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JOURNAL OF PROTECTIVE COATINGS & LININGS
The Voice of SSPC: The Society for Protective Coatings

Cover design by Peter Salvati

Angels and Demons in the Realm of Protective Coatings: The Underworld of VOCs

By Mike O'Donoghue, Ph.D.; V.J. Datta, MS; and Russell Spotten, International Paint, LLC

The authors examine the "angels and demons" that coatings with exempt solvents pose for surface preparation and the success or failure in immersion service. Potable water and petrochemical service are the focus of the internal linings discussion.

30 Potential Risks of Ballast Water Treatment Systems on Ballast Tank Coatings

***By Brian Goldie,* JPCL**

This article reviews presentations made at a one-day workshop in London organized by Informa Maritime Events. Presentations dealt with the problem with the potential impact of water treatment systems on protective coating systems on ships.

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Photo courtesy of the U.S. Navy

SSPC Honors Coating Projects in 5th Annual Structure Awards

***By Jodi Temyer,* JPCL**

SSPC presented the fifth annual structure awards at SSPC 2011 featuring GreenCOAT, held Jan. 31-Feb. 3 in Las Vegas. The awards recognize standout jobs on industrial or commercial coatings projects, with a new military coatings award presented this year. The recipients are recognized with a photo essay.

Also this month

From the Offices of SSPC The Society For Protective Coatings

SSPC recently launched an all-new sspc.org! For quick access, use your smart phone to capture this barcode.

JPCL STAFF

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Emmons To Give SSPC/*JPCL* Webinar on Durable Concrete Repairs

The foremost authority on concrete repair in the U.S., Peter Emmons, will present an SSPC/*JPCL* Education Series Webinar entitled, "Achieving Durability in Concrete Repair," on May 11 from 11:00 a.m. to noon, EST.


Peter Emmons

The webinar, which will be presented at an introductory level, will focus on how to select and use repair materials for structural concrete, such as bridge piers, in a way that assures the durability of the repair.

Register online at www.paintsquare.com/education.

Education Series Webinars provide continuing education for SSPC recertifications, as well as technology updates on important topics. Participation in the webinar is free, but for those who wish to receive continuing education credits from SSPC, a test is available after the webinar. Cost of the test service is $25. All participants, however, will receive a free certificate of completion.

Peter Emmons, CEO of Structural Group, the Baltimore, Maryland-based company he founded in 1976, has more than 30 years of experience in structural concrete repair and is considered to be among the industry's foremost authorities.

Emmons is the author of the book *Concrete Repair and Maintenance Illustrated* (1993), has written numerous technical articles, and is a frequent speaker at the World of Concrete.

Emmons is a past member of the American Concrete Institute (ACI) Board of Directors and serves on several ACI committees, including 546-Repair and 364-Rehabilitation. He also is past president of the International Concrete Repair Institute (ICRI). Emmons has received several industry awards, including the prestigious Arthur R. Anderson Award from ACI for his contributions to the development and dissemination of knowledge regarding the repair, rehabilitation, and maintenance of concrete.

BASF is the sponsor of the webinar.

Manous Appointed to SSPC Board

SSPC recently announced that Garry D. Manous has been appointed by SSPC President Russ Brown to the Board of Governors.

Manous is the senior project manager for Atsalis Brothers Paint Company (Warren, MI) and oversees numerous high-profile bridge painting projects.

He holds a BS in civil engineering from Purdue University in West Layfayette, IN. Manous became a member of SSPC in 1994. He serves on the PCCP Advisory Committee and is active in MITA (Michigan Infrastructure and Transportation Association) and CIM (Construction Industries of Massachusetts, Inc.).

Manous replaces Bob Ziegler, who was first elected to the Board in 2005. Ziegler's demographic designation changed from contractor to consultant, and he has resigned his position on the Board in accordance with SSPC Bylaws. He has been appointed an ex-officio member by Brown to continue his work with the new SSPC Scholarship Program and the Government Affairs Committee.

For more information about the SSPC Board of Governors, including a call for nominations, see p. 59 of this issue and visit sspc.org.

Webster Receives Tess Award

Dr. Dean C. Webster of North Dakota State University, Department of Coatings and Polymeric Materials, will receive the Roy W. Tess Award in Coatings for 2011. The announcement was made by the Officers and Award Committee of the Division of Polymeric Materials: Science and Engineering (PMSE) of the American Chemical Society (ACS).

The Tess Award is presented annually in recognition of outstanding contributions to coatings science and technology. It is funded by a grant from Dr. and Mrs. Roy W. Tess and is meant to encourage interest and progress in coatings science technology and engineering. The award consists of a plaque and a $3,000 prize.


Dr. Dean C. Webster

Webster began his career in coatings in 1984 and was involved in resin development for industrial coatings and research in new resins and crosslinking chemistry. He later led project teams in application development for new monomers, new chemistry for coatings systems, and polymer development.

He joined NDSU as a professor in 2001. Webster carries out research in the synthesis and characterization of novel polymers.

He received his Ph.D. in materials

engineering science at Virginia Polytechnic Institute and State University. Webster has authored over 75 peer-reviewed papers and publications and is credited with 11 patents, with an additional 18 pending, on coatings-related topics. He has also given numerous presentations on coatings and has received several best paper awards. He is a past chair of the PMSE division of ACS, is on the professional development committee of the ACS, and was recently named an editor for the journal *Progress in Organic Coatings*.

Webster will receive the Tess Award from Dr. Todd Emrick, chair of the PMSE division, on Aug. 29, 2011, during the 242nd National Meeting of the ACS in Denver, CO.

ASTM Presents Award for Corrosion Work

Dr. Harvey Hack has received the ASTM International Frank W. Reinhart Award from Committee G01 on Corrosion of Metals and the ASTM Committee on Standards for his work on creating a joint ASTM/NACE terminology standard.

Dr. Harvey Hack

Hack is a senior advisory engineer at Northrop Grumman Corp.

An active member of ASTM International since 1978, Hack currently chairs the Joint ASTM/NACE Committee on Corrosion and its subcommittees on laboratory immersion tests and terminology. The standard that Hack was recognized for, NACE/ASTM G193, Terminology and Acronyms Relating to Corrosion, was published in 2009.

Hack is a member-at-large on Committee G01 and also works on Committees F07 on Aerospace and Aircraft, F25 on Ships and Marine Technology, and F41 on Unmanned Maritime Vehicle Systems. An ASTM fellow, Hack was chairman of the ASTM board of directors in 2000. He has been honored with the ASTM Award of Merit and the Francis L. LaQue Memorial Award for his contributions to G01.

He earned a B.S. in physics and an M.S. in metallurgy and materials science from Carnegie Mellon University and holds a Ph.D. in metallurgy from The Pennsylvania State University. His professional work focuses on marine corrosion control through materials selection, design, coatings, and cathodic protection.

Hack is also a member of SSPC: The Society for Protective Coatings, NACE International, ASM International, the Washington Academy of Sciences, and the Institute of Corrosion.

Polyguard Welcomes New Pipeline Sales Rep

Polyguard Products (Ennis, TX) has announced the appointment of Billy Russell to the position of technical sales representative for the Pipeline division.

Billy Russell

Russell has over 19 years of industrial coating experience and is NACE III-certified. He has inspected coatings in refineries, elevated water storage tanks, and DOT bridges and overpasses. He also has experience with lead abatement, full containment of elevated structures, and specialized coating application to refinery process equipment.

He will assist in developing the U.S. and Canada market to promote the company's products.

Polygon Names Director of Sales & Marketing

Polygon (Amesbury, MA), formerly the MCS division of Munters, has announced a new structure to enhance its customer service and operations and to further build its business.

Polygon was formed on Oct. 1, 2010, as an independent company focused on the property damage restoration and temporary humidity control markets.

Jeff Rainville, named director of sales and marketing, is responsible for strategic planning and implementation of all sales and marketing strategies in North America. He reports directly to the president of U.S. and Canada operations, Elvir Kolak.

Jeff Rainville

The company now has three regional directors for its U.S. operations—Ken Gernenz, regional director, south; Larry Waltemire, regional director, north; and Frank Dobosz, regional director, west. Fabio Bernardo, general manager of the Canada region, heads the three offices in Canada.

Elvir Kolak

Two directors now oversee all company accounts and projects. David Simkins, director of industrial services, manages construction drying, surface preparation and coating, and temporary humidity control operations. Brady Key, director of restoration services, leads the property damage restoration business.

In addition, sector managers will work with national account representatives and local sales people to handle industry-specific segments.

What Else Is New?

Turn to pp. 59–67 for more news about SSPC, other industry associations, companies, and products.

Southern Nevada Water Authority Tests Linings for Transmission Pipe

By Cynthia L. O'Malley, KTA-Tator, Inc.; Scott Christensen, HDR Engineering, Inc.; and Gina Neilson, Southern Nevada Water Authority

The Southern Nevada Water Authority (SNWA) is a regional agency with the mission of managing water resources and developing solutions that will ensure adequate future water supplies for the Las Vegas Valley. Its primary water resource is the Colorado River through Lake Mead. Since 2000, persistent droughts have resulted in decreasing water levels in Lake Mead. To reduce its reliance on the Colorado River, SNWA has begun planning for the development of in-state groundwater resources north of Las Vegas. Initial planning efforts identified project-specific requirements that could potentially justify the use of polyurethane lining systems for more than 200 miles of large diameter water transmission pipeline.

The potential benefits of using polyurethane lining on steel pipelines instead of traditional cement mortar lining include improved hydraulic characteristics, superior long-term outdoor storage capability, reduced impact on water quality during low or no flow periods, and reduced cost because of the ability to optimize the steel wall by using higher strength steel. While the potential benefits are significant, a potential concern is the lack of long-term history on the use of polyurethane as a lining for large diameter steel pipes for groundwater.

In smaller diameter steel water pipelines at treatment facilities, polyurethane lining systems have been used for 12 to 15 years, and standards have been developed by the American Water Works Association (AWWA C222 and C210). The standards, however, are for minimum and general requirements of polyurethane and epoxy coatings for the steel water pipe with regard to material composition, installation, and performance of coatings. Some steel pipe manufacturers have made significant investment in developing the ability to install this type of product as a lining system, and product manufacturers are continually working to improve their products, including epoxy lining systems, for application in large diameter steel pipeline for groundwater transmission.

Testing coating impedance by electrochemical impedance spectroscopy (EIS). Photos courtesy of KTA-Tator, Inc.

Because SNWA is committed to providing high quality and reliable service to its customers, it developed an independent test program, designed by a committee of industry professionals, to address the suitability of these alternative lining systems for large steel water transmission pipelines. The objective of the test program, which began in August of 2009 and was completed in October of 2010, was to provide data to base opinions on the viability of using a polyurethane or an epoxy lining for SNWA's specific project. Comparisons of the performance of various manufacturers' products within the same generic category were not an objective of this test program.

This article describes the test program and the performance characteristics deemed critical to assess the useful life expectancy of polyurethane and epoxy lining systems in steel pipeline for groundwater transmission.

Test Program and Protocol

The test program for the polyurethane and epoxy linings was designed by a group of industry professionals from engineering firms, coating manufacturers, pipeline consulting and inspection firms, and the SNWA. The test program design was based on research of records from manufacturers of steel pipe, producers of polyurethane, and water agencies to understand where the lining has been used, examine previous test results, and determine whether there are documented failures. As a result of this research, it was determined that there was also a sufficient history of the performance of epoxies for lining large

Continued

Editor's Note: This article is a condensed version of a paper the authors presented at SSPC 2011, the conference of SSPC: The Society for Protective Coatings, held January 31, 2011—February 3, 2011. The full version of the paper is in the conference Proceedings, *available from SSPC (www.sspc.org).*

diameter steel water pipelines for groundwater transmission and that these lining systems should also be considered in this test program.

The performance characteristics deemed critical to assessing the useful life expectancy of polyurethane or epoxy lining systems included each lining's inherent ability to protect the pipe from internal corrosion; meet Federal, State, and local drinking water standards; provide a long and reliable service life; and be suitable for application by skilled contractors under the conditions that may exist in the shop and the field during manufacture and installation. The test program included five polyurethanes and two epoxies from seven coating manufacturers. Each coating manufacturer submitted a repair system and a "parent" system for testing; thus, 14 coatings were tested.

The program began with defining the surface preparation and coating thickness parameters that would accommodate all the coatings tested, while simultaneously minimizing variables that might affect coating performance among different manufacturers' products. The parameters included hot-rolled carbon steel panels prepared according to SSPC SP-5, "White Metal Blast," with a nominal 3- to 3.5-mil angular surface profile. The target dry film thickness for all products was 40—50 mils. An independent coating contractor applied the coatings. All coatings were cured at ambient temperature for one week at the application facility before packaging and shipping them to the test laboratory. The coated panels were submitted blind. Accordingly, the laboratory performing the testing was not biased by manufacturer information.

An independent coating testing laboratory was selected based on its quality program and expertise in the industry. The requirements of the test facility were that it be a certified third-party independent testing agency with a minimum of five years' experience in specified ASTM testing procedures on coating systems. The independent laboratory also was required to provide credentials and a letter stating that its staff understood and had the proper equipment and expertise to successfully complete specified testing, and that they had no conflict of interest or connection to any product manufacturer or applicator. The laboratory quality program of the selected laboratory included a specified scope of testing accredited by the American Association for Laboratory Accreditation (A2LA) for ISO 17025. The in-process laboratory testing was witnessed by a coating consultant contracted by the engineering firm for third-party verification of test parameter execution. Additionally, the project manager from the engineering firm witnessed in-process testing of the coatings.

Cathodic disbondment testing in accordance with ASTM G8.

The test program protocol and the laboratory selection for the program were finalized in August 2009. Application began in October 2009.

Test Program

The test program included five tasks.

• Task One: Receipt of test panels, including coding and inventory assessment for testing

The laboratory received fourteen coating systems supplied by seven manufacturers (applied to fabricated and abrasive blast-cleaned steel panels and as free-films) between October and December 2009. The panels and free-films were inventoried, evaluated for suitability for the project test protocol, then photographed and coded.

• Task Two: Measurement of coating thickness and evaluation of the condition of received panels

The thickness of the coating was measured on each panel. Nondestructive coating thickness measurements were obtained from four locations on each panel according to ASTM D7091. The thickness of the free film samples was measured using digital calipers.

• Task Three: Cutting of free-film matrix samples

• Task Four: Testing of panels in accordance with the submitted test matrix

• Task Five: Reporting of generated data in monthly status reports and at the test's conclusion

Program Design

The program design included 16 property or characteristic tests as follows.

Resistance to Water Immersion

Testing was performed in accordance with ASTM D870-02. The test parameters included deionized water immersion at 38 C ± 2 degrees C for 180 days with evaluations at 30-day intervals, and at 60 C ± 2 degrees C for 180 days, also with evaluations every 30 days. Evaluations included degree of blistering in accordance with ASTM D714, degree of rusting in accordance with ASTM D610, and adhesion in accordance with ASTM D4541.

Coating Impedance

ISO 16773 was followed for impedance testing. The test parameters included 5% salt solution prepared with deionized water with attached cells maintained at 38 C ± 2 degrees C for 180 days or 60 C ± 2 degrees C for 120 days with evaluations every 7 days. Impedance values were obtained at 0.1Hz.

Continued

Resistance to Cathodic Disbondment

Cathodic disbondment was tested in accordance with ASTM G8, and with ASTM G95, Attached Cell Method. The test parameters for ASTM G8 included 120 days at ambient temperature with an impressed current of -1.5V. ASTM G95 parameters included 180 days at ambient temperature with an impressed current of -3.0V. Evaluations for ASTM G8 testing were performed after 30 and 120 days. Evaluations for ASTM G95 testing were performed after 30 days and every 30 days up to 180 days. Evaluations involved measuring the radius of disbondment from the intentional holiday.

Water Absorption

ASTM D570 was followed to test for water absorption. The test parameters were deionized water at ambient temperature for 180 days. Evaluations, made every 30 days, included dimension measurements and weight of samples.

Adhesion to Steel

Adhesion was tested according to ASTM D4541. A self-aligning, hydraulic adhesion tester (conforming to Method E) was used; the coating was scored to the metal surface before testing.

Immersion and Vapor Phase Resistance (Atlas cell testing) and Wet Adhesion

This testing was performed at ambient temperature for 30 days in accordance with ASTM C868. Post-test evaluations included hardness in accordance with ASTM D2583, and dry film thickness in four locations on each panel, as required in ASTM D7091. Additionally, the adhesion was evaluated in accordance with ASTM D4541; similar to the baseline adhesion testing, a self-aligning, hydraulic adhesion tester (conforming to Method E) was used, and the coating was scored to the metal surface before adhesion assessment.

Resistance to Cavitation

Cavitation resistance was assessed in accordance with ASTM G32. The 500-watt ultrasonic probe was adjusted to oscillate at a frequency of 20 kilohertz. The amplitude of the oscillation was adjusted to achieve the desired peak-to-peak displacement. The distance between the probe tip and the specimen surface was adjusted to approximately 1 mm. The specimen test surface was immersed in the deionized water approximately 12 mm below the surface. The diameter of the horn tip was 0.5 in. The evaluations consisted of calculating the rate of erosion determined by the mass loss of coating after 11 and 24 hours of exposure or until substrate was visible, whichever occurred first.

Continued

Test Standards Cited

ASTM D7091, "Standard Practice for Nondestructive Measurement of Dry Film Thickness of Nonmagnetic Coatings Applied to Ferrous Metals and Nonmagnetic, Nonconductive Coatings Applied to Non-Ferrous Metals."

ASTM D870-02, "Practice for Testing Water Resistance of Coating sUsing Water Immersion."

ASTM D714, "Test Method for Evaluating Deg re of Blistering of Paints."

ASTM D610, "Test Method for Evaluating Deg re of Rusting on Painted Steel Surfaces."

ASTM D4541, "Test Method for Pull-Off Strength of Coatings Using Portable Adhesion Testers," Method E (hydraulic).

ISO 16773, "Paints and Varnishes-Electrochemical Impedance Spectroscopy (EIS) on High Impedance Coated Specimens."

ASTM G8, "Test Methods for Cathodic Disbonding of Pipeline Coatings."

ASTM G95, "Test Method for Cathodic Disbondment Test of Pipeline Coatings (Attached Cell Method)."

ASTM D570, "Test Method for Water Absorption of Plastics."

ASTM D4541, "Test Method for Pull-Off Strength of Coatings Using Portable Adhesion Testers."

ASTM D5894, "Practice for Cyclic Salt Fog/UV Exposure of Painted Metal (Alternating Exposures in a Fog/Dry Cabinet and a UV/Condensation Cabinet)."

ASTM D2583, "Test Method for Indentation Hardness of Rigid Plastics by Means of a Barcol Impressor."

ASTM C868, "Test Method for Chemical Resistance of Protective Linings."

ASTM G32, "Test Method for Cavitation Erosion Using Vibratory Apparatus."

ASTM D543, "Test Method for Resistance of Plastics to Chemical Reagents."

ASTM E96, "Test Methods for Water Vapor Transmission of Materials."

ASTM G14, "Test Method for Impact Resistance of Pipeline Coatings (falling weight test)."

ASTM D522, "Test Methods for Mandrel Bend Test of Attached Organic Coatings."

ASTM D412, "Test Methods for Vulcanized Rubber and Thermoplastic Elastomers—Tension."

AWWA Standard, C222-08, "Polyurethane Coatings for the Interior and Exterior of Steel Water Pipe and Fittings."

AWWA Standard, C210, "Liquid-Epoxy Coating Systems for the Interior and Exterior of Steel Water Pipelines."

Chemical Resistance
Assessed in accordance with ASTM D543, chemical resistance tests included 10% sulfuric acid, 20% sodium chloride, 30% sodium hydroxide, and No. 2 diesel fuel. Changes in mass and dimensions were calculated after 30 days' immersion, with the solutions' temperature at ambient laboratory conditions.

Water Vapor Permeance
ASTM E96 was followed to assess water vapor permeance. Procedure BW-Inverted water method was used. Dishes were supported to provide circulation of air around individual test containers. The permeance of water vapor was calculated in inch-pounds.

Impact Resistance
Assessed in accordance with ASTM G14, impact resistance was reported in units of inch-pounds.

Flexibility
Flexibility was assessed in accordance with ASTM D522, with modifications from CSA Z245.20-06 to include testing at 23 C and 0 C. Pass/fail criteria were established by American Water Works Association (AWWA) references to CSA Z245.20.

Tensile Strength and Elongation
These two properties were assessed at ambient temperature in accordance with ASTM D412.

Leachability
The leachability of the linings was tested by the SNWA laboratory for compliance with regulations for drinking water quality.

Baseline Chemical Fingerprint
Infrared spectroscopic analysis was performed using a Fourier transform infrared spectrometer. Two techniques were used to analyze the liquid components and the mixed components of the resultant dried films. The individual liquid components were analyzed by the potassium bromide (KBr) sandwich technique. Each component material was placed between two KBr plates and the resultant KBr sandwich was placed in the optical path of the spectrometer. The technique used for the dried film produced from mixed components involved combining sample scrapings with KBr powder and forming pellets under high pressure. The pellets were then placed in the optical path of the spectrometer.

Spectra obtained ranged from 4000 to 400 cm^{-1}.

Resistance to Cyclic Accelerated Weathering
Cyclic accelerated weathering testing was performed because of the potential need to pre-purchase significant amounts of steel pipe that might require exterior storage for extended periods. Resistance to cyclic weathering was assessed in accordance with ASTM D5894. The test parameters included continuous exposure for four hours at 60 C (UVA-340 lamps), followed by four hours' water condensation at 50 C. The fog/dry cycle was one hour of fog at ambient temperature (approximately 23 C) and one hour of dry-off at 35 C. The fog consisted of a solution of 0.05% sodium chloride and 0.35% ammonium sulfate. Evaluations, performed at 30-day intervals up to 120 days, included degree of blistering in accordance with ASTM D714 and degree of rusting in accordance with ASTM D610.

Summary of Test Data

The test data revealed that the polyurethane and epoxy materials' performance characteristics were comparable, and that both materials may be viable alternatives to cement mortar

Continued

lining for steel pipe. The results obtained from this test program are not shown here but are given in the tables in the full SSPC 2011 paper, available from SSPC in its SSPC 2011 *Proceedings* (www.sspc.org). The American Water Works Association (AWWA) Standards, C222-08 and C210, contain performance property requirements for some of the tests in the scope of this program; these requirements are also not given here but are available in the full SSPC 2011 paper.

Although the criteria were not directly applied to the test results, the comparison of the AWWA standard requirements for the testing performed in this study for polyurethane and epoxy lining systems in steel pipe supports the general conclusion that both materials may be viable alternatives to cement mortar lining for steel pipe.

At 30 days, the values for resistance to cathodic disbondment of the majority (11 of 14) of the coatings tested were below the maximum radial disbondment allowed in AWWA C222, even at the more negative potential used in the test program. The additional test parameters of this program of up to 180 days resulted in 50% of the coating systems performing per the AWWA C222-08 criteria.

The AWWA C210 specification for qualification requirements and test parameters for laboratory-applied epoxy coating systems are different from AWWA C222. The majority of the coating systems tested in this program (12 out of 14) were below the maximum allowable radial disbondment requirement of the AWWA C 210 standard, which specifies ASTM G8 with a 30-day test duration. This test program included testing duration up to 120 days, and 50% of the coating systems tested were below the maximum allowable disbondment.

The other test properties that are a component of the AWWA specifications are impact resistance, chemical resistance, and water absorption. All of the coating systems included in this test program exceeded the minimum performance requirements of AWWA C222 for impact resistance, chemical resistance, and water absorption. The test program included a 180-day duration of water absorption testing compared to the 30-day requirement of AWWA C222. After 180 days of water absorption testing in accordance with ASTM D570, the majority of coating systems (10 out of 14) conformed with the AWWA C222 specification requirement, which is based on 30 days of testing.

Conclusion

Steel pipe manufacturers and coating system manufacturers have combined efforts and made significant investments in developing the ability to provide polyurethane and epoxy linings for large diameter steel water transmission systems. The data from this test program have provided valuable collaborative information in determining the suitability of polyurethane and epoxy for use on SNWA's project. Additionally, the information obtained from the evaluation and test program has provided a basis that can be used to develop a guide specification for steel pipe linings for future SNWA Projects.

Cynthia O'Malley, an SSPC-certified protective coating specialist, is the laboratory manager for KTA-Tator, Inc.

Scott Christensen, a civil engineer, is a senior project manager with HDR Engineering.

Gina Neilson, a P.E. in Nevada and a civil engineer, is an engineering project manager for the SNWA.

engineering science at Virginia Polytechnic Institute and State University. Webster has authored over 75 peer-reviewed papers and publications and is credited with 11 patents, with an additional 18 pending, on coatings-related topics. He has also given numerous presentations on coatings and has received several best paper awards. He is a past chair of the PMSE division of ACS, is on the professional development committee of the ACS, and was recently named an editor for the journal *Progress in Organic Coatings*.

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On Holidays in Linings for Immersion Service

This Month's Question: What is the maximum number of holidays that should be permitted for linings used in immersion service, and why?

From Gunnar Ackx
SCICON worldwide bvba

Frankly speaking, no holidays should be allowed on linings in immersion service.

First of all, the lining is often installed because the medium stored is corrosive to the substrate. So, every pinhole left over is likely to lead to local corrosion, which, depending on the medium, may lead to rapid perforation of the substrate and take the storage tank out of service prematurely. For example, a rubber-lined sulfuric acid storage tank was perforated within 3 months after the refitting of a new rubber lining that was not 100% holiday-free.

Second, tank linings are often installed to prevent contamination of the medium (or cargo) with corrosion from the substrate. Again, any pinholes in the coating will likely lead to a reaction with the medium or cargo, leading to a loss of product quality. For example, six TDI storage tanks had to be taken out of service and relined because recent coating repairs (on an inorganic zinc tank lining) were not done properly, leading to pinpoint corrosion, which reacted with the TDI cargo and degraded the quality of the high purity TDI.

And on a final note, leaving even

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Editor's Note: This question was posted on the daily electronic newsletter, PaintSquare News (PSN), on behalf of JPCL. *Responses, including the ones here, were solicited through the PSN posting. The answers have been selected and edited to conform to* JPCL's *style and space limitations. To read other Forum questions and responses, click the* JPCL *Problem Solving Forum of any issue of PSN. If you would like to receive PSN, visit www.paintsquare.com.*

small amounts of small holidays or pinholes in a tank lining has huge potential for setting up a galvanic corrosion cell (if any other dissimilar materials are used inside the storage tank, which is often the case). At that point, the surface ratio between the anode (pinholes/holidays) and the cathode (other dissimilar metal) will promote rapid corrosion of the substrate, which again is likely to lead to perforation in a matter of weeks or months.

For example, when the carbon-steel outer shells of a condenser were lined, perforation of the condenser housing was observed within 18 months. Investigation revealed a couple of 'weak spots' in the lining (where the scaffolding had been placed), exposing small bare steel surfaces that had now become a very small anode versus the huge cathode that was also present inside the condenser, the titanium tube-plat, and heat-exchanger-tubes. In that respect, every tank lining should be holiday-tested over 100% of its surface, e.g., in accordance with NACE SP188-2006. If any holidays are found, they should be repaired as directed in the lining manufacturer's instructions, and the repairs themselves need to be re-tested as well. (A repair is not always a guarantee for a holiday-free surface.)

In the event of premature corrosion or coating failure, the coating repairs themselves can already be quite expensive (e.g., if scaffolding has to be re-installed), but most often the collateral damage (cleaning costs, downtime, loss of income, for instance) are going to be much greater than the costs of the coating repairs themselves. And 'holiday-testing' is not just rubbing a copper-wire brush over the coating-surface; it takes a well-trained and experienced coating inspector to properly execute this type of quality inspection.

Gunnar Ackx of SCICON is the international representative on the Board of Governors of SSPC: The Society for Protective Coatings.

The Case of... The Fix is Worse than the Problem

Sporadic Coating Delamination from Brick on a Historic Building

By Chrissy M. Stewart, KTA-Tator, Inc.
Richard A. Burgess, Series Editor, KTA-Tator, Inc.

The restoration of historic landmark buildings can be very challenging. The structures often contain multiple coats of paint (some containing toxic metals like lead), and the substrate may be deteriorated or may contain moisture from centuries of exposure to the environment. Removal of the existing paint layers without damaging the substrate often requires specialized equipment and expertise. Oftentimes the building owner requires new paint systems to match the color of the original paint, which can be very difficult to achieve and is often based on a match to the color of the paint as it is today. The bottom line is that removal and replacement of the existing paint systems on historic buildings can be an expensive undertaking, and it is important that the new coating system protect the structure for as long as possible.

In this case from the F-Files, a historic brick court house had been coated with a polyurethane finish for aesthetic reasons—to restore the original color of the brick. The product applied, however, failed to adhere to large portions of the building but remained intact on other portions. An investigation was undertaken to determine the reason behind the sporadic delamination of the polyurethane finish coat from the brick surfaces.

Background

Over time, during periods of external building maintenance, deteriorated brick was removed and replaced with new brickwork. This replacement resulted in a variation of brick colors, since the existing brick was centuries older than the replacement brick. Because of this inconsistency in appearance, the building owner chose a polyurethane topcoat for all the brick surfaces to achieve a more uniform color. Moreover, the topcoat would provide additional protection against moisture intrusion and help maintain the integrity of the brick. Shortly after application of the polyurethane, it exhibited widespread peeling and delamination. A powdery residue was evident on the backside of the disbonded topcoat. The building owner contracted for a laboratory investigation of the cause of the delaminating coating. No field investigation was requested or performed.

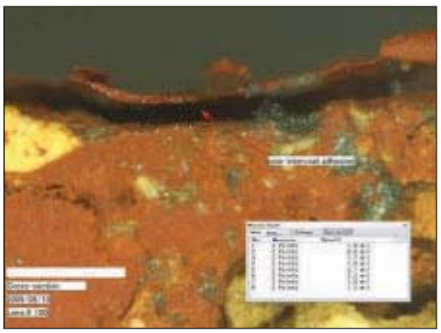


Fig. 1: Cross-section of failing sample with poor adhesion. Photos courtesy of KTA

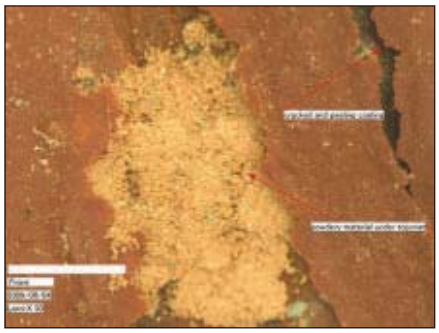


Fig. 3: Failing powdery residue under topcoat (terra cotta substrate)

Visual and Microscopic Examination

Visual and microscopic examinations of a substrate and a failing coating can provide considerable insight at the initial stage of a failure investigation. When combined with thorough background information, the information obtained from the microscopic examination often gives the analyst direction about the type of analytical methods needed to learn more about the failure.

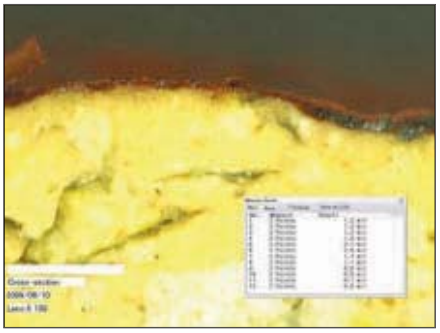


Fig. 2: Non-failing sample cross-section

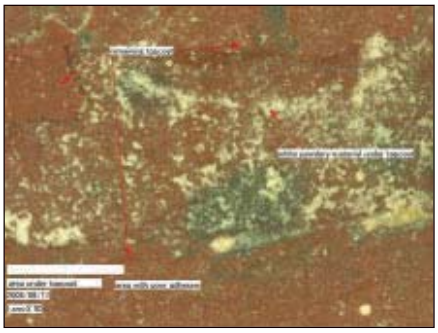


Fig. 4: Non-failing powdery residue under topcoat (beige substrate)

Typically, samples are examined visually, and then microscopically with a digital microscope (up to 200X magnification) to assess the number and thickness of coating layers and the condition of the interface (smooth, rough, surface contamination, etc.).

In this case, the laboratory received six samples, consisting of portions of

brick substrate with the topcoat either firmly or loosely attached. Three of the six samples were marked "failing" by the building owner. When the samples were examined, it was evident that four of the six samples (all red brick), not just three, were failing. When the coating on the fourth sample was probed with a knife blade, the topcoat could be easily removed; the two remaining samples (beige brick) showed excellent adhesion between the topcoat and the brick.

Cross-sectional examination of the disbonded coating revealed two layers. The thickness of the polyurethane topcoat ranged from 0.3—2.3 mils on the failing samples. The other layer revealed by the cross-sectional examination was a glaze coat reportedly applied to the brick during previous restoration activities. The glaze coat measured 0.8—2.5 mils thick. One of the non-failing samples had an additional layer of the red topcoat. On this sample, the first topcoat layer measured 4.7—7.6 mils thick, and the second layer measured up to 2.8 mils thick (Figs. 1 and 2).

The break was between the polyurethane finish coat and the red glaze coat. When the two coats were separated, a powdery substance between the coating layers was evident. The powdery substance was especially concentrated when the glaze coat and the substrate beneath it had a crack. The powdery residue was a more muted color of the substrate. That is, when the substrate was red brick (the original brick color), the powder was pink; when the substrate was beige brick (the replacement brick color), the powder was light beige (Figs. 3 and 4).

Although the two beige-colored bricks (non-failing samples) had less of the powdery residue than the four red brick failing samples, the residue was present on all samples. In fact, one of the non-failing samples exhibited a small isolated area of poor adhesion where a heavier concentration of the powdery residue was present beneath the topcoat. The residue appeared to be embedded in the coating from the failing samples, which indicated that the polyurethane coating had been applied directly over the residue and without the brick being cleaned before application.

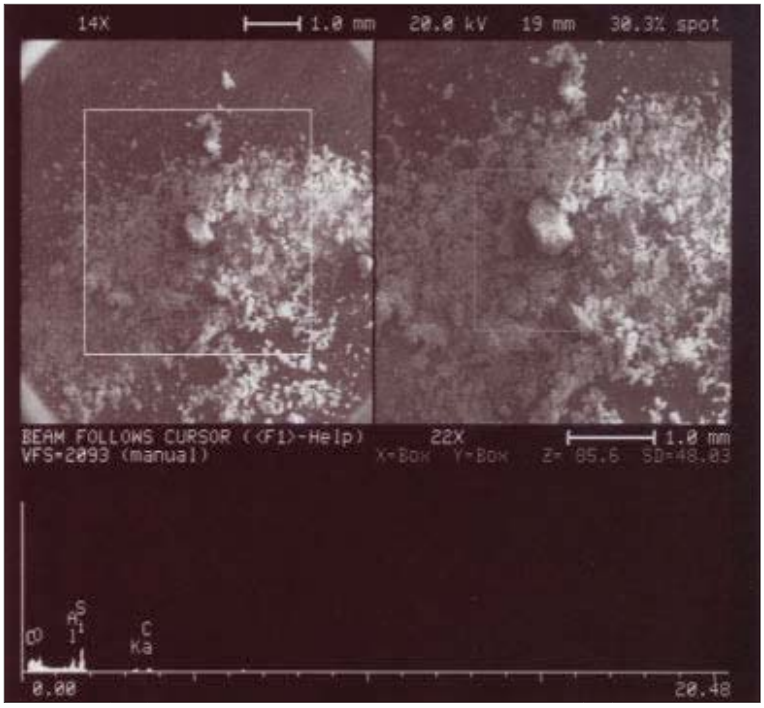


Fig. 5: Scrapings of substrate

Further Examination of the Residue

Other types of analysis, including infrared spectroscopic analysis and scanning electron microscopy-energy dispersive x-ray spectroscopy (SEM-EDS), were needed to determine the nature and source of the residue.

The microscopic examination revealed that the areas exhibiting failure directly correlated to the presence of the powdery substance. The non-failing samples also showed the presence of the substance, but not in the quantities of the failing samples. Infrared spectroscopic analysis was performed to generically identify the chemical composition of the substance in order to determine whether it was deteriorated coating or brick.

Samples of the substances from the failing and non-failing brick were analyzed using Fourier transform infrared spectroscopy. Spectra were obtained over the range of 4000-400 cm^{-1}. There was no evidence of coating resin in the residue. The residue consisted predominately of silicates.

Scanning electron microscopy-energy dispersive x-ray spectroscopy (SEM-EDS) was performed to confirm that the residue was chemically consistent with the brick composition. The powdery residue and brick fragments were analyzed to determine the elemental composition. The powdery residue consisted primarily of carbon, oxygen, silicon, and aluminum. (Note that the presence of aluminum was most likely attributed to the mounting stub.) Moderate amounts of potassium and calcium were also present. This analysis was compared to the analysis of portions of the brick. Both analyses revealed the same elements in practically identical quantities. A mapping or topographical representation of the location of the elements on the surface of the samples was also consistent and suggested identical materials. Based on this analysis, it was determined that the powdery residue was actually deteriorated brick migrating through the cracks in the substrate and the glazing to the (then) surface of the brick (Figs. 5 and 6).

Continued

Conclusions

The original bricks in the structure (red brick) were exhibiting failure of the polyurethane topcoat, while the same coating on the beige (replacement) bricks exhibited good adhesion. The poor adhesion resulted from the presence of the powdery residue, which was caused by deteriorated portions of the brick substrate migrating through cracks in the brick and glaze coat.

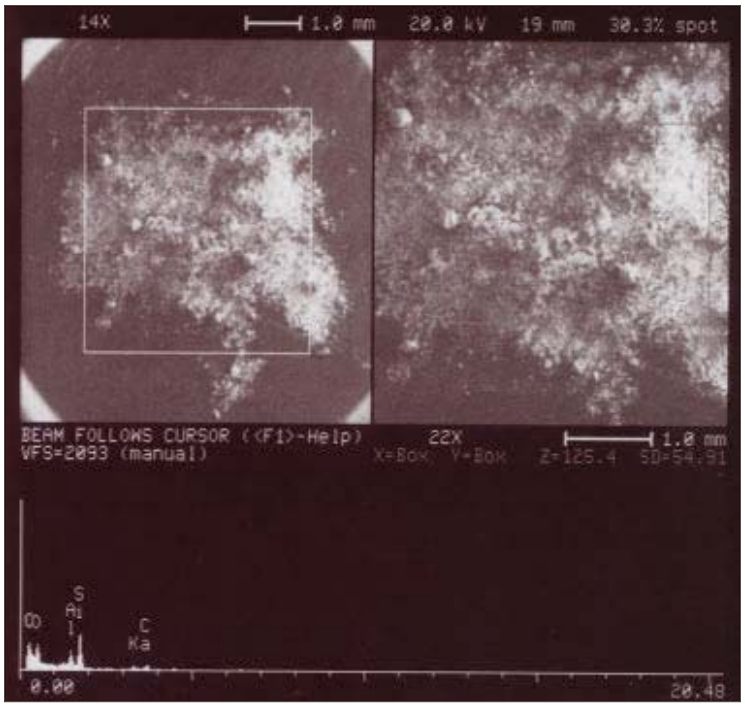


Fig. 6: Powdery residue

The fact that the residue was imbedded in the backside of the topcoat indicated that the structure was likely not cleaned before application of the polyurethane topcoat. The powdery substance acted as a bond breaker between the brick and the finish coat. Since the beige brick was in place for significantly less time than the red brick, it had not deteriorated as drastically, and the concentration of the powdery substance was substantially less. The moisture in the brick could have facilitated the migration of the brick constituents to the surface. This migration is similar to laitance of concrete surfaces, which produces a powdery substance on the surface.

Similar to the construction of a home or building, the quality of the foundation is paramount to the structural integrity of whatever is placed on the foundation. The "foundation" for a coating system is the substrate and the preparation of the substrate for coating application. In this case, surface preparation (removal of surface contamination by pressure washing or other methods) was either not invoked by the project specification, or ignored by the coating applicator. Application of a coating to brick or CMU construction, especially an aged substrate that has been subjected to decades or centuries of atmospheric exposure, requires an initial assessment of the condition of the substrate and a properly prepared specification describing surface preparation and coating work. Ironically, in this case, efforts to improve the aesthetics of a historic building resulted in catastrophic coating delamination, an unsightly appearance and costly rework.

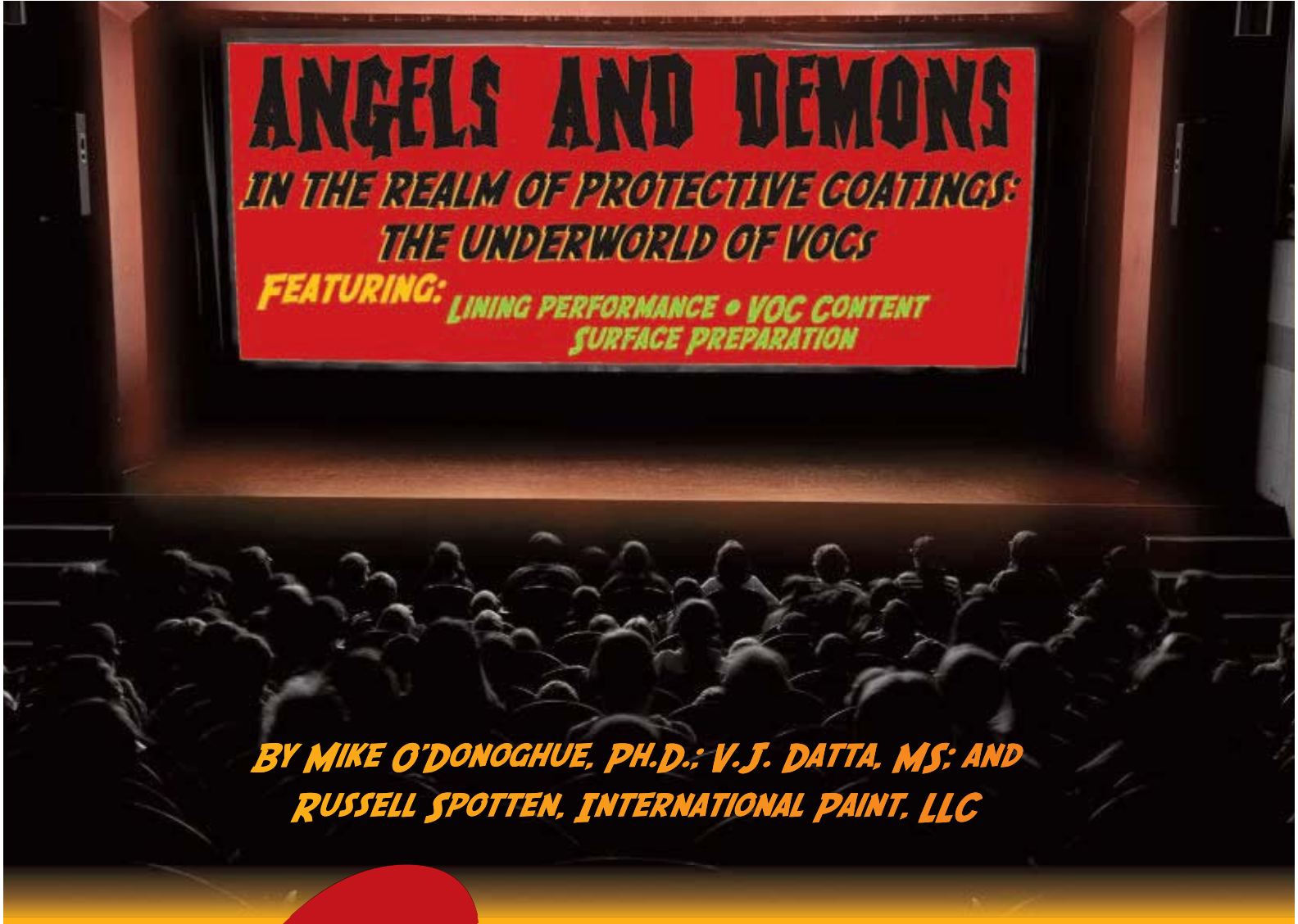
Remedy

Because no field investigation was performed by the investigating laboratory,

there was no recommendation requested or provided for remediation of the failure. Without seeing first-hand the condition of the brick and obtaining information on the surrounding properties, laboratory analysts did not think that a recommendation for removal and replacement of the failing coating would be prudent.

However, in theory, the building owner may have several options for removal of the failing coating, including chemical stripping; pressure washing (at a level that would not affect the brick and mortar but would remove the coating); sodium bicarbonate blast cleaning; removal of the coating using a pliant media conforming to SSPC-AB 4, "Recyclable Encapsulated Abrasive Media (in a compressible cellular matrix)"; or perhaps even blast cleaning with an agricultural media such as pulverized corn cobs, walnut shells, or peach pits, which may remove the coating but not harm the historic brick. After cleaning (and neutralization, if required), removal of surface dust and careful inspection of the prepared surfaces, the brick could be coated. The coating manufacturer should always be consulted before applying a protective coating to such an unusual substrate.

Chrissy Stewart is a Chemist with KTA-Tator, Inc., a consulting engineering firm specializing in industrial protective coatings. Employed with KTA since 2006, she is involved in coating failure investigations and comparative coatings testing services provided by both the analytical and physical testing laboratories. She holds a BS in chemistry from Mercyhurst College. Ms. Stewart is a member of the American Chemical Society (ACS) and SSPC.



ANGELS AND DEMONS

IN THE REALM OF PROTECTIVE COATINGS: THE UNDERWORLD OF VOCs

BY MIKE O'DONOGHUE, PH.D.; V.J. DATTA, MS; AND RUSSELL SPOTTEN, INTERNATIONAL PAINT, LLC

OURS IS AN AGE OF STRINGENT VOC REGULATIONS, AND ONE OF THE POSITIVE RESPONSES FROM COATING FORMULATORS HAS BEEN THE ADVENT OF INNOVATIVE HIGH-SOLIDS COATINGS THAT CONTAIN EXEMPT SOLVENTS. While proper surface preparation for applying lining systems has always been crucial to long-term coating success, our field experience has shown that this is all the more the case with coatings formulated with one or more exempt solvents.

This article examines an underworld of the hidden "angels and demons" implications that coatings with exempt solvents pose, first for surface preparation and then for success or failure in immersion service. Potable water and petrochemical service will be the focus of the internal lining discussion.

"Light and darkness" potable water case histories will point to how the success of a high-performance lining system using VOC exempt solvents depends more on surface profile characteristics than hitherto anticipated.

BACKGROUND

In the mystery thriller movie *Angels and Demons*, a canister of antimatter is stolen from CERN's Large Hadron Collider. Supposedly, the Illuminati stole the dastardly stuff and then threatened to blow up the Vatican with it. Practitioners of the dark arts with their antimatter are about to cause a lot of problems for the good guys in the Roman Catholic Church. Gripping stuff!

Gripping stuff of an adhesive nature also abounds in the mysterious world of protective coatings, where it has often been said that chemistry and coatings are more akin to art than science. And to make matters (pun intended) even more intriguing, the paint and coatings profession has occasionally been likened to the realm of the dark arts, notably black magic.[1] Indeed, the genesis of chemistry, or alchemy (exemplified by the fixation to transmute base metals into gold) was sometimes consid-

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ered an ethereal mix of occultism and magic. While angels and demons battle cosmically, they also do battle metaphorically in the underworld of low VOC coatings.

Chemists, therefore, are the modern descendents of ancient alchemists. As Johan Joachim Becher so eloquently wrote in 1667 in *Physica Subterranea*, "chemists are a strange class of mortals, impelled by an almost maniacal impulse to seek their pleasures amongst smoke and vapour, smoke and flames, poisons and poverty, yet amongst all these evils I seem to live so sweetly that I would rather die than change places with the King of Persia."[2]

Kings of Persia are no more—but we chemists live on!

INTRODUCTION

Multiple forces are at work to maintain a healthy environment and ecosystem. For air quality, volatile organic compounds (VOCs) are particularly high on the list of priorities across the globe. VOCs are hydrophobic or hydrophilic compounds that participate in atmospheric photochemical reactions, thereby contributing to atmospheric pollution.

For paint and coatings manufacturers, one fundamental driving force of their research and development "craft" is to comply with increasingly rigorous VOC regulations. To contend with VOC stringency, three of the positive strategies from the vanguard of coating formulators have been the advent of innovative waterborne coatings, high-solids coatings that contain exempt solvents, and solvent-free coatings.

For instance, waterborne high-performance acrylics have been formulated to provide enhanced barrier performance and corrosion resistance comparable to high quality alkyds, polyurethanes, and some two-component epoxy coatings. Some new two-component waterborne epoxy coatings exhibit performance similar to solvented epoxy coatings.

In addition, a variety of proprietary low VOC, low viscosity, and high-solids coatings has been developed for harsh industrial and marine environments. Unique, mono- and difunctional reactive resins, together with curing agents having excellent molecular mobility have been identified for complete corrosion protection.

And new generation low or zero VOC, one-coat lining products, applied at high dry film thicknesses (DFT), cure in a few hours. With outstanding chemical resistance and no risk of solvent entrapment, they save time and labor as well as satisfying VOC regulations.

The aforesaid VOC reduction strategies are not exhaustive, given recent advances in powder, radiation-cured, and thermal spray coatings as well advances in pigment, additive, and tint system technologies.

THE UNDERWORLD OF VOCS

Here is a non-exhaustive list of issues where angels and demons are encountered in the underworld of low VOC coatings.

1. Inadequate surface preparation
2. Inappropriate profile
3. Embedment of abrasive media
4. Poor wetting of resin systems and solvents
5. Poor application of the coatings
6. Improper cure of the coatings
7. Inappropriate accelerated tests of coatings
8. Blistering of coatings
9. Soluble salts
10. Amine blush

The focus of this article is primarily on issues 1 through 4 for high-solids coatings that use either exempt or non-exempt solvents in their formulation. In particular, the authors will examine the influence that surface profile characteristics of abrasive blasted steel have on the coating and lining (immersion) performance.

The Environmental Protection Agency (EPA) defines exempt solvents as "organic compounds that are not considered volatile organic compounds due to negligible photochemical reactivity" (40 CFR Part 59.401).[3] On a macro-scale, exempt solvents help alleviate certain atmospheric concerns, a definite boon for the global environment.

The omens are not always good, however, in the micro- and nano-scale of the coatings world when exempt solvents are used. In fact, the effects of using exempt solvents must be weighed carefully in terms of the solvent effects at the substrate-coating interface and within the coating film. Also from the coating applicator's perspective, the application and curing characteristics of a liquid coating containing exempt solvents can present interesting challenges. Arguably, a veritable underworld of hidden forces ("angels and demons") is associated with conditions necessary for successful high-performance coatings and linings formulated with exempt solvents.

Failure to properly understand the nature and appropriate use of the exempt solvents and their implications for wetting and adhesion forces can have serious repercussions for coating and lining performance. In a nutshell, while proper surface preparation for applying lining systems has always been crucial to long-term coating success, this is all the more the case with coatings formulated with one or more exempt solvents.

Solvents are sometimes perceived as little demons for the environment. Yet for high-performance coatings, they are beneficial by providing molecular lubricity and mobility, dissolving high molecular weight resins, and lowering surface tension;

thus, solvents are a far cry from what some might construe as "the stuff that makes paint dry."[4] Solvent properties such as (a) solvency (hydrogen bonding ability and solubility parameter), (b) viscosity, (c) boiling point and evaporation rate, and (d) flash point are key considerations in the judicious selection of both exempt and non-exempt solvents for coating systems.[5]

The most familiar exempt solvents are acetone, parachlorobenzotrifluoride (PCBTF), or tert-butyl acetate (TBAc).[3] The following outlines some of the light and potentially dark properties of these exempt solvents.

Acetone

A strong and polar solvent, acetone is an inexpensive low boiler with little photochemical reactivity, excellent solvency and moderate hydrogen bonding ability. Unfortunately, acetone is hydrophilic and water-miscible, properties that can result in all sorts of maladies, from cooling the surface of coatings and promoting blushing to causing poor application and leveling of a coating by drying too fast. The major, widely recognized weaknesses of acetone are its fast evaporation rate, low flash point, and fire hazard.

In epoxy coatings, acetone can associate with amine curing agents to form ketimines, upset the cure reaction, and increase dry times. For this reason, acetone would be employed in the epoxy base component as opposed to the curing agent. So to lower the VOC of high-performance coatings, a satisfactory solvent system design strategy for binder systems will often consist of acetone blended with say, PCBTF, with or without a high-boiling VOC solvent.

Parachlorobenzotrifluoride (PCBTF)

This relatively non-polar chlorinated hydrocarbon solvent is a medium boiler and one of the "best friends" of the coating formulator. It is hydrophobic, VOC exempt, and neither an ozone-depleting substance (ODS) nor a hazardous air pollutant (HAP). With a broad-spectrum solvency and an evaporation rate similar to xylene, PCBTF has a compact, planar shape and diffuses more readily from coating films—certainly not as fast as acetone. Unlike acetone, PCBTF is not reactive with any amines in two-component epoxies, and is unreactive in most coating systems.

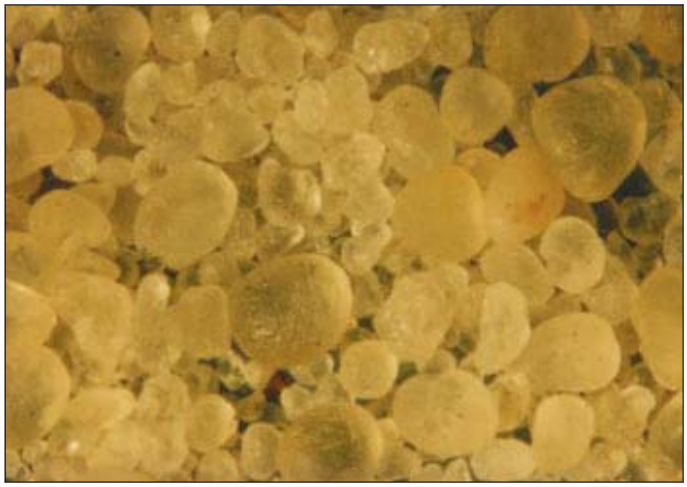
Unfortunately, PCBTF can impart odor/taste-related problems to potable water coatings. Additionally, with cost reduction a priority these days, the price of PCBTF is high and can severely impact the attractiveness of coatings that use high levels of PCBTF to yield VOC levels approaching 100 g/L.

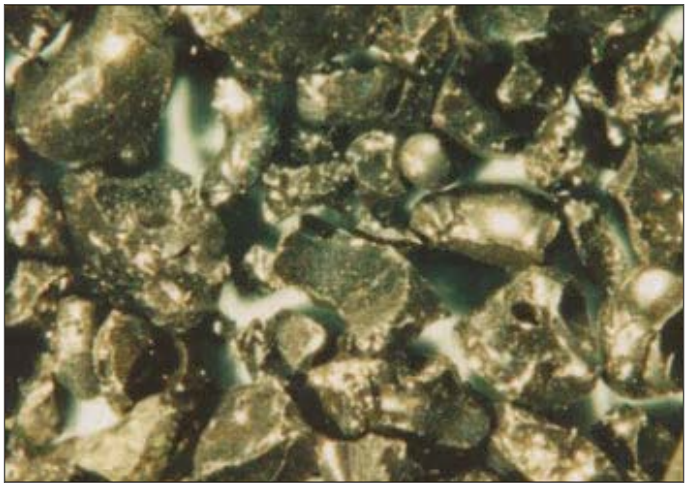
Tertiary Butyl Acetate (TBAc)

With an evaporation rate similar to toluene, TBAc is a VOC-exempt solvent because of its limited reaction to form smog and its low environmental and health impact. A versatile solvent for the coatings formulator, TBAc has moderate hydrogen bonding ability; resists aminolysis, hydrolysis, and acidolysis; and is used in a variety of generic coating types, including polyurethane finishes and two-component epoxies. Interestingly, TBAc may be successfully used to replace xylene in new-generation epoxy coatings. Limitations for TBAc are that it is not a particularly strong solvent for high-molecular-weight epoxy resins and it has a rather low flash point.

Used alone, or in blends, exempt solvents like PCBTF, acetone, tertiary butyl acetate cause neither ground level ozone formation nor stratospheric level ozone depletion.

Other things being equal, the angels and demons can clash at the steel substrate—coating interface where the cleanliness (absence or presence of contaminants such as abrasive media embedments) and roughened condition of the abrasive blasted steel surface have a significant bearing on how well coatings will perform in service.





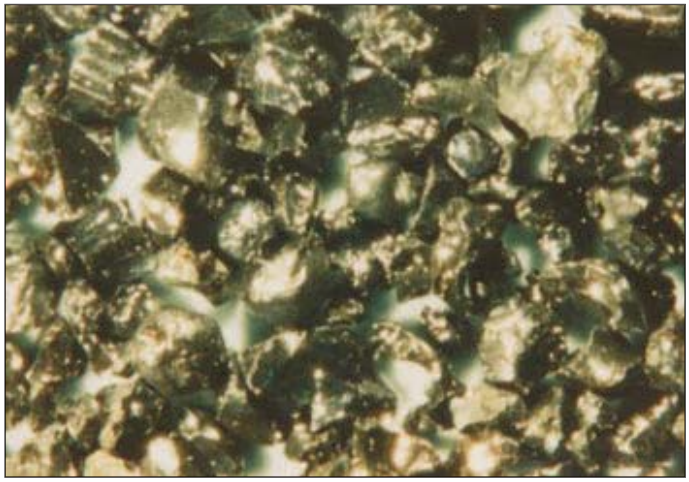


Fig. 1 (top left): Silica sand 50/60. Magnification 14X.
Fig. 2 (top right): Nickel slag 20/40. Magnification 14X.
Fig. 3 (bottom left): Nickel slag 16/30. Magnification 14X.
See p. 20 for discussion of Figs. 1-3.

Adhesion and Wetting: Resins and Solvents

In multi-coat applications, the last line of defense for underlying metallic substrates is the primer. Ideally, a primer will have wetted and penetrated a well-prepared substrate so effectively that intimate contact is assured on a nanometer (1 nm=10^{-9}) scale.

Adhesion of an epoxy coating is largely attributable to polar secondary valence forces such as hydrogen bonds, dipole forces, and Van der Waals forces. Regardless of the type of adhesion, all intermolecular attractions operate below 10 nm with the highest attractions generally at approximatey 1 nm. Since Van der Waals attraction forces are proportional with the inverse of the intermolecular distance to the sixth power, it is important to remove even benign contamination from the surface to be coated.[6]

Adhesion of coatings to surfaces used to be envisaged primarily in terms of polar forces between the polymer and substrate, but, more recently, adhesion has been considered in terms of acid-base interactions.[7] Increasing the surface area increases the number of reactive sites to which the coating can adhere, thereby enhancing mechanical and polar adhesion. Regardless of the surface profile depth, the concentration of chemically or electrically reactive foreign materials (e.g., soluble chlorides and sulfates) on the substrate must be lowered to threshold levels below which they cannot cause premature failure.

The work of adhesion (Wa) is expressed by the following:

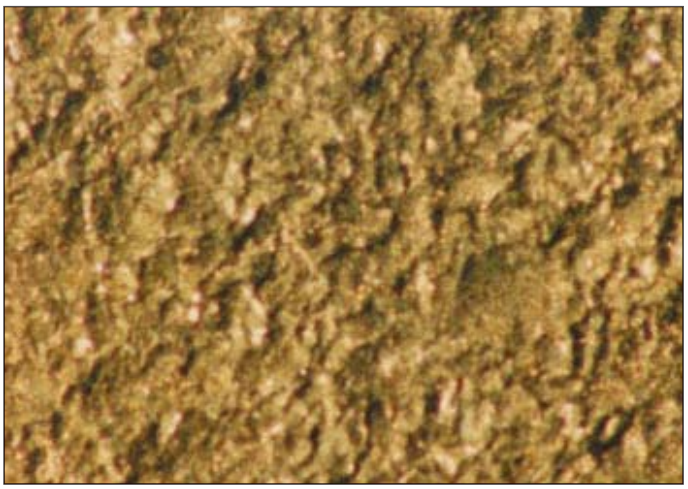
$Wa = (\delta s - \delta i) + \delta l$

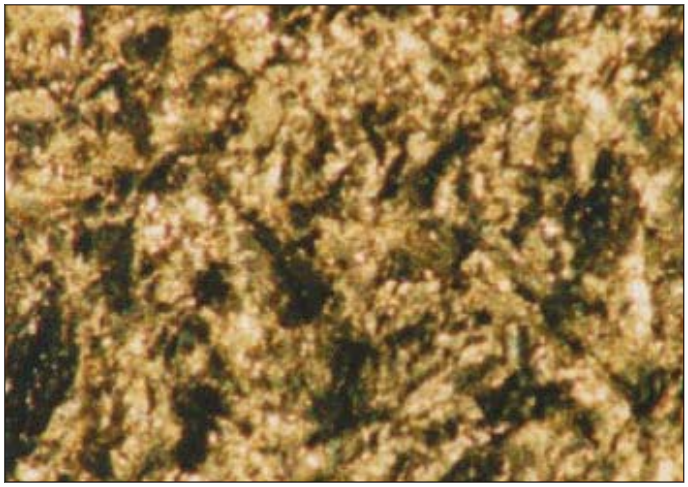
where δ is the surface free energy with subscripts referring to solid (s) interface (i), and liquid (l)

The objective is to make the process spontaneous. In the case of a technically smooth surface and intimate liquid contact, the expression in parenthesis must attain a positive value, i.e., wetting and adhesion is assured when the solid surface tension (solids' free surface energy) exceeds that of the liquid. Some free energies of solvents and their classification as exempt or non-exempt are shown in Table 1 (p. 18).

In non-ideal cases, the equation above can be used with appropriate factors that take into account varying surface roughness and the dynamics of interfacial surface contact. (Surface free energy values are determined for solids, liquids and interfaces by tensiometric measurements and contact angle determination). "Clean" substrates are in fact contaminated with micro-impurities (embedded in surface irregularities) and adsorbed layers of gaseous or liquid phase molecules.

Wet adhesion is the adhesion of the coating to steel (or any substrate) when the coating is exposed to immersion or high humidity sufficient to saturate the film. That is a far more important phenomenon than dry adhesion. Funke holds that corrosion beneath a submerged coating begins after the loss of





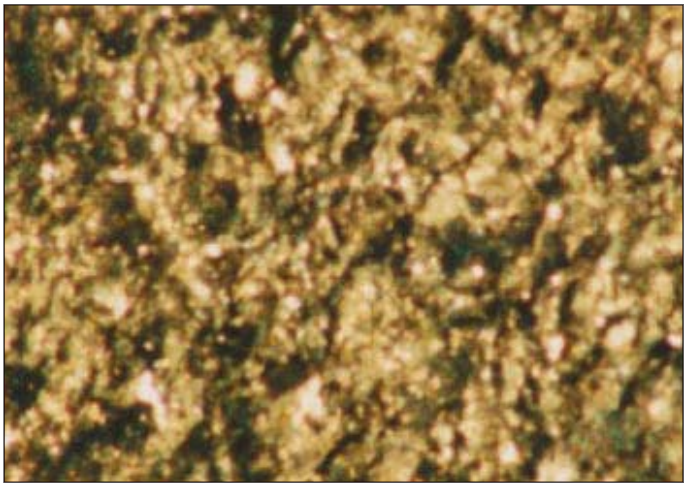


Fig 4 (top left): Silica sand 50/60. Profile 2.7–3.1 mils. Magnification 40X.
Fig. 5 (top right): Nickel slag 20/40. Profile 3.1–3.3 mils. Magnification 40X.
Fig. 6 (bottom left): Nickel slag 16/30. Profile 3.8–3.9 mils. Magnification 40X.
See p. 20 for discussion of Figs. 4-6.

wet adhesion.[8] On the other hand, Walker maintains that wet adhesion and corrosion need not be related processes, and that once loss of wet adhesion has occurred, the onset of corrosion may be delayed for years.[9]

Tank Linings, Surface Profile, and Solvents

In a rather simplistic way, it is considered that abrasive blasting with sharp angular media provides a greater surface area and therefore, other things being equal, the adhesion of coatings to the substrate will be enhanced.

Consider a two-coat, solvent-borne epoxy lining system to be applied to either new potable water or petrochemical tanks. A lining formulated with exempt solvents (such as PCBTF or a PCBTF-xylene blend, or an acetone-TBAc composition) can satisfy environmental considerations. But those same exempt solvents typically do not have as good solvency and wetting characteristics as many of the hydrophobic non-exempt solvents. The authors have noted this in their field applications of epoxy lining systems, with and without exempt solvents, and further laboratory research is planned

Table 1: Surface Tension of Solvents

Solvent	mN/m	Classified
Water	72.7	-
Xylene	23.3	Non-exempt
TBAc	22.4	Exempt
PCBTF	25.0	Exempt
Acetone	23.3	Exempt

to compare coatings performance as a function of solvent line-up (exempt and non-exempt) vs surface profile characteristics.

Abrasive blasting the new steel tank internals with steel grit or a sharp smelter abrasive like nickel slag will cause a significant increase in surface area compared to the area of planar surface of the original and unblasted steel. The resulting percentage area increase and angularity of the profile in the steel will be related in part to the sieve size, hardness, velocity, and shape of the abrasive media.[10-14]

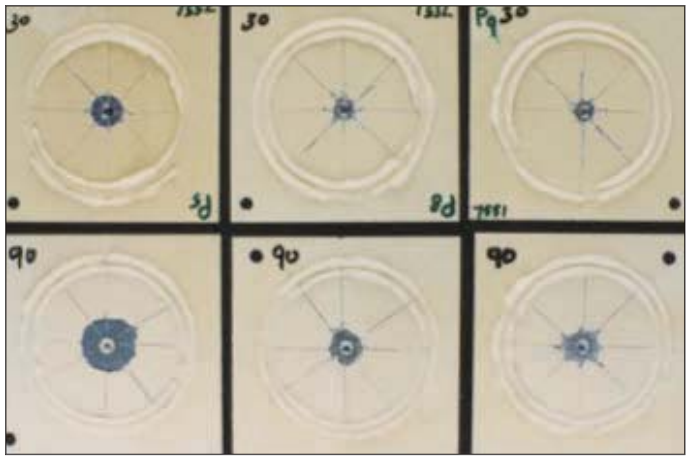
One of the keys to success in the application of the lining system containing exempt solvents will be to obtain a deeper profile of approximately 3—3.5 mils in the abrasive-blasted steel. It is even more important that the profile be jagged rather than peened. Again, the percentage area of reactive sites for wet and dry adhesion will be increased as the profile is deepened; the profile angularity, not just profile amplitude, is important; and both favor an enhanced wetting of the surface and hence enhanced coating adhesion.

In contrast, the conventional wisdom for a two-coat high-solids epoxy (containing non-exempt solvents) for potable water tank internals is often to have a profile depth of 2—3 mils as well as an angular profile.

Silica 50/60 Nickel slag 16/30 Nickel slag 20/40

Temperature: 250 F/121.1 C
Pressure: 1000 psi/6.9 MPa
Aqueous Phase: Water – 5% NaCl Brine
Hydrocarbon Phase: Kerosene/Toluene @1:1 by Volume
Gas Phase: 5% H_2S, 5% CO_2, 90% CH_4

Fig. 7: Autoclave post-test appearance of epoxy novolac
See p. 20 for discussion of Fig. 7.



Silica 50/60 Nickel slag 16/30 Nickel slag 20/40

The top row shows the results of the epoxy novolac exposure to a cathodic disbondment test environment for 30 days. The bottom row is for a test environment of 90 days. The areas of bare substrate showing directly adjacent to the holiday sites are the total disbondment area.

The same figure indicates that these areas are time dependent. Silica 50/60 disbondment areas were larger than disbondment areas for nickel 16/30 and 20/40 after both tests (30 and 90 days).

Fig. 8: Cathodic Disbondment post-test of epoxy novolac
See p. 22 for discussion of Fig. 8.

Abrasive Media Selection: Surface Profile

Abrasive media are typically sharp and angular and can be steel grit or a variety of mineral abrasives. Sometimes steel shot is used with an addition of steel grit to provide the necessary angular profile (shot: grit approximately 70:30). Steel shot by itself provides a rounded, crater-like appearance in the steel substrate where the width of the depression is greater than the depth.[15]

Several authors have clearly demonstrated that peak height is not the only parameter that influences the coating and lining performance. In a study comparing the performance of several coating systems on steel grit-blasted steel and shot-blasted steel, Ward (from the present authors' company) found that the number of peaks per unit length also affected coating performance.[16] Accelerated tests have demonstrated that corrosion resistance of immersion-grade linings was indeed a function of profile angularity and amplitude in abrasive blasted steel.

In other investigations by Roper, Weaver, and Brandon using steel grit as abrasives, it was reported that "surface roughness, as determined by the number of peaks per unit length, has a measurable impact on adhesion and scribe undercutting resistance."[17] The peak count density was varied while a constant profile height was maintained. A variety of coatings were applied to these substrates and subjected to ASTM B117 salt spray, ASTM D5894 Prohesion/UV-con and salt water immersion tests. The panels were examined at 1,000-hour increments up to a total of 4,000 hours (some at 5,000 hours). Roper, Weaver, and Brandon showed that high peak count surfaces performed better than low peak count surfaces for all the tests carried out and then discussed five interesting theories as a result of their work.

- Theory 1: "A surface with a consistent profile height will provide better coating performance than a surface with an inconsistent profile height."[17]
- Theory 2: "Surfaces prepared to SSPC-SP 10 may have higher peak counts than surfaces prepared to SSPC-SP 5, all else being equal."[17]
- Theory 3: "The optimum conditions for a wide range of standard coatings that will completely wet the surfaces are a 2.5 mil (65 µm) profile height and a peak density between 120 and 150 peaks per inch (50 and 60 peaks per cm)."[17]
- Theory 4: "Surfaces contaminated with micronic backside contamination are susceptible to premature coating failure."[17]
- Theory 5: "Optimum performance will be obtained when the peak count is matched to the wetting characteristics of the primer."[17]

In an earlier study of the effects of surface preparation methods on adhesion of organic coatings to steel substrates, Momber et al. concluded that "a layer of microscopic, finely crushed abrasive particles embedded in the surface seems to affect bonding between the substrate and the coating for some

coating systems, while for others it does not."[18] Notwithstanding, the study showed a sensitive balance between the surface preparation method and the coating to be applied.

Study A. Silica- and Nickel Slag-Blasted Steel: Epoxy Novolac Coating

Using steel substrates that had been abrasive blasted with silica sand or nickel slag media, an investigation was carried out to evaluate the influence of the abrasive on the performance of an applied epoxy novolac lining.[19,20]

Experimental

Each test panel was prepared from a single plate of new A-36 steel. Figures 1–3 (p. 17) show the abrasive media using 14X magnification.

Aside from the influence of surface profile on coating performance, the effect of using two grades of the nickel slag, namely 16/30 and 20/40 was investigated. Using a magnification of 40X, Figs. 4–6 (p. 18) show the profiles obtained by the various abrasive media. The profile obtained from silica sand 50/60 is in the range of 2.7–3.1 mils; the nickel slag 20/40 produced a profile range of 3.1–3.3 mils; and the nickel slag 16/30 produced a profile with a range of 3.8–3.9 mils. Table 2 shows the appearance of the abrasive blast media.

Accelerated laboratory tests were used to characterize the performance of the epoxy lining system. Autoclave (TMO174), atlas cell (TMO185), cathodic disbonding (ASTM G8), and adhesion pull-off tests (ASTM D4541) were employed.

Results and Discussion

- NACE TMO174, Autoclave tests.

Inspection of Fig. 7 (p. 19) shows the autoclave post-test appearance of the epoxy novolac as a function of testing in an autoclave at 250 F, 1,000 psi, an aqueous phase of 5% brine, and a hydrocarbon phase of kerosene/ toluene at 1:1 by volume. The gaseous phase was 5% H_2S, 5% CO_2 with the balance being methane. It was noted that blistering of the epoxy novolac coating system was not blast media dependent.

Blistering occurred mainly in the water phase with medium to medium-dense ASTM #6–8 size blisters in evidence. In addition, the epoxy novolac applied to nickel slag 20/40-blasted steel developed medium ASTM #6 size blisters in the hydrocarbon phase. Loss of post-test adhesion was found in the epoxy novolac that had been applied to nickel slag-blasted steel surfaces (16/30 and 20/40) as well as in the gas phase of the epoxy novolac applied to silica 50/60-blasted steel.

From the results obtained using the epoxy novolac system and two types of blast media (silicate and non-silicate), it can be concluded that the two blast media producing a profile in excess of 3 mils have a similar effect on coating performance under the test conditions used (Fig. 7 and Tables 3–5).

- NACE TMO185, Atlas cell tests.

Coated panels measuring 6 in. by 6 in. were installed on the atlas cell. Distilled water was placed in the cell, thereby forming a water phase and vapor phase at a 2/3:1/3 ratio. The tests were carried out until such time as blisters formed. The internal temperature of the atlas cell was 175 F/79.4 C and the jacket temperature was 125 F/51 C. The test samples were visually examined on a daily basis. Tests were terminated when blistering occurred (Table 4).

Table 2: Abrasuve Blast Media Appearance (Magnification 40X)

Abrasive Blast Media	Profile on Steel (mils)	Sieve size	Abrasive Media Appearance
Silica	2.7–3.1	#3	Round
Nickel Slag	3.1–3.3	20/40	Jagged
Nickel Slag	3.8–3.9	16/30	Jagged

Blast profile measured by replica tape

Fig. 9: G 55 (left, magnification 7X)) and S330 (right, magnification 7X)

Table 3: Autoclave Test Results - NACE TM-01-85 - Abrasive Media Profile Obtained from Silica 50/60

	Test Results			
Physical Parameters	Pre-Test	Gas Phase	Hydrocarbon Phase	Water Phase
Thickness	12.5–13 mils	No Change	-	No Change
Adhesion	A	B-	-	a
Blisters	None	None	-	M#4

Table 4: Autoclave Test Results - NACE TM-01-85 - Abrasive Media Profile Obtained from Nickel Slag 16/30

	Test Results			
Physical Parameters	Pre-Test	Gas Phase	Hydrocarbon Phase	Water Phase
Thickness	12–13 mils	No Change	-	No Change
Adhesion	A	A	-	B-
Blisters	None	None	-	MD#4–M#4

Table 5: Autoclave Test Results - NACE TM-01-85 - Abrasive Media Profile Obtained from Nickel Slag 20/40

	Test Results			
Physical Parameters	Pre-Test	Gas Phase	Hydrocarbon Phase	Water Phase
Thickness	12.5–13 mils	No Change	-	No Change
Adhesion	A	B-	-	A
Blisters	None	None	-	MD#4–M#4

Samples were ranked for their adhesion to the steel substrates and the hours recorded for the threshold time of coating blistering onset. The results obtained showed that all samples developed blisters of approximately ASTM size #4 in the water phase. The blisters were largely concentrated at the water–vapor interface. Table 6 (p. 22) shows that the blister density and time required for blistering to occur was dependent upon on the blast media.

From these preliminary studies, it was noted that the nickel slag 16/30 and 20/40 induced an equal or better performance of the epoxy novolac compared to the use of silica 50/60 abrasive. Furthermore, the nickel slag 20/40 that developed a profile of approximately 3 mils afforded an improved epoxy novolac lining performance compared to that

Table 6: Epoxy Novolac: Time Until Blistering as a Function of Abrasive Blast media–Atlas Cell Test NACE TM-01-74

Epoxy Novolac	Time Until Blistering (Hrs)
Silica 50/60	123
Nickel Slag (20/40)	170.5
Nickel Slag (16/30)	120

Table 7: Cathodic Disbonding as a Function of Abrasive Media Profile–ASTM G8, Method B

Epoxy Novolac	CD radius (mm^2) 30 days	CD radius (mm^2) 90 days
Silica 50/60	124.7	467.99
Nickel Slag (16/30)	24.75	82.3
Nickel Slag (20/40)	38.76	101.63

resulting from the nickel slag 16/30 that developed a much deeper profile.

• ASTM G8, Cathodic disbonding tests.

These tests were conducted for both 30 days and 90 days with an impressed current of -1.5 volts and using a brine solution. Upon completion of the testing, all coated samples were rinsed with tap water and visually inspected for any evidence of blistering, delamination, or other coating damage.

The maximum radius of disbondment was determined by making four cross cuts across the initial holiday, and extending the cuts to the edge of the exposed area. As shown in Fig. 8 (p. 19) and Table 7, the average radius and area of disbondment was calculated for each sample.

Figure 8 (p. 19) and Table 7 show that the total area of disbondment was shown to be time and blast media dependent. Areas of disbondment increased with time and the extent of failure was higher in the case where the epoxy novolac had been applied to silica 50/60 blasted steel compared with either nickel slag blasted steel.

As in the autoclave study, it was noted that the nickel slag 20/40 grade (profile slightly greater than 3 mils) was a slightly better abrasive media compared to nickel slag 16/30 grade (profile closer to 4 mils). This may be due to the peaks of the profile curling somewhat in the case of the nickel slag 16/30 and somewhat inferior wetting/adhesion occurring of the epoxy novolac in the case of the steel prepared with the 16/30 grade of abrasive media.

Study B. Grit- and Shot-Blasted Steel: Epoxy Glass Flake Coating

Steel substrates were abrasive blasted with steel grit or steel shot to evaluate the influence of the abrasive on the performance of a two-coat, and low VOC, glass flake epoxy novolac lining system. The latter was selected for evaluation due to its proven track record of superior anticorrosive performance.[16]

Figure 9 (p. 20) shows a comparison of sharp steel grit (G55) and round steel shot (S330) abrasive media. Figures 10 and 11 show the jagged profile and peen patterns obtained using steel grit and steel shot, respectively. The former is markedly more preferable because it increases the angularity and roughness, thereby providing a greater density of sites for polar adhesion and mechanical adhesion.

The coating performance was assessed using accelerated laboratory test methods, namely NACE TM0404, ISO 20340, ASTM B117, and ASTM D5894. All test panels had a 2 mm x 50 mm horizontal scribe introduced down to the substrate (except for NACE TM0404, which had a 2 mm x 90 mm vertical scribe). All scribes were prepared mechanically using a drill press and a 2 mm flat-ended slot drill.

Twelve weeks after testing (2,016 hours of exposure timer), each of the test panels was removed from the test cabinets.

Experimental

• ASTM B117, "Standard Practice for Operating Salty Fog Apparatus."

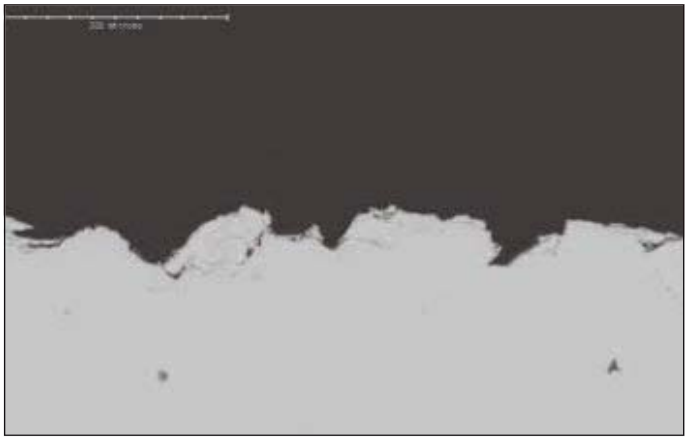
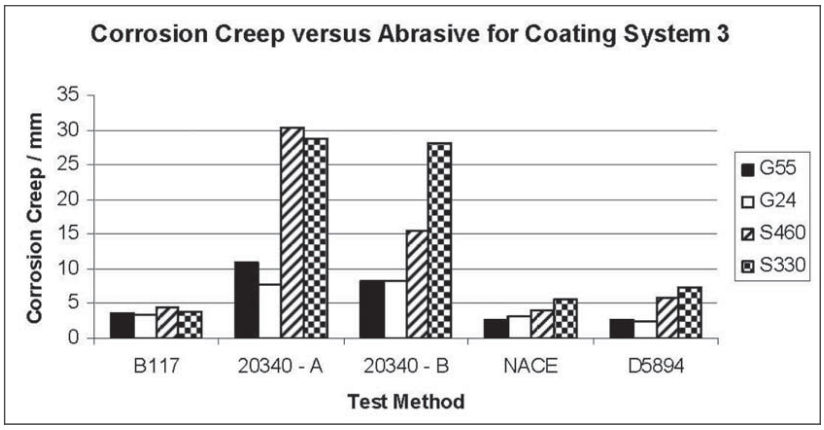


Fig. 10: Grit-blasted substrate—angular

Fig. 11: Shot-blasted substrate—smooth



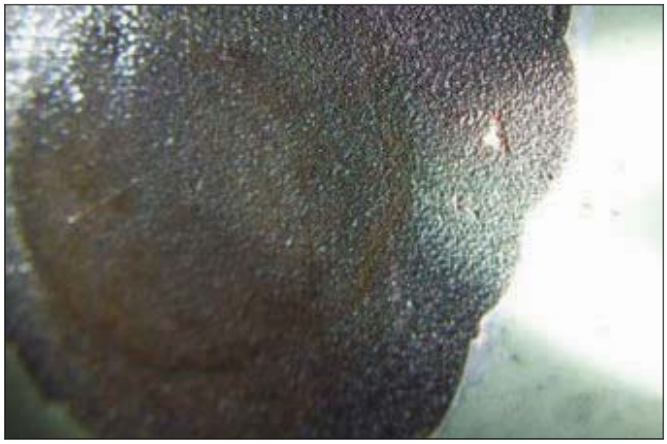


Fig. 12: (top left) Corrosion creep vs. abrasive for Coating 3 (2 cts of glass flake epoxy)[16]
Fig. 13: (top right) Potable water tank internals lined with epoxy coatings containing exempt solvents (roof) and solvent-free epoxy lining (shell and floor) where the steel was grit-blasted to a 3-mil jagged profile
Fig. 14: (bottom left) Blistered epoxy lining containing exempt solvents (in a potable water tank) where the steel was shot-blasted to a 2- to 3-mil peened profile
See p. 26 for discussion of Figs. 13 and 14.

Though largely discredited nowadays, this test was run so as to compare the scribe creep on the test panels. The latter were exposed to a continuous salt fog at 350 C (950 F) using a 5% NaCl solution as the electrolyte.

- ASTM D5894, "Standard Practice for Cyclic Fog/UV Exposure."

Test panels were exposed to alternating periods of one week in a fluorescent UV/condensation chamber (ASTM G53) and one week in a cyclic salt fog/dry chamber (ASTM G85).

- ISO 20340, "Performance Requirements for Protective Paint Systems for Offshore and Related Structures."

This cyclic corrosion test primarily was selected given that it is used to evaluate coatings for use in offshore environments, such as oil and gas exploration. Both Annex A and B procedures were used in the study.

- NACE TM0404, "Offshore Platform Atmospheric and Splashzone New Construction Coating System Evaluation."

The rust creep resistance test was one part of this testing protocol. The test procedure was a modification to ASTM D5894 with the electrolyte changed to synthetic sea water, ASTM D1141.

Each panel was assessed for coating defects in accordance with ISO 4628, "Evaluation of Degradation of Paint Coatings—Designation of Intensity, Quantity and Size of Common Types of Defect."

Upon completion of the tests, an initial visual assessment of the coating was made followed by a determination of coating removal around the scribe area and the extent of any underfilm corrosion.

Results and Discussion

Figure 12 indicates that testing according to ASTM B117 showed no difference in coating performance with respect to surface profile. In contrast, ISO 20340, Annex A and B, both showed significant improvement in coating performance when applied to grit-blasted steel. With respect to NACE TM0404 and ASTM D5894 tests, it is clear that only moderate improvements in performance were obtained in the case of grit-blasted steel.

The results clearly revealed the benefit of using grit (vs. shot) abrasive to improve the corrosion protection of the coating. Significantly reduced levels of underfilm corrosion were measured when grit was used as the abrasive.

In a nutshell, ASTM B117 (a non-cyclic corrosion test) was unable to distinguish between abrasive selection and coating performance, but ISO 20340, NACE TM0404, and ASTM D5894 all showed that coatings performed better on the grit blasted substrates, with lower corrosion creep values obtained. ISO 20340, ASTM D5894, and NACE TM0404 tests are all examples of cyclic corrosion tests with temperature variations, wet/dry conditions and UV exposure. These test methods have more synergy with natural exposure due to their cyclic

nature and are therefore more predictive in terms of actual performance.

In all examples, exposure to ISO 20340 produces higher levels of corrosion creep than either NACE TM0404 or ASTM D5894. Both NACE TM0404 and ASTM D5894 use prohesion (1 hour dry at 35 C/1 hour salt fog at 23 C) to induce stress in the coating. ISO 20340 has a cycle of 3 days' continuous salt fog at 35 C followed by a 1-day dry cycle.

The ISO 20340 protocol of allowing the coating to fully dry out for one day is more aggressive than the prohesion cycle because the coating is potentially plasticized during prohesion by water absorption (water not fully released due to the relatively short dry out period). Increasing the wet/dry periods in the prohesion cycle should increase the corrosion rate because a longer cycle will allow the water to be fully released from the coating.

Average Profile Height					
Abrasive Type	1 mil	1.5 mils	2 mils	2.5 mils	3-4 mils
Steel Grit	G-80	G-50	G-40	G-40	G-25
Steel Shot	S-110	S-170	S-230	S-280	S-330
Garnet Aluminum	80	36	36	16	16
Oxide	100 grit	50 grit	36 grit	24 grit	16 grit
Coal Slag	30/60	30/60	20/40	20/40	12/40
Copper Slag	30/60	30/60	16/30	16/30	12/30
Silica Sand	30/60	16/35	16/35	8/35	8/20

Average Profile Height Obtained by Blasting Steel with Various Abrasives [21]

CASE HISTORY #1

Potable Water Tank Internals (Angels)

Several 1- to 5-million gallon potable water tanks were lined with two-coat systems of a low VOC and NSF 61-certified, modified phenalkamine epoxy. The latter contained an exempt solvent, PCBTF.

The specification called for the application of two contrasting colored coats of the epoxy at 6–8 mils DFT per coat applied to an SSPC-SP 10, Near-White Metal finish. For some of the tanks, the floors and shell were coated with a solvent-free version of the phenalkamine epoxy technology in a one-coat application of 16–25 mils DFT.

A stationary wheel blast unit was used to abrasive blast steel plate to a three-mil profile. The abrasive media was a mixture of steel shot (S280) and steel grit (SG25) in a 70:30 mix ratio.

As shown in Fig. 13 (p. 24), two years later, the tanks were found to be in virtually perfect condition, a testament to the use of an approximately three-mil jagged profile, good application of the lining system, and use of high-performance lining systems with or without exempt solvents.

CASE HISTORY #2

Potable Water Tank Internals (Demons)

A large potable water tank was built where the steel plate had been steel shot abrasive blasted in a stationary wheel blast unit to an SSPC-SP 10, Near-White Metal finish. The result was a 2- to 3-mil peen pattern as opposed to a jagged profile. As in Case History #1, the same low VOC and NSF 61-certified and modified phenalkamine epoxy coating system (containing exempt solvent, PCBTF) was then applied in a two-coat system of 6–8 mils DFT per coat.

After being in service for several months, the tank lining with the exempt solvent line-up was deemed to have failed by blistering (Fig. 14, p. 24). This was a marked contrast to all the successful applications of the fabricator using the same epoxy but with non-exempt solvents. The refurbishment procedure consisted of first steel grit blasting in the field to achieve a jagged profile of approximately 3 mils followed by application of exactly the same NSF 61-certified coating originally applied at the new construction stage.

One year later, the low VOC refurbishment lining system that contained the exempt solvent was in perfect condition with no blisters. Since then, the manufacturer of the tanks has changed its blast media from essentially straight steel shot to a 70:30 steel shot/steel grit mixture, given that it was recognized that the sharp and angular "jagged" profile afforded the success of the potable water lining system.

CONCLUSIONS

For immersion service, it is recommended that low VOC and solvent-free coatings be applied to steel having a sharp angular profile of approximately 3 mils.

The need for a 3-mil jagged profile in steel becomes even more critical for immersion service when using solvent-free or high-solids coatings containing exempt solvents.

Steel surfaces that have been abrasive blasted using steel grit (not steel shot) have a jagged and angular profile suited to linings for immersion coating service.

The increased performance of linings on grit-blasted steel is due to both the increased area and increased roughness that respectively afford enhanced polar (secondary valance force) bonding and physical bonding.

Corrosion creep data identified that grit blasting—as opposed to shot blasting—was the preferred method of sur-

face preparation when applying liquid coatings in aggressive environments.

ISO 20340 produced higher levels of corrosion creep than either ASTM D5894 or NACE TMO404 for equivalent exposure times.

An epoxy novolac lining applied to steel prepared with nickel slag abrasives (yielding profiles of 3—4 mils) generally showed superior immersion performance for oilfield work than with the same lining applied to steel prepared with silica sand 50/60.

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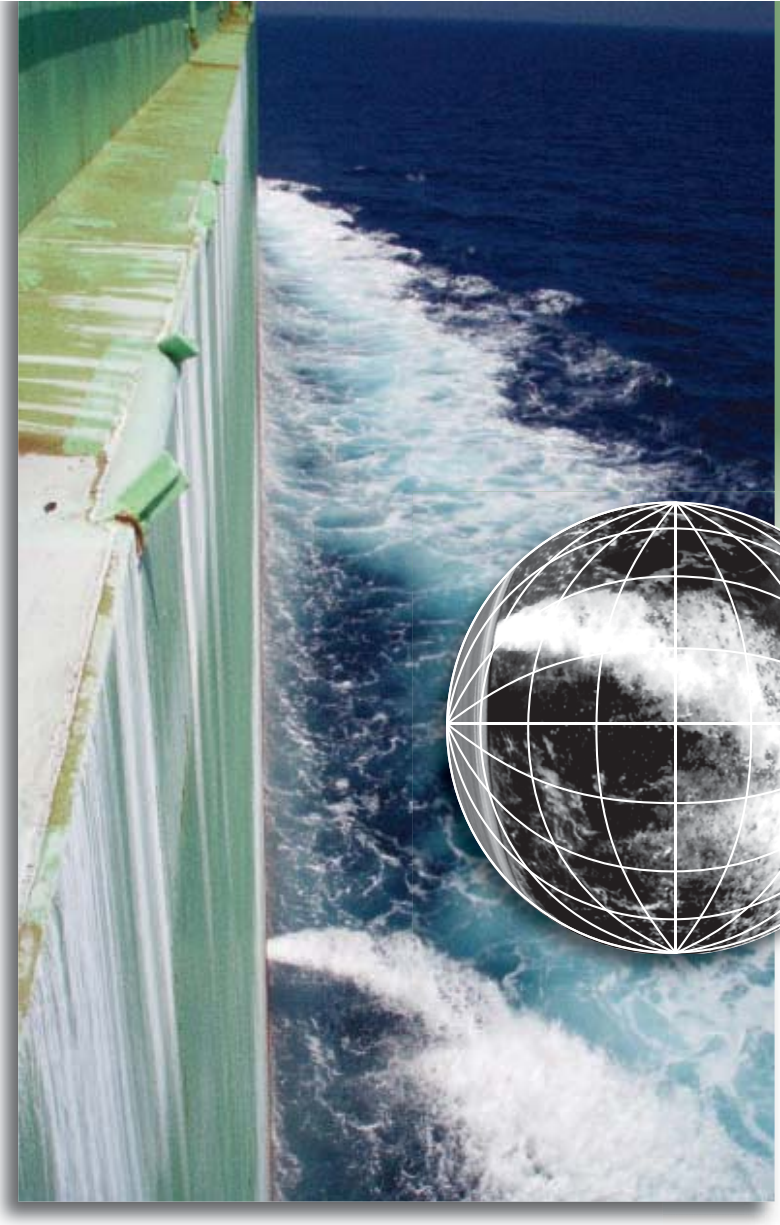


Potential Risks of Ballast Water Treatment Systems on Ballast Tank Coatings

By Brian Goldie, *JPCL*

The global transport of goods by sea is cost-effective. However, it does bring problems for local marine life through the accidental transport of one country's (or continent's) indigenous marine species to a country or continent where that species is not indigenous.

The species can come from marine fouling on a vessel's hull or, more likely, by discharge of ballast water, as occurred in the Zebra mussel infestation of the Great Lakes in North America. Zebra mussels are common in Europe but are not indigenous to North America. Transported into the Great Lakes in the late 1980s, the mussels have since spread to many other lakes and rivers in the USA and Canada. They consume large quantities of phytoplankton (and small zooplankton), effectively starving the native populations of infested lakes and rivers. They also interfere with the fish supply for humans and other animals, clog hydropower plant intakes, and interfere with other activities and structures in the lakes and rivers.

IMO has addressed the problem of unwanted transport of water species. The IMO's Ballast Water Management Convention (although not currently ratified) requires that all vessels be equipped with a ballast water treatment system to ensure that any discharged water is free from marine organisms. However, the adoption of the treatment system could pose problems for the coatings applied in these tanks to protect against corrosion, causing breakdown and ultimately affecting the structural integrity of the vessel. The potential impact of water treatment systems on protective coating systems on ships was the sub-

ject of a one-day workshop, organized by Informa Maritime Events, in London (December 6, 2010).

This article reviews the presentations made at this workshop.

Ballast Water Treatment – Assessing the Risks

The scene was set by Lynda Speed of Safinah Ltd, who introduced the new IMO regulation and explained how it was in conflict with the existing Performance Standard for Protective Coatings (PSPC) for ballast tanks. Vessels must comply with the PSPC (IMO Resolution MSC.215), which requires coatings used in ballast tanks to be approved and to have a 15-year life expectancy in good condition. However, the IMO PSPC does not use treated water to qualify coatings.

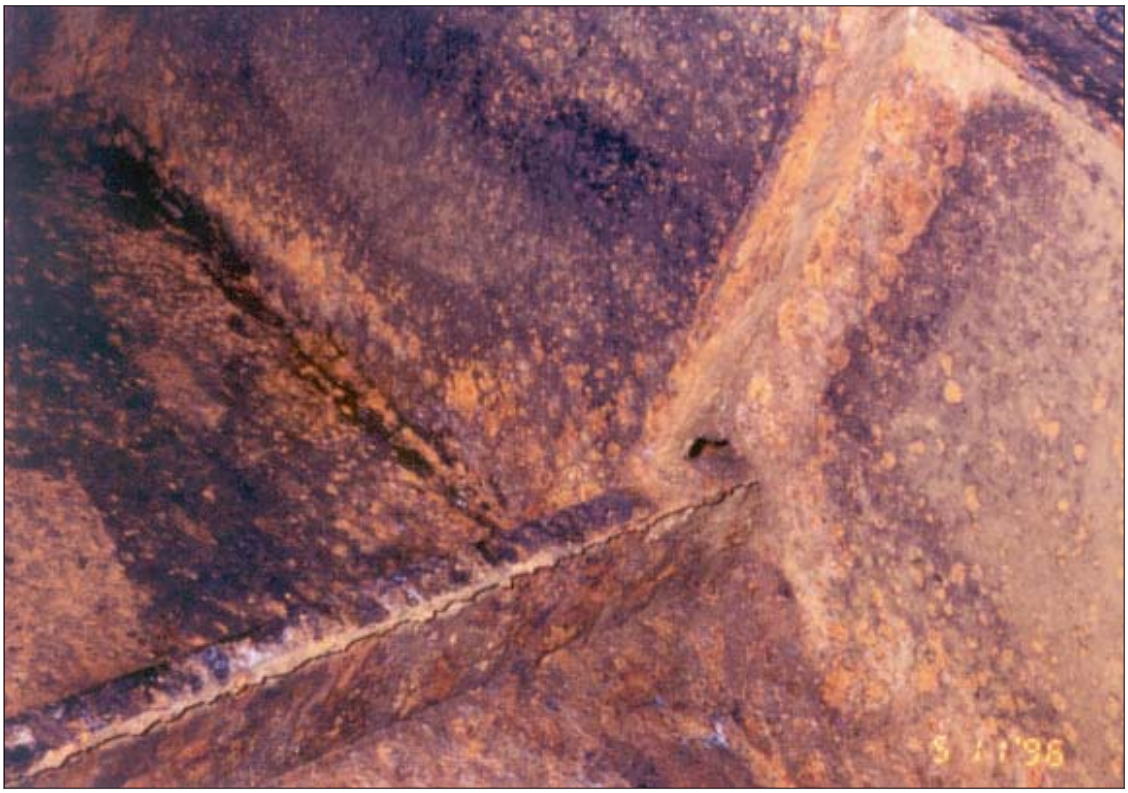
Ballast water treatment (BWT) alters the composition of the water/environment in the tank. The effect that the change could have on the tank coating will depend on the type of treatment system used. Current treatment systems comprise mechanical methods (filtration, separation); physical (deoxygenation); chemical (electro-chlorination, chlorine dioxide, ozone); or combinations of these. Each carries different risks, but the biggest potential threat to the ballast tank coating comes from the use of chemical methods, which use highly oxidizing species. These species are known to cause rapid breakdown of epoxy coatings—the major class of coatings approved for ballast tank use. There are over 30 such treatment systems on the market today, the majority of which use active substances. As part of the IMO approval process, the BWT equipment supplier has to carry out compatibility testing with coatings; however, what testing has actually been carried out and its results are not generally made known to the users (or paint companies). In addition, the IMO test protocol for water treatment systems is not linked to the prescribed testing for an approved ballast tank coating, nor does it address the potential for surface degradation of the coating with time, which would be the main failure mode with oxygenating systems.

(Above): Ballast tank with lining in good condition. Courtesy of Exova
(Facing page): Ship discharging ballast water. Courtesy of OceanSaver

Paint Industry View

The coating industry's perspective was presented by Evert van Rietsachoten of PPG Marine Coatings, on behalf of the PSPC working group of the International Paint & Printing Ink Council (IPPIC).

The speaker explained that interest in the market for Ballast Water Treatment (BWT) systems was increasing, and coating suppliers were receiving questions about the systems from owners, shipyards, and BWT-system suppliers on a regular basis. In many cases, coating suppliers were being asked to "approve" compatibility of their coatings with certain BWT systems. However, at this stage, all manufacturers can do is advise—approval of BWT systems is in the hands of the Administration (Flag State, although normally delegated to the



Ballast tank in poor condition.

classification societies) in line with the IMO regulations.

The testing procedure is outlined in IMO's Guidelines for Approval of Ballast Water Management Systems [G8 IMO resolution MEPC.125(53)]. To get approval, the equipment supplier must go through a multi-step test procedure involving GESAMP and BWWG approval of the environmental impact of the discharged water, the Flag State's approval of the system after land-based and sea-based trials, and, finally, the Flag State's issuance of a Type Approval Certificate (although the Flag State will normally use a classification society to verify and assure the quality of the test and data, and to issue the certificate).

Paint companies can only advise on compatibility at this stage because BWT is still an evolving technology, and there is limited in-service experience with the systems. To understand the operation of these systems, and the exact conditions generated, requires specialist knowledge, which the paint manufacturers do not have. The speaker emphasized that the systems that work by chemical treatment are of most concern to the paint industry.

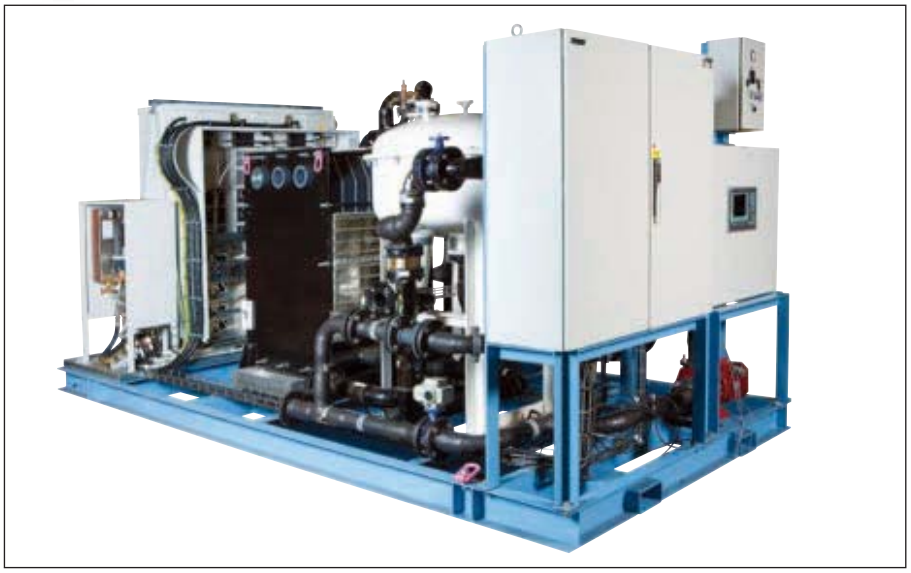
The BWT test requirements are set by IMO MEPC (based on advice of the Group of Experts on the Scientific Aspects of Marine Environmental Protection, GESAMP). The approval process and responsibilities are clearly described. However, the current test protocol and review process could be improved. Improving the process is the responsibility of GESAMP/IMO MEPC, the recognized body to approve test methods, evaluate results, and approve systems.

From an IPPIC point of view, the main concerns are that several systems rely on active substances that could potentially have an adverse effect on the ballast tank protective coating. The test method for BWT in combination with coatings is not standardized, and the current test protocol does not address any coating surface degradation with time. In addition, the testing is not always carried out by an independent third party, and the results are not widely available. Finally, correlation of tests with performance at sea has not been validated.

IPPIC, which has IMO NGO status, can help by being the point of contact between suppliers and GESAMP Ballast Water Working Group (BWWG). It can advise on coating testing and can also analyze and comment on test results, according to the speaker.

View from Classification Society

The Regulatory status and Classification Society position was highlighted by Helge Vold, Principal Engineer within the Materials Technology group of DNV. Vold started by reviewing the IMO PSPC requirements for ballast tank coatings and the testing required for the PSPC. The speaker suggested that there should be a GESAMP water ballast tank corrosion test for uncoated substrates and substrates coated with epoxies that had already passed the IMO PSPC test. The



Example of typical BWT equipment
Courtesy of OceanSaver

substrates should be subjected to a water immersion test (e.g., ISO 2812-2, Paint and varnishes—Determination of resistance to liquids—Part 2: Water immersion method), with the test using, at a minimum, untreated and treated effluents under continuous exposure. The evaluation of the uncoated substrates should include an estimate of the corrosion rates and the depth and density of localized corrosion, according to Vold. The coated samples should be evaluated for adhesion (Pull-Off Test, ISO 4624); degree of blistering, rusting, cracking, and flaking (ISO 4628 series); and delamination at the scribe (ISO 4628-8). The speaker also suggested detailed test procedures and acceptance criteria for testing compatibility of BWM systems and PSPC-qualified epoxies.

Vold noted that ballast water treatment systems are also required for existing ships, which may not have modern hard (epoxy) coatings for corrosion protection. The proposed treatment systems should only be acceptable for use with soft or semi-hard coatings when the results of testing bare steel were acceptable, and epoxy (or other hard coatings) not tested according to PSPC or a previous similar test methods should be individually tested.

The Insurer's Perspective

Bruno Saverys, of Groupama Transport Insurance, raised several interesting points. Insurers are currently covering 5-year guarantees on standard ballast tank coatings, which can be increased to 5+5+5 years, subject to intermediate 5-year condition surveys. The insurers are aware of the concerns about the (unknown) impact of ballast water treatment systems on standard coatings and about the testing of coatings in contact with these systems. And insurers, the speaker said, are questioning whether they have to change their insurance terms to reflect a change in risk.

If the insurers have proof that ballast water treatment is not affecting the properties of ballast tank coating systems, then there will be no influence on policy conditions, guarantee duration, or insurance premium/rating. However, as long as there is no proof, insurers will have to ask for additional testing, or for more thorough inspection requirements, and could adapt their conditions to reflect a possible negative impact.

Testing

Leif Erik Caspersen, of BWT supplier OceanSaver AS, raised the question of what testing has been done to date. He began by stating that a "tidal wave" of technologies entering the approval process all use electrolysis at high chlorine levels. He gave examples from 7 suppliers' technologies in which the minimum dosage level was 10 mg Cl_2/litre. Another 7 technologies combine this type of treatment with another technology in order to reduce the chlorination levels required. Of 25 technologies now proposed for BWM approval, more than half use oxidizing agents, such as chlorine, at very high levels. Caspersen emphasized that not only are chlorine systems an area of concern but also the use of ozone is a concern because although it has a rapid reaction, it generates chlorine and bromine reaction products, which are both powerful oxidants.

It should be noted that when a system is evaluated for final approval by the GESAMP group, they also evaluate corrosion issues and make comments. These comments are never reflected in the Type Approval Certificate for BWT systems. For example, a typical comment from the GESAMP group could be something to the effect that the group considered that the actual exposure time for the treatment dose was insufficient for long-term corrosion rates and that the data are insufficient to characterize long-term corrosion rates of steel subjected to the treatment system accurately.

Caspersen stated that to his knowledge, only a few suppliers of BWT systems have carried out serious testing regarding corrosion effects of their sys-

Wave test tank
Courtesy of Exova

tems, and only 2 vendors he knows can provide any form of serious documentation regarding their systems' effect on ballast tank coatings. In fact, some vendors have presented tests carried out by themselves that are in conflict with accepted knowledge regarding corrosion effects.

Caspersen then highlighted testing that two independent laboratories carried out on his company's BWT system (cavitation with N_2 supersaturation). Testing consisted of a 6-month wave tank program, and 12 and 15 months' corrosion testing on board ships.

Steel test plates with a total of 8 different epoxy coatings, supplied by the major marine paint manufacturers, were subjected to the Water Ballast Tank/Wave Tank test (formerly known as the Marintek test) for 6 months to simulate ballast tank conditions. Some of the panels were scribed and others had anodes attached. The conclusion reached was that the proprietary treatment had no detrimental effect on the coatings or their corrosion protection properties. However, it was recognized that, in terms of corrosion, the six-month test period was too short to find any significant differences between the tank containing treated water and the tank with untreated water. The same coating systems were also tested for 15 months on board a bulk carrier. Test panels were placed in different areas in two ballast tanks, one of which had the treatment system installed. A similar test was also carried out on a car carrier for 12 months. Therefore, the speaker concluded that it is easy to set up realistic testing, which should be for a minimum of 12 months.

A Proposal for Testing Protocol

Because of the question of reliability, or uncertainty of testing already carried out, and the industry's lack of knowledge of the BWT systems, John Carter, of the independent testing company Exova, described a proposal for a new test program to confirm the compatibility of BWT and ballast tank coatings.

He started with the testing required for ballast tank coatings under the PSPC Resolution (MSC.215) and also explained "crossover testing." Shipbuilders reserve the right to use different manufacturers' primers with approved topcoats, and to check compatibility between approved products from different suppliers, a crossover test can be performed by a third party; it is not necessary to carry out the full PSPC evaluation.

For BWT system compatibility, rather than reinvent the wheel, he proposed to use the existing PSPC test method modified for this requirement and using it as a crossover test. A detailed protocol was then described.

This testing would not conflict with the original approvals for the coatings systems. It is not mandatory, only a possible solution to the problems raised at this workshop.

Closing Thoughts

The last presentation was by Giles Candy (NEI Treatment Systems), who reviewed the impact of the PSPC on Ballast Water Management. BWT systems are now being required, and in the next 10 years or so, the entire fleet will be using such systems. It is clear that a BWT system can affect a coating. He noted, however, that the Ballast Water Convention addresses this problem by stating that a BWT system should not impair the health or safety of a ship. The Convention also provides recommendations for corrosion testing, which has been completed to differing degrees by the suppliers of the approved and certified systems. So far, the procedures for testing a coating have not formally addressed the type of BWT system the coating will have to work with. The coating manufacturers, BWT system manufacturers, and the regulatory bodies need to work together to overcome this, Candy concluded.

Brian Goldie is the technical editor of JPCL.

JPCL

SSPC Honors Coating Projects in 5th Annual Structure Awards

By Jodi Temyer, *JPCL*

Whether it's the new construction of a bridge 900 feet above the Colorado River or maintenance work on a statue of a Roman god, protective coatings play a crucial role in providing long-term service of infrastructure and historic landmarks the world over. The SSPC Annual Structure Awards are an opportunity for outstanding high-performance coatings work to receive recognition from SSPC: The Society for Protective Coatings.

For the fifth year, SSPC honored teams of contractors, designers, end users, and other personnel for the excellence and expertise demonstrated on their industrial or commercial coatings projects. This year, SSPC added a Military Coatings Project Award of Excellence.

The Annual Structure Awards were presented at SSPC 2011 featuring GreenCOAT during the Annual Business Meeting & Awards Luncheon on Jan. 31. The conference and exhibition took place in Las Vegas, NV, from Jan. 31 to Feb. 3. SSPC Executive Director Bill Shoup announced the awards, and SSPC President Russ Brown presented them.

The winners are presented over the next several pages in *JPCL*'s Annual Structure Awards photo essay. Information about the projects was obtained from the nomination materials submitted to SSPC in 2010 and from information presented at the awards ceremony. All winners were selected from more than 20 projects nominated.

Military Coatings Project Award of Excellence

The USS Nimitz (CVN 68)

This year's SSPC Structure Awards included a new award, expanding the annual honors for industrial and commercial coatings projects to include a military coatings project. The Military Coatings Project Award of Excellence recognizes exceptional coatings work performed on U.S. military ships, structures, or facilities.

The first-ever recipient of the award is the USS Nimitz (CVN 68), one of the largest warships in the world. Over 170,000 square feet, comprised of 66 tanks and voids, was abrasive blast cleaned and preserved with an edge retentive, ultra-high solids epoxy while the hull was waterborne.

The work was accomplished during pierside availabilities without significantly affecting other maintenance operations. This level of pierside preservation below the waterline was unprecedented in U.S. Navy history for preservation of tank and void structure. Pierside preservation allows the Navy to separate the link between drydocking and tank preservation.

Hull temperature was a major concern because NAVSEA requires a surface temperature of 70 F and 50% relative humidity. During the course of the work, shell plating was in direct contact with cooler temperature water as deep as 30 feet. However, this work demonstrated that nearly all portions of the aircraft carrier structure could be made accessible to preservation in less than ideal conditions when using sophisticated, modern coatings.

USS Nimitz (CVN 68) gets underway from Naval Air Station North Island on a scheduled deployment. Photograph by Mass Communication Specialist Seaman Jake Berenguer. Courtesy of the U.S. Navy.

Location: North Island Naval Air Station
Structure Owner: U.S. Navy
Start Date: June 2006
Completion Date: December 2008

(l-r) SSPC President Russ Brown and James Wigle, COMNAVAIRPAC, Corrosion Engineer, U.S. Navy. Photo courtesy of SSPC.

William Johnson Award

Central Plant Renovation–Thermal Energy Storage Tank

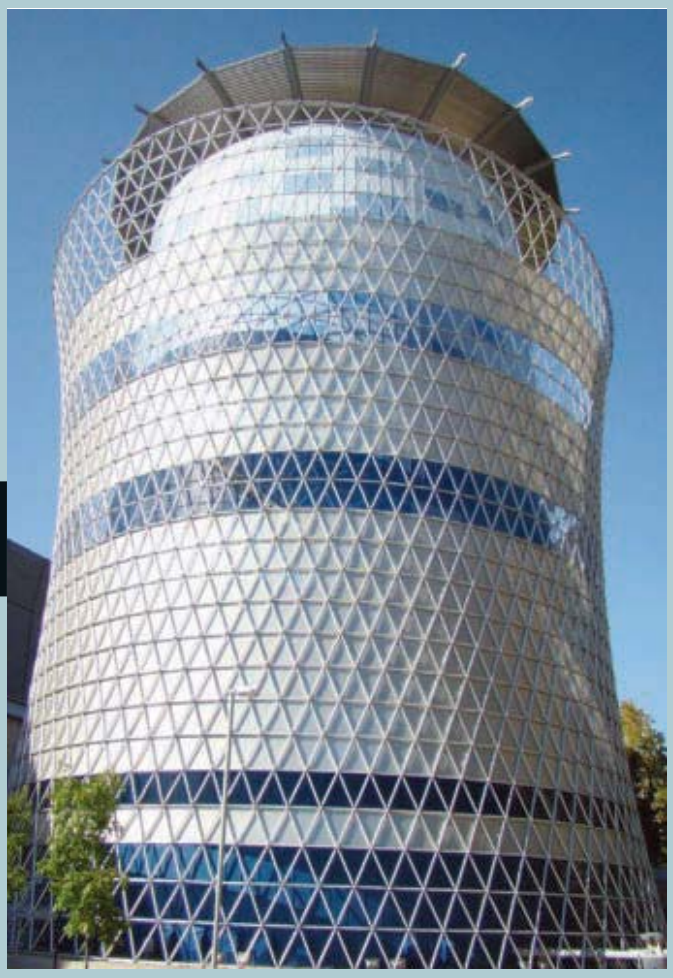


Photo courtesy of Tnemec Company, Inc.

The William Johnson Award represents outstanding achievement in aesthetic merit in industrial or commercial coatings work. The coating may represent a theme, an object, or a specific graphic design. The qualities considered for the award include color, gloss or texture, or that the coating on the structure compliments the environment while enhancing the structure itself.

The late William Johnson was a consultant with KTA-Tator whose work in coatings formulation, failure analysis, and surface preparation was instrumental in advancing the industry.

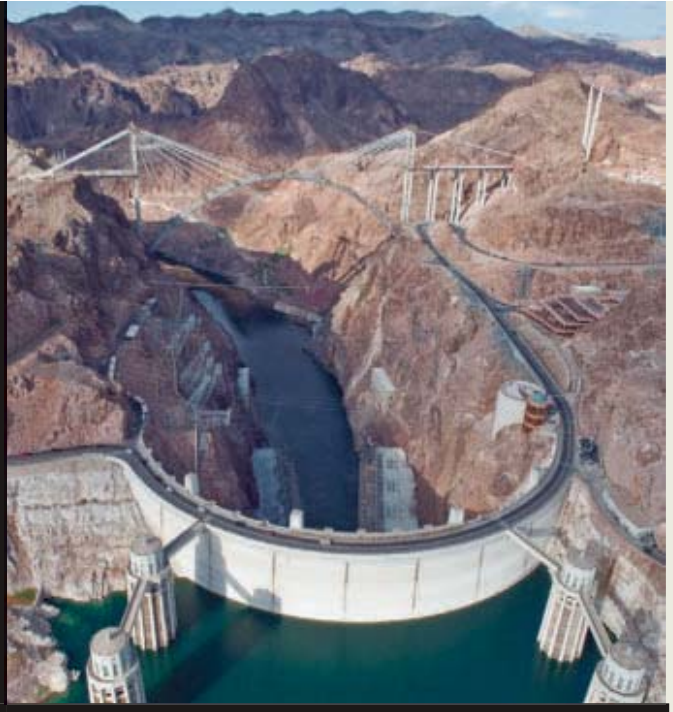
The winner of this year's award is the Central Plant Renovation-Thermal Energy Storage Tank, a design-build project intended to resemble a modern art sculpture within the mixed-use area where it stands.

The tank's unique design required a high-performance coating system on the interior, exterior, and exposed architectural features.

The 4.25-million-gallon tank is part of a chilled water system that serves 22 state buildings in downtown Sacramento. The tank and its environmentally-friendly central plant are on track to receive LEED Gold certification.

Location: Sacramento, CA
Structure Owner: State of California, Department of General Services
Contractor/Applicator: CB&I
Coating Material Supplier: Tnemec Company
Start Date: December 2009
Completion Date: June 2010

(l-r) Terry Wallace, VP of Sales, Tnemec Company, Inc.; SSPC Predsident Russ Brown; William Hansel, State of California, Dept. of General Services; Jeffrey Jones, Construction Supervisor, CB&I.
Photo courtesy of SSPC.



Crone Knoy Award

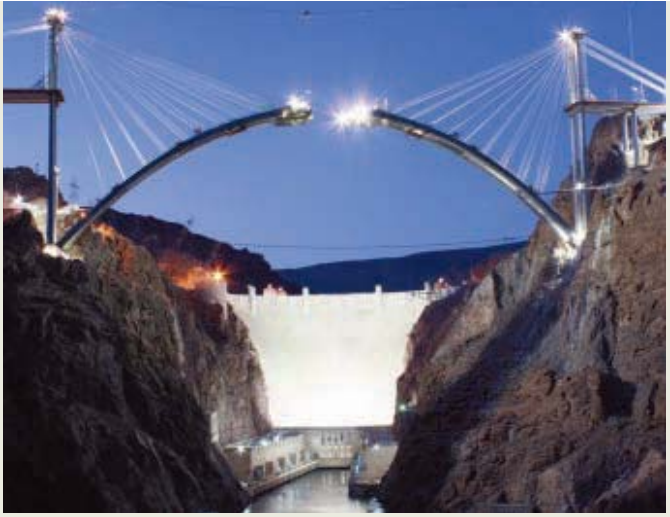
Hoover Dam Bypass–Colorado River Bridge

Named for E. Crone Knoy, the late founder and president of Tank Industry Consultants, this award stands for coatings work that demonstrates innovation, durability, or utility. Qualities representing outstanding achievement may include excellence in craftsmanship or execution of work or the use of state-of-the-art techniques and products to creatively solve a problem or provide long-term service. This year's winner is the Hoover Dam Bypass-Colorado River Bridge.

For decades, the top of the Hoover Dam carried U.S. Highway 93—a two-lane stretch of road whose increased traffic, sharp curves, and post-911 vehicle inspections had created a safety and congestion problem in need of a solution.

The solution was the Hoover Dam Bypass Project, which eliminated having to drive over top of the dam. To move U.S. 93 traffic off the dam, the Colorado River Bridge was built approximately 1,500 feet south of the Hoover Dam, spanning the Black Canyon and sitting 900 feet high above the river. At 1,900 feet long and with an arch span of 1,060 feet, the U.S. Bureau of Reclamation says, it is the longest concrete arch in the Western Hemisphere, in addition to being the first concrete-steel composite arch bridge built in the U.S.

The scope of the project included coating the interior and exterior of the steel girders, spans, catwalks, tubs, bearing pads, and 67 handrail sections that were each 30 feet long. Spans were coated with a primer coat and two coats of urethane. Handrails were power-washed and spray-coated with a



rust grip primer coat. They were then coated with a unique coating system that utilizes a heat dissipating material. This can lower the surface temperature of the handrails by 10% and reflect 95% of radiation from the sun, both important factors in the life of a substrate sitting in extreme desert temperatures and high UV sun exposure. Handrails also received clear and tinted enamo grip coatings.

Work was completed 900 feet over the Colorado River, with winds reaching 15 to 20 knots and temperatures rising over 100 F. There were no OSHA Recordable Incidents during the two-year painting work.

The Colorado River Bridge has been named the "Mike O'Callaghan-Pat Tillman Memorial Bridge." O'Callaghan was formerly a Nevada governor and passed away in 2004. Tillman played for the Arizona Cardinals until leaving the NFL to join the Army. He was killed in Afghanistan in 2004.

Location: Spans the Colorado River between Nevada and Arizona
Structure Owner: Federal Highway Administration
Contractor/Applicator: United/Anco Services, Inc.
Coating Material Supplier: Superior Products International (SPI) and PPG Protective and Marine Coatings
Start Date: August 2008
Completion Date: October 2010

(l-r) Rodney McKnight, Operations Support, United/Anco Services; Shawn Nelson, Regional Manager West, PMC Marine Group, PPG; John Woods, Account Executive, Pacific Southwest Coatings, PPG Distributor; Bonnie Klamerus, FHWA Structures Manager; Bruce Batinich, Dir. of Business Development, West Region, The Brock Group, United/Anco Services; and Craig Smith, Technical Director, Superior Products International. Photo courtesy of SSPC.

The Brown Screen Building

Erection of structural steel. Photos courtesy of Tembec Industries

The winner of this year's Charles G. Munger Award for longevity is the Brown Screen Building—Structural Steel in a Pulp Mill.

Named for the late Charles Munger, the award honors an outstanding industrial or commercial coatings project that demonstrates the long service life of the original coating. To qualify for the award, the structure may have had spot repairs or overcoating with the original coating still intact.

Mr. Munger advanced the use of zinc-rich primers and was a widely published author on a range of topics within the coatings industry.

For this project, a coating system consisting of a zinc primer, epoxy anticorrosive, and polyurethane was invented to assist the International Association of Bridge, Ornamental, and Reinforcing Iron Workers in Alberta, Canada, as well as the Iron Workers of North America.

The coating system was applied to some 400 tons of structural steel, which had been abrasive blast cleaned to Commercial, SSPC-SP 6. The urethane finish coat was spray applied with polyolefin beads to create an slip-resistant coating system and a safer walking surface. The polyolefin beads were dispersed into the urethane finish and applied by airless spray.

Excellent corrosion resistance and good color and gloss retention 18 years later.

Location: Skookumchuk, British Columbia, Canada
Structure Owner: Tembec Pulp Group, Skookumchuk Operations
Contractor/Applicator: Waiward Steel Fabricators, Ltd.
Coating Material Supplier: International Paint, LLC
Start Date: 1993
Completion Date: 1993

(l-r) Sean Adlem, Operations Manager, International Paint LLC; Don Oborowsky, CEO, Waiward Steel Fabricators Ltd.; and Michael O'Donoghue, Ph.D., Engineering and Technical Service Manager, International Paint LLC. Photo courtesy of SSPC.

George Campbell Award

1st Ave Bridge at Maple Canyon

The George Campbell Award honors the completion of difficult or complex industrial or commercial coatings projects. These difficulties may include extreme environmental conditions, strict time constraints, limited access or high traffic areas, complex structural components, or coordination with multiple trades or subcontractors.

The award is named for the late George Campbell, founder of Campbell Painting Company in New York.

This year, the award was presented to three projects whose varying complexities spanned a wide range of challenges the contractors had to overcome.

Intricacy and many risks were among the challenging factors to be considered when a depression-era steel arch truss bridge required removal of lead-bearing coatings and a new three-coat system in a seismic retrofit project.

At 100 feet tall, the historic First Avenue Bridge over Maple Canyon is situated close to residential areas and the San Diego Harbor, which meant preparing for minimal noise and dust while also bracing against weather coming off the harbor.

The steel was abrasive blast cleaned to a Near-White Metal, SSPC SP-10, to completely remove the lead-bearing coatings. For protection from contaminated dust, the bridge required complete containment with negative air in the form of shrink-wrapped scaffolding framework provided by Safway Scaffolding. SMS Engineering designed an airflow management system engineered to accomplish negative air and lead particle removal using a 45,000 CFM diesel dust collector and inserting large, flexible ducts into the containment to move huge quantities of air.

Abrasive blasting was done with copper slag blended with an additive used to render lead waste non-hazardous.

Photos courtesy of Bruce Birney of Techno Coatings, Inc.

Blasting operations used one 1,600 CFM compressor; one 850 CFM compressor; and two 8-ton canned-sand units. Six blasting nozzles were active most of the time. Spent media was recovered and recycled with a large vacuum system.

Bridge coating was accomplished with airless pumps and hand-brushing hundreds of rivets. The coating specification called for a prime coat of moisture-cured urethane zinc rich primer, a micaceous iron oxide-filled moisture-cured urethane intermediate coat, and a micaceous iron oxide-filled aliphatic urethane finish.

The historic handrails from 1931, which line each side of the 463-foot-long bridge, were shipped to the contractor's shop facility in Anaheim, CA, where they were abrasive blasted to remove lead-bearing paint and individually dressed to retain the 30s-era architecture. The same three-coat system used on the main structure was shop-applied to the handrails.

Inspection services were provided by Coating Specialists and Inspection Services (CSI).

Location: San Diego, CA
Structure Owner: City of San Diego
Contractor/Applicator: Techno Coatings, Inc. (SSPC-QP 1, QP 2, and QP 3)
Coating Material Supplier: The Sherwin-Williams Company
Start Date: February 2009
Completion Date: April 2010

(l-r) Michael Tarr, Techno Coatings, Inc.; Tom Puett, Techno Coatings, Inc.; Anton Handal, Resident Engineer, City of San Diego; SSPC President Russ Brown; Bruce Birney, Techno Coatings, Inc.; Chuck Whitehead, Techno Coatings, Inc.; and Paul Trautman, The Sherwin-Williams Company. Photo courtesy of SSPC.

Statue of Roman God Vulcan

Photos courtesy of Vulcan Painters Inc.

Maintenance, such as painting and sealing, on historic structures can pose many challenges—high traffic in the area, prominent placement as a landmark, finding the right rigging to safely clean and coat a 56-foot-tall Roman god.

These were just some of the difficulties to be faced when Vulcan Park & Museum and The City of Birmingham let a contract for two phases of maintenance on "Vulcan," the largest cast iron statue in the world, standing at 56 feet tall on top of a 124-foot 1938, WPA-era sandstone pedestal.

Phase one consisted of pre-cleaning, surface preparation, and application of a multi-coat stone and masonry sealant. Phase two consisted of surface preparation, spot repairs, and a refresher topcoat to the statue.

Freezing temperatures and wind in March delayed the application of coatings on the statue, so painters began the job by rigging, cleaning, and sealing the pedestal. Previously, the pedestal had been covered up with marble cladding for 30 years, but, during the previous renovation, the covering was removed to give the statue a more authentic look. The stone and mortar of the pedestal were more porous than anticipated, and water seeping through the pedestal damaged the inner staircase and marble lobby. A single-point suspension man basket was slowly dropped from rigging on the observation platform down each of the eight sides of the pedestal so that dirt and mold could be removed before sealing. Two wet-on-wet coats of sealer were applied under the guidance of the manufacturer's technical representative to ensure proper penetration. Window frames in the pedestal received surface preparation, caulking, and a two-coat paint system.

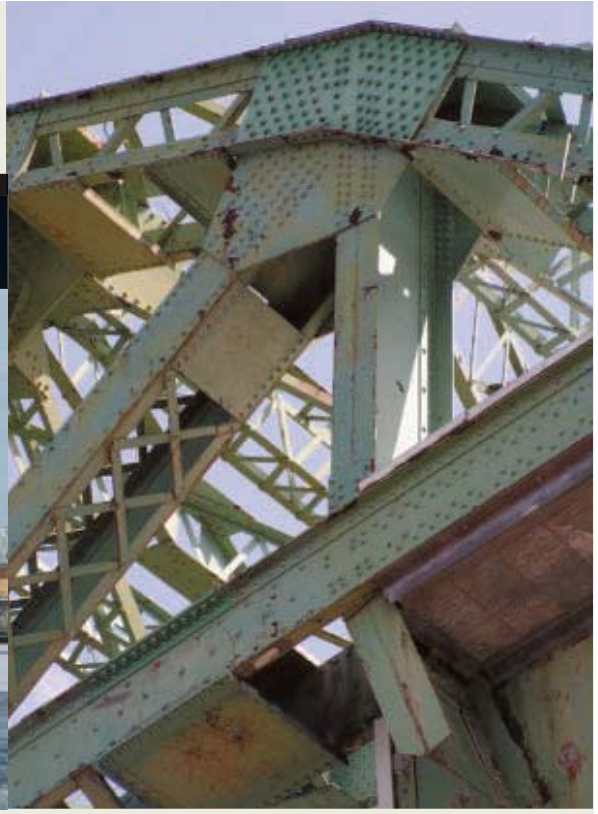
The statue was to be primed where paint was peeling and given a complete refresher coat. Painters had to work around the statue's demanding social schedule, including school field trips, company parties, and plentiful visitors. During the week, the observation platform was closed and the surrounding area roped off, but on weekends painters had to pack up all rigging, safety tape, drop cloths, and window protection so that visitors could enjoy the statue.

Some of the highest areas, such as Vulcan's outstretched arm and spear, required a little help from CraneWorks to get the refresher coat. Reaching these parts, which were coated last, was made possible with a 400-ton crane with 285 feet of boom and 114,000 pounds of counterweight. A suspended metal basket on the boom swung close enough to the statue that a painter could finish the job.

Location: Vulcan Park & Museum, Birmingham, AL
Structure Owner: City of Birmingham; Operated by Vulcan Park Foundation
Contractor/Applicator: Vulcan Painters (SSPC-QP 1, QP 2, QP 3, QP 8, QP 9, and QS 1)
Coating Material Supplier: SteelCon Coating Systems; Tnemec High Performance Coating Systems
Start Date: March 2010
Completion Date: June 2010

(l-r) Jeff Theo, President of Operations at Vulcan Painters, Inc., and Darlene Negrotto, President and CEO of Vulcan Park and Museum. Photo courtesy of SSPC.

George Campbell Award



La Salle Causeway Bridge

When one bridge is critical to transportation for the surrounding area, a watchful public can be just as big of an obstacle as weather and lead paint. Such was the case with the La Salle Causeway Bridge. Once the center of three rivet construction bridges over the Rideau Canal, it became the center of attention (and traffic) as the only one still remaining.

Originally built in 1917, the bridge is a Strauss trunnion bascule lift bridge that carries only one lane of traffic in each direction and is the only crossing point for the downtown area of Kingston. Specifications required the bridge to remain open to vehicle and pedestrian traffic with single lane closures permitted at night and one full closure allowed to coat the bearings and front structure. Scaffold access and environmental enclosures for all areas of the bridge were erected, in addition to a temporary tunnel hoarding and overhead roadway protection system.

Extensive specifications for the blasting and coating of 60,000 square feet of steel were prepared by McCormick Rankin Corporation, Consulting Engineers. Surface preparation required blasting to Near-White, SSPC SP-10, and the application of a Ministry of Transportation of Ontario-approved coating system. Previous coatings contained lead, which had to be fully removed.

The coating system consisted of an inorganic zinc primer suitable for application at low temperatures, an organic zinc primer in selected areas, an epoxy mid-coat, and an aliphatic polyurethane topcoat. Canadian winter conditions included temperatures as low as 14 F at night and 20 F during the day.

The project was divided into three phases: the underside of the bridge over water section, the upper structure above the roadway, and the counter weight structure. Project completion by deadline was crucial because hundreds of private craft and commercial vessels are stored in the harbor until weather permits the bridge to reopen, typically around mid-May. Failure to complete the project on time would have been costly to the contractor, who would have to remove all equipment from the site and remobilize the following year.

Location: Southern end of the Rideau Canal in the City of Kingston, Ontario, Canada
Structure Owner: Public Works and Government Services Canada (PWGSC)
Contractor/Applicator: Harrison-Muir, Inc., Ajax, Ontario, Canada
Coating Material Supplier: Carboline Canada
Start Date: November 2009
Completion Date: May 2010

(l-r) Bill Mogavero, VP of Operations, Harrison Muir, Inc.; Abbas Khan, Senior Civil Engineer, Public Works and Government Services Canada (PWGSC); Pedro Escudero, B. Eng., MBA, PCS Coating Specialist, Carboline Canada; Dan Orrett, PE, President, Harrison Muir.; and Jack Mills, PE Secretary and Chief Estimator, Harrison Muir, Inc. Photo courtesy of SSPC.

RINA Approves SSPC PCI Program

SSPC announced that RINA (Registro Italiano Navale), the 150-year-old ship classification society based in Genova, Italy, has approved SSPC's Protective Coatings Inspector (PCI) Program as equivalent to NACE Coating Inspector Level 2 and FROSIO Inspector Level III. This was effective as of January 15, 2011.

RINA is the third classification society to approve SSPC's PCI program, which was launched in 2007 and is an affordable, high-quality alternative to other inspector certifications.

"PCI has gained rapid acceptance in the coatings industry because it is a thorough and intensive program that prepares coatings inspectors to perform at a high level," stated Bill Shoup, SSPC's Executive Director. "RINA is the third major independent organization to audit PCI and verify that it meets the strict criteria of the IMO Performance Standard for Protective Coatings."

The PCI program is a one-week program designed to train individuals in the proper methods of inspecting surface preparation and the installation of industrial and marine protective coatings and lining systems on a wide variety of steel structures. Students who meet certain prerequisites are eligible to sit for the certification exam that is offered at the end of the program.

To gain RINA approval, the PCI program needed to meet the stringent criteria of Section 2.3 of IACS Procedural Requirement No. 34 (Corr.1 August 2009) and of PSPC 6 of IACS Unified Interpretation SC 223 (Rev.1 July 2010) concerning the qualification of the coating inspector referred to in paragraph 6.1.1 of IMO Resolution MSC.215(82). Procedural Requirement (PR) 34 addresses "Application of the IMO Performance Standard for Protective Coatings (PSPC)." Section 2 focuses on the procedure for assessment of coating inspectors' qualifications, with 2.3 specifically covering equivalent qualifications.

SSPC training and professional development programs have been certified by other independent agencies, such as the American Bureau of Shipping (ABS), Lloyd's Register, the International Association for Continuing Education and Training (IACET), and the American Institute of Architects (AIA).

Reminder: Board Nomination Deadline

The deadline to nominate candidates to fill three openings on the SSPC Board of Governors is April 25, 2011. SSPC is seeking nominations in the Coating Contractor, Coating Material Supplier, and Other Service Providers categories.

All nominees must be SSPC members. To nominate a candidate, submit a brief statement detailing the nominee's qualifications to: Attn: Bill Shoup, Executive Director, 40 24th Street, 6th Floor, Pittsburgh, PA 15222-4656; fax: 412-281-9992; email: shoup@sspc.org.

New SSPC Web Site Launches

SSPC launched a new web site on April 1. The address is still sspc.org, but old login information is no longer valid. If you have not received an email with instructions for updating your login information, contact SSPC. Features include easier member downloads, contractor searches, account management, and more.

associations

Navy Plans Mega Rust 2011

The American Society of Naval Engineers (ASNE) will present the annual Mega Rust 2011: U.S. Navy Corrosion Conference on June 6–9 in Norfolk, VA. The conference brings together government, military, owners, operators, shipyards, research facilities, and coatings manufacturers and suppliers.

Mega Rust is cosponsored by NAVSEA and the U.S. Fleet Forces Command. The annual event combines five annual meetings and conferences.

- U.S. Navy and Industry Corrosion Technology Exchange, "Rust" Conference
- Commander, U.S. Fleet Forces Command's Fleet Corrosion Control Forum
- Naval Shipyard Coatings Group Meeting
- USCG Coatings & Corrosion Control Tiger Team Meeting
- U.S. Navy Submarine Preservation Conference

Photo courtesy of VisitNorfolk

The Mega Rust conference provides a consolidated focus on Navy corrosion issues, which are a major factor in the readiness and total ownership cost of naval systems. The conference provides updated information on programs, policies, standards, and Fleet experience.

For information on events, technical presentations, exhibits, and more, visit www.navalengineers.org/events.

ASTM Debuts Concrete Profile Standard

ASTM's Industrial Protective Coatings subcommittee has developed a new standard for replicating and measuring concrete surface profiles.

ASTM D7682-10, "Standard Test Method for Replication and Measurement of Concrete Surface Profiles Using Replica Putty," describes how to obtain a permanent replica of the concrete surface, which can then be compared to visual profile standards or evaluated quantitatively for profile depth. A permanent replica may also prove useful in resolving future disputes.

ASTM says the new standard will be useful for coating inspectors, owners, contractors, coating manufacturers, and engineers.

The test method is suitable for both field and laboratory use. The procedure was developed for concrete substrates but may be appropriate for other rigid surfaces, according to ASTM.

This standard complements the use of the visual comparators called Concrete Surface Profiles (CSP) from the International Concrete Repair Institute (ICRI).

Visit www.astm.org for more information.

OSHA, NIOSH Release New Guidance on Testing Workers' Lung Function

The Occupational Safety and Health Administration (OSHA) and the National Institute for Occupational Safety and Health (NIOSH) have developed two guidance documents, one for workers and one for employers, on the use of spirometry testing to help reduce and prevent worker exposure to respiratory hazards.

Spirometry is a common pulmonary function test that measures how well a person moves air in and out of his or her lungs. The spirometry test may detect breathing problems or significant changes in a worker's lung function at

Continued

Call for 2012 Tess Award Nominations

The American Chemical Society's PMSE division is seeking nominations for the 2012 Roy W. Tess Award in Coatings. The award recognizes outstanding individual achievements and noteworthy contributions to coatings science, technology, and engineering.

The deadline for nominations is Sept. 1, 2011.

Nominations are welcome from all sectors of the industry, government, and academia. A form listing the preferred contents and format for nomination is available from Dr. Theodore Provder, chair of the Tess Award Committee.

Nominations can be sent to the Chair, Polymers and Coatings Consultants, 5645A Emerald Ridge Parkway, Solon, OH 44139; email: tprovder@att.net.

Each nomination will be considered during the next four award years.

associations

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JPCL SSPC The Society For Protective Coatings
Webinar Education Series

Webinar Explains How To Make Concrete Repairs Last

Peter Emmons, a foremost authority on concrete repair, will present a free SSPC/*JPCL* webinar entitled ***"Achieving Durability in Concrete Repairs"*** on May 11.

The webinar, presented at an introductory level, will focus on selecting and using repair materials for structural concrete, such as bridge piers, in a way that assures the durability of the repair.

Peter Emmons is CEO of Structural Group, the Baltimore-based company he founded in 1976. He is author of the book, *Concrete Repair and Maintenace Illustrated*; Past President of the International Concrete Repair Institute (ICRI); and a former Board member of the American Concrete Institute.

Sponsor:

BASF
The Chemical Company

Date:
May 11, 11:00 a.m.-Noon

Register at
paintsquare.com/education

an early stage. Information in the guidance documents assists employers with identifying and eliminating hazardous workplace exposures and with helping reduce or prevent the chances of workers developing lung disease.

According to OSHA, spirometry is the best available test for early detection of decreasing or abnormal lung function.

For more information, visit www.osha.gov.

companies

ITW Unites Four Brands

Spray and equipment manufacturer ITW has united its Binks, DeVilbiss, Ransburg, and BGK brands into one new operating unit, called ITW Finishing Equipment Americas.

The consolidation was made to take advantage of the synergies between the four groups, all of which are involved in developing and manufacturing equipment for the finishing industry.

The four companies previously operated and sold their equipment independent of one another. Binks manufactures spray guns, accessories, handling pumps, pressure tanks, and paint circulating systems. DeVilbiss makes products for industrial spray finishing. BGK manufactures infrared curing systems for liquid and powder finishing and supplies material handling systems. Ransburg manufactures liquid electrostatic painting and related electronic fluid handling equipment.

Mergers and Acquisitions Roundup

The following is a brief summary of mergers and acquisitions that have been reported on PaintSquare News (paintsquare.com) since the beginning of 2011.

• Evans Analytical Group Inc. (EAG) acquired Chemir Analytical Services and its affiliates CAS-MI Laboratories and Cyanta Analytical Services.

• Shaw Pipe Protection Limited, a subsidiary of ShawCor Ltd., has agreed to buy the coating assets and business of Altus Energy Services Partnership, Altus Energy Services Ltd., and Nusco Northern Manufacturing Ltd. Assuming court approval, the transaction should be completed April 6.

• Berkshire Hathaway Inc. is acquiring specialty chemical maker Lubrizol Corp. The transaction should be completed by the third quarter of 2011.

• The Valspar Corp. announced that is has acquired Brazilian coatings maker Isocoat Tintas e Vernizes Ltda.

• BASF is selling its Surface Technologies business to Curtiss-Wright Corp.

• Elcometer Limited announced the acquisition of Dakota Ultrasonics, Inc. Terms were not disclosed.

products

Paint Stripper Has VOC-Free Formula

Solvent Kleene Inc. (Peabody, MA) has introduced a zero-VOC stripper designed to remove organic paints, varnish, mil-spec CARC paints, cured powder coatings, multi-layer coatings, and E-coatings from ferrous and non-ferrous metals, plastic, and silicon substrates.

D-Zolve 917 is designed for energy-efficient use at low temperatures, is non-flammable, and contains no ozone-depleting components or carcinogenic compounds, the manufacturer says.

Used in an immersion tank, it penetrates coatings to break the bond with the substrate, causing the paint to delaminate from the substrate and drop to the bottom of the tank.

Visit www.solventkleene.com.

Polyurea Boasts Chemical Resistance

Ultimate Linings has introduced a fast-setting, 100% solids, two-component

spray polyurea for a variety of industrial concrete and metal applications.

The company calls UL KG 8012 a rapid-curing, flexible, aliphatic, color-stable coating with a fast gel time that makes it suitable for applications down to 20 F.

The coating may be applied in single or multiple applications without appreciable sagging and is relatively insensitive to moisture and temperature, allowing application in most temperatures, the manufacturer says.

KG 8012 comes in Clear and Neutral, with custom colors available upon request. According to the manufacturer, the coating is odorless, has no toxic vapors, has no VOCs, and has excellent thermal stability.

Go to www.ultimatelinings.com for more information.

Elcometer Revamps DFT Gauges

Elcometer has introduced the next generation of its 456 digital coating thickness gauge, with a range of models designed to be more powerful and easier to use.

The company promises repeatable, reproducible measurements up to 30 mm (1200 mils) of coating on metal substrates.

The new line includes improvements in the units' visual display, ease of operation, ruggedness, measuring speed, and memory capacity, according to Elcometer. A range of models is available for measuring dry film thickness on ferrous and non-ferrous metal substrates.

For more information, visit www.elcometer456.com.

Hull Coating Helps Save Fuel

Jotun has wrapped its premium SeaQuantum X200 marine coating into a new service and technical support package that includes performance measurement tools and a guarantee.

The package is called Jotun Hull Performance Solutions.

The silyl acrylate, self-polishing antifouling SeaQuantum line was developed to reduce film thickness through hydrolysis, Jotun says. SeaQuantum X200 is based on silyl methacrylate binder technology.

With the measurement and analysis system, customers install sensors to measure shaft power, vessel speed, wind, and draft. Once the data are collected, Jotun can plot the speed deviation relative to the vessel's speed performance after dry-dock. A long-trend analysis of the hull performance provides a reliable statistical foundation for a high-performance guarantee for the coating, the company says.

Continued

For more information, visit jotun.com/hps.

Proceq Unveils Moisture Meter

Swiss testing instrument maker Proceq has added the Hygropin Moisture Meter to its family of concrete testing instruments.

Proceq says Hygropin is the only moisture meter to use both in-situ and ambient probes simultaneously, a combination that offers interior measurement of relative humidity and concrete temperature. The in-situ technique measures moisture below the surface.

The in-situ probe has a diameter of 5 mm, minimizing potential damage to the concrete surface, the manufacturer says. The in-situ reading is available within five minutes. The ambient probe is directly connected to the instrument, which displays results of the two independent sensor channels simultaneously.

The instrument also calculates psychrometric parameters and the difference between the values measured by the two probes.

Trend indicators show when stable temperature and humidity values are reached, and the unit allows up to 10,000 logs. The unit also has a USB interface and carries a two-year warranty.

More information: www.proceq.com.

SATA Debuts Lighter, Smaller Spray Gun

German spray equipment manufacturer SATA has introduced the SATAjet 4000 B spray gun—smaller and lighter than its predecessor.

The gun replaces SATA's 3000 B model.

SATA has redesigned the gun handle and lowered the center of gravity to improve the gun's balance and minimize wrist strain. The 4000 B is 15% lighter than its predecessor, with an integrated digital pressure gauge and RPS disposable cup.

Control elements have been redesigned with a profile that allows adjustment even when wearing gloves. The round/flat spray control has also been revamped, so that only one quarter turn is required to close the gun. The spray fan can also be precisely tuned to the shape of the object to be painted.

A trigger cover element protects the paint needle from overspray, increasing the lifetime of the needle packing, while self-tensioning paint needle and air piston packings minimize maintenance and

repairs, the company says.

Like its predecessor, the 4000 B has a Quick Cup Connector with bayonet for a quick, clean cup change. The air cap thread has been shortened. The air cap is made of chrome-plated brass; the fluid tip and paint needle are stainless steel.

More information: www.sata.com.

Diesel Power Now Offers Doosan

Diesel Power Equipment Company Inc. (Omaha, NE) has expanded its portfolio to offer the full mobile generator line from Doosan Portable Power.

Diesel is a full-service company providing sales and rental of standby and mobile power generation systems ranging from 7 to 1,500 kW. The addition of Doosan mobile generation ranges from 25 kVA to 570 kVA.

Visit www.dieselpower.com for more information.

New Lights Are Explosion-Proof

Larson Electronics' Magnalight.com announced the addition of the EPL-TP-1x150LED-100 tripod-mounted, explosion-proof LED light.

The portable light provides 8,000 sq ft of area coverage with 10,000 lumens of light output, the company says. The light head offers 360-degree rotation and a 90-degree tilt. The company says that the LEDs are rated at 60,000 hours of life.

The company also recently added the EPL-16C-1MLED-100 cart-mounted LED tank light. The light produces 10,000 lumens of light in wide flood patterns, and has a removable 16-inch LED light head and wheeled non-sparking aluminum cart, the company says.

Visit www.magnalight.com.

Gas Detector Made for Confined Space

Industrial Scientific (Oakdale, PA) introduced the Ventis MX4 multi-gas detector, a lightweight, configurable instrument that detects up to four gases.

The unit is designed for confined-space monitoring and personal monitoring in potentially hazardous environments.

The detector can draw samples from up to 100 feet with the integral pump, the company says. The unit alerts users with an audible alarm, visual LED alarms, and a vibrating alarm.

Visit www.indsci.com.

New Coating Adheres to Rust

CETCO Corrosion Protection Solutions (Hoffman Estates, IL) has introduced a

Continued

new line of water-based, zero-VOC protective coatings designed to adhere directly to rust and suitable for application in confined spaces.

The new Perlastic line is formulated for industrial applications, with an asphalt-based formula that can be applied to most substrates, the company says. The spray grade (SG) is a two-part, spray-applied elastomeric membrane engineered to halt corrosion/chemical attack and is formulated for use as a corrosion protection barrier, tank lining, secondary containment, or equipment protective coating, according to the company.

The single-component roller grade (RG) is a thick, brushable coating used alone or with the spray grade. The company says it can be applied directly to a prepared, but not rusted, surface and to previously coated areas.

The trowel grade (TG) is a thick, trowelable coating used alone or with the SG or RG. This coating is best used for filling cracks and repairing bugholes, the company says.

More information: corrosionprotection.cetco.com

3D Portable Profilometer Now Available

Nanovea has announced the release of the Jr25, 3D Non Contact Portable Profilometer, a high performance profilometer that measures a wide range of materials and geometries.

The product has an optional battery pack and carrying case and is designed to use optical pens with white light axial chromatism measurement. According to the company, surfaces of almost any type can be measured regardless of how reflective/non-reflective, transparent, or diffusive the material is. A fully rotational, single axis head allows for measuring at difficult angles.

For more information, visit www.nanovea.com.

International Introduces New Epoxy

International Paint has introduced Interline®9001, a new bimodal epoxy coating for the cargo tanks of chemical tankers.

The coating is designed to deliver greater efficiency and flexibility in the operation of chemical tankers by allowing an easy switch from one cargo to the next with minimal downtime, according to the company. The coating has a low cargo absorption profile to reduce the risk of contamination and, the company says, can cut cleaning time by up to 70%.

Visit www.international-marine.com for more information.

Denso Releases New Pipeline Protection

Denso has just released a new line of protection for pipeline coatings called Rock Shield. The product is a protective diamond mesh manufactured from polyethylene.

The company says it can protect pipelines that are constructed through rocky terrain, and the company can provide rolls in length of 100 feet or custom pads. It is manufactured to withstand extreme weather conditions and temperatures.

Both standard duty and heavy-duty versions are available. Visit www.densona.com for more information.

Want More News?

To receive up-to-date industry news Monday to Friday, sign up for the *PaintSquare News* enewsletter. Visit paintsquare.com or use the scanner on your smartphone to capture this barcode.

Got More News?

If you have news about associations, companies, or products for the protective and marine coatings industry, send items to

- Mary Chollet, Editor, *PaintSquare News*, mchollet@paintsquare.com, and
- Karen Kapsanis, Editor, *JPCL*, kkapsanis@protectivecoatings.com.

Thermico Wins Tridge Staining and Painting Project

Thermico, Inc. (Midland, MI) secured a contract of $48,880 from the city of Midland to stain wood surfaces and coat structural steel on the Tridge, a three-way pedestrian bridge over the confluence of the Chippewa and Titabawassee Rivers in downtown Midland. The Tridge was built in 1981 at a cost of $732,000. The majority of the wood, except walking surfaces and concealed underside surfaces, will be stained with a semi-transparent alkyd-based finish. Select steel elements will be coated with an epoxy primer and a urethane gloss enamel finish. The project requires precautionary measures to prevent debris, surface preparation waste, stain, and coatings from entering the rivers. The spill prevention plan also prohibits spray application of the stain and coatings.

Coatings Unlimited to Recoat Filtration Plant Dredge

Coatings Unlimited, Inc. (Kent, WA) secured a contract of $32,308.50 from the city of Everett, WA, to perform coatings work on a 28-foot-long by 9-foot-wide dredge that is used at a water filtration plant. The project will be performed at the contractor's shop or an environmentally controlled temporary structure at the plant. Approximately 900 square feet of metal dredge components, including pontoons, underwater metal, walking surfaces, and engine covers will be refinished with an elastomeric polyurethane system.

TarTob Awarded Park Coating Project

The town of Addison, TX, awarded a $16,785 agreement to TarTob Commercial/Industrial Services (Rockwall, TX) to perform six small coating projects at five park sites, including select support arms on the "Blueprints" sculpture. The sculpture, which was created using over 400,000 pounds of steel, adorns a roundabout in the center of Addison Circle, a new mixed-use development. The vase-like structure, which is finished in a specially blended "Sharpie Blue" color, features five blueprint traceries of phases in the town's development. The project involves coating the support arms, metal fencing on a trail and at a dog park, handrails, light poles, and other miscellaneous metalwork with an epoxy-acrylic polyurethane system.

Photo courtesy of Addison, TX

New Jersey DOT Awards $11.7M for Bridge Painting

The New Jersey Department of Transportation awarded two bridge painting projects with a combined total of over $11.7 million. Anka Painting Company (Palisades Park, NJ), SSPC-QP 1- and QP 2-certified, won a contract of $7,327,000 to recoat 18 bridges in Essex and Passaic Counties, while Allied Painting, Inc. (Franklinville, NJ), SSPC-QP 1- and QP 2-certified, secured a contract of $4,431,723.10 to recoat six bridges in Bergen County. Both contracts include removal of lead-bearing coatings with a Near-White blast (SSPC-SP 10) in Class 1A containment structures (SSPC-Guide 6), prior to application of a zinc-rich primer, a high-build epoxy intermediate, and a urethane finish. The contracts, which required SSPC-QP 2 certification, include pro-

Continued

viding a NACE Level 1 inspector as part of the quality control plans.

Amstar Wins Two NYS Bridge Jobs

Amstar of Western New York, Inc. (Cheektowaga, NY), SSPC-QP 1- and QP 2-certified, signed two agreements with the New York State Department of Transportation to recoat a total of nine bridges. Amstar was awarded a contract of $1,600,000 for four bridges in Delaware County and a contract of $1,260,000 for five bridges in Broome County. Both contracts involve Near-White (SSPC-SP 10) blast cleaning and zinc-epoxy-urethane coating application, which will be performed within Class A containment structures.

Massachusetts DOT Lets Bridge Painting Project

The Massachusetts DOT awarded a contract of $2,391,060 to Prime Coatings, Inc. (Salisbury, MA), SSPC-QP 1- and QP 2-certified, to recoat three bridges in Newburyport. The steel will be abrasive blast cleaned to a Near-White finish (SSPC-SP 10) and recoated with a organic zinc-epoxy-urethane system selected from NEPCOAT List B. The existing coatings are presumed to contain lead; the work includes erecting containment according to SSPC-Guide 6 and disposing of waste according to SSPC-Guide 7.

Clemson Awards Stadium Waterproofing

Photo of Clemson University

Clemson University awarded a contract of $927,300 to Volunteer Restoration (Knoxville, TN) to apply a waterproofing coating to concrete surfaces inside Memorial Stadium. The 80,000-person-capacity football stadium was built in 1942 and has acquired the welcoming nickname of "Death Valley." The project entails removing seating and recoating interior concrete, including the lower bowl, stairs, and walkways. The concrete will be prepared by water, abrasive, or shot blast cleaning before refinishing with a three-coat, moisture-cured urethane pedestrian traffic coating, with skid-resistant aggregate incorporated in the intermediate coat. The project will be completed by August 4, allowing time to prepare for the Tigers' season opener less than a month later.

Hi-Tech Industrial Coatings Wins Shop-Painting Bid

Photo courtesy of WDFW

Hi-Tech Industrial Coatings, Inc. (Parker, WA) was awarded a contract of $14,646 by the Washington State Department of Fish and Wildlife to pick-up, shop-coat, and deliver three drum screens that are used by the Westland Irrigation District for fish screening. The six-foot-diameter by twelve-foot-long screen components, which were disassembled for storage at the department's Yakima shop, will be abrasive blast cleaned to a Near-White finish (SSPC-SP 10) and coated with a high-build epoxy system.

Ahern Awarded Viaduct Rehabilitation

Ahern Painting Contractors, Inc. (Woodside, NY), SSPC-QP 1- and QP 2-certified, was awarded a contract by the New York State Thruway Authority for steel repairs and coatings application on the New England Viaduct, a 2,640-foot-long bridge in Westchester County. The contract, which is valued at $2,654,321, includes over-coating the superstructure. The steel will be pressure-washed, spot-power-tool-cleaned to Bare Metal (SSPC-SP 11), spot-primed with organic zinc, and over-coated with an epoxy intermediate and a polyurethane finish. The surface preparation will require localized containment of lead-bearing paint.

Anderson & Associates Secures Standpipe Engineering Work

Anderson & Associates Construction, Inc. (Blacksburg, VA) signed a professional services agreement with the town of Christiansburg, VA, to perform inspection and design services for the planned rehabilitation of a 500,000-gallon standpipe. The owner anticipates the project will entail interior and exterior coatings and various repairs, based on recommendations by Liquid Engineering Corp. (Billings, MT), which completed an in-service inspection in May 2009. The contract includes conducting additional assessments, designing contract documents, providing contract administration assistance, and performing inspection services for the renovation of the 38-foot-diameter by 65-foot-high standpipe.

JPCL

COMING UP

Courses

April 19-20 SSPC Floor Coatings, Cincinnati, OH, www.sspc.org

April 19-20 SSPC C14 Marine, Hawaii, www.sspc.org

April 21-22 SSPC C12 Airless Spray, Hawaii, www.sspc.org

April 29 EMU Understanding Ctg Raw Materials, Ypsilanti, MI, www.emich.edu/cri

May 1-6 SSPC PCI Prot Ctgs Insp, Cairo, Egypt, www.sspc.org

May 2-3 SSPC QCS Qual Cntrl Spvr, Port Orchard, WA, www.sspc.org

May 2-6 SSPC C1 Fundamentals of Ctgs, Rochester, NY, www.sspc.org

May 3-4 SSPC Floor Coatings, Atlanta, GA, www.sspc.org

May 4-5 SSPC ATT Train-the-Trainer, Port Orchard, WA, www.sspc.org

May 4-5 EMU Basics of Polyurethane Ctgs, Ypsilanti, MI, www.emich.edu/cri

May 6 SSPC CAS Ctg App Spclst, Port Orchard, WA, www.sspc.org

May 9-13 MS&T Intro to Paint Formulation, Rolla, MO, www.coatings.mst.edu

May 11 SSPC/*JPCL* Webinar Concrete Repairs, www.paintsquare.com/education

May 12 SSPC Using PA2, Houston, TX, www.sspc.org

May 13 SSPC Thermal Spray, Houston, TX, www.sspc.org

May 14 SSPC C7 Abrasive Blast, Chesapeake, VA, www.sspc.org

May 14-18 SSPC C1 Fundamentals of Ctgs, Saudi Arabia

Meetings

April 19-21 FHWA 2011 Pacific Northwest Bridge Inspection Conf, Portland, OR, www.fhwa.dot.gov/bridge

April 21 SEAOI 8th Annual Midwest Bridge Symp, Chicago, IL, www.seaoi.org/about.htm

May 1-6 ECS Spring Meeting, Montreal, Quebec, www.electrochem.org

May 2-6 AASHTO Spring Meeting, Las Vegas, NV, www.transportation.org

May 1-4 TAPPI PaperCon Conf, Covington, KY, www.tappi.org

May 3-5 Western States Corrosion Seminar, Pomona, CA, www.westernstatescorrosion.org

May 10-12 Electric Power 2011, Rosemont, IL, www.electricpowerexpo.com

May 11 AISC NASCC Steel Conf, Pittsburgh, PA, www.aisc.org

May 11-12 ASTM Mtgs F06 Resilient Flr Cvr, Clearwater, FL, www.astm.org

May 11-13 SF Expo China + Coat Expo China, Guangzhou, www.sf-expo.cn

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