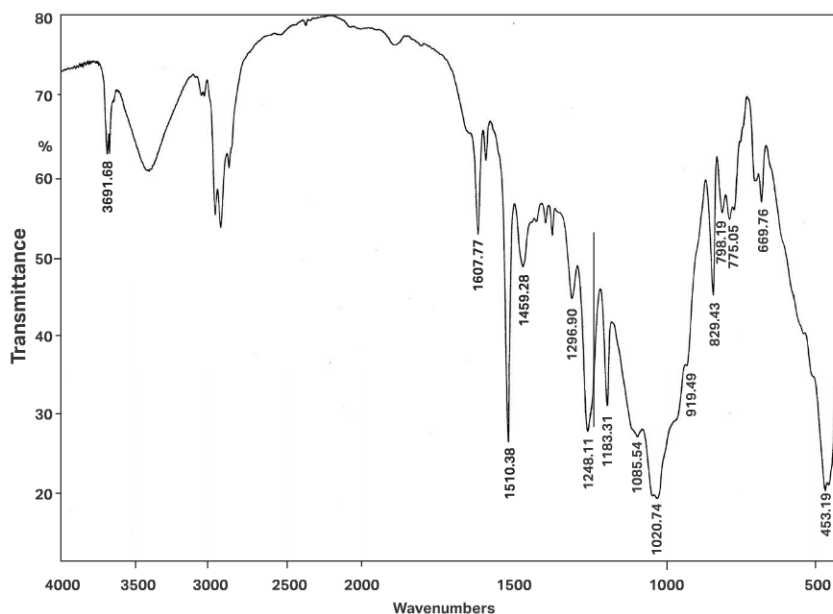


Fig. 4: Infrared spectrum of the specified polyamidoamine epoxy primer.

chip, which appeared to be due to a very thin residue of the underlying red primer (Fig. 3). This chip consisted of only a single coat of topcoat (as specified), and was 8 to 9 mils thick.

Yet another chip was examined from a fourth pipe. Although there were no rust stains, reddish primer residues or dirt, there were large numbers of white overspray particles on the back of the

Table 1: Primer/Topcoat Thickness from Failing and Non-failing Samples

Coating Condition	Primer Thickness	Topcoat Thickness
Failing	3–7 mils	Range of 4.0–14.2 mils (avg. 9.1)
Non-failing	4–5 mils	Range of 3.0–7.6 mils (avg. 5.3)

failing topcoat. The chip consisted of a single coat about 6 mils thick.

Several other samples of failing topcoat were examined, and most of them displayed one or sometimes two of the features seen in the four chips previously described. This clearly indicated that there were some application problems associated with the coating failure.

Too Thick or Too Thin?

Paint thickness can sometimes contribute to coating failures. Table 1 summarizes thickness measurements obtained from both the jobsite and laboratory investigations.

Clearly, there is a correlation between the thickness of the topcoat and its performance. The average thickness of the non-failing topcoat fell within the specified range of 3 to 6 mils, while the average thickness of the failing topcoat was well above the specified thickness.

Messing with the Mix?

Another technique utilized in the investigation was infrared spectroscopy (see the author's column in the December 2014 *JPCL*). Numerous spectra were obtained, from both jobsite samples and liquid control samples of the specified coatings that were mixed and applied in the laboratory. The results were as follows.

The control sample of the specified primer (Fig. 4) is an epoxy pigmented with crystalline silica and talc. While not conclusive, the spectrum suggests that it could be of the polyamidoamine variety.

The red primers removed from several pipes at the jobsite (Fig. 5, p. 36), including both failing and non-failing pipes, are epoxies and match one another. They might also be of the polyamidoamine variety. However, they are pigmented not with crystalline silica and talc, as was the control sample of the specified epoxy, but instead with barium sulfate (barytes) and talc. Therefore, the specified primer was not used.

The spectra of failing and non-failing (fair adhesion) topcoats match one another, and also match the spectrum of the specified polyamidoamine epoxy topcoat. Therefore, the correct topcoat was used.

While infrared spectroscopy can sometimes be used to determine the mix ratio of an epoxy coating, nitrogen analysis is often more reliable. Because epoxy curing agents are



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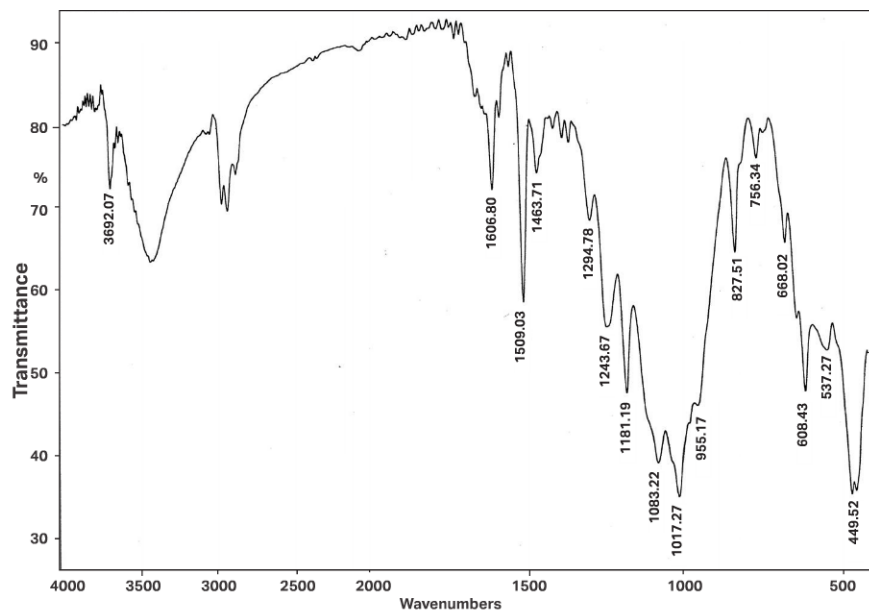


Fig. 5: Infrared spectrum of the actual primer used on the pipes. While similar, it clearly differs from the spectrum of the specified primer.

typically nitrogen-based (such as polyamidoamines), the amount of nitrogen in the dried film is usually an accurate measure of the coating's mix ratio. In order to do such an analysis, the liquid control sample is often applied in the laboratory at different mix ratios in order to "calibrate" the technique.

A mix ratio analysis could not be done on the primer, as it was not the specified primer and hence a control sample was not available. However, the analysis was done on several samples of topcoat. This showed that, of six samples of failing topcoat, four of them had been applied at the correct mix ratio, while two had been applied with a large excess of epoxy (insufficient curing agent).

Multiple Conclusions

The aforementioned results show that there are several factors that contributed to the failure of the field-applied topcoat to adhere to the shop-applied primer. These include the following.

- Application of the topcoat over a dirty primer.

- Application of the topcoat over a primer that had poorly adherent overspray on it. Overspray can have poor adhesion because it is often very dry when it settles on the surface, since the droplets have travelled much farther than normal and contain very little solvent. The lack of solvent means that it cannot wet out the substrate surface, nor can it soften a lower coat of paint.
- Application of the topcoat over a thin, chalky residue of primer. Since some of the shop-primed pipes may have been stored outdoors for a fair amount of time prior to topcoating, it is possible that the epoxy primer may have chalked. Indeed, one of the drawbacks of epoxies is their tendency to chalk upon exposure to sunlight. If not removed, this chalky residue can interfere with the adhesion of subsequent coats.
- Application of the topcoat at the wrong mix ratio. This issue was only found on two of six samples analyzed, but clearly shows that mis-mixing did occur at some locations. A mis-mixed

epoxy, especially one so far off from the specified mix ratio, can have very inferior properties, including reduced adhesion.

- Use of an unspecified primer. Although the primer was an epoxy, and possibly of the polyamidoamine variety, it was not the primer that was specified. However, while it is generally not a good idea to use the wrong primer, locations were found where the topcoat had fair adhesion to this primer. Hence, the use of the non-specified primer was certainly not the sole cause of the failure, although it is possible that the topcoat may have had better adhesion had the specified primer been used.
- The thickness of the topcoat. The topcoat was specified to be applied at 3 to 6 mils DFT. In non-failing areas the topcoat thickness ranged from 3.0 to 7.6 mils, while in failing areas it ranged from 4.0 to 14.2 mils. When coatings cure, they shrink, and impart a stress known as shrinkage stress. The amount of this stress is proportional to the thickness of the coating, with thicker coatings imparting more stress than thinner ones. This stress can contribute to adhesion failures. Clearly, in this project there was a correlation between topcoat thickness and coating failure. Some areas of thin topcoat also failed, but that may have been for any of the other five factors previously mentioned.

When one encounters a coating failure, it is often tempting to assume that there is a single, simple cause. Sometimes this is indeed the case. However, as this project demonstrates, sometimes it takes more than one straw to break the camel's back. **JPCL**



Fiberglass Reinforced Plastic for Pipelines

PROTECTING
ANTICORROSION
COATINGS
DURING
TRENCHLESS
CONSTRUCTION

Photos courtesy of the author.

By Xu Huanhui, CYG Changyuan New Materials Company, Shenzhen, China

Coating Failures

Normally, fusion bonded epoxy (FBE), three-layer polyethylene (3LPE) and three-layer polypropylene (3LPP) coatings are factory-applied pipeline anticorrosion coatings, and heat-shrinkable sleeves (HSS) are used as a field-joint coating. During trenchless construction, external coatings are prone to damage by abrasion from gravel, stone and hard rocks, especially during pullback or thrust boring.

Fiberglass Reinforced Plastic (FRP)

FRP is a composite material consisting of strong fiber cloth and binding resins. Fiberglass cloth is a useful reinforcing material due to its good mechanical and chemical properties; it's also low cost, there is sufficient supply and it's easy to use onsite. Epoxy, phenolic and unsaturated polyester (UPR) can be used as binding resins. FRP combines both the advantages of resin and fiberglass cloth while providing high strength, heat insulation, good chemical resistance and electrical insulation.

A fiberglass reinforced 2K-epoxy resin consisting of modified epoxy resin and fiberglass cloth has excellent performance and complies with the China National Petroleum Company specification, CNPC-Q/SY 1477-2012, "Specification on External Coatings of Pipelines in Horizontal Directional Drilling."

FRP can be applied on pipeline or field joints during trenchless construction. The build-up of the epoxy FRP overcoat can be varied depending on the design, such as 2-ply fiberglass cloth plus 5-ply epoxy resin, 3-ply fiberglass cloth plus 6-ply epoxy resin or 4-ply fiberglass cloth plus 7-ply epoxy resin. The minimum thickness is 1,200 μm (47 mils),



Applying the fiberglass wrap.

1,500 μm (59 mils) and 1,800 μm (70 mils), respectively. Generally, the number of epoxy resin and fiberglass cloth layers is dependent upon the soil condition. The applied epoxy FRP overcoat features high bonding strength to polyethylene (PE) and steel, high hardness, very good abrasion resistance, scratch resistance and simple application; and the application quality is controllable onsite.

Application

Before the application of epoxy FRP overcoat onto trenchless pipe, a level ground of 1.5 meters (5 feet) wide on both sides of the pipeline, and 0.5 meter (1.5 feet) clearance height under the bottom of the pipe is required. The factory-applied, external anticorrosion PE or polypropylene (PP) coatings should be cleaned to remove any soil, grease or dirt.



For an effective adhesion of the FRP overcoat, a power-driven wire brush can be used to roughen the PE coating surface and flame heating at 80 to 90 C (176 to 194 F) used to polarize the PE coating surface. The roughness of the PE coating surface should be 100 to 300 μm (4 to 12 mils) when inspected by a roughness meter. The primer coat of modified epoxy resin can then be applied.

After the primer is touch-dry, one layer of epoxy resin is applied and a layer of fiberglass cloth is wrapped around it. No air bubbles, voids or fisheyes are permitted.

When the first layer of epoxy resin is touch-dry, apply another layer of resin and wrap another layer of fiberglass cloth in accordance with the design specification.

Finally, the topcoat of modified epoxy resin is applied to strengthen the FRP.

The application sequence then, is one layer of primer, one layer of resin, one layer of FRP wrap, a second layer of resin, a second layer of FRP wrap (repeated to the total specified), then one layer of topcoat.

Quality Control

Quality control of epoxy FRP overcoat is important during application and normally a visual inspection, thickness measurements, curing test and bonding strength test are implemented.

Visual Inspection

The finished epoxy FRP overcoat surface should be level and smooth without any defects such as cracks, wrinkles, voids, sagging, delamination, fisheyes or exposure of fiberglass yarn. Both edges and overlap areas should be bonded tightly and evenly, and the mesh of the fiberglass cloth should be fully filled with epoxy adhesive.

Thickness Measurement

After the epoxy FRP overcoat becomes hard dry, the overcoat thickness should be measured with a magnetic thickness gauge. Normally, three positions are randomly selected on axial direction of each coated pipe and the coating thickness arbitrarily measured at four points distributed evenly along the circumferential direction at the selected positions. The total thickness of FRP overcoat should be in the specified range.

Curing Test

After the epoxy FRP overcoat is set thoroughly, hardness should be measured at three points evenly distributed along the axial direction of the pipe, using a Barcol or Shore hardness meter. Normally, the measured Shore D hardness should not be less than 80 and the Barcol hardness should not be less than 30.

Bonding Strength Test

After the epoxy FRP overcoat is set thoroughly, test the bonding strength



Applying the resin to the fiberglass wrap (right) and the finished field joint to be protected (above).

Fiberglass Reinforced Plastic

(adhesion) of the epoxy FRP coating on at least one pipe from every 100 pieces of coated pipe in succession. If adhesion does not meet the specification, a double-check is required. Normally, the bonding strength of epoxy FRP overcoat to a PE coating should not be less than 3.5 MPa.



The fiberglass-plastic-protected field joints.

Protection Measures During Application

A number of protection measures may be required depending on the specific site condition. For instance, a temporary shed may be required during a rainy season. A braided chemical fiber cloth or plastic film should be placed on any muddy ground to prevent the finished epoxy FRP overcoat from contamination. A black UV-proof plastic film can be wrapped around the finished epoxy FRP overcoat to prevent it from chalking in sunlight.

Conclusion

FRP can effectively protect anticorrosion coatings during trenchless pipeline construction. However, for an efficient epoxy FRP overcoat protection, it is imperative that the correct application and quality control procedures are employed during the process.

About the Author

Xu Huanhui is vice president of technology and global service of CYG Changtong New Materials Company in Shenzhen, China. He is a senior engineer



and has been involved in research and application of anticorrosion high polymer materials for 15 years, with a number of national and

provincial awards, six patents for inventions and nine patents for utility models. Xu is a distinguished postgraduate tutor of Wuhan Institute of Technology, deputy secretary general of the Corrosion and Insulation Committee of the Computer-Aided Process Engineering Center (CAPEC), a distinguished expert of Shenzhen Municipal Science and Technology Innovation Council, and an assessment expert of the Shenzhen Municipal Economy and Trading Information Council. **JPCL**

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RUNNING A TIGHT SHIP

UHP WATERJETTING AND SURFACE-TOLERANT COATINGS IN NEWBUILDING APPLICATIONS

By Nuno Cipriano, Ultrablast Lassarat Ltd., Brazil

Almost 20 years ago, ultra-high-pressure (UHP) waterjetting started to gain popularity as a surface preparation method for maintenance in shipyards and for offshore projects due to the development and availability of surface- and moisture-tolerant coating technology. Recognized by the U.S. Navy and global energy company Petrobras, the push started with maintenance projects in the 1990s and conversion projects in the early 2000s, and by 2008, a good deal of thought, study and testing was dedicated to the next step: the adoption of UHP for newbuilding projects. Used for both offshore and marine assets, the method was initially focused on ballast tanks, according to the International Maritime Organization (IMO) standard adopted in 2008, "Performance Standard for Protective Coatings (PSPC), IMO PSPC for Water Ballast Tanks."

Now, about two decades after early use of UHP in Brazil, 13 years after the booming adoption of UHP at Singaporean shipyards for floating production storage and offloading (FPSO) conversion, and five years after the idea of its use being extended into newbuilding yards in the context of IMO PSPC regulations, this progression has led to the building of a series of 10 Suezmax vessels (a naval

architecture term for the largest ship measurements capable of transiting the Suez Canal in loaded condition, almost exclusively used in reference to tankers) in northeastern Brazil. This article is a contractor's view of the practical challenges, the difficulties, and ultimately the success of UHP adoption by shipyards for newbuilding projects.

UHP WATERJETTING AND SURFACE-TOLERANT COATINGS

As sandblasting has not been used in Brazil for more than 20 years by environmentally responsible companies and driven by proponents like Joaquim Quintela, Fernando Fragata, Carlos Augusto and others, waterjetting has become the favored method of surface preparation there.

The Centro de Pesquisas Leopoldo Américo Miguez de Mello (CENPES, the research center of Petrobras responsible for research, development and engineering), has been working with paint manufacturers to develop paints for application over wet and less-er-prepared or flash-rusted surfaces and for more than 20 years, Petrobras has successfully been using UHP waterjetting with surface-tolerant paints in maintenance, conversion and newbuilding projects.

Onshore and offshore maintenance projects also employ these combined technologies but when considering conversion or newbuilding situations, a combination of UHP waterjetting and abrasive blasting, together with surface-tolerant paints, can be employed.



Machinery area behind the blasting chambers. Photos courtesy of author.



FPSO P66 being assembled (top), block being UHP waterjetted inside blasting chamber (above) and surface-tolerant coating being applied (right).

Even when using abrasive blasting, both shipyards and owners can see advantages with wet surface-tolerant paints, independent of the surface preparation method used, because they are more flexible in terms of the surface preparation condition

before painting, the weather conditions during application, ease of application and achieving thickness build. Also, it is commonly recognized that having surfaces washed before painting assures that they are free from salt and coating performance increases drastically.

Moving into the 21st century, the health, safety and environmental (HSE) regulations have become stricter forcing Brazilian companies to adapt to new techniques of surface preparation and to direct their coating departments to work mainly with water-jet-prepared surfaces when working in shipyards. Additionally, the new pre-qualification constraints impacted the selection of paints for ship building in 2006, with the resolution of IMO MSC 215.82, "Performance Standard for Protective Coatings for Dedicated



UHP Waterjetting and Surface-Tolerant Coating



UHP machines at Ecovix shipyard (left) and FPSO block being installed inside blasting chamber for UHP waterjetting (right).



Seawater Ballast Tanks in all Types of Ships and Double-Side Skin Spaces of Bulk Carriers." Therefore, when the push for environmentally cleaner UHP waterjetting as a surface preparation method was felt most acutely in Brazil, the paints to match it were also

required to pass more strict testing criteria.

Between 2008 and 2010 one paint manufacturer began testing products to meet the IMO PSPC requirements in unusual conditions (applying the coating system over wet, flash-rusted,

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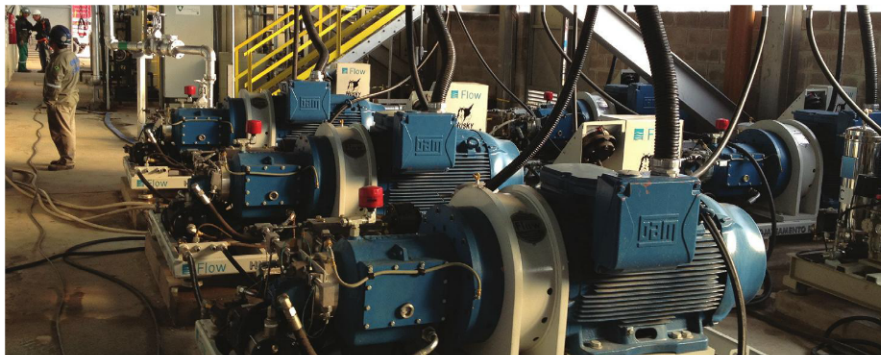


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Second system coat being applied (top left), electrically operated UHP waterjetting machines working at 40,000 psi (top right) and worker waterjet cleaning to SSPC-SP WJ-2/ NACE WJ-2 standard (above).

UHP-waterjetted panels, instead of panels that had been abrasive blasted and shop-primed with zinc silicate). This not only delivered a good result, passing PSPC criteria, but also launched a heated debate between paint manufacturers, classification societies and shipyards in Brazil which lasted a few years. In the end, the least probable of outcomes surfaced: one coating system received recognition (by means of Type Approval) as an IMO PSPC-approved system that could be applied at block stage in shipbuilding over UHP waterjetted bare metal. This outcome was critically important, enabling the adoption of this new concept in emergent shipyards in Brazil.

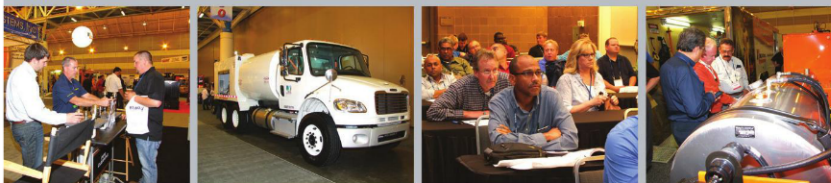


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UHP Waterjetting and Surface-Tolerant Coating

THE SYSTEM IN ACTION

One of the most important and game-changing projects was started in the Estaleiro Atlântico Sul Shipyard (EAS) in northeast Brazil, when company management chose to use UHP waterjetting on a newbuilding project. The objective was to build

20 Suezmax and Aframax (a medium-sized crude tanker with a deadweight tonnage ranging between 80,000 and 120,000) vessels employing an IMO PSPC-compliant universal coating system that could be used at the block stage over UHP waterjetting, including over weld seams. The

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Third and final system coat being applied.

blast cabins were therefore designed to use only UHP waterjetting which made the shipyard construction project much simpler and economically more appealing.

After EAS had been using this system for four years, another new shipyard, Ecovix (Engevix Construções Oceânicas), in the south of Brazil, followed in its footsteps and made UHP waterjetting their main surface preparation method, used together with wet surface-tolerant paints. Ecovix, however, took the EAS example and improved the blast cabins by fixing all the equipment in one area, thus increasing the efficiency of the operation. Also, in order to comply with their environmental license, the shipyard had to ensure that the subcontractor operating the blast cabins had a complete water-treatment system with 100 percent water effluent recycling. This allowed the shipyard to set new standards by using an environmentally responsible process and at the same time cutting costs of water consumption and external water treatment and dumping.

Together with the resident contractor for UHP waterjetting and



Workers being trained in UHP waterjetting operation.

painting, Ecovix developed modified UHP waterjetting cabins which today can be considered worldwide references. Up to 42 nozzles/guns can work simultaneously in any three of the eight available cabins where the water is recovered instantly during operation, sent to underground tanks that store the effluents to be treated in the water treatment stations. The chemical process in use is quite simple but due to the specific components of the effluent, there was a learning and improvement process that lasted over two years. Each unit is capable of treating 20 to 25 cubic meters (700 to 900 cubic feet) of effluent per hour and 100 percent of the effluent is recycled and reused in the UHP waterjetting machines within the manufacturer's parameters [Hardness (CaCO_3) < 17 mg/L; ferrous (Fe) < 0.1 mg/L; chloride = 0; manganese (Mn) < 0.1 mg/L; silica < 14 mg/L; pH = 6.5 – 7.5; Conductivity < 150 $\mu\text{S}/\text{cm}$; Solids < 10 μm].

Since the inception of this project at Ecovix, the contractor has blasted more than 850,000 square meters (9,150,000 square feet), which is nearly 470 blocks and two platforms, using only UHP waterjetting as the surface preparation method and applying only wet surface-tolerant paints inside the cabins and on-board. The contractor had installed 21 electrically driven 40,000 psi, two-gun pumps, plus six diesel-powered 40,000 psi two-gun pumps at the shipyard. There was no need to remove and treat weld-burn areas and construction damage, and

production rates for preparing epoxy shop primer to SSPC-SP WJ-2/ NACE WJ-2, "Waterjet Cleaning of Metals – Very Thorough Cleaning," ranged from 8 to 16 square meters (172 square feet)/per hour/ per operator. The blasting chambers have also been structured to







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UHP Waterjetting and Surface-Tolerant Coating



Application of first system coat after UHP waterjet-cleaned surface.

work independently from all other construction in the shipyard, having all the utilities needed for their operation.

CONCLUSION

During normal operation of this shipyard, the major advantages of using these combined technologies amount to a cleaner shipyard, no abrasive material to dispose of, less cost, and the ability to carry out simultaneous projects of various natures 24 hours a day without being dependent on ambient conditions. Despite working with dangerously high water pressure, UHP waterjetting offers fewer overall health risks due to the absence of abrasive media.

ABOUT THE AUTHOR

Nuno Cipriano has been the director of operations at Ultrablast Lassarat Ltd. since 2012 and works on new-



building projects for replicant platforms for Petrobras being constructed in Brazil. He has over 10 years of experience in newbuilding and

ship repair as a paint inspector of several Petrobras projects in Singapore, China, Brazil, Bahrain, Dubai, Vietnam, Portugal and Italy. Cipriano holds a bachelor's degree in chemical engineering from the Instituto Politécnico de Lisboa and a post-graduate qualification in project management from the Instituto Superior de Gestão. **JPCL**

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REPLICA TAPE

Photo: Pamela Simmons

Unlocking Hidden Information

By David Beamish
DeFelsko Corporation

*All figures courtesy of the author
unless otherwise noted.*

Steel surfaces are frequently cleaned by abrasive impact or by power tools prior to the application of protective coatings. This process removes previous coatings, mill scale, rust and contaminants. It also roughens the surface to improve coating adhesion.

The resultant surface profile, or anchor pattern, is composed of a complex pattern of peaks and valleys which must be accurately assessed to ensure compliance with job or contract specifications and ensure a successful coating

project. It is generally accepted that the nature of these surfaces is predictive of long-term coating performance. Characteristics of a blasted surface include peak height, peak density, developed surface area, angularity, sharpness and shape.

Today, only peak height (H) is commonly measured. If this height is insufficient, paint will not adhere. If too great, more paint is required to fill the "valleys" and the high peaks may protrude through the paint to become foci for corrosion.

While the importance of measuring peak height is undeniable, one parameter alone does not fully describe the dynamics of a coating/substrate relationship. Peak density (P_d) is also an important indicator of performance and can now be

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measured thanks to recent developments in field instrumentation.

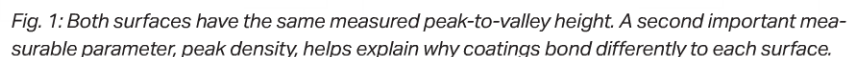
Counting Peaks

In 1974, J.D. Kean, J.A. Bruno and R.E.F. Weaver wrote in an article titled, "Surface Profile for Anti-Corrosion Paints," that a surface prepared for painting via blast cleaning could not be completely described by measuring peak-to-valley distance (H) alone. Their paper supported field experience which suggested that there was another important parameter besides H, namely, the number of peaks per unit length or peak count (P_L), or peaks per unit area or P_a . Besides increasing the bonding surface area, their paper explained that increasing the number of peaks in a defined area increased the angularity of that area. That put more shear adhesion stress on the coating rather than tension (pull-off) stress. This increased coating bond strength for the applied coating as shear values are always higher than tensile values. The applied coating, of course, must wet out 100 percent of the surface ("wet out" meaning wet the surface thoroughly).

Figure 1 is a simplified example of why both peak height and peak density are important in understanding coating performance. The two surfaces have different geometries yet their height measurements are the same. To get a clearer picture of the surface available for bonding, peak count measurements must also be obtained. Furthermore, both measured values make it possible to investigate the increase in surface area resulting from the abrasive blasting process.

There is little doubt that peak density measurements are important to the corrosion industry, but the problem until now is that peak counts have not been easy to determine.

In June of 2005, *JPCL* published a significant paper by Hugh J. Roper, Weaver and Joseph H. Brandon titled "The Effect of Peak Count on Surface

[illegible]

In a follow-up article they concluded that “the optimum steel profiles for a wide range of standard industrial coatings that will completely wet the surfaces are a 2 to 3 mil (50 to 75 micron) profile height and a peak count between 110 and 150 peaks per inch (40 and 60 peaks per centimeter)”. The authors recommended that stylus roughness instruments, the best field instrument available at the time, be used in the corrosion industry to provide both critical pieces of profile information — peak height and peak density.

Stylus roughness instruments record the up and down movements of an external stylus traversing across a surface (Fig. 2). They measure a height parameter called R_t in compliance with ISO 4287, "Geometrical Product Specifications (GPS) — Surface texture: Profile method — Terms, definitions and surface texture parameters," which yields the vertical distance between the highest peak and lowest valley within any given evaluation length of 0.5 inches (12.5 mm). Five traces are made and R_t values averaged to obtain the average of the maximum peak-to-valley distances.

In 2011, an ASTM round-robin study (Research Report RR:D01-1169) determined peak-to-valley height R_t as measured by stylus roughness instruments related closely to H as measured by both depth micrometers and replica tape. But if



Fig. 2: Stylus roughness instruments.

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Fig. 3: Burnishing replica tape.

stylus roughness instruments could generate measurements of both peak height and the number of peaks encountered along a sampling length, why has the corrosion industry been slow to adopt them?

Likely this reluctance is based on economic and practical reasons. Stylus profilometers are fragile in nature since they depend on a precisely calibrated stylus that often extends a distance from the body of the device itself. They can be complex to set up and to operate and they report a number of roughness parameters that are of limited interest to the coatings industry. All these factors likely dissuade potential users.

A lesser known fact is that stylus-based roughness testers, although popular in metal machining industries, are challenged by the complex patterns generated by surface-cleaning operations. They measure only a single line on a roughened surface and most of the features recorded as peaks are actually peak "shoulders" where the stylus traced over the side of the peak rather than over the top of the peak.

What other measuring solutions are available? It is anecdotally believed within the corrosion industry that definitive measurement devices must use laboratory methods such as white light interferometry, focus variation microscopy, confocal laser microscopy

or atomic force microscopy. But these powerful devices are also challenged when measuring complex blasted surfaces. They are costly to purchase, do not operate in the field, and require extensive training to set-up myriad test parameters for topographic analysis.

It is therefore desirable to have one affordable, robust field instrument designed specifically for the corrosion industry that can provide both H and P_a measurements to give inspectors a more meaningful and functionally correlative prediction of coating performance during surface preparation. The solution lies with replica tape.

Measuring Peak Density: A New Solution

Replica tape has been used to characterize surfaces since the late 1960s (Fig. 3). It is simple, relatively inexpensive and is particularly useful on curved surfaces. Its operation is described in a number of international standards including ASTM D4417, "Standard Test Methods for Field Measurement of Surface Profile of Blast Cleaned Steel"; ISO 8503-5, "Preparation of steel substrates before application of paints and related products — Surface roughness characteristics of blast-cleaned steel substrates — Part 5: Replica tape method for the determination of the surface profile" and NACE RP0287,

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"Field Measurement of Surface Profile of Abrasive Blast-Cleaned Steel Surfaces Using a Replica Tape." Compared to other methods, it has the advantages of ruggedness, relatively low start-up cost, good repeatability and the ability to retain a physical replica of the surface being evaluated.

Replica tape is made of a layer of compressible foam affixed to an incompressible polyester substrate of a highly uniform thickness. When pressed against a roughened steel surface the foam collapses and forms an impression of the surface. Placing the compressed tape between the anvils of a micrometer thickness gage and subtracting the contribution of the incompressible substrate, 2 mils or 50.8 microns, gives a measure of surface profile height.

Accessing New Information

As common as this product is, it is not widely known that these surface replicas contain far more information than just peak height as measured by a micrometer. Significant data is available through digital imaging.

A new measurement approach is to use a property of the tape that is related to, but different from, its capacity to replicate surfaces; that is, the tape's increase in transparency where it is compressed. Using this principle, a three-dimensional map of the surface can be generated from an optical scan of the burnished replica tape. Peak counts can be determined by simply counting bright spots on the image taken by a digital image sensor.

A photograph of a back-lit piece of tape reveals light areas of higher compression (peaks) and dark areas of lower compression (valleys) (Fig. 4, p. 57). A portable instrument can identify peaks and determine areal peak density, that is, how many peaks are present per square millimeter, or P_d , as defined by ASME B46.1, "Surface Texture (Surface Roughness, Waviness, and Lay)."

3-D Surface Mapping

Going a step further, additional surface parameters can be extracted once the thickness/transparency relationship has been applied to the intensity image using 3-D rendering software. The result is a 3-D map of the blasted steel surface at a cost far less than interferometric or confocal profiling devices. An example of how the process works is shown in Figure 5 (p. 57) and Figure 7 (p. 59).

Correlating Replica Tape Measurements to Established Measurement Technique

To validate 3-D replica tape measurements, the parameter measurements obtained from the tape (H and P_d) were compared to two established surface roughness measurement methods: confocal microscopy and stylus profilometry.

The first step taken was to confirm that light intensity imaging of replica tape yielded values comparable to those obtained using known laboratory methods. A study was carried out using three steel panels blasted with grit 50, garnet coarse, and shot 230/grit 40 media. The panels were sent to a university lab along with three sets of burnished replica tape for measurement with a confocal microscope. The 3-D replica tape measurements were found to closely correlate with the laboratory methods (Table 1, p. 58)

To compare measurements from 3-D replica tape images with those determined from stylus roughness instruments, measurements of peak density were taken on the five panels used in the 2011 ASTM round-robin study. Two-dimensional stylus profilometer measurements are not directly comparable with the 3-D optical replica tape measurements. However, a direct correlation was observed.

Adhesion Testing

Given the previous research by Roper and others on the correlation between



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adhesion and both H and P_d , an adhesion study was carried out to determine if 3-D replica tape imaging methods gave similar results. Twenty-five steel samples were prepared using a variety of blast media and measurements were performed with the 3-D replica

tape imager. The samples were then sprayed with three coatings: an epoxy, a two-component acrylic and a polymer composite coating, and allowed to cure. Three pull-off adhesion tests were then performed on each sample following the test method described

in ASTM D4541, "Standard Test Method for Pull-Off Strength of Coatings Using Portable Adhesion Testers" using a Type V hydraulic pull-off adhesion tester described in Annex A4 (Test Method E) of that standard.

Correlation of Adhesion with Surface Profile Height

In the 2006 Roper et al. paper, it was theorized that "the optimum steel profiles for a wide range of standard industrial coatings that will completely

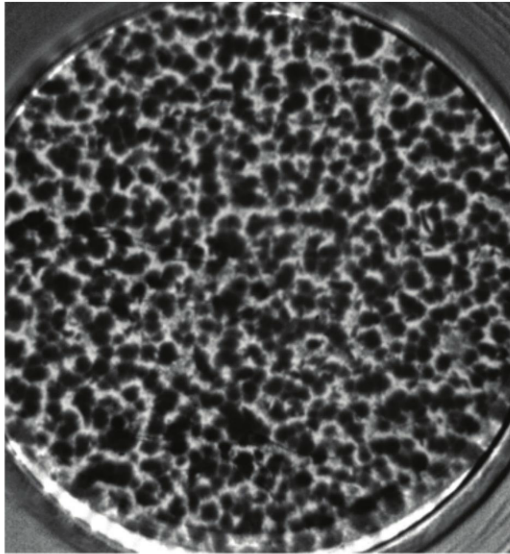


Fig. 4: This figure depicts a 2-D image derived from replica tape (above) and digitally counting bright spots or peaks (right).

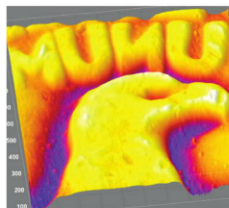
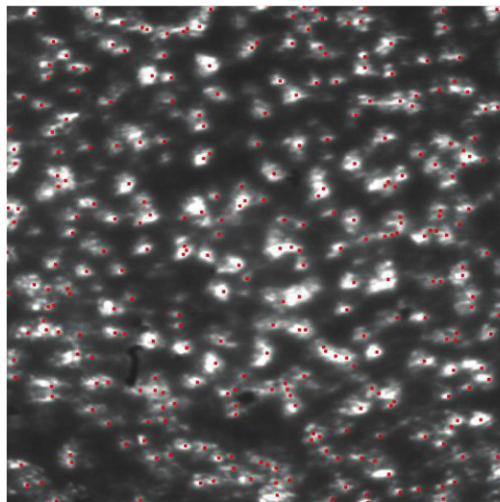
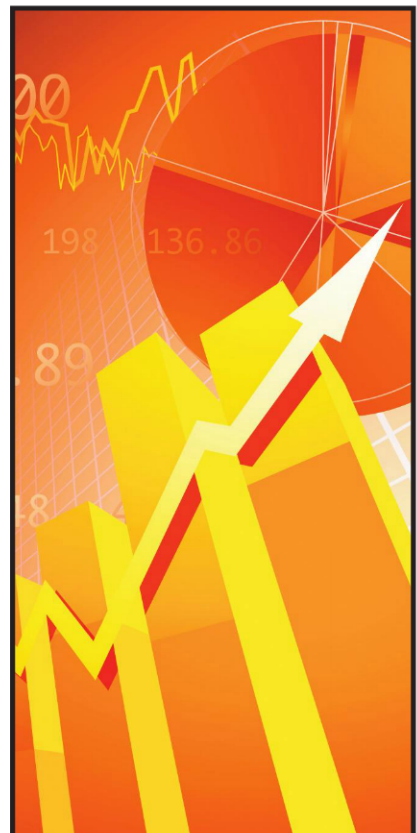


Fig. 5: Replica tape embossed over a coin (center), a digital surface image created from the tape and from a field instrument (right).



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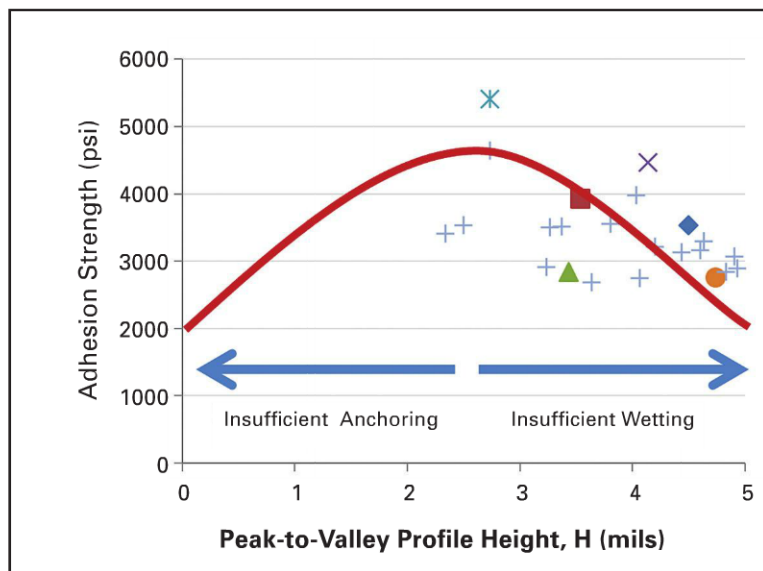


Fig. 6: Observed peak-to-valley profile height versus adhesion strength for various blast media types with hypothesized trend and justification.

Table 1: Comparison of Peak Density (P_d) Calculations Between a Field and a Lab Instrument

Sample	Field Instrument RTR-P (peaks/mm ²)	Lab @ 1000 μm^2 (peaks/mm ²)
G50	25	34
Garnet Coarse	11.8	13.8
S230/G40	8.3	7.6

wet the surfaces are a 2- to 3-mil (50- to 75-micron) profile height". The highest adhesion strengths were observed in the 2 to 3 mil range with adhesion values decreasing as profile heights increased above 3 mils, likely because the coating failed to fully wet the substrate. The observations in this study appear to affirm this hypothesis although no samples were taken with profile heights below 2 mils. It is theorized that adhesion

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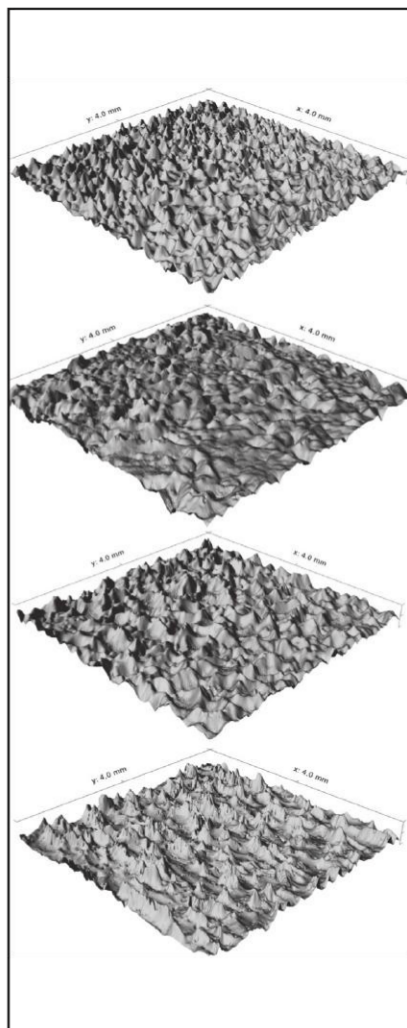


Fig. 7: 3-D images of blasted surfaces derived from replica tape using a field instrument. In order from top: G50, Garnet, S230/G40 and hand-held bristle blasting tool. (Z-axis enhanced for clarity.)

levels would begin to decrease below this figure because of insufficient profile to anchor the coating. A hypothetical trend line, with P_d held constant, is overlaid on this study's data in Figure 6.

Correlation of Adhesion with Peak Density (P_d)

There appears to be a strong positive correlation between peak density and adhesion, reinforcing Roper's hypothesis that peak count is relevant to coating performance.

Their paper asserted "the optimum steel profiles for a wide range of standard industrial coatings that will completely wet the surfaces are ... a peak count between 110 and 150 peaks/in (40 and 60 peaks/cm)."

As stated earlier, a stylus profilometer counts the number of

peaks in a straight line (expressed in millimeters) whereas a replica tape reader counts peaks in a unit of area (expressed in square millimeters). Since those authors used a stylus profilometer in their research, their numbers are not directly comparable to the data in this study. However, based on our study,



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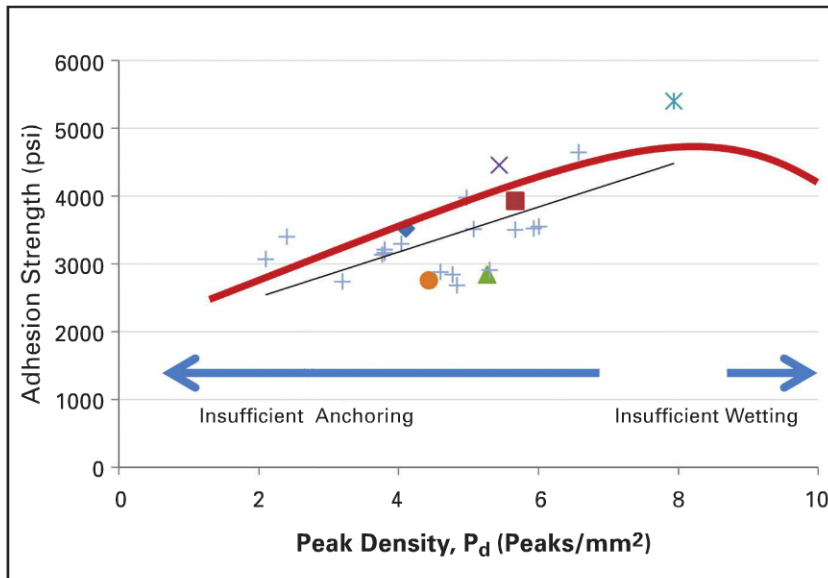


Fig. 8: Observed peak density versus adhesion strength with hypothesized trend and justification.

an optimal 3-D peak density of around 8 peaks per square millimeter was observed. It is hypothesized that the observed positive relationship between adhesion strength and peak density would not persist at peak densities greater than those observed in this study. This theorized relationship between adhesion and P_d with H held constant is shown in Figure 8.

Conclusion

It is generally accepted that the nature of abrasive blast cleaned steel surfaces is predictive of long-term coating performance. The corrosion industry does not fully understand the dynamics of this complex problem but it has several measurable parameters available to it, including peak height, peak density, surface area, angularity, sharpness and shape. Commonly

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held industry beliefs would suggest that increasing several of these parameters will improve long term coating performance. Empirical data suggests it is not that simple.

The most important of these parameters, H, is commonly measured today and is usually the only parameter

reported. While its importance is undeniable, one parameter alone does not fully describe the dynamics of a coating/substrate relationship.

P_d is also an important indicator of performance. While it also cannot be a sole measure like H has been for several decades, together with H it provides

a better prediction of long-term coating performance as measured by pull-off adhesion testing.

$$A = f(H, P_d)$$

This relationship helps to explain why H measurements alone have not always been a reliable method for predicting performance for all coating types. A coating may bond to a surface with low H and high P_d just as well as to one with high H and low P_d . For this reason the corrosion industry should report both values so that customers can determine the best ratio for their particular coating application. Both parameters are controlled with the proper selection of abrasive material type and size. Perhaps a hybrid parameter will be specified in the future.

About the Author

David Beamish is the president of DeFelsko Corporation, a manufacturer of hand-held coating test instruments sold



globally. He has a degree in civil engineering and more than 27 years of experience in the design, manufacture and marketing of these instruments in a variety of international industries

including industrial painting, quality inspection, and manufacturing. Beamish conducts training seminars and is an active member of various organizations including SSPC, NACE, ASTM and ISO. *JPCL*

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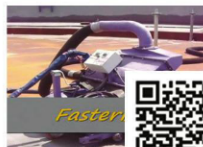
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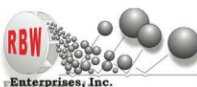
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n. The measurement of the humidity content of the air by use of a psychrometer.

P

Psymplified Psychrometrics

Psychrometrics has often been a confusing and misunderstood area of the industrial coating business. Used every day in the HVAC and humidity control industries, the mechanical engineer or refrigeration professional may have a clear understanding of the princi-

The ability for any or all of these compounds to be suspended as part of the air mixture is impacted by two things: pressure and temperature.

The impact of pressure on moisture content can be illustrated when the separator on an air compressor is drained. As the air is compressed, it can hold less water and the excess will collect in the bottom of the tank. Barometric pressure of the air around us has a similar impact on the air's ability to hold water. Barometric pressure changes with altitude and weather systems and these differences in barometric pressure are largely insignificant in the industrial coating world.

What is significant however, is the air temperature and its ability to change the air's capacity to "hold" water. As is the case with many things in nature, when cooled, there is less energy; energy to dissolve things when we cook or clean, energy to polymerize when we mix up an epoxy coating or energy required for water to remain in vapor form. When the air is cooled and it loses energy, the water that it contains does not remain in vapor form as easily. When

ples, but the industrial painter is involved with just a small part of this science and may not thoroughly comprehend the concepts that affect his or her job every day. This article will explain conditions to watch for on the job, what causes conditions to deteriorate, and how to correctly predict humidity as closely as possible and measure these parameters.

What Causes Fluctuations in Relative Humidity?

The earth's atmosphere consists of a mixture of gases in various concentrations. Air is commonly the name given to this mixture which includes mainly oxygen, nitrogen and carbon dioxide, as well as water.

By Robert Ikenberry,
California Engineering
Contractors, Inc.
and Don Schnell,
Polygon (formerly
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Psymplified Psychrometrics

cooling continues, eventually the sum of the water vapor will become liquid in the form of condensation or rain.

When and How Does Condensation Occur?

Condensation, very simply, is the formation of water droplets from air that is cooled to below its dew point temperature. What we see when condensation occurs is water moving from a gas to a liquid form. When the air is cooled to below its dew point temperature (also called saturation), the water molecules must leave the air and they find something to attach to. In the upper atmosphere, the water droplets form on microscopic specks of dirt or dust to form raindrops and while on earth, the droplets attach to the most convenient surface, forming dew.



During the blasting of surfaces, high humidity can cause flash rusting to occur before prime coats are applied.

To further explain the relationship between water and air, imagine that heat (energy) is like a juggler. The harder he works, the more balls (water molecules) he can keep in the air. When he gets tired (less energy), he can't keep them all moving and some of them fall out of the

air, which is a rough conceptual parallel of why the water sticks to surfaces as dew.

Contrary to popular belief, a cold surface does not draw moisture to it. A cold surface cools the air adjacent to it and, if cooled enough, causes the air to give up moisture. That moisture then

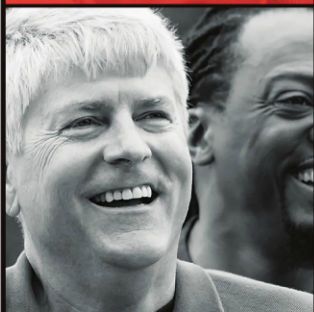
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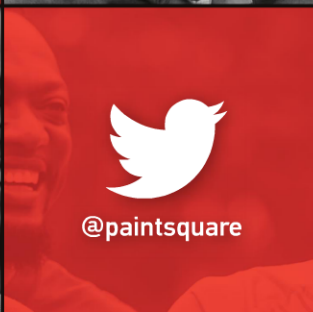
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These submarines are under containment to control the amount of moisture present during the coating process. Projects in coastal climates are typically at a higher risk for adverse humidity conditions.

deposits itself on the surface in the form of dew or, if below freezing, frost.

The heat that a surface loses by radiation is related to its temperature and the net radiation loss depends on the temperature of surrounding surfaces. If you imagine a ball sitting in a room, if the walls are the same temperature as the ball there won't be any net loss by radiation. What it radiates out, it gets back from the surroundings. If the walls are hotter (even if the air is air-conditioned) the ball will get warmer. You would "feel the heat" on your skin from radiation (infrared). Think of sitting next to a pot belly stove, even if the room is cold, the radiant heat will warm you.

The sky at night is very cold. The effective temperature is about 40 degrees below zero. Surfaces exposed to the sky radiate their heat out and get nothing back, and therefore, cool faster. Horizontal surfaces lose their heat faster because they face the sky. This is why the hood of your car or the roof of a water tank has more dew or frost. These surfaces condense first because as the surface loses its heat to the atmosphere, it cools the air around it to below the dew point and the moisture is forced to find a place to condense.

How Do Air and Surface Temperature Affect Relative Humidity and Condensation?

Relative humidity is defined as the amount of water vapor in the air as a percentage of what it can hold when it

is completely saturated. Air at 50 percent relative humidity (RH) holds one half of the water that it can. Air at 100 percent RH is holding as much water as it can. At 100 percent RH, we say the air is saturated ... it can hold no more.

As mentioned earlier, when the air is cooled, it cannot hold as much water. So, if the air is at 100 percent RH and we cool it, some of the water will condense. If we heat the air, its capacity to hold water increases; therefore, the RH will drop accordingly.

Moisture and Painting

Controlling moisture during painting and curing, particularly with clean or freshly painted surfaces, is critical. Knowing how moisture interacts with steel surfaces and paint is also helpful. To keep surfaces clean, particularly blasted surfaces, less moisture is better. Moisture at the surface causes two major problems:

Firstly, if surfaces are exposed to humidity levels above about 50 percent RH, corrosion (flash rusting) can occur in a matter of hours. Absolutely clean steel won't rust in the presence of non-condensing atmospheric conditions for a long while, but no surfaces are absolutely clean.

It is important to remember that the 50 percent RH measured in the center of the tank does not represent the condition at the surface. The air adjacent to the surface of the steel



Sling psychrometers collect ambient temperature and humidity information by being whirled about for three 20- to 30-second intervals. Photos courtesy of KTA-Tator, Inc.

assumes the steel temperature, therefore impacting the RH there at the surface.

Some contaminants, like those found in industrial environments and smog, sulfur dioxide (SO₂) for example, create conditions for flash rusting to start at around 65 percent RH. A more common contaminant, particularly in marine environments, is sodium chloride (table salt – NaCl) which will cause flash rusting at about 55 percent RH. This is why the rule of thumb for dehumidification to hold a blast and postpone flash rusting is to stay below 50 percent RH. Some types of contamination on the surface can make flash rusting occur at even lower humidity levels, but are very rare, and therefore, the most common contaminants will not cause flash rusting below 50 percent RH.

The second problem is that moisture at the surface can cause direct condensation. If there is liquid (water) on the surface, most coatings will not successfully adhere. Water on the surface as a liquid is generally a contaminant, preventing most types of paint from a successful application.

In cold weather, frost is of particular concern. Ice may not always be visible, especially if it is a thin film, but it will prevent adhesion and proper



curing. This issue is why almost all coatings recommend a difference of 5 degrees F (or 3 degrees C) between the atmosphere dew point and the temperature of the surface to be coated.

Even after application, condensing conditions can cause serious problems. Many coatings are not water resistant until fully cured. Condensation can interfere with initial curing and permanently degrade acrylic, vinyl and other coatings that form films primarily by evaporation and consolidation. Epoxies in particular are sensitive to liquid water during cure and can develop an amine blush where surface moisture has preferentially reacted with some of the active sites in the resin, creating an oily residue on the surface, rather than the cross-linked polymer desired. Similarly, isocyanate groups in polyurethanes will preferentially react with water rather than the intended polyols if the surfaces of fresh films get wet. Other types of coatings may be discolored and have final cure delayed by exposure to liquid water on the



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surface. This is undesirable, even if the problems are temporary or cosmetic. One needs to be particularly concerned about outdoor locations where the coating is exposed to clear night skies and the temperatures drop significantly overnight. If there is frequently dew on steel surfaces when the sun rises, expect that condensation can occur overnight after paint is applied.

The moisture in the air can transfer to opened paint and solvents as well. As one example, due to the sensitivity of polyurethanes to water in the mixed paint, use of thinners that have not been certified for use with urethanes (anhydrous) or even solvent containers that have been left open for a period of time, may have enough water in them to cause problems such as reducing pot life or interfering with proper cure.

Too little moisture can also be a problem, although a less common one. Low humidity, particularly in cooler temperatures, will retard or prevent the proper cure of ethyl silicate inorganic zincs. They will remain soft and not fully cured until enough moisture is present, sometimes requiring misting with water to achieve a full cure. Moisture-cured urethanes, as the name implies, also require a reaction with atmospheric water

to cure and may not be a good choice in very dry climates.

Knowing the details about atmospheric moisture, or more broadly, psychrometrics, will help control surface cleaning and the application and curing of protective coatings, leading to more successful and profitable projects.

About the Authors



Robert Ikenberry, PCS, has been in industrial painting and construction since 1975. Currently safety director and project manager for California Engineering Contractors, Robert stays busy rehabbing, retrofitting and painting bridges and blogging for *PaintSquare News*. His documentary on the demolition of the 1927 Carquinez Bridge was the pilot for National Geographic's *Break it Down* and an episode of *MegaStructures*. He's also working on documenting the demolition of the San Francisco-Oakland Bay Bridge currently underway.

Don Schnell has rejoined the company where he began his career in the climate control and restoration



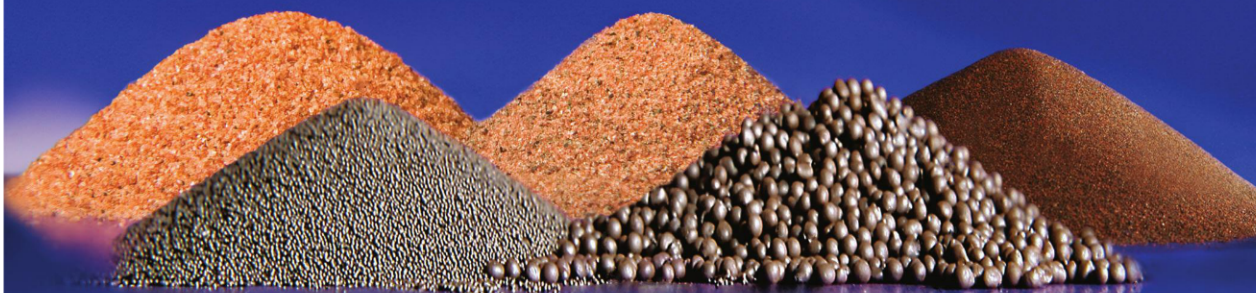
business. As business development manager for Polygon US (formerly Munters Moisture Control Services), his focus is the construction drying

business in the eastern region of the U.S. Schnell has worked in the climate control and industrial coatings businesses for over 30 years. He attended North Dakota State University and is involved in multiple professional organizations including the Society for Protective Coatings (SSPC), National Association of Corrosion Engineers (NACE), Construction Specifications Institute (CSI) and Property Loss Research Bureau (PLRB). **JPCL**



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SSPC Board of Governors Election Results In

SSSPC is pleased to announce the results of the 2015 Board of Governors election.

In the Coating Material Supplier demographic, two positions were up for election. The winning candidates are:

- Brian Skerry, global director, corrosion programs, The Sherwin-Williams Company (second term); and
- Ahren Olson, market manager, corrosion protection, Bayer MaterialScience LLC.

In the Coating Contractor demographic,

one position was up for election. The winning candidate is:

- Sam Scaturro, president, Alpine Painting & Sandblasting Contractors.

In other Board news, SSPC President Jim King has appointed Joyce Wright, manager of process excellence at Huntington Ingalls Industries-Newport News Shipbuilding, to complete the remaining term of Gail Warner, also of HII-Newport News, who has retired.



Brian Skerry



Ahren Olson



Sam Scaturro



Joyce Wright

SSPC Certifies 12 New PCSs

Twelve coatings professionals across the globe recently earned SSPC's highest level of certification, the Protective Coatings Specialist (PCS).

The PCS certification recognizes industrial coating professionals for their extensive knowledge in the principles and practices specific to industrial coatings technology. Each individual has been evaluated for his or her mastery of coating type, surface preparation, coatings application and inspection, contract planning and management, development of specifications and the economics of protective coatings. SSPC congratulates these individuals for their achievements.

The recently certified Protective Coatings Specialists follow. For more information on the PCS certification, visit sspc.org/training.



Alejandro Exposito Fernandez,
Optimiza Protective & Consulting
(Cartagena, Spain)



Andrew Tong Tak Wah,
Alfasi Constructions (HK) Ltd.
(Hong Kong, China)

SSPC Poster Session Abstracts Due Aug. 30

SSSPC will hold its second annual Poster Session during SSPC 2016 featuring GreenCOAT, which will be held at the Henry B. Gonzalez Convention Center in San Antonio, Texas, from January 18 to 21, 2016.

A Poster Session is composed of presentations of research information by an individual or representatives of research teams — typically college students or young professionals — at a conference with an academic or professional focus. SSPC's first-ever Poster Session was held in February at the SSPC 2015 conference in Las Vegas.

In order to be considered for a poster presentation, interested parties should submit an abstract to Sara Badami at badami@sspc.org by August 30, 2015. First drafts for each poster are due by September 30. Drafts will be

reviewed by a selection committee for approval and presenters will be notified of acceptance by October 15. Final drafts will be due by November 15.

Posters will be displayed in the Convention Center from Tuesday, January 19 through Thursday, January 21, 2016. All posters must include the following categories:

- Title;
- Abstract/Introduction;
- Objectives;
- Results/Discussion;
- Future Research;
- Conclusion; and
- References/Acknowledgements.

Further information on the SSPC 2016 conference can be found at sspc2016.com. If you have questions, please email Sara Badami, SSPC, at badami@sspc.org, or call 412-281-2331, x2208.

SSPC Board of Governors Election Results In

SSSPC is pleased to announce the results of the 2015 Board of Governors election.

In the Coating Material Supplier demographic, two positions were up for election. The winning candidates are:

- Brian Skerry, global director, corrosion programs, The Sherwin-Williams Company (second term); and
- Ahren Olson, market manager, corrosion protection, Bayer MaterialScience LLC.

In the Coating Contractor demographic,

one position was up for election. The winning candidate is:

- Sam Scaturro, president, Alpine Painting & Sandblasting Contractors.

In other Board news, SSPC President Jim King has appointed Joyce Wright, manager of process excellence at Huntington Ingalls Industries-Newport News Shipbuilding, to complete the remaining term of Gail Warner, also of HII-Newport News, who has retired.



Brian Skerry



Ahren Olson



Sam Scaturro



Joyce Wright

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Arthur Ruff,
Schuff Steel (Phoenix, Ariz.)



Manoj Abraham,
Hempel (Daha, Qatar)



Rama Pandian Sankara Kumar,
Oilfield Supplies Center, Ltd. (Dubai, UAE)



Atanas Cholakov,
ACT UAE (Duabi, UAE)



Michael Moran,
Protective Coatings & Epoxy Systems
(Fowlerville, Mich.)



Zameel Abdul Kareem,
Kuwait Oil Company
(Ahmadi, Kuwait)



Bradley Wilder,
Intech Contracting (Lexington, Ky.)



Brent Trombley,
Commercial Sand Blasting & Painting
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Ali Hasan Al-Qatan,
Bahrain Petroleum Company
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Titan to Rehab Belle Vernon-Speers Bridge for \$22.4M

Titan Industrial Services, Inc. (Baltimore, Md.), SSPC-QP 1- and -QP 2-certified, secured a \$22,462,604 contract from the Pennsylvania Department of Transportation to rehabilitate the Belle Vernon-Speers Bridge over the Monongahela River in southwestern Pennsylvania. This 2,065-foot-long through and deck truss steel bridge was built in 1951 and was last rehabilitated in the mid-1990s.

This contract includes cleaning and recoating the bridge's structural steel surfaces. The steel will be abrasive blast-cleaned to a "Near White" finish (SSPC-SP 10/NACE No. 2), tested for soluble salt with as-needed chloride remediation and recoated with a three-coat organic zinc-epoxy-urethane system selected from NEPCOAT List B. The bridge suspender cables will also receive "Hand Tool Cleaning" (SSPC-SP 2) and will be overcoated with a high-build acrylic system. The contract also includes 5,719 square yards of penetrating sealant protective coating application for reinforced concrete superstructure surfaces, and 14,750 square yards of epoxy-based surface treatment application for bridge deck surfaces.

Three other contracting companies bid on the contract. The second-lowest bid came in at \$24,919,030, while the highest bid was for \$26,992,532.

Crane Rehab Contract at Priest Rapids Dam Awarded

Grant County Public Utility District No. 2 (Ephrata, Wash.) and Western Equipment Manufacturing Company, Inc. (Spokane, Wash.) agreed on a \$1,796,411 contract

Quick Hits

- Osseo Construction Co., LLC (Osseo, Wis.) outbid four other companies to win a \$366,275 contract from the city of St. James, Minn., to clean and recoat the interior and exterior of a 600,000-gallon elevated water storage tank.
- F.D. Thomas, Inc. (Medford, Ore.), SSPC-QP 1- and -QP-2-certified, and the California Department of Transportation agreed on a \$1,354,008 contract to clean and recoat a bridge over the Navarro River in Mendocino County.
- The city of Bay City, Mich., awarded a \$945,800 contract to Horizon Brothers Painting (Howell, Mich.) to clean and recoat in the interior and exterior of an ellipse-style, 2 MG elevated water storage tank.



Photo courtesy of Grant County Public Utility District No. 2.

to rehabilitate two steel bulkhead cranes — one 25-ton and one 35-ton — at the Priest Rapids Dam. This 10,103-foot-long, 178-foot-high dam on the Columbia River has been generating hydroelectric power since 1959.

The contract includes on-site cleaning and recoating of the crane surfaces. The steel will be ultra-high-pressure

waterjet cleaned to the SSPC-SP 12/NACE No. 5 standard, "Surface Preparation and Cleaning of Metals by Waterjetting Prior to Recoating," and recoated with a micaceous iron oxide zinc-rich primer and a polyaspartic aliphatic urethane topcoat. Class 2W containment according to SSPC-Guide 6 is required.

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SSPC COURSES

Course information available at sspc.org

Aug. 3-4	Bridge Ctg Assess, Ventura, Calif.
Aug. 3-6	C3 Lead Pt Removal, Newington, N.H.
Aug. 3-7	C1 Fundamentals, Houston, Texas
Aug. 3-8	PCI Prot Ctg Insp Levels 1 & 2, Seattle, Wash.
Aug. 6	Using PA 2, San Diego, Calif.
Aug. 6-7	C13 Water Jetting, Honolulu, Hawaii
Aug. 7	C5 Lead Pt Refresher, Newington, N.H.
Aug. 7	Nav Std Item 009-32, San Diego, Calif.

Aug. 8	Lead Pt Worker Safety, Newington, N.H.
Aug. 8	Estimating, Batam, Indonesia
Aug. 9	PCI Level 3, Seattle, Wash.
Aug. 10-14	NBPI NAVSEA Basic Pt Insp, San Diego, Calif.
Aug. 10-14	C2 Plan & Spec, Norfolk, Va.
Aug. 10-15	PCI Levels 1 & 2, Pittsburgh, PA
Aug. 10-15	PCI Levels 1 & 2, Manila, Philippines
Aug. 13	CAS Refresher, Irving, Texas
Aug. 14	CAS Level 1, Irving, Texas
Aug. 15	PCS Enrollment, Norfolk, Va.

Aug. 15-16	C7 Abrasive Blast, Chesapeake, Va.
Aug. 16	PCI Level 3, Pittsburgh, PA
Aug. 16	PCI Level 3, Manila, Philippines
Aug. 17-22	BCI Bridge Ctg Insp Levels 1 & 2, Ft. Lauderdale, Fla.
Aug. 19-20	C12 Airless Spray, Port Angeles, Wash.
Aug. 21	Nav Std Item 009-32, Pearl Harbor, Hawaii
Aug. 24-28	NBPI, Pearl Harbor, Hawaii
Aug. 24- Sept. 4	PCI Levels 1 & 2, Singapore City, Singapore
Aug. 30	Using PA 2, San Diego, Calif.
Aug. 31	Nav Std Item 009-32, San Diego, Calif.