A Few November Thoughts

By the time you read this editorial, we citizens of the U.S. will have elected our 44th President. I hope the President-elect will have the leadership, character, and vision to begin to solve some of this country's major issues such as the economy, health care, the deficit, immigration, and foreign policy. As a citizen and representative of your coatings association, I worry about our aging infrastructure and what the federal, state, and local governments are going to do to begin to fix this major problem.

I recently mentioned to someone in the office that I did not understand why someone would want to be the President of the United States, with all the pressure and responsibility of the Office. Riding in Air Force One and living in the White House cannot make up for the pressure of the job and the scrutiny that the President and his or her family would have to endure. If you compare an official photo of a President when taking office with a photo of him after leaving office, you will see a significant change. I am thankful that there are people willing to be public servants and that I live in a country where this process is done peacefully rather than by force.

I have leadership on my mind because of the election and because I recently read Lee Iacocca's book, *Where Have All the Leaders Gone?* The author is well known for his revival of the Chrysler Corporation. While you may not agree with the title, the book is quite thought provoking. Much of the book is devoted to the "Nine C's" that Iacocca thinks a good leader must have: curiosity, creativity, communication, character, courage, conviction, charisma, competence, and common sense. He writes that we no longer have good leaders in Congress and the White House. He made it clear that he gets angry when he hears politicians say, "Stay the course." In an excerpt from the book, he writes, "Stay the course? You've got to be kidding. This is America, not the damned Titanic. I'll give you a sound bite: Throw the bums out!"

I hope that the President-elect has a majority of Iacocca's C's and will be an outstanding leader who will try to bring folks together in a true bi-partisan manner to solve the problems I mentioned above.

I am sure you are looking forward to celebrating Thanksgiving. I hope you are able to spend it with friends and family and have the opportunity to reflect on all those things that we all should be grateful for. Personally, I have a lot to be thankful for, and I sometimes forget that fact when things at SSPC or at home do not go as planned.

My last thought is a sad one. Recently, SSPC lost a friend in Scott Blackburn, who was the National Sales Manager for Clemco before his retirement. He had served on the SSPC Board and had also contributed his time, expertise, and effort many years ago to the development of our Abrasive Blasting Program (C-7). After Scott left the board, we maintained contact, sharing e-mails, mostly about golf. He was originally from the Pittsburgh area, and he had contacted me to get course recommendations before he came back to the area to play golf with a couple of high school friends. He passed away while on the links with those close friends. Scott was a great person, and I already miss sharing e-mails with him. My thoughts and prayers go out to Scott's wife, Shirley, and his entire family. I am thankful that I knew him and am a better person because of his kindness and friendship.

Bill Shoup
Executive Director, SSPC

Obituary: S. John "Jack" Oechsle, Jr., P.E.

S. John "Jack" Oechsle, Jr., P.E., passed away on September 21, 2008, at the age of 83. A mentor and friend to many in the corrosion field, Mr. Oechsle was born and raised in Philadelphia, PA. He began his career in corrosion as early as junior high, working with his father at Metalweld, Inc., a high quality coating/lining application company. He enlisted in the U.S. Air Force and was in pilot training from 1944 to 1945. After the war ended, Mr. Oechsle attended college from 1945 to 1947. From 1947 to 1985, he served as president of Metalweld, and he was on the Board of Directors from 1985 to 1988. He was president of Surface Protection Engineering Consultants from 1985 to 1988, and then joined S.G. Pinney & Associates as a senior associate at the Port St. Lucie, FL, home office.

Mr. Oechsle was active in many organizations. He was a member of SSPC and active in its committee work. He belonged to AWS (American Welding Society), NACE, The Young Presidents Organization, The Air Force Organization, and the Metco System Contractors Association. Extremely active with NACE International, he chaired 19 of its committees and task groups. He also held several positions with ASTM, including membership in ASTM D 33, Coatings for the Power Generation Industry. In addition, he served on the Technical Advisory Group with ISO (International Organization for Standardization). Mr. Oechsle was also a founding member of the National Board of Registration for Nuclear Coating Engineers and Specialists and was a certified nuclear coating engineer.

Mr. Oechsle presented 61 lectures or addresses on subjects about good coating and lining practices with topics ranging from ship painting, metallizing, FRP pipe and lining to rubber lining and painting of nuclear power plants. He was also the author of 11 technical papers.

S. John Oechsle

Mr. Oechsle will be missed greatly by his friends, family, and those in the corrosion industry. He leaves behind his wife of 35 years, Mary Jane; four children; two siblings; and 15 grandchildren.

New ASTM Standard Will Help Visual Inspection

ASTM International has developed a new standard, E2630, "Test Method for Luminance Ratio of a Fluorescent Specimen Using a Narrow Band Source." A request from the U.S. Navy was the driving force behind the new standard, and Subcommittee E12.05 on Fluorescence, part of ASTM International Committee E12 on Color and Appearance, developed it.

The Navy was looking for improved visual inspection techniques to prevent corrosion on newly painted shipboard tanks, according to Richard Harold, a consultant for Color and Appearance Consulting, LLC and the chairman of Committee E12.

In addition to helping the U.S. Navy, ASTM E2630 will be useful to the U.S. Department of Transportation, the Federal Highways Commission, companies manufacturing paint for corrosion control, and other organizations.

Participation in Subcommittee E12.05 from paint and flashlight companies and suppliers, asset owners, and others is welcome. For membership information, contact Thomas O'Toole at 510-832-9739 or totoole@astm.org. Technical information can be directed to Richard Harold, 571-926-9434 or rwharold@worldnet.att.net.

New Coatings Consulting Firm Created

Kaked LLC is a new coatings consulting firm in Elmhurst, IL, that was formed to provide coating failure analysis, coating condition surveys, coating selection, laboratory and field research, specification development, training, and expert witness services. The company will assist paint manufacturers, contractors, facility owners, and paint distributors in the industrial and architectural coating markets.

Tim Race

Tim Race, founder and owner of Kaked, has been an active member of SSPC since 1986. He serves on the Standards Review Committee as well as several others. Race is also a member of the Federation of Societies for Coatings Technology, NACE International, and the American Chemical Society. He has written for *JPCL* and other journals. To reach the new company, call 630-247-5936 or email tracekaked@gmail.com.

Feldstein Receives Volunteer Award

Joseph Feldstein, the manager of MSA's fall protection technical services, was awarded the ASSE (American Society of Safety Engineers) Charles V. Culbertson Award for Outstanding Volunteer Service in 2007-2008. Mr. Feldstein is being recognized for his work on the ANSI Z359-2007 Fall Protection Code and his service since 1999 as chairman of the U.S. Technical Advisory Group to ISO TC94/SC4.

Joseph Feldstein (right) receives his award from presenter James D. Smith

Mr. Feldstein has 18 years of experience in fall protection product design and standards development, according to MSA. He has been published in over 15 publications, including *JPCL*. He holds a patent for the curvilinear design feature, currently being used in a full-body harness for fall arrest.

The ASSE has presented this award to 111 select members in the past 25 years, recognizing them for volunteer service that has helped advance occupational safety, health, and environmental profession.

AkzoNobel Science Award Presented

AkzoNobel (Strawinskylaan, Amsterdam) presented this year's Science Award to Professor Martien Cohen Stuart in Haarlem, Netherlands. Professor Cohen Stuart is renowned for his work in the physical chemistry of soft condensed matter, which deals with understanding how molecules organize themselves to give materials specific properties, such as softness, elasticity, or transparency. He has been widely recognized for his ability to convert discoveries into innovations. AkzoNobel board member Leif Darner presented the award and gave a speech on the importance of technology and science to AkzoNobel. The company manufactures coatings, paints, and specialty chemicals.

Martien Cohen Stuart

Nordson Acquires Assets of Swiss Company

Nordson Corporation (Westlake, OH) has acquired the assets of Wachter, Paul and Co. (Vilters, Switzerland), the operator of Bigger Dosier Klebetechnik. The company has been distributing Nordson's EFD brand product line for 40 years and will become part of Nordson's subsidiary Nordson (Schwiez) AG. Terms of the deal were not disclosed.

Nordson produces dispensing equipment that applies adhesives, sealants, and coatings, as well as equipment used in testing electrical components.

EPA Cuts Allowable Airborne Lead Level

The Environmental Protection Agency (EPA) announced that it has dramatically strengthened the nation's air quality standards for lead to improve public health protection, especially for children. The new standards tighten the allowable lead level 10 times, from the current 1.5 micrograms of lead per cubic meter of air (μg/m^3) to 0.15 μg/m^3. The announcement came October 16, 2008.

EPA's action sets two standards: a primary standard at 0.15 μg/m^3 to protect health and a secondary standard at the same level to protect the public welfare, including the environment. The previous standards were set in 1978.

The existing monitoring network for lead is not sufficient to determine whether many areas of the country would meet the revised standards. EPA is redesigning the nation's lead monitoring network, which is necessary for the agency to assess compliance with the new standard.

No later than October 2011, EPA will designate areas that must take additional steps to reduce lead air emissions. States have five years to meet these new standards after designations take effect.

Lead can be inhaled or can be ingested after settling out of the air. Once in the body, lead can affect many organ systems.

Lead emissions have dropped nearly 97% nationwide since 1980, largely the result of the agency's phase-out of lead in gasoline. Lead in the air comes from a variety of sources, including smelters, iron and steel foundries, removal of old paint, and general aviation gasoline. More than 1,300 tons of lead are emitted to the air each year, according to EPA's most recent estimates.

For more information, visit www.epa.gov/air/lead.

Covering the Peaks of a Profile

I was taught that at least 4 mils of primer are needed to cover the peaks of a three-mil profile, but I also see specifications for primer thicknesses of 2 to 4 mils. Is this a mistake? If 2 mils of primer are applied to a three-mil profile, will the peaks of the profile be exposed?

John Fletcher, Elcometer, UK

There are a number of issues raised by this question.

With modern primers, it is possible to obtain conformal coating properties so that the primer flows evenly over the surface and follows closely the surface profile of the substrate, giving an even coating over the peaks and valleys.

Some primers flow down the peaks into the valleys, leaving less on the peaks but still providing some protection.

Some thick-build primers completely cover the rough surface well above the peaks but shrink as they dry, leaving a smooth surface only slightly above the peaks while filling the valleys.

A paint chemist designs the primer to behave in a particular way and sets the parameters to achieve this performance. The applicator should follow this recommendation closely.

A wet film comb can be used to measure the thickness of a freshly applied primer over the peaks (if the solvent is slow to evaporate). But the more dynamic primers will probably move around before drying, making it difficult to estimate dry film thickness (DFT) based on a wet film measurement.

For DFT measurement, the guidance is that films with a thickness equal to or less than the profile height cannot be measured reliably with coating thickness gauges. For example, see ISO 19840 (Paints and Varnishes—Corrosion protection of steel structures by protective paint systems—Measurement of, and acceptance criteria for, the thickness of dry films on rough surfaces). The only way to get accurate thickness measurements in these circumstances is to spray a smooth steel test panel alongside the profiled steel and mea-

sure the test panel. This method has been used successfully with adhesives sprayed on blast-cleaned profiles.

This prompts the question: What did the designer mean by the specification of 2–4 mils on a three-mil profile? Is this the thickness of the coating over the peaks, which means that when measuring with a DFT gauge that uses the electromagnetic induction principle, the uncorrected reading will be 3–5 mils? (The correction value for a three-mil profile for a gauge adjusted for measurement on a smooth surface is 1 mil, so to get a corrected value, the operator must subtract 1 mil from the reading. Some gauges can do this automatically.)

For the case in the question, I have concerns that the designer has not made the link between the recommended DFT in the paint manufacturer's technical data sheet, probably based on tests carried out on smooth steel test panels, and the profile specified elsewhere for the structure.

Ken Trimber, KTA-Tator, Inc., U.S.

I am not familiar with recommendations that a minimum of 4 mils of primer must be applied to cover a three-mil profile.

When priming blast-cleaned steel, apply enough material to fill the profile and provide the specified thickness above the peaks of the profile. For example, if the specification requires 2–4 mils of primer and the profile is 3 mils, the contractor must apply a sufficient volume of material to completely fill the profile, plus yield 2–4 mils (DFT) above the peaks.

Traditional non-destructive DFT gages read to a point somewhere below the tops of the peaks, but that "distance" is accounted for during the accuracy verification process that is established in SSPC-PA 2, Measurement of Dry Coating Thickness with Magnetic Gages. If the instrument is used per SSPC-PA 2, and the DFT of the primer is measured at 2–4 mils, it means that there are 2–4 mils of primer above the peaks of the profile, irrespective of the profile depth.

Note, however, that as the surface profile becomes deeper, there is a greater likelihood that higher rogue peaks could be present. As a result, for some primers, the manufacturer might recommend increasing the DFT by a mil or two to make certain the random peaks are adequately covered. When you encounter surface profile/DFT conditions outside the published product data sheets, consult the manufacturer for guidance.

Ken Trimber's bio can be found of p. 22 of this issue.

John Fletcher is Elcometer's technical support manager. As a member of CEN/TC139/SC1 Working Group 2, he was instrumental in developing a method for testing and reporting coating thickness for painted structures.

Ballast Tank Test Yields Long-Service Epoxy

By Brian Goldie, JPCL

The Swiss-based Allseas Group S.A., an offshore pipe laying and subsea construction company, operates specialized vessels, including the largest pipe laying vessel in the world, PLV Solitaire (Fig. 1). In 1999, when the coating system in the Solitaire's seawater ballast tanks needed replacing, Allseas decided to carry out patch tests and, as a result, selected a solvent-free epoxy system as the replacement. The coating selected through the testing is still performing well after eight years.

How the Test Was Done

A specialist contractor was commissioned to prepare the No. 7 port double-bottom tank for this trial by hydroblasting the tank while the vessel was afloat. Using a pressure of 10,000 psi (approximately 700 bar), the loose coating and corrosion were removed, leaving a rough steel surface of approximately HB 2 quality (International Paint's Standard, Thorough Hydroblast Cleaning). The contractor cleaned the tank with fresh water, removed all debris, and dried the tank using dehumidifiers. Then, the contractor applied seven coating test patches (conventional and 100% solids coatings) from various paint suppliers.

To aid the application of the solvent-free epoxy system by airless spray, the contractor designed an electrically heated portable water bath to keep the paint components at 25 C (77 F) before application. One coat of primer was applied at 100 µm dry film thickness (dft), followed by a stripe coat of topcoat at critical areas. The topcoat was then applied at 200 µm dft. Control of the application thickness was based on the volume of paint applied.

Epoxy System Gets Green Light

The test patches were examined after about six months, and the condition of the solvent-free epoxy system was found to be very good, compared to the other products tested. As a result, all water ballast tanks and void spaces of PLV Solitaire were coated with this system. A contractor-supplied riding crew carried out the work during voyages while the vessel was in full production. Surface preparation and coating application were carried out exactly as in the trial. The coated tanks were again inspected in May 2002, after 40 months in service, and found to be in good condition. As a result, Lloyd's Register decided to extend the yearly tank inspections to a cycle of two and one-half years.

Fig. 2: The 100% solids coating can penetrate crevices formed from tightly adherent rust and old coatings. Courtesy of Van Zonderen Offshore

Properties Found in the Solvent-Free System

Out of the seven patches tested, the solvent-free epoxy system performed the best. According to its manufacturer, conventional epoxies have a pigment volume concentration (PVC) of at least 35%, and their use of fillers and extenders makes them inflexible in service. When placed under stress, these epoxies can crack. In the solvent-free epoxy system, the primer has a PVC of less than 2%, and the topcoat's PVC is less than 12%, making the system more flexible, which was confirmed by a study carried out by DNV.[1]

Fig. 1: PLV Solitaire Courtesy of Allseas Group

According to the manufacturer, the primer has a hydrophilic additive that can accommodate incidental amounts of water, so that it easily wets out most surfaces and penetrates crevices formed from tightly adhering rust and old coatings (Fig. 2). The primer has a low inert content and is semi-transparent. During application, an even, greenish color indicates complete penetration and cover. (The low PVC also means that the primer is transparent until a dft of greater than 15 µm is achieved.)

The primer's flexibility and low shrinkage on curing allows it to resist impact damage common to conventional epoxies, said the manufacturer.

The 100% solids topcoat is also specifically formulated to be permanently flexible as well as resistant to chemicals, heat, and abrasion, according to the manufacturer. Suited primarily for seawater ballast tanks and potable water tanks onboard ship, the topcoat can be used in new building over most shop primers after sweep blasting and one coat of the epoxy primer. It is, however, in maintenance situations where the topcoat outperforms other systems, the manufacturer claims. It is compatible with hard and semi-hard coatings, is surface tolerant, and is UL/NSF Standard 61-certified for potable water use. The topcoat is transparent up to a dft of 150 µm, thus ensuring proper application.

Fig. 3: Solvent-free epoxy after 8 years in service Courtesy of Van Zonderen Offshore

Performance To Date

The PLV Solitaire was last inspected in September 2007 after some tanks had been coated for more than eight years. The tanks were found to be in better than good condition (Fig. 3), as defined in the latest IMO regulations relating to seawater ballast tanks (Performance Standard for Protective Coatings, IMO MSC 215 (82)). Only minor coating repair was necessary in some tanks. This performance is excellent, considering that all the work was done with riding crews, and is in part due to the professionalism of the contractor, the coating manufacturer says. Allseas has confirmed that it is satisfied with the use of the solvent-free epoxy system in the ballast tanks of the Solitaire.

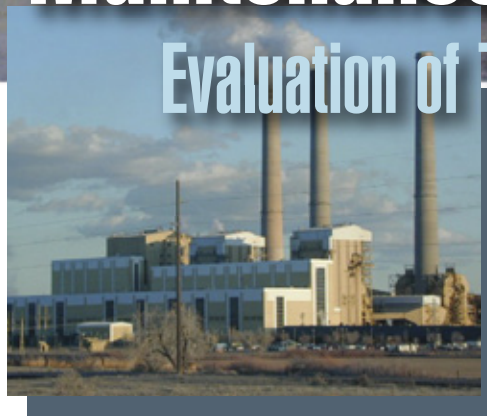
Van Zonderen Offshore (Rotterdam) performed hydroblasting and coating application. Royal Coatings Inc. (Belle Chasse, LA) manufactures the solvent-free epoxy system.

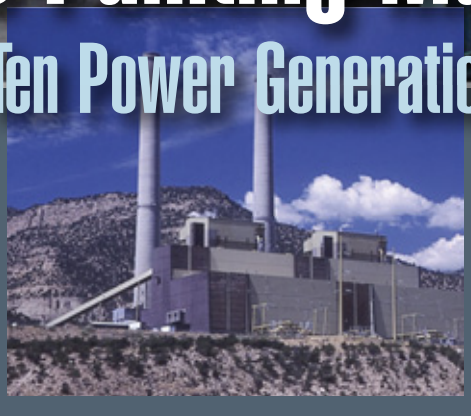
Reference

1. E. Askheim et al., "Why do Paints Crack?" *Protective Coatings Europe*, March 2001, pp. 49-55.

Maintenance Painting Management:

Evaluation of Ten Power Generation Facilities





by Lon Udy, PacifiCorp Energy; and Kenneth A. Trimber and Kirk Wissmar, KTA-Tator, Inc.

PacifiCorp Energy (PacifiCorp), a division of PacifiCorp, provides 7,750 megawatts of electricity every hour from 12 coal-, gas-, and geothermal-fired generating plants in Utah and Wyoming. MidAmerican Energy Holdings Company acquired PacifiCorp in 2006 and identified coatings maintenance as a priority, both in terms of corrosion protection and aesthetics. In response, PacifiCorp Energy's Generation Engineering group engaged the services of an independent coatings expert to assess the painted surfaces throughout 10 of PacifiCorp's 12 facilities to establish painting priorities, painting cost estimates, and specifications for maintenance of the coatings.

This article describes the consultant selection process, the field survey process, results of the field surveys, and the next steps to be taken.

Fig. 1 (Facing page, below): Three of the 10 PacifiCorp facilities included in the survey. The pilot study was done in the Naughton plant, on the lower right. Photos courtesy of the authors
Fig. 2 (Facing page, top): A sample survey was conducted as part of the consultant selection process. Sample survey, Unit 1 ID fan, duct, and surrounding steel

Fig. 3: Sample survey, Unit 1 boiler, feed pumps, and surrounding steel

Goals of the Maintenance Painting Program

In 2007, after deciding to hire a consultant to help establish a five-year maintenance painting program for ten of PacifiCorp's facilities, the energy company set several goals for the program (Fig. 1).

The program had to clearly define painting needs for all structures in each facility, from the power house and coal handling areas to warehouses and administrative offices. The only areas excluded from the program at each plant site were the substations and structures related to transmission and distribution. The five-year program had to identify the surfaces to be painted each year, give cost estimates for conducting the work, provide comprehensive specifications for surface preparation and coating application, and address the controls required when disturbing lead-based paint. Painting priorities were based on continued service life of the operating equipment and structures).

One significant challenge was added to the project: work on the surveys, reports, recommendations, and specifications had to begin in June 2007 and be completed by the end of November 2007. Because of the amount of work required, the aggressive schedule, and the tremendous investment being made in money and personnel, PacifiCorp made it clear from the beginning that for the project to succeed, the power company and the consultant had to work together as partners in every aspect of the project to address issues and concerns as soon as they were recognized and to resolve them collectively.

Consultant Selection Process

Because of the financial outlay and the need to do the work on a "time and materials" basis—due to a number of unknowns that could affect the completion of the surveys—PacifiCorp developed a unique, multi-phase consultant selection process. The first phase involved identifying firms that PacifiCorp thought would be capable of completing the project. The list was developed by researching information on the Internet. The candidate firms (bidders) were required to attend a pre-bid meeting in Salt Lake City, Utah, where the scope of work was presented in detail, and questions regarding the project were openly discussed. Once the scope was understood, the firms were given a tour of the Gadsby Plant, one of the ten facilities to be surveyed as part of the contract. The purpose of the tour was to make certain that the entire scope of the project was fully understood by all bidders.

The firms were then required to complete a small, representative survey of two locations within Unit 1 of the plant (Figs. 2 and 3). The surveys had to be comprehensive, with the data entered into each firm's respective computer program. The surveys allowed PacifiCorp to see examples of each program's capabilities and overall product, based on familiar surfaces and structures.

The survey results and other technical and financial information were incorporated into proposals submitted a few weeks after the pre-bid meeting. PacifiCorp reviewed the proposals and arranged to visit the two short-listed firms.

The first day with each firm was spent examining the capabilities of the firm and interviewing key personnel who would support the project. The consultants also presented their bid proposals and discussed in detail their maintenance painting management programs.

The second day with each short-listed firm involved a tour of a facility where each consultant's proposed program was being used. The facility owners and PacifiCorp also held private discussions about the pros and cons of the consultants' work and their programs. The tour and discussions allowed PacifiCorp to develop an unbiased opinion about the benefits and capabilities of each firm and to deter-

mine whether their proposed programs would completely address PacifiCorp's requirements.

After the proposal presentations and site tours, PacifiCorp's project team collaborated to evaluate each consultant's proposal and sample assessment. From this process, the company selected a consultant and awarded a contract.

Pilot Study

The aggressive schedule for completing the surveys and coatings recommendations for the ten plants created several unique challenges. First, there are many ways to subdivide a facility for the collection of coating condition data. Any logical approach can be used to conduct a survey at a single facility. However, because this work involved ten facilities, it was important to develop a plan that was consistent with the manner in which PacifiCorp views the facilities and that would be acceptable fleet-wide. Due to the schedule, the plan had to be established before the consultant had the opportunity to visit each facility.

Second, the consultant needed to conduct surveys in as many as four plants simultaneously; therefore, it was not possible to use the same inspection crew at every location. Steps had to be taken to assure that the data collected at each facility was consistent and that the terminology was standardized as much as possible.

Third, it was clear that there would not be time to change the survey process once PacifiCorp reviewed the first report because surveys in other facilities would be underway or even completed before the initial reviews were finished.

Fourth, the support required from PacifiCorp, both its corporate office and the facilities, had to be determined before beginning each survey, as did a means for collecting it. The support included drawings of each facility and available painting histories, piping and structure color codes, information on the prior use of lead paint, and other project-specific information.

Fifth, estimates of the cost and time to complete the entire project, as well as schedules for visiting all ten facilities, had to be established within the first few weeks following the award of the contract.

Because of the challenges above and other concerns, PacifiCorp and the selected consultant agreed that a pilot survey should be conducted at one of the facilities to resolve questions and concerns before starting work in multiple facilities simultaneously. The decision proved to be invaluable to the success of the project.

The Naughton plant (Fig. 1), located south of Kemmerer, Wyoming, was selected for the pilot study. The PacifiCorp project team participating in the pilot included the project management team from corporate (Generation Engineering) and the supervisory staff of the Naughton plant. The consultant team consisted of corporate project management, four consultant survey team leaders, and a data entry supervisor from the consultant's home office. The four consultant team leaders would be in charge of data collection at the other facilities once the pilot program was completed.

The consultant's corporate project management team led the pilot study to assure that a uniform method for subdividing the facilities was developed, to establish appropriate terminology, to develop consistency in data collection, to streamline the data entry process, to identify PacifiCorp support needs, and to work out other project logistics. Based on the time required to complete the pilot survey and on the size of the pilot facility relative to the other nine plants, PacifiCorp worked with the consultant to develop a schedule for conducting the remaining surveys. Two weeks after completion of the pilot, the consultant's project management team met with PacifiCorp to present the pilot results and to reach an agreement on the process that would be used for the remaining surveys, which started immediately thereafter.

Field Survey Process

To control the field survey process, the consultant developed a site manual that defined the survey process and contained administrative and technical procedures. The manual assured that the teams followed a standard operating procedure at each facility and that communication and coordination with PacifiCorp were standardized across the fleet.

The field survey required that each specific piece of equipment and associated process systems be identified and assessed together with structural steel, walkways, and other structures (Fig. 4 and box on p. 16). Essentially, all painted surfaces (primarily steel at PacifiCorp's direction) were included (Fig. 5). For each item inventoried, the total painted surface area was estimated (Fig. 6). The consultant had developed a unique rating scale and used it to assess the overall amount of visible deterioration on each item. The scale is

Fig. 4: The survey required the identification of all painted components (structural steel, equipment, piping, etc.) throughout each facility.

Fig. 5: The field survey process was largely focused on steel, at PacifiCorp's direction.

based on SSPC-VIS 2, "Standard Method for Evaluating Rusting on Painted Steel Surfaces." The percentage of deterioration is typically linked to a maintenance strategy.

Although the consultant developed the unique rating system, the maintenance strategies (no action, localized touchup, full overcoating, or complete removal/replacement of the coating) based on the percentage of deterioration are generally consistent with the recommendations found in SSPC-TU 3, "Overcoating." The general service environment was categorized; temperatures were measured for high temperature equipment; and accessibility factors were assigned to each component. The accessibility factor is a multiplier assigned to the base square foot price

Fig. 6: Surface area is required for the cost analysis because the various maintenance strategies are assigned a unique cost per square foot.

to account for additional costs associated with rigging or complexity. Digital photographs were taken and stored in the computer program with the field data.

The existing coating type was documented when known by the facility, but a laboratory analysis to determine the generic coating type was not included in the initial surveys. The presence or absence of lead-based paint on each component was established, based on the facility's painting history and random spot checks using field lead detection swabs; however, a laboratory analysis was not included during the initial survey stage. Laboratory analysis for lead will be conducted as necessary before awarding the painting application contracts, and appropriate coating thickness and adhesion tests will be completed. The thickness/adhesion testing will be performed on those surfaces scheduled for overcoating to confirm that the integrity of the existing coating is adequate to receive an overcoat.

Quality Control and Communication

Because of the amount of work being undertaken simultaneously, the consistency and accuracy of data collection, data entry, and data analysis were key factors that had to be controlled throughout the process. The necessary level of control was achieved through multiple steps and checks. First, the pilot survey was performed with the consultant's project manager and each of the team leaders to develop and ensure a consistent survey format. The surveys at the facilities followed the site manual and were managed by one of the consultant team leaders. A survey technician assisted each team leader. Having team leaders conduct the pilot was a critical step in assuring the consistency of the data collected in the remaining nine facilities.

As a second step, the consultant's project manager spent a few days with each team at the start up of their first facilities, providing further assurance that consistency would be achieved.

A third check occurred at the time of data entry. Each day, the data was transferred electronically to the data entry supervisor (who had also participated in the pilot) in the consultant's home office, where the data was reviewed for consistency before being forwarded to data entry personnel. At the same time, the corporate project manager provided a quality control function by examining the data for reasonableness and resolving questions with the field teams. After the data was entered, the data entry supervisor spot-checked the entries.

As a further step to address quality and assure a high level of communication, PacifiCorp facilitated weekly project status meetings through conference calls each Monday (Fig. 7). PacifiCorp's project management team,

Fig. 7: One of the progress meetings held every Monday

each of the consultant team leaders, consultant project management, the data entry supervisor, and accounting personnel participated in the conference calls. Informal communication between PacifiCorp and the consultant's management also occurred daily.

In addition to trips by consultant project management to PacifiCorp headquarters and to various facilities during the project, PacifiCorp project management visited the consultant when the field data was first being refined to establish guidelines for the analysis of the data. For example, the computer program might recommend localized touchup to address corrosion protection. While a spotty appearance is not objectionable in many cases, it is not acceptable in every instance. Accordingly, PacifiCorp established guidelines for overriding the touchup recommendations and reassigning an overcoating maintenance strategy. Likewise, the maintenance recommendations needed to be established with consideration for the remaining life of the asset, the timing of overhauls, and other site-specific issues that had to be conveyed to the consultant.

The communication among all parties was effective throughout the project, enabling the two companies to truly partner and work as a team. All issues and concerns were addressed immediately, assuring that the quality of work, costs, and schedule were not affected. Such teamwork was also instrumental to the success of the project.

Minimum Data Collected for Each Item

- Substrate type
- Surface area
- Coating type
- Visible deterioration (SSPC-VIS 2)
- Presence of lead
- Service environment
- Temperatures (for high temperature items)
- Accessibility factors

Additional Data Collected prior to Specifying Painting Work

- Coating thickness
- Coating adhesion
- Additional lead tests as needed

Painting Specifications

The contract also required the development of painting specifications to address the aspects of surface preparation and coating application required to achieve long-lasting coating system per-

formance. Master corporate specifications were developed, addressing requirements from cleaning to mixing the coating, application, and film continuity.

Paint system specifications, each three or four pages in length, were attached to the master specification. The paint system specifications provided cleaning and painting requirements that were unique to the system (e.g., degree of surface preparation required, restrictions on ambient conditions, coating thickness, and product brand names). This approach provides PacifiCorp with the flexibility to easily add or delete systems in the future. Separate tables were developed to identify the appropriate system for painted surfaces in each environment.

Delivering the Data

The consultant offered to license the computer program to PacifiCorp, which would allow each facility, as well as corporate, to adjust and analyze the data. However, for at least the first year, PacifiCorp decided that such analysis was best left to experienced personnel because no one within PacifiCorp was specifically focusing on protective coatings. Accordingly, rather than delivering the program or hard copies of program-specific documents, the consultant exported the data, after analysis, to a more widely used and accepted spreadsheet. PacifiCorp can use the spreadsheet to examine key data downloaded from the program.

All items identified in each subdivision of each facility were listed. The following data was provided for each item: the condition of the coating on the item, the painted surface area of the item, the type of substrate involved (e.g., steel or concrete), whether or not lead was present in the paint, the maintenance painting strategy recommended over a five-year period (touchup, overcoat, remove/replace, or do nothing), the future cost for painting each

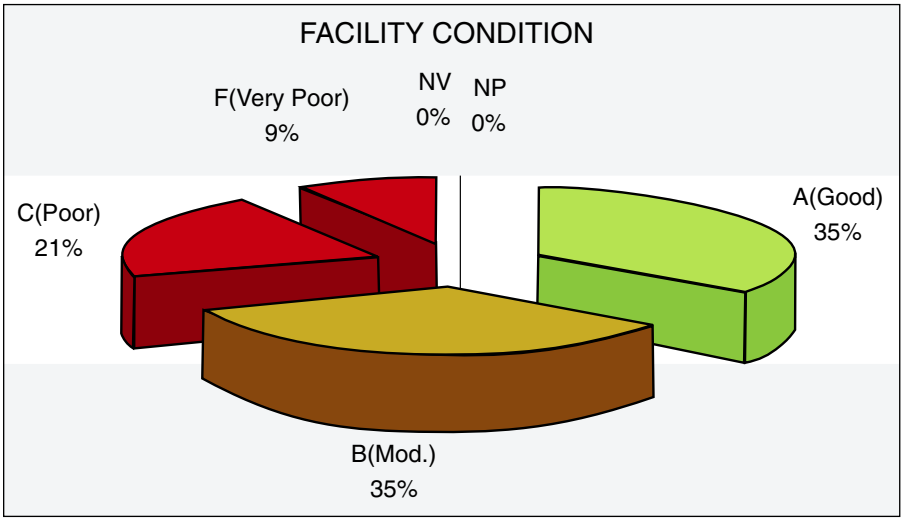


Fig. 8: Pie chart showing the percentage of coatings in good, moderate, and poor condition throughout an entire facility

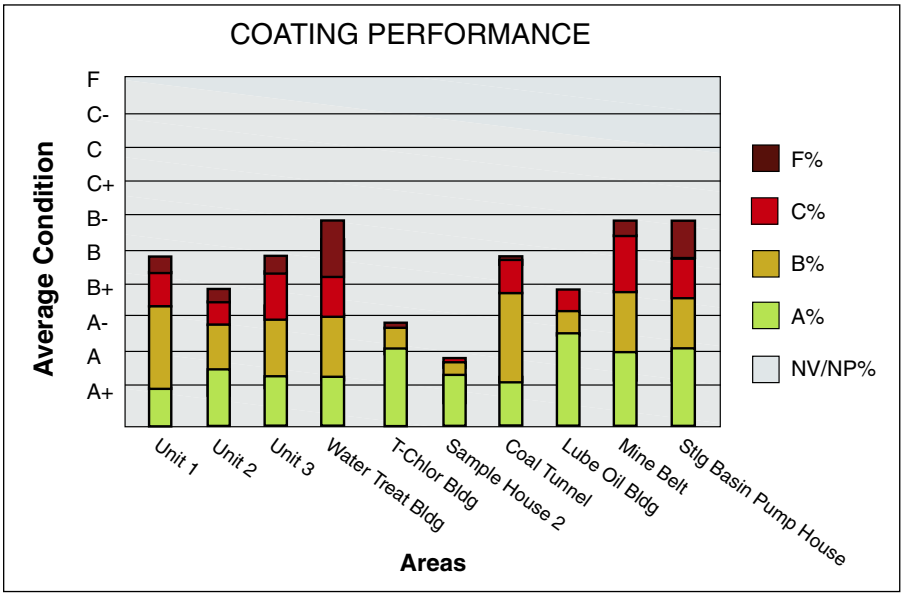


Fig. 9: Bar charts showing the condition of the coatings in each area of the plant. Similar bar charts are provided to compare the overall condition of the coatings among the 10 plants.

year (budgetary estimate), net present value, and any unique comments about the item. Representative photographs of the items were also included.

The spreadsheets were appended to the painting recommendations, which were summarized in a written report together with total cost estimates for the work required each year over a five-year period. Graphics illustrated the comparative condition of various areas within each facility, as well as the composite condition for each facility (Figs. 8 and 9).

The reports and comparative analysis enable PacifiCorp to quickly determine the allocation of maintenance painting funds, both in terms of one facility versus another and specific areas within each facility. In short, the reports and recommendations are used by PacifiCorp to manage overall painting needs fleet-wide for years to come.

Next Steps

Before the five-year maintenance painting program began at the facilities, a series of meetings were held with PacifiCorp's owners and key facility personnel. The meetings outlined the results of the surveys and the maintenance painting recommendations for the next five years. The first meeting was held in March 2008 and was followed by the site-specific reviews of the new maintenance painting programs a few months thereafter. The program recommendations and specifications have been successfully used for a few projects in 2008.

With the assistance of the consultant, PacifiCorp also developed a qualified contractors list. PacifiCorp made a decision that beginning in 2009, contractors doing painting work in PacifiCorp facilities will have to be SSPC-QP 1-and QP 2-certified. A long list of contractors was reduced to a short list based on a review of initial submittal packages. Select firms were then invited to participate in interviews. For the interviews, PacifiCorp required the bidding contractors to have a management representative, a project superintendent, and a QC inspector. After an initial presentation by the company, specific questions were presented to each representative, and only that representative was permitted to respond. This means of interviewing proved to be very effective. It showed how key field staff respond to situations, rather than only hearing from corporate management or business development. The list of contractors was reduced further as a result of the interviews, and only the selected group will be invited to bid on PacifiCorp painting projects for the next three years. The first project at a PacifiCorp facility using the qualified contractor list will be performed at the end of 2008.

As painting work at the various facilities is completed, the data in the program will be updated to remain current. At the same time, cost adjust-

ments for more accurate budgets and revisions to the existing data will be made as necessary.

In a few years, the surveys may be repeated to update the accuracy of the projections. Since the initial surveys represent a snapshot in time, it is possible that a surface painted "yesterday" appeared to be in excellent condition at the time of the survey, regardless of the quality of the underlying preparation or integrity of the pre-existing coating. As a result, the program will project that maintenance work is not required for many years. However, by quickly reexamining the surfaces after a few years, such conditions will be revealed, and the data populating the program will become more reliable. Repeating the surveys will take a fraction of the time required for the initial surveys because key data has already been collected.

The second round of surveys also helps to refine the projected rates of coating deterioration for each coating system in each service environment, with the default coating deterioration curves that are an integral part of the computer program, adjusted as required.

The goal is to continue following the recommendations in the program until the coatings throughout all facilities are upgraded to the point at which only minimal routine touchup is required to effectively protect the assets from corrosion and to enhance the aesthetics of the PacifiCorp Thermal Generating fleet.

Conclusions

During 2007, PacifiCorp's owners determined that greater emphasis should be placed on protecting corporate assets and improving aesthetics. Rather than engineer the maintenance painting program through internal resources alone, PacifiCorp solicited independent expertise to project the painting needs in 10 of 12 power gener-

ating facilities over a five-year period, together with the development of specifications, coating material selection, and budgetary estimates for the recommended work. A unique consultant selection process was developed by PacifiCorp to evaluate the suitability of the candidate firms and their programs to deliver the desired results. Also, a painting contractor selection process was undertaken in order to develop a qualified contractor list for bidding projects for at least the next 3 years.

The data collection phase was deemed to be a strong success by all parties involved. All painted components were examined and entered into a powerful computer program that issued specific recommendations and cost estimates for a new five-year painting plan. PacifiCorp is confident that it now has the information necessary to make informed maintenance painting decisions and, with the aid of the computer program, it will be able to evaluate the cost/benefit of nearly any maintenance painting scenario that might be considered in the future.

Lon C. Udy is the manager for PacifiCorp Energy's Project Management Department in its Generation Engineering organization located in Salt Lake City, Utah. He holds a BS in construction management from Washington State University. Mr. Udy has over 27 years of experience in the project management profession for the construction industry, power plant maintenance services, and power generation industry.

He began his career as a designer in the nuclear industry and then worked as a construction manager for a construction management and power plant maintenance firm located in the Seattle, Washington area. Following his years of service in the construction and maintenance industry, he "jumped ship" to join the power generation industry, where he has been a part of engineering and project management with PacifiCorp for the past 16 years, both at the power plants and at the corporate level. Currently, he is the department manager for a project management group that supports PacifiCorp Energy's fleet of thermal generation plants located in Utah and Wyoming.

Kenneth A. Trimber is the president of KTA-Tator, Inc. (Pittsburgh, PA). He holds a BS from Indiana University of Pennsylvania, is a NACE-certified Coatings Inspector, is an SSPC Protective Coatings Specialist, is certified at a Level III coating inspection capability in accordance with ANSI N45.2.6, and is certified as a Nuclear Coatings Specialist by the NBR. Mr. Trimber has more than 30 years of experience in the industrial painting field, is a past president of the SSPC, chairman of the Surface

Preparation Committee, chairman of the Visual Standards Committee, and chairman of the Task Group on Containment. He is also past chairman of ASTM D1 on Paints and Related Coatings, Materials, and Applications. Mr. Trimber wrote *The Industrial Lead Paint Removal Handbook*, and co-authored Volume 2 of the handbook, *Project Design*. He was named Coatings Specialist of the Decade at the SSPC National Conference in 1990 and is also a past technical editor of the *Journal of Protective Coatings & Linings*. Mr. Trimber is a principal instructor for SSPC's "Supervisor/Competent Person for Deleading Projects Course (C-3)" and the NHI/FHWA courses, "Bridge Coatings Inspection" and "Hazardous Bridge Coatings: Design and Management of Maintenance and Removal Operations."

Kirk Wissmar is the surveys department supervisor at KTA-Tator. Mr. Wissmar holds a BS in civil engineering from the West Virginia University Institute of Technology, holds EIT in the state of West Virginia, and is a NACE Coatings Inspector Level 1–Certified. Mr. Wissmar was instrumental in the development and implementation of KTA's computerized coating assessment software program. In addition to overseeing survey work performed by other professional staff, Mr. Wissmar provides coating condition assessment and engineering services on projects involving bridges, storage tanks, power generation facilities, and other industrial structures.

To find more *JPCL* articles on power plants and condition surveys, go to www. paintsquare.com and search "Publications/Library."

Testing Membrane Coatings for Corrosion Mitigation in Reinforced Concrete

By A.M. Peek and R.J. Paull, GHD Pty Ltd, Materials Technology Group, Perth, Australia

Editor's Note: The following article is an abridged version of a paper that originally was presented at the Australasian Corrosion Assocation Corrosion and Prevention 2006 in Hobarth, Australia, and is published here with permission; it was also published in the August 2008 issue of Surface Coatings Australia (SCA). *The SCA article summarizes the aggressive use of high-performance coating materials for protection of high value concrete buildings and highway structures, mainly in Australia but also in other Asia-Pacific locations. The detail and history regarding the specifications provide a useful set of lessons learned for specifiers as we proceed to a more appropriate technical level of specification for concrete bridge coatings here in the U.S. Particularly interesting is the authors' description of the use of relative diffusion coefficients for both concrete and waterproofing films of various thicknesses and qualities. As we move forward toward more aggressive (lighter) concrete designs applied in more aggressive environments, the use of protective coatings as a surrogate for a specific additional thickness of concrete cover in the context of overall structure durability design is interesting.*

As the authors describe, the problems faced in other areas of the world are essentially the same as in the U.S.—continuous pressure on service life extension and a constant battle to achieve performance through definition and application of the highest quality materials. In this regard, it is interesting and useful to examine the robust approach taken by other nations as our efforts to apply coatings to protect concrete expand.

For more information about the original, complete article, contact the ACA: www.corrosion.com.au.

Bob Kogler
Series Editor

For many years now, the traditional use of architectural membrane coatings for decorating structures has been combined with requirements for corrosion mitigation and waterproofing performance. Although these issues are traditionally addressed by separate standards, corrosion mitigation and waterproofing are often inextricably linked. Research has shown that in many circumstances, the episodic absorption of water dictates mean corrosion rate and time to appearance of damage once corrosion has been initiated. This article briefly presents the approximately 30-year history of development of test methods for properties of coatings that relate to corrosion mitigation, such as carbon dioxide and chloride diffusion resistance, and their usage in Australia over more than 20 years. It also discusses the development of standards and specifications for these properties in Australia. In addition, the article compares the current status of usage and enforcement with experiences in Singapore and Hong Kong, where corrosion in high-rise reinforced concrete (R/C) facades is prevalent.

With the advent of the AS/NZS 4548 series of standards in 1999,[1] Australia was one of the first countries to adopt a national standard that included criteria and guideline test methods for architectural membrane type coatings to help mitigate corrosion of reinforcing steel in concrete. Not only are parameters such as carbon dioxide and chloride ion ingress important, but simple waterproofing is also. Previous research has shown that, particularly in carbonated concrete, episodes of water absorption by rainfall or irrigation are the primary factors in determining overall corrosion rates once corrosion has begun.[18]
[Editor's Note: For further discussions of AS/NZS 4548 and related issues, see the original article and Peek, Ref. 2, and Bartlett, Refs. 5 and 6.]

Testing Membrane Coatings for Corrosion Mitigation in Reinforced Concrete

By A.M. Peek and R.J. Paull, GHD Pty Ltd, Materials Technology Group, Perth, Australia

Editor's Note: The following article is an abridged version of a paper that originally was presented at the Australasian Corrosion Assocation Corrosion and Prevention 2006 in Hobarth, Australia, and is published here with permission; it was also published in the August 2008 issue of Surface Coatings Australia (SCA). *The SCA article summarizes the aggressive use of high-performance coating materials for protection of high value concrete buildings and highway structures, mainly in Australia but also in other Asia-Pacific locations. The detail and history regarding the specifications provide a useful set of lessons learned for specifiers as we proceed to a more appropriate technical level of specification for concrete bridge coatings here in the U.S. Particularly interesting is the authors' description of the use of relative diffusion coefficients for both concrete and waterproofing films of various thicknesses and qualities. As we move forward toward more aggressive (lighter) concrete designs applied in more aggressive environments, the use of protective coatings as a surrogate for a specific additional thickness of concrete cover in the context of overall structure durability design is interesting.*

As the authors describe, the problems faced in other areas of the world are essentially the same as in the U.S.—continuous pressure on service life extension and a constant battle to achieve performance through definition and application of the highest quality materials. In this regard, it is interesting and useful to examine the robust approach taken by other nations as our efforts to apply coatings to protect concrete expand.

For more information about the original, complete article, contact the ACA: www.corrosion.com.au.

Bob Kogler
Series Editor

For many years now, the traditional use of architectural membrane coatings for decorating structures has been combined with requirements for corrosion mitigation and waterproofing performance. Although these issues are traditionally addressed by separate standards, corrosion mitigation and waterproofing are often inextricably linked. Research has shown that in many circumstances, the episodic absorption of water dictates mean corrosion rate and time to appearance of damage once corrosion has been initiated. This article briefly presents the approximately 30-year history of development of test methods for properties of coatings that relate to corrosion mitigation, such as carbon dioxide and chloride diffusion resistance, and their usage in Australia over more than 20 years. It also discusses the development of standards and specifications for these properties in Australia. In addition, the article compares the current status of usage and enforcement with experiences in Singapore and Hong Kong, where corrosion in high-rise reinforced concrete (R/C) facades is prevalent.

With the advent of the AS/NZS 4548 series of standards in 1999,[1] Australia was one of the first countries to adopt a national standard that included criteria and guideline test methods for architectural membrane type coatings to help mitigate corrosion of reinforcing steel in concrete. Not only are parameters such as carbon dioxide and chloride ion ingress important, but simple waterproofing is also. Previous research has shown that, particularly in carbonated concrete, episodes of water absorption by rainfall or irrigation are the primary factors in determining overall corrosion rates once corrosion has begun.[18]
[Editor's Note: For further discussions of AS/NZS 4548 and related issues, see the original article and Peek, Ref. 2, and Bartlett, Refs. 5 and 6.]

Here's a view from Down Under on performance coatings and the infrastructure

For many years now, the use of coatings other than the traditional heavy-duty industrial type coatings to assist in corrosion mitigation in new, existing, and repaired reinforced concrete structures has been gaining acceptance—to the point where using the alternative coatings is now standard practice in many parts of the world. For many infrastructure owners, protective/decorative coatings are a central component of asset management strategies.[7,8] The effective use of coatings in concrete repair and protection has been widely discussed in various forums since the early 1990s.[9,10,11]

This form of corrosion mitigation applies to many situations, but the two major areas are probably public infrastructure such as bridges and viaducts, and high-rise buildings where both decorative and protective functions are required. In many Asian cities, relatively poor standards of off-form finish concreting resulted in the adoption of cement plaster and ceramic tile finishes as the norm. Such structures are now often showing evidence of corrosion-related deterioration, and a common mitigation practice is to overcoat the facades with a combined waterproofing and anti-carbonation membrane coating.

Around the 1970s the economic life of a high-rise office or apartment tower was considered to be about 30 years. As a result, by today's standards, provision for long-term durability at the design and materials selection stage was limited. Today, therefore, many structures are past their design life, but demolishing and replacing them is not economically or logistically desirable. It is necessary to prolong their service lives by judicious selection of repair and preservation technologies.

In the last decade of the 20th century and moving into the 21st century, it has become more common to think in terms of longer asset life and to design and select materials accordingly. The Australian concrete design code, AS 3600,[13] is based on a nominal 40- to 60-year service life to first maintenance. The Australian bridge design code, AS 5100,[14,15] is based on 100 years for major concrete elements, while for the majority of maritime structures AS 4997[16] nominates 50 to 100 years.

History and Development of Test Methods

The majority of the pioneering work in developing assessment methods for the ability of coatings to protect concrete against reinforcement corrosion was performed in Europe during the 1970s and early 1980s.[2] *[Editor's Note: For a discussion of research and testing on CO_2 barrier coatings and chloride barrier systems, see the original article and Peek and Green et al., Refs. 17, 19, 20; Peek, Ref. 2; and Wei, Ref. 12.]* The work was introduced to the Australasian region in the latter half of the 1980s.[3,4]

The Australian Situation

Australia has two sets of "national" standards relating to various properties of paints and surface treatments/coatings. One is the national standards body, Standards Australia. The second is the Australian Paint Approval Scheme (APAS), a Commonwealth non-statutory body currently managed by the CSIRO Manufacturing & Infrastructure Technology Division.

The two systems are not completely redundant, originally being constructed to serve different functions; however, there is now a significant interaction between the two.

Standards Australia

Standards Australia is responsible for developing, maintaining, and publishing standards at a national and international level. Table 1 shows the key elements of Standards Australia specifications for concrete coatings. *[Editor's Note: For details of the history of Standards Australia, see the original article and Refs. 21 and 22.]*

Table 1: Key Elements of Standards Australia Specifications for Coating Concrete

AS/NZS 2311 "Guide to the painting of buildings"[23] Provides general information on types of paints and their uses, typical application methods, etc. The only reference to corrosion mitigation in concrete structures is Clause 4.19.1.10, which refers to anti-carbonation coatings in a single paragraph, but provides no information on performance criteria. The clause also erroneously states that the majority of such coatings are low-build solvent-borne acrylics. While historically this may have been the case, one of the oldest and most successful systems still in use after 30 or so years is a solvent-borne methacrylate. In the authors' experience the majority of systems tested and marketed in Australia over the last 10-15 years have been water-borne acrylic or styrene-acrylate copolymers with recommended DFT's of 250-500 microns. Cross-references to AS/NZS 4548 occur elsewhere in the document but do not make reference to the corrosion mitigation properties therein.
AS/NZS 4548 series of standards, "Long-life coatings for concrete and masonry"[1] "Latex-extensible" coatings, Type B38 in AS/NZS 2311.[23] Specified properties, many with suggested performance criteria and guideline test methods, include water and water vapor transmission, carbon dioxide gas and chloride ion diffusion resistance, elasticity, and crack bridging resistance.
AS 3730 series of standards, "Guide to the properties of paints for buildings"[24] These standards provide specifications for a number of wet and dry properties but do not address properties relevant to corrosion mitigation. These paints comprise Types B6 to B9 in AS/NZS 2311.[23]
HB 73 "Handbook of Australian Paint Standards" A compendium of relevant standards. Part 1 "General" contains AS/NZS 2310,[26] AS/NZS 2311,[23] AS/NZS 2312,[27] and APAS Documents D125[28] and D126.[29] Part 4 "Architectural Paints" contains selected relevant parts of AS 3730.[24]
DR99449-DR99450 "Exterior waterproofing membrane systems"[30] Draft, yet to be promulgated as standards. DR99449 deals with requirements for materials, DR99450 with design and installation issues. Apart from properties related to mechanical strength and water/water vapor transmission, no properties relevant to corrosion mitigation are discussed.
HB 84 "Guide to concrete repair and protection"[31] A joint publication by Standards Australia with the CSIRO Division of Building, Construction and Engineering, and the Australian Concrete Repair Association (ACRA).[56] The document provides useful information on concrete repair practices; however, the use of protective coating systems in relation to both carbonation and chloride induced reinforcement corrosion receives very little attention, and insufficient information is provided to assist with specification of a coating system.

Australian Paint Approval Scheme

The Australian Paint Approval Scheme (APAS) was originally constituted in 1943 as the Defence Paint Committee to provide quality assurance for paint purchased by the Defence Department in the face of shortages of imported raw materials. After World War II, the Scheme was expanded to other Commonwealth departments, and the organization was renamed the Commonwealth Paint Committee (CPC). During the mid-1960s, State Government purchasers who recognized the benefits were permitted to join, and eventually all State and Territory Governments joined the scheme. The scheme was rebranded as the Government Paint Committee (GPC) in 1974, and again as APAS in 1996. In addition to the name changes and many changes in departmental affiliation, the scheme underwent a major restructuring in 1970 to an "onus of proof" scheme, where the evidence of compliance for approval has to be provided by the paint manufacturer.[32]

APAS not only provides a range of specifications for paints and surface treatments, but it also operates a third-party approval system where manufacturers can obtain certification of compliance of products and processes that meet the required standards.

During the organization's incarnation as the GPC, specifications for paint systems were numbered as GPC-<letter>-<number>. Over the last few years, the specifications have been updated and renumbered, and APAS publishes several cross-referenced lists[33,34,28,29,36] between old designations, new designations, Australian Standards, and paint reference numbers (PRNs) used in AS/NZS 2311.[23] An abbreviated, consolidated, descriptive guide to the types of paints represented by each specification is also available.[35] Referencing of

APAS requirements to paints described in Australian standards is increasing.[36]

Traditionally, APAS specifications concentrated mainly on generic formulation and selected wet and dry properties. More recently, protective properties are specified, sometimes indirectly by reference to relevant Australian standards.

EN 1504—The Ultimate Concrete Repair Standard?

Possibly the most comprehensive standard applying to repair and preservation of concrete structures is the European Norm, EN 1504, "Products and systems for the protection and repair of concrete structures—Definitions—Requirements—Quality control and evaluation of conformity," developed cooperatively by the member states of the European Union under CEN TC104.[37] The document is in ten parts, not all of which are fully developed and published at this time.

Of particular relevance to the subject of this article is EN 1504-2:2004 "Surface protection systems for concrete." The standard not only contains detailed performance criteria but also nominates test methods to be used in assessment and addresses quality control and conformity evaluation requirements to be met by manufacturers.[38] Table 2 lists the 24 performance requirements variously nominated for different applications.[38]

Public Service Specifications

Examples

Several public service bodies already publish standard specifications for works that include requirements for architectural coatings that also fulfil protective functions. The most common protective function required is anti-carbonation; however, chloride diffusion resistance is also sometimes specified. A brief summary of several typical specifications is given in Table 3. This summary is not intended to be exhaustive but to be a sample typical of the authors' experience.

To the authors' current knowledge,

many Australian public service bodies do not have particular specifications for protective requirements for architectural membrane coatings. These bodies include RailCorp and the Roads & Traffic Authority in New South Wales, Main Roads Western Australia, and the Water Corporation of Western Australia. Instead, these bodies often implement specifications provided by external consultants on an as-recommended basis for particular projects.

VicRoads Specification, Section 686

Section 686 of the VicRoads "Standard specifications for roadworks and bridgeworks"[39] provides a detailed specification for applying protective coatings to concrete structures, including performance requirements and quality assurance testing requirements. The specification was first released in July 2000.

The specification details all of the performance requirements; however, the way the data is presented is confusing and contradictory. Often, because of the inconsistency of related requirements, suppliers are left unable to demonstrate "full" technical compliance with coating systems that meet or exceed the specification.

Clause 686.05(b) specifies anti-carbonation performance as follows.

"In addition to the general requirements of Clause 686.05(a), approved coatings shall also satisfy the following minimum performance criteria:

(i) Equivalent Air Layer Thickness (R) greater than 150 metres;

(ii) Equivalent Thickness of Concrete (Sc) greater than 450 millimetres;

(iii) CO_2 Diffusion Co-efficient of less than $2 \times 10^{-7} cm^2/s$;

(iv) Water vapour equivalent air layer thickness of less than 4 metres;

(v) Dry film thickness of at least 150 Fm (*sic*) (micron);

(vi) Water or Acrylic based (*sic*), solvent free unless otherwise approved by the Superintendent."[39]

The main difficulty with the above specification is that it specifies too many parameters in relation to CO_2 diffusion. The properties quoted in requirements (i), (ii), and (iii) are all mathematically

Table 2: Performance Requirements for EN 1504-2: 2004

Linear shrinkage, coefficient of thermal expansion, crack bridging ability
Compressive strength
Abrasion resistance, slip/skid resistance, impact resistance, antistatic behavior
Adhesion before and after thermal cycling, adhesion on wet concrete
Carbon dioxide diffusion, water vapor permeability, capillary absorption and permeability to water, chloride resistance
Freeze-thaw cycling with de-icing salt immersion, thunder-shower cycling (thermal shock), thermal cycling without de-icing salt impact, resistance to thermal shock
Chemical resistance, resistance to severe chemical attack, reaction to fire, behavior after artificial weathering
Depth of penetration, water absorption and resistance to alkali test for hydrophobic impregnation, drying rate for hydrophobic impregnation

Table 3: Standard Specification Documents

Specifying Authority	Document	Requirements
VicRoads	"Standard Specifications for Roadworks and Bridgeworks" Section 686[39]	Specifies a number of properties relevant to corrosion protection but in a contradictory manner. See discussion below.
VicRoads	"Standard Specifications for Roadworks and Bridgeworks" Section 685[40]	Provides anti-carbonation performance requirements for situations where coatings are anti-graffiti required to provide both anti-graffiti and anti-carbonation protection
DIER Tasmania	"Bridgeworks Specification B.23– Penetrating Sealers and Coatings for Concrete"[41]	Coatings for concrete specified to comply with GPC 0117/3[42] which in turn calls up the protective barrier properties cited in Clause 4 of AS/NZS 4548.2 or AS/NZS 4548.3[1]
Hong Kong Government Civil Engineering Dept.	"Model Specification for Protective Coatings for Concrete"[44]	Highly detailed specification, including application and performance requirements for all properties related to corrosion mitigation in a variety of circumstances
Singapore Land Transport Authority	"Painting of Protective Coatings on Concrete Surfaces"[45]	Quotes requirements for testing but does not give performance criteria
Singapore Housing & Development Board	Various specifications	Requirements for anti-carbonation performance

related to one another; properties (i) and (ii) are also related to the dry film thickness; and the SC value is calculated by assuming a value for the CO_2 diffusion resistance of a "typical" concrete.

One issue is that the relationship between R, the diffusion coefficient, SC, and the DFT is unique to a particular coating formulation. It is therefore easy to meet any one of the three criteria given, possible to meet two of them, but difficult to meet all three at once unless your formulation is similar to the example product used in generating the specification. The second issue is that, in our opinion, specification of SC without indicating the reference concrete value is somewhat pointless, as there is a range of values that can be arguably applied in order to manipulate compliance.

Sidney Harbor Bridge

In our opinion, it would be better to delete requirements (ii) and (iii), leaving requirement (i) as an unambiguous criterion. It would also be more technically accurate for item (vi) to refer to a "Water-based acrylic, ...".

Clause 686.05(c)(i)(2) further requires that the above diffusion coefficient requirement of $<2x10^{-7}cm^2/sec$ also be met after 2,000 hours of accelerated weathering, the "accelerated weathering" regimen not being specified. Historically, an 8-hour UV at 60 C /4-hour condensation at 50 C cycle in a QUV-type instrument as described in ASTM standards D 4587[46] and G 154[47] has been most commonly used for assessment of anti-carbonation coatings. This regimen was formerly known as "Condition D," but is now designated "Cycle 4" in the current standard. UV-B (UVB-313 lamps) exposure has most commonly been used, although UV-A (UVA-340 lamps) is sometimes specified,

for example in the HK CED specification.[44]

As Clause 686.05(c) is titled "Performance Requirements for Moisture and Chloride Resistance," it would be more sensible if this CO_2 diffusion requirement was moved to Clause 686.05(b), and more practical if it referred to maintaining the required R-value.

Other requirements are

- Clause 686.05(a)(ii): Ability to bridge cracks to 0.3 mm width, no test method nominated;
- Clause 686.05(c)(i)(1): Water absorption not to exceed 0.01 mL/m^2/sec at 10 minutes by the ISAT method to BS 1881:Part 5,[48] which has been superseded by BS 1881:Part 208,[49] and
- Clause 686.05(c)(i)(2): Chloride diffusion co-efficient less than 5 x 10^{-9} cm^2/sec after 2,000 hours of accelerated ultra-violet (UV) weathering, the test method and "accelerated weathering" regimen not being specified. Historically, the same regimen discussed above for anti-carbonation coatings has generally been applied.

In all, the specification provides the necessary criteria for a competent corrosion mitigation system; however, the presentation of the information could be clarified.

VicRoads Specification, Section 685

Section 685 of the VicRoads "Standard specifications for roadworks and bridgeworks"[40] provides a detailed application specification for anti-graffiti protective coatings for concrete structures, including performance requirements and quality assurance testing requirements.

Clause 685.16(a)(iii) provides requirements for anti-carbonation performance for situations where both anti-carbonation and anti-graffiti protection are needed. The CO_2 diffusion resistance parameters are the same as those specified in Clause 686.05(b) discussed above, and the same comments apply.

The current version was released in July 2000; however, the first release was in 1998.

Other Pacific Rim Agencies

The Department of Infrastructure, Energy and Resources (DIER) in Tasmania specifies protective properties for architectural membrane coatings indirectly. Their Specification B.23[41] specifies that such coatings comply with the requirements of the latest edition of APAS 0117/3,[42] which includes requirements for water and water vapor transmission, carbon dioxide gas and chloride ion diffusion resistance, and crack bridging (requirements not included in earlier versions of the APAS Specification).[43] The specification thus imposes unambiguous and standardized requirements.

The Hong Kong Government publishes a relatively large specification document covering a number of issues.[44] It not only addresses performance requirements for architectural membrane coatings, but it also addresses coating concrete in marine applications and aggressive chemical exposures such as sewage. The Hong Kong document allows calculation of the required minimum R-value for an anti-carbonation coating system, based on the measured in-situ carbonation depth, in-situ cover to reinforcement, the age of the structure, and the required lifetime prior to corrosion initiation. It also specifies water permeability, water vapor transmission, chloride ion diffusion resistance, crack bridging ability, and chemical resistance. The performance criteria are notably onerous, requiring retention of specified properties after 4,000 hours of QUV accelerated weathering under nominated conditions. Despite such a comprehensive document being available in the local market since 1994, the document is rarely used, and currently the dominant practice in Hong Kong is to use proprietary specifications from paint suppliers

or documents drawn up by consultants on a project basis.[50]

The Singapore Land Transport Authority (LTA) specification[45] includes requirements for anti-carbonation, water vapor transmission and chloride ion diffusion resistance test results, but it does not provide any compliance criteria for these parameters. As in Hong Kong, the dominant practice in Singapore is to use proprietary specifications from paint suppliers or documents drawn up by consultants on a project basis.[51]

Professional and Industry Associations

Publications produced by various industry bodies and professional organizations also provide advice on using protective coatings in reinforcement corrosion mitigation as well as repair and preservation of concrete structures.[52,53,54,55,56,31,57,58]

Repair and protection methods followed in the UK, Europe, Middle East, Australia, and parts of Asia generally have an awareness of reinforcement corrosion mitigation through control of chloride ions, carbonation, and water ingress. The North American region appears to have a very high awareness of chloride salt-related corrosion issues, but very limited attention is paid to carbonation-induced corrosion. For example, NACE RP0390[57] provides information on concrete repair, references to cathodic protection practices, and information on waterproofing but does not mention use of anti-carbonation coatings.

Sunset Clauses and Validity of Test Data

Coating film properties such as gas and ionic diffusion are highly formulation dependent, and small changes in formulation can have unexpectedly drastic effects on the performance of the film. In practice, paint formulations do not remain completely unchanged over extended periods of time. Manufacturers are perpetually seeking to contain or reduce production costs, changing suppliers for reasons of cost or availability of materials, improving particular properties, or optimizing a product for a particular market or application. These are all sound commercial reasons for reformulating products, and constitute the normal cycle of product development.

As a result of the above, specifications for architectural membrane type coatings that require the coating system to provide corrosion mitigation should include a "sunset clause" for the validity of test data demonstrating the claimed performance of the coating system. The maximum acceptable age for performance data is a compromise between a time period over which a formulation can be reasonably expected to be

unchanged and a time period during which potentially significant changes can reasonably be expected to have occurred.

In the authors' experience, the common practice in Europe, the Middle East, Singapore, Malaysia, and Hong Kong is to set this validity period at a maximum of two to three years prior to tender. Coating systems that only have data older than the specified maximum age are excluded from the bid list on the basis of non-compliance with the technical specification until the information is updated by additional testing.

In Australia, certain consultants include sunset clauses of two to three years in project-specific tender documents. Of the public service bodies, Clause 686.04 of the VicRoads specification requires that "[m]aterial details shall include documented evidence of previous performance and relevant test results shall not be more than thirty-six (36) months old."[39] Where coatings are to provide both anti-graffiti and anti-carbonation protection in accordance with Section 685, it should be noted that Clause 685.04 further restricts the validity period to 24 months.[40] The Singapore Housing & Development Board also imposes a two-year limit on validity of performance test data.

Unfortunately, this lack of coating systems with available "current" data means that the situation often arises where none of the products tendered for a specific project fully comply with the technical specification because none have "current" performance data available.

Conclusions

The science of testing and evaluating coating systems for properties relevant to mitigating reinforcement corrosion in concrete structures is relatively mature, having been commercially available for some 30 years. There are still some issues that are worthy of research to improve our understanding of factors that potentially affect performance. *[Editor's Note: For a discussion of recent research on anti-carbonation coatings and problems with some of the work, see the original article and see Refs. 59-68.]*

Minimum performance criteria are also readily available; however, their incorporation into "official" standards and specifications has been relatively slow. Even where such documents are available, the rate of usage is often small, and there can be relatively high levels of ignorance in the market regarding their existence and content.

The majority of the market appears to rely on either generic specifications prepared by manufacturers for specific products, or project-specific documents produced by consultants and contractors. This practice means that there are attendant risks associated with issues such as outdated technical specifications that are "cut-and-pasted" by "specifiers" who don't understand them, with technical errors perpetuated in the same man-

References

1. AS/NZS 4548-1999, Parts 1-5, "Long-life coatings for concrete and masonry," Standards Australia, Sydney.
2. Peek, A.M., "AS/NZS 4548; Performance Requirements for Protective Coatings For Reinforced Concrete and Masonry," *Proceedings Corrosion & Prevention 2000*, Auckland, Australasian Corrosion Association (ACA).
3. Browne, R.D. and Robery, P.C., "Practical Experience in the Testing Of Surface Coatings for Reinforced Concrete," *Proceedings 4th International Conference on Durability of Building Materials and Components*, Singapore, RILEM, 1987.
4. Green, W.K., "Evaluation of Coatings as Carbonation Barriers for Reinforced Concrete," *Proceedings of Conference 28,* "Corrosion–A Tax Forever," Perth, ACA, 1988.
5. Bartlett D.J., *Proceedings. Corrosion & Prevention '99,* Paper 39–010, Sydney, 22–24 November 1999.
6. Bartlett, D.J., "High-Build Latex Coatings for Protecting and Decorating Concrete and Related Building Surfaces," *JPCL*, September 2001.
7. Carse, A.H., "Asset Management of Concrete Structures Investigation and Repair Options," *Concrete in Australia* Vol. 29, No. 2, 2003.
8. Hara, N., Sato, Y., Fuse, T., "The latest techniques in suppressing reinforced concrete deterioration," *Corrosion of reinforcement in concrete*, Elsevier Applied Science (UK) p. 446, 1990.
9. Vassie, P.R., in *Corrosion of reinforcement in concrete*, Elsevier Applied Science (UK) p. 456, 1990.
10. Ho, D.W.S. and Ritchie, D., "Surface coatings and their influence on the quality of the concrete substrate," *Proceedings. Rehabilitation of Concrete Structures,* RILEM, Melbourne, 1992.
11. Browne, R.D., "Reinforced concrete repair systems—the future," *Proceedings, Rehabilitation of Concrete Structures*, RILEM, Melbourne, 1992.
12. Wei, W., Rothwell, G.W., Davies, H., in *Corrosion of reinforcement in concrete*, Elsevier Applied Science (UK) p. 397, 1990.
13. AS 3600-2001, "Concrete Structures," Standards Australia, Sydney.
14. AS 5100.1-2004, "Bridge Design Part 1: Scope and general principles," Standards Australia, Sydney.
15. AS 5100.5-2004, "Bridge Design Part 5: Concrete," Standards Australia, Sydney.
16. AS 4997-2005, "Guidelines for the design of maritime structures," Standards Australia, Sydney.
17. Peek, A. and Green, W., *Concrete in Australia* Vol. 21, No. 4, pp. 24-26, 1995.
18. Peek A.M., Green W.K., and Trinder P.W., *Proceedings. 13th International Corrosion Congress*, Paper 174, Melbourne, 25-29 Nov. 1996.
19. Peek, A.M., Andrews-Phaedonos, F., Collins, F.G., and Green, W.K., *Proceedings. Corrosion & Prevention '97*, Paper 010, Brisbane, 9-12 November 1997.
20. Peek, A.M., Andrews-Phaedonos, F., Green, W.K., and Payne, D.J., *Proceedings. Corrosion & Prevention '98*, Paper 026, Hobart, 23-25 Nov. 1998.
21. www.standards.org.au/cat.asp?catid=21
22. www.standards.org.au/cat.asp?catid=24
23. AS/NZS 2311:2000, "Guide to the painting of buildings," Standards Australia, Sydney.
24. AS 3730, "Guide to the properties of paints for buildings," Standards Australia, Sydney.
25. HB 73, *Handbook of Australian Paint Standards,* Standards Australia, Sydney.
26. AS/NZS 2310:2002, "Glossary of paint and painting terms," Standards Australia, Sydney.
27. AS/NZS 2312:2002, "Guide to the protection of structural steel against atmospheric corrosion by the use of protective coatings," Standards Australia, Sydney.
28. APAS Document D125, "APAS Specifications – Cross reference to other Standards/Specifications – PRN Order," Australian Paint Approval Scheme, Melbourne, 2004.
29. APAS Document D126, "APAS Specifications History—GPC and PRN equivalence, GPC Order," Australian Paint Approval Scheme, Melbourne, 2004.
30. DR99449-DR99450, "Exterior waterproofing membrane systems," Standards Australia, Sydney, 1999.
31. HB 84:1996, "Guide to concrete repair and protection," Standards Australia, Sydney.
32. www.apas.gov.au/history.htm.
33. APAS Document D120, "APAS Specifications—Listed in Numerical Order," Australian Paint Approval Scheme (APAS), Melbourne, 2004.
34. APAS Document D121, "APAS Specifications—Listed in Key Word Order," APAS, Melbourne APAS, 2004.
35. APAS Document D124, "Technical Guide to Specifications," APAS, Melbourne, 2004.
36. APAS Document D128, "Equivalence of APAS Specifications & Australian Standards," Melbourne, 2001.

ner, and with inappropriate specifications where the cause and future effects of deterioration have not been properly considered. The infrastructure owner is left somewhat at the mercy of the knowledge levels of the practitioner that he employs.

Specifications have to be carefully prepared, and any conflicts with the requirements laid down by product manufacturers to assure the required performance must be resolved prior to commencement of work. Thereafter, adequate supervision of the work to verify compliance is essential. A major issue perceived, particularly in the Australian market, is failure to properly enforce sunset clauses on the validity and timeliness of performance data.

Acknowledgements

The authors wish to thank the Directors of GHD Pty Ltd for permission to publish this paper. They also wish to acknowledge the assistance of their colleagues Mohammad Ali, Chris Weale, and Graeme Joynson; and particularly their former Taywood Engineering Limited colleagues Fong Weng Khiong and Daniel Brown in its preparation.

Andrew Peek has over 17 years of experience in durability, deterioration, and protection of construction materials, both as a consultant and concurrently as manager of NATA accredited laboratories for Taywood Engineering Limited and GHD Pty Ltd. He has particular expertise in the use of protective coatings and treatments for concrete structures in aggressive environments. Mr. Peek has authored over 20 technical papers and presentations given to professional societies. He has experience in specification for new installations and remedial works, failure investigation, and the design and implementation of fitness-for-purpose test programs. For over 16 years he has been conducting performance testing of concrete repair materials and protective coatings for concrete and masonry.

Rodney Paull is a Service Line Leader for Materials Technology at GHD and has over 26 years of experience in construction materials technology, strategic asset management, and financial analysis. He worked for Taywood Engineering Limited for 18 years in its Australia, Singapore/Malaysia, and Hong Kong branches. Mr. Paull was previously a design engineer at Water Corporation and a technical engineer at The Readymix Group in Western Australia. He has authored over 40 technical papers on materials consultancy topics, with an emphasis on the investigation and repair of reinforced concrete structures.

37. "European Standards for Repair and Protection of Concrete," Hywel Davies Consultancy, 2005 (available from the Concrete Repair Association website: www.concreterepair.org.uk).
38. Factsheet 2, "British Standards for Concrete Repair: Surface protection systems for concrete," Concrete Repair Association, Farnham, 2005.
39. "Standard specifications for roadworks and bridgeworks," Section 686, "Coating of Concrete," VicRoads, Melbourne, July 2000.
40. "Standard specifications for roadworks and bridgeworks," Section 685, "Anti-Graffiti Protection," VicRoads, Melbourne, July 2000.
41. "Bridgeworks Specification B.23—Penetrating Sealers and Coatings for Concrete," Department of Infrastructure, Energy and Resources, Tasmania, April 2003.
42. Specification 0117, "Long Life Texture Coating for Exterior Concrete and Masonry," APAS, Melbourne, current Rev. 8 of November 2003.
43. GPC-C-117, "Long life coating systems for exterior concrete and masonry," APAS, Melbourne, 1997.
44. "Model specification for protective coatings for concrete," Civil Engineering Department, Hong Kong Government, 1994.
45. Particular Specification Appendix V, "Painting of Protective Coatings on Concrete Surfaces" Singapore Land Transport Authority.
46. ASTM D4587-05, "Standard Practice for Fluorescent UV-Condensation Exposures of Paint and Related Coatings," ASTM, U.S.
47. ASTM G154-00a, "Standard Practice for Operating Fluorescent Light Apparatus for UV Exposure of Nonmetallic Materials," ASTM, U.S.
48. BS 1881:Part 5:1970, "Methods of Testing Concrete Part 5. Methods of testing concrete for other than strength," British Standards Institute.
49. BS 1881:Part 208:1996, "Testing Concrete Part 208: Recommendations for the determination of the initial surface absorption of concrete," British Standards Institute.
50. Brown, D., Private communications, 2006.
51. Fong, W.K., Private communications, 2006.
52. ACI 515.1R-85, "Guide to the Use of Waterproofing, Dampproofing, Protective, and Decorative Barrier Systems for Concrete," American Concrete Institute, Farmington Hills, MI, U.S., 1979.
53. "Rehabilitation, Renovation, and Preservation of Concrete and Masonry Structures," American Concrete Institute, Farmington MI, U.S., 1979.
54. *Concrete Repair Manual*, 2nd Edition, International Concrete Repair Institute, Des Plaines IL, U.S., 2002.
55. TR50, "Guide to Surface Treatments for Protection and Enhancement of Concrete," The Concrete Society, Camberley, 1997.
56. "Guide to Concrete Repair and Protection," Australian Concrete Repair Association, Sydney, 1996.
57. RP0390-2006, "Maintenance and Rehabilitation Considerations for Corrosion Control of Atmospherically Exposed Existing Steel-Reinforced Concrete Structures," NACE, Houston, TX, U.S., 2006.
58. TN130, "Protection of Reinforced Concrete by Surface Treatments," Construction Industry Research and Information Association, London, 1987.
59. www.infolink.com.au/articles/4E/0C02854E.aspx, "Testing a Concrete Idea," 21 October 2004.
60. www.infolink.com.au/articles/EF/0C0292EF.aspx, "Concrete Cancer Test," 17 November 2004.
61. "Test for Coatings," *Concrete in Australia,* Vol. 31, No. 1, p. 11, 2005.
62. "Evaluation of the Performance of CO_2 Barriers in Preventing the Deterioration of Concrete Structures Located in Australian Coastal Regions," *Sustainable Tourism CRC News*, Volume 5, Issue 1, January 2006. (www.crctourism.com.au/CRCServer/documents/education/Farschid completion%20report2.doc)
63. Homayouni, F., Ronagh, H., Dux, P., and Beal, D., "Evaluating the Performance of Concrete Coatings as CO_2 Barriers," *Proceedings of Concrete 2003*, Melbourne, Concrete Institute of Australia.
64. BS 1881:Part 122:1983, "Testing Concrete Part 122: Method for determination of water absorption," British Standards Institute.
65. ASTM C373-88(2006), "Standard Test Method for Water Absorption, Bulk Density, Apparent Porosity, and Apparent Specific Gravity of Fired Whiteware Products," ASTM, U.S.
66. AS1012.21-1999, "Methods of testing concrete. Method 21: Determination of water absorption and apparent volume of permeable voids in hardened concrete," Standards Australia, Sydney.
67. ASTM C642-97, "Standard Test Method for Density, Absorption and Voids in Hardened Concrete," ASTM, U.S.
68. Hurley, S.A., *Protective Coatings Europe,* March 1999, pp. 32–40.

Hull Performance, Fouling, and Coatings

By the JPCL Staff

Strategies and technologies continue to be developed for combating the growth of plant and animal life on coatings applied to ship hulls. These developments occur within the context of an awareness of the environmental and fuel efficiency significance of hull coatings. Recent papers describing research into three quite different approaches to hull coatings—biocide-containing antifouling coatings, foul release coatings, and surface treated coatings—are reviewed below. These papers were given at the *JPCL-PCE* Marine Coatings Conference (MCC), held in Hamburg, Germany on September 24–25. The MCC was held in conjunction with SMM: The Shipbuilding, Machine, and Marine Technology International Trade Fair. Two related papers also given at the MCC are reviewed in sidebars accompanying this article.

But first, a little background on hull coatings and fouling organisms is in order.

Fouling and its Economic and Environmental Impact

Barnacles, mussels, tubeworms, sea weeds such as enteromorpha and ectocarpus, and other plant life generically referred to as "slime" attach themselves to all types of coatings. (They also adhere to uncoated substrates such as wood and steel.) The time needed to attach varies: some sea weeds adhere in as little as a few hours, while barnacle larvae take about 48 hours.[1] By and large, the fouling does not occur when a ship is in transit at speeds above 4–5 knots; the force of the moving water strips away the fouling because it has not had enough time to fully adhere to the coating. Consequently, most fouling occurs when a ship is docked. Water temperature and pH, salinity, and flow speeds affect the degree of fouling. Warm tropical waters, for example, induce more fouling growth.[2]

The attachment of fouling causes the severe roughening of a hull surface, creating increased drag as the vessel moves through water. This drag either slows down the running speed of the ship, or increases the fuel needed to power the ship to sustain maximum running speed. Operational costs are increased either way. This increase in costs is far from insignificant. By some estimates, a

Continued

10,000-ton (9,000-tonne) fouling-laden cruiser, after 6 months in temperate waters, may use up to 45% more fuel to maintain a speed of 20 knots, compared to a fouling-free vessel.[3]

In addition to the increased fuel costs, increased fuel consumption entails the release into the atmosphere of greater amounts of pollutants. This release of pollutants is also far from insignificant: total CO_2 emissions from the global trading fleet for commercial shipping in the year 2007 has been estimated at 1,120 million tonnes.[4] The difference between increased fuel consumption and increased CO_2 emissions is that a ship owner pays nothing for the latter; there is no tax on the environmental damage caused by CO_2 emissions.[5] [*Editor's Note: There are, however, regulations coming into force that restrict other pollutants from ship exhaust, e.g., NOx (nitrogen oxides).*]

There are a number of ways that hull coatings function to reduce fouling and thereby reduce fuel use and environmental impact. The technology with perhaps the longest history of use is antifouling coatings, which contain biocides (toxins) that, over time, leach into the micro-layer of water immediately surrounding a ship hull. The toxins inhibit the growth of fouling organisms, essentially poisoning them. Copper oxide and tributyl-tin (TBT) are examples of biocides that have been employed in antifouling coatings; the amount of these biocides, the specific formulation of a coating, and environmental and other factors all affect the rate at which the biocide is released into the water surrounding a ship hull. Depending on the service environment, antifouling coatings have service lives of as little as six months.[6]

Further development of antifouling coatings occurred when TBT biocides were formulated with polymer chemistry, leading to the creation of so-called "self-polishing" co-polymers (SPCs). The non-biocidal components of these coatings, polymer residues, are somewhat water-soluble after hydrolysis. So not only does the biocide leach into the water, but the other coating components slowly erode as well, exposing underfilm layers of toxic polymer for renewed hydrolysis. The surface of the film thus becomes smoother, or polished. This polished surface creates less drag, which enhances fuel efficiency. Some SPCs are noted for providing as long as a five-year service life.

There are, however, negative environmental consequences from the use of biocide-containing antifoulings. Evidence has been gathered throughout the globe of the increasing bioaccumulation of tin, copper, and other toxins in fish, crustaceans, and other marine organisms that do not cause fouling (non-target organisms).[7] This creates

a seeming paradox—coatings that aid in the reduction of fuel consumption and the associated air pollution are toxic to non-target organisms in the seas. The old adage applies: it's hard to tell the poison from the cure. The use of antifoulings with TBT as a biocide is now banned; the International Maritime Organization (IMO) adopted the International Convention on the Control of Harmful Anti-Fouling Systems on October 5, 2001, and the Convention came into full force on September 17, 2008.

Foul-Release Coatings

Developments in an alternative technology are discussed in the paper, "Operational and Environmental Impact of Foul Release Coatings," by C.W. O'Leary of International Paint Ltd., UK.

Foul-release coatings are biocide free; instead, they are formulated to create a non-stick surface similar to the inside of non-stick cookware. The coating film, by virtue of its very low surface energy, is slippery and thus minimizes the ability of fouling to adhere. Even when a ship is inactive and fouling attaches to a foul-release-coated hull, the fouling is removed in one of two ways: either by the shear force of moving water as the ship travels, or by underwater cleaning, which requires significantly less shear force than needed to remove fouling from hulls coated with an antifouling coating. The diminished force needed to remove the fouling also results in less damage to the coating, O'Leary points out.

Foul-release chemistry, developed in the 1990s, typically is based on silicone. O'Leary addresses the next generation of foul-release technology, patented in 2007, based on fluoropolymer chemistry. According to O'Leary, this new chemistry represents a significant improvement over the silicon-based systems: 2% improved fuel efficiency and 2% reduced emissions; and, compared to typical SPC antifoulings, 6% improved fuel efficiency and 6% reduced emissions.

The author attributes the advantages of the new fluoropolymer technology to several factors. The average hull

Continued

An Owner's View of Foul-Release Coatings

The shipping industry is in the middle of an energy crisis reminiscent of the 1970's, and owners are busy trying to save energy. The use of efficient antifouling systems is one of the main methods to obtain fuel cost savings. Since the tin ban, the use of silicone foul-release coatings has been the method of choice. John Drew of the Carnival Corporation gave an owner's perspective of applying silicone or foul-release coatings to newbuildings, at the recent Marine Coatings Conference (Hamburg, 24–25 September 2008).

Carnival Corporation decided to use foul-release coatings and has a track record of their use on more than twenty ships, all coated at repair. For optimum savings and performance, however, the question to be answered is, "Do we apply the coatings at newbuilding, or on vessels that are already operational (first drydocking)?" The factors to be considered are cost differences (application and operational); outfitting issues; delays in delivery of ships, which are very costly; and other factors, such as new antifouling systems and underwater cleaning options.

With a tight schedule, a silicone-based paint system can be applied in seven days. The following are various options.

- Apply at newbuilding. This might also be done at the pre-delivery stage before completing the vessel.
- Apply it at first docking, after about 2.5 years of service. This leads to different potential fuel savings. The advantage is less drag in the water.

Most operators would like to apply the coatings straightaway, but this practice could lead to delaying the completion time of the ship and add to initial costs. On the other hand, the first docking will be a little less expensive, as usually a washdown and some touchup is all that is required. Postponing the application of the system to the first docking will extend this docking time, compared to applying it during newbuilding. Missing a single planned cruise has a severe cost penalty. In addition, the reliability might be reduced due to inferior adhesion to the first antifouling layer.

Carnival has not considered practical the option of application after the block building stage because it is difficult to move the segments around without damaging the paint. One also has to deal with masking when the next construction phase is under way.

Alternatively, it could be applied during the pre-delivery phase, whereby the hull is launched with sacrificial anodes attached to it. This approach at least saves masking.

- A further option might also be to apply it to the flat bottom only, after sweep blasting as a surface pre-treatment.

There are pros and cons for the shipyard and the owner in the alternatives. This comparative study is ongoing. There is no universal solution, no "one size fits all."

roughness (AHR) is singled out as critical. According to O'Leary, measurements performed on hundreds of vessels indicate an AHR of 125 microns (5 mils) for SPC antifouling-coated hulls; an AHR of 100 microns (4 mils) for silicon-based foul-release-coated hulls; and 75 microns (3 mils) for a fluoropolymer-based foul-release-coated hull.

The low surface energy advantages of fluoropolymer foul-release coatings are attributed by the author to their amphiphilic properties. That is, these coatings are both hydrophobic (repelled by water) and hydrophilic (attracted to water). Their amphiphilic nature is significant because some marine fouling organisms have a hydrophobic nature, while others have a hydrophilic nature. The amphiphilic surface of the fluoropolymers enables the coatings to minimize the chemical and electrostatic adhesion between the surface and a wide range of foulings.

The resistance of these new coatings to slime build-up is also reported to be 50% greater than the resistance of silicon-based foul release coatings.

The author, in conclusion, projects a mean savings comparison between these new coatings and an SPC antifouling for a Very Large Crude Carrier (VLCC): over a five-year period, a savings of over 9,300 tons of fuel (USD 2.8 million based on a price of $300 per ton); and a reduction in CO_2 emissions of around 12,000 tons.

Antifoulings Revisited

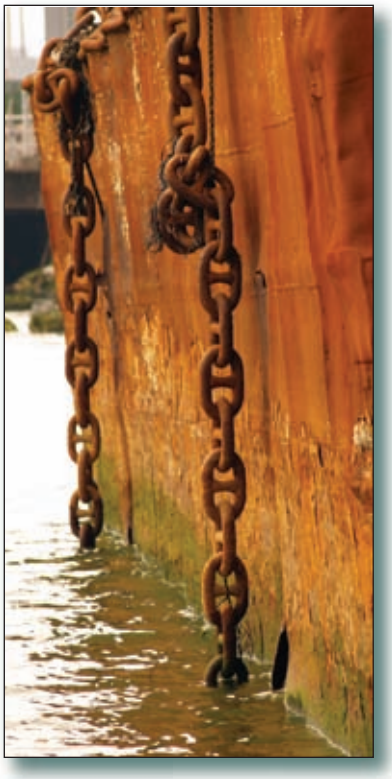
Eivind A. Berg presents a quite different perspective on fouling reduction in his paper, "The Environmental Trade-Off." According to Eivind, the leaching of biocides from antifouling coatings presents far less of an environmental threat than the greenhouse gases (GHGs) emitted from commercial shipping.

In Berg's analysis, hull smoothness imparted by foul-release coatings is diminished during service due to microbial growth and slime attachment. Regular cleaning of such surfaces is required to prevent this fouling and regain acceptable fuel economy. Therefore, he concludes, state-of-the-art biocide-based antifoulings outperform foul-release coatings in terms of reduced fuel use and GHG emissions. By "state-of-the-art," the author is referring to biocides currently used in antifoulings, subsequent to the IMO's TBT ban. These biocides are not listed or detailed in the article but are noted to be documented as environmentally acceptable. Two criteria are named for this

Continued

acceptability: the biocide, once leached from the coating, must degrade or deactivate in hours or days to become non-toxic; and the biocide must not create the potential for bioaccumulation in organisms or food chains.

Berg also discusses the transport of hull-attached, invasive, non-indigenous species from one global region to another. Environmental hazards are associated with this transport; take, for example, the damaging translocation in the 1980s of zebra mussels from the Caspian Sea into the U.S. Great Lakes. The author makes two points regarding the transport of invasive species: first, that it is not regulated nor taken into account in assessing environmental impact; and second, that antifoulings outperform foul-release coatings in the prevention of this transport. [*Editor's Note: Transport of invasive species via ballast water exchanged is being regulated.*]



According to the author, hull roughness defines environmental impact. In light of this, he says that foul-release coatings are softer than antifoulings and are more easily damaged by anchor chains, quays, and other ship equipment. Foul-release coatings are also more difficult to repair and maintain, the author says.

Surface Treated Coatings

Yet another strategy for dealing with fouling on hull coatings has been recently developed. This strategy is described in "Surface Treated Coatings and Ship Hull Performance," written by B. Van Rompay of Hydrex NV/Subsea Industries NV. Surface treated coatings (STCs) are biocide free. They are formulated to be durable and to undergo regular underwater power-tool cleaning and conditioning throughout the service life of the coating, without the need for reapplying the coating.

The conditioning aspect of the strategy is

Continued

designed to improve the surface characteristics of the coating, while the cleaning aspect is designed to remove any fouling in the early stages of development. Therefore, hull smoothness is of paramount importance for STCs: it is the primary factor in reducing fuel consumption and hence reducing GHG emissions. A graph in the paper demonstrates that, compared to a newly applied STC, hull roughness actually decreases after the coating has been in service and has then been cleaned and conditioned. The author further notes that there is now a patented technique that combines the conditioning and cleaning operations of an STC, thereby reducing maintenance costs.

One commercially available STC formulation is described in the paper—a vinyl ester with a high concentration of embedded glass flakes. This STC, applied at high film thickness, is reported to have good anti-corrosive properties and to be approved as a superior-grade ballast tank coating, the application for which it was originally designed. Furthermore, the author cites tests that indicate that after more than 500 cleanings of the same STC-coated surface, smoothness is improved compared to the hull as originally coated.

Van Rompey says that another advantage of STCs over foul-release and antifouling coatings is the STCs' superior removal during cleaning of smaller fouling, e.g., protozoa and spores of algae. After cleaning, foul-release and antifouling coatings are reported to have more crevices than STCs; smaller foulings take shelter in these crevices, increasing drag. According to the author, it has also been demonstrated that removing fouling from a vessel without reapplying an antifouling paint increases the susceptibility of the surface to new fouling.

The author also describes an ongoing EU-funded research project that assesses the economical and environmental benefits of applying STCs. According to the author, other testing also indicates that the underwater conditioning of STCs, which releases fine particulate matter into seawater, is an environmentally safe process.

Monitoring Hull Performance

Hull performance is critical for both fuel economy and fuel emissions control. The ability to accurately monitor fuel economy and emissions was the subject of a presentation, "Hull Performance Monitoring: A Tool for Fuel/Emissions Management," by Daniel Kane, Propulsion Dynamics, also given at the Marine Coatings Conference.

The speaker presented a monitoring system that has been in use for about five years. The system gives a precise speed-through-water analysis and the corresponding fuel consumption. The factors affecting hull performance are

- age of ship/ time out of dock;
- time in port;
- service speed;
- water temperature;
- fouling; and
- loading conditions.

All ships have "performance monitoring systems," and all owners say they are aware of their fuel consumption per day. The factors affecting consumption that owners can control are coating selection during newbuilding, drydocking interval, hull pre-treatment and coating at drydocking and a maintenance program. The speed log, however, isn't measured relative to the water conditions. Wind, and, to a certain extent, the fuel itself and the loading conditions are all parameters that influence the sailing characteristics. By making use of the hydrodynamic technique in the proprietary monitoring system, these and variables like trim and fouling can be monitored. The problem is then correcting the performance data into actual speed through the water. For example, 60% power can lead to anything between 19 and 26 knots.

By using the performance-monitoring program, examples were given to show

- how polishing the propeller can reduce drag by up to ten percentage points;
- that cleaning the hull led to reducing the fuel consumption from 190 to 170 tons a day in one instance;
- that a ship that anchored for four weeks used up nine tons a day more than before anchoring; and
- different antifouling coatings can be compared for effectiveness.

By analyzing all the operational variables for a vessel, an accurate picture of hull performance (drag) can be obtained, and the optimum cleaning/coating cycle can be predicted to give maximum fuel savings and minimum emissions. It has been calculated that typical average fuel savings in the merchant fleets worldwide are about 5–15 tons a day.

Furthermore

For more information on the papers reviewed, contact *JPCL*'s Brian Goldie—email: brianpce@aol.com.

Notes

1. Clive H. Hare, *Protective Coatings: Fundamentals of Chemistry and Composition*, Technology Publishing (Pittsburgh, PA), 1994, p. 486.
2. Hare, p. 486.
3. Hare, p. 485.
4. Review of MARPOL Annex VI, IMO, Sub-Committee on Bulk Liquids and Gases 2007.
5. Berg, Eivind A., "The Environmental Trade-Off," paper presented at the Shipbuilding, Machinery, & Marine Technology International Trade Fair (SMM; Hamburg, Germany) 2008.
6. Hare, p. 486.
7. Hare, p. 488.

Testing Moisture Content in Concrete Subfloors: Preventing Floor Coating Failures

Dennis J. Pinelle, Simpson Gumpertz and Heger Inc.*

We have seen a number of floor finish failures caused by moisture from the concrete substrate. In many instances, moisture tests were conducted before installing the floor covering or finish to specifically assess the moisture content of the concrete substrate. In many instances, results of the tests suggested the concrete was dry enough to install the flooring , but failure of the flooring still occurred, induced by moisture from the substrate.

(above and below): Delamination and blistering caused by moisture in concrete. All photos courtesy of the author

All concrete slabs contain varying amounts of moisture from a number of sources: the water used to mix, place, and cure the concrete; rain during the construction phase of the building; leaks; or ground water. Flooring contractors are often required to measure the moisture content of the concrete slab before installing the floor finish to assure that the concrete's moisture content meets the manufacturer's recommendations.

Continued

**Now with Pinelle Construction Sciences, LLC*

However, as seen by the large number of flooring failures, these tests do not always detect the levels of moisture that are high enough to cause failure.

The most common test method for measuring moisture levels in concrete slabs involves placing a container of anhydrous calcium chloride under a dome sealed to the slab surface. The calcium chloride is a desiccant and collects water vapor that transmits from the concrete surface into the sealed dome. ASTM International publishes two standards that use this technique: ASTM E1907, "Standard Practices for Determining Moisture-Related Acceptability of Concrete Floors to Receive Moisture-Sensitive Finishes," and ASTM F1869, "Standard Test Method for Measuring Moisture Vapor Emission Rate of Concrete Subfloor Using Anhydrous Calcium Chloride."

Another test method rapidly gaining popularity, ASTM F2170, "Standard Test Method for Determining Relative Humidity in Concrete Floor Slabs Using in situ Probes," involves drilling a hole into the concrete and inserting a probe to measure the internal relative humidity of the concrete.

This article describes the calcium chloride and relative humidity (RH) test procedures, the significance of the results, tips on interpreting the results, and the limitations of the test methods. The article also presents some other, less common techniques used to measure moisture in concrete floor slabs.

Quantitative Anhydrous Calcium Chloride Tests

The anhydrous calcium chloride test is fairly simple, and typically, the flooring contractor conducts the test and reports the results to the flooring manufacturer. Both ASTM E1907 and ASTM F1869 use a small container of anhydrous calcium chloride placed under a dome that is sealed to the floor. The container of calcium chloride is weighed at the beginning and end of the test. A desiccant, the calcium chloride theoretically collects the water vapor emitted from the concrete surface over a 60- to 72-hour time frame (Fig. 1).

ASTM E1907 provides a procedure for measuring the moisture emissions (ME) from a concrete subfloor. ASTM F1869 measures the moisture vapor emission rate (MVER). The two procedures are similar, but the methods of calculating the ME and MVER differ slightly. ASTM F1869 requires the area of the calcium chloride container to be subtracted from the dome area when calculating the MVER, while ASTM E1907 does not call for subtracting the area of the container when calculating the ME.

Commercially available calcium chloride test kits usually provide a calculation that incorporates the areas of the plastic dome and calcium chloride container. The calculation produces the moisture emitted in pounds per 1,000 sq ft per 24 hours, which is the unit specified under both ASTM procedures.

Sampling frequency differs between ASTM F1869 and ASTM E1907. ASTM F1869 specifies three tests for the first 1,000 sq ft of floor and one test for each additional 1,000 sq ft of floor. ASTM E1907 specifies three test locations for the first 500 sq ft of floor and one additional test for each additional 500 sq ft of floor. We do not normally see test frequencies that comply with either requirement, but we often see frequencies on the order of one test per 10,000 sq ft of floor area.

Fig. 1: Calcium chloride test in place

There has been much discussion about what the acceptable moisture emission (ME) or moisture vapor emission rate (MVER) should be prior to installing a floor finish. ASTM E1907 notes in the appendix that most flooring product manufacturers require a moisture emission rate of less than 3 lb/1,000 sq ft/24 hr, but manufacturer-published requirements can be higher depending on the material; for example, a growing number of manufacturers consider 5 lb/1,000 sq ft/24 hr acceptable for certain products.

Continued

ASTM F2170, Internal Relative Humidity Testing

ASTM F2170, "Standard Test Method for Determining Relative Humidity in Concrete Floor Slabs Using in situ Probes," is gaining popularity as an alternative to calcium chloride testing. The procedure involves drilling a hole into the concrete. The depth of the hole is determined by whether the slab is allowed to dry from both the top and bottom or just from the top. For a slab that can dry from the top and bottom, the hole depth is to be 20% of the slab thickness. If the slab can dry from the top only (e.g., slab-on-grade with vapor retarder or an elevated slab on a metal deck), then the hole is to be drilled to a depth of 40% of the slab thickness.

The hole is sealed with a special plug for three days to allow the internal RH inside the hole to equilibrate with the moisture in the surrounding concrete. A RH probe is then inserted down into the sleeve in the hole, which is self sealing around the probe. The internal RH is read from a meter connected to the probe (Fig. 2). We have also used self-sealing probes connected to data loggers to monitor the drying of concrete slabs over longer periods of time (Fig. 3).

Fig. 2: RH meter in use

The frequency of testing that ASTM F2170 specifies is three tests for the first 1,000 sq ft of floor area and one test for each additional 1,000 sq ft. However, we have not normally seen internal RH testing done with this frequency. Budget and traffic limitations usually make the frequency of testing to comply with the ASTM standard difficult.

Similar to the discussion about allowable limits for moisture emission levels using calcium chloride, there is much discussion about allowable internal RH levels. Depending on the floor finish, the slab's maximum allowable RH is usually in the range of 75% to 80%.

One of the advantages of this test is that the probes can be wired to data loggers, and data can be collected over time. Data collected over time can be useful for determining how fast a slab is drying. Also, if the project allows long-term monitoring, the impact of seasonal variations can also be determined.

Tips on Using the Tests

ASTM F1869 and F2170 state that before testing the concrete slab, the floor shall be maintained at a temperature and humidity consistent with the intended use for 48 hours. If a

Fig. 3: Data logging RH

48-hour pretest period is not possible, then ASTM F1869 specifies that the space be kept at 75 F ±10 degrees F and 50% ±10% RH for 48 hours prior to testing. We have seen instances where the ambient conditions have an impact on the test results, particularly in refrigerated areas in food processing facilities. In cool areas, the calcium chloride test will almost always measure a low MVER, even if there is substantial moisture in the concrete. In one food processing facility, we observed standing water under the slab, but measured a MVER of less than 2 lb/1,000 sq ft/24 hr.

If possible, moisture testing should be done at a temperature and humidity consistent with the intended use of the

Continued

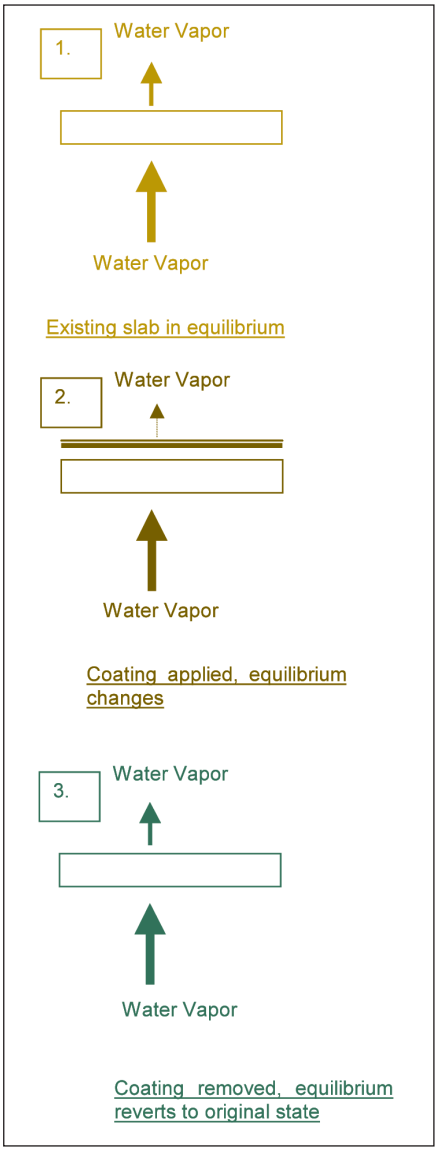


Fig. 4: Moisture levels within concrete flooring assemblies change over time.

space, not the generic conditions defined in ASTM F1869, or error may result. Also, the 48-hour preconditioning period is too short if the ambient conditions change substantially (e.g., temperature is lowered from 75 F to 40 F). The time required for the concrete to respond to such changes is typically longer than 48 hours.

If there is a pre-existing floor finish, the ASTM standards require removing it and allowing the concrete floor slab to vent (i.e., stay open to the air) for 24 hours. This requirement may be difficult because the tester must arrive two days before testing to prepare the test areas, return to place the test kits/equipment, and then return again in three days to collect the kits and record the results.

In some of the investigations we have done where there is a pre-existing floor finish, we have measured the in-service moisture condition by removing only a small sample of the flooring and quickly installing the anhydrous calcium chloride test. The amount of moisture trapped just under an existing floor covering evaporates quickly, and even after just 24 hours, much is gone and will not be detected if an anhydrous calcium chloride test is done a day later. This practice is a modification of the pretest 24-hour venting (drying out)

Continued

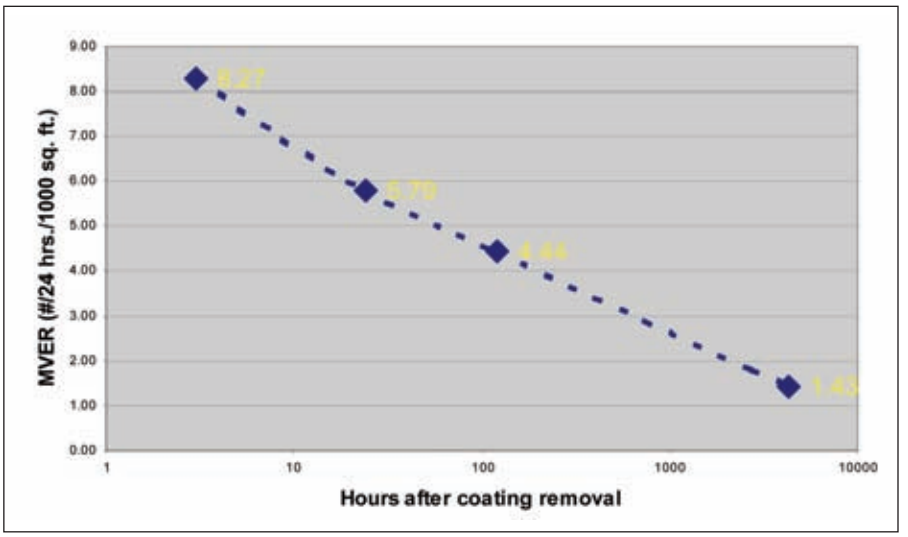


Fig. 5: MVER vs. hours after coating removal

requirement of ASTM F1869.

However, the kits placed immediately after removing the flooring provide useful information about the amount of moisture that will accumulate when equilibrium is reached on that particular slab under a floor covering/coating.

A common misconception is that the calcium chloride test generally detects moisture coming through the slab. The test appears to actually measure the moisture in the top inch or less of the concrete subfloor. The implication of this finding is that moisture deeper in the slab, or in wet materials below the slab such as insulation, is not always accurately detected by the calcium chloride test.

Use of calcium chloride and RH tests on a slab-on-grade with no vapor retarder beneath is not meaningful and will not predict the anticipated high moisture levels in the future. When there is no vapor retarder under a slab-on-grade, water vapor from the soils below can diffuse up into the floor assembly over time. Also, most floor covering materials will impede vapor emissions from the top of the slab, trapping moisture in the slab and under the flooring after installation. (Figs. 4 and 5 on the previous page). Trapped moisture has been found to cause a number of different types of floor failure.

Using either the calcium chloride or the RH test on a concrete slab provides no information about how future moisture levels change over the seasons or how outside moisture sources enter the flooring systems. Computer modeling of water vapor migration through the floor assembly, as well as long-term monitoring, can detect or predict seasonal moisture changes and may be helpful in determining future moisture contents after the new moisture equilibrium is established under the installed flooring.

In refrigerated environments, we

Continued

have found that the calcium chloride test is ineffective. The cold air temperature above the slab will slow the amount of vapor emitted from the surface of the slab. Also, the calcium chloride itself loses the ability to absorb moisture in cold environments. Combined, these two factors produce low test results that are almost always below 3. In an investigation of a refrigerated food processing facility, our calcium chloride tests were all below 3. We cored the slab and found it was insulated with cork, which was sitting in liquid water. The calcium chloride test in this case gave us no indication that there was a potential high level of moisture in the insulation under the slab.

> **Calcium chloride tests alone are not always effective in accurately detecting moisture in lightweight concrete. Measuring the internal RH in conjunction with the calcium chloride tests can better measure the moisture in lightweight concrete**

The standard calcium chloride test does not always detect internal moisture levels in lightweight concrete slabs. We have found that internal RH measurements are a more reliable way to determine the internal moisture levels for lightweight concrete. We have often found low moisture levels as measured by the calcium chloride test, but high levels of moisture deeper in the lightweight concrete, as tested with the RH test.

Interpreting Test Results

As already stated, when there is no vapor retarder beneath a slab-on-grade, we do not rely on the moisture tests to predict future moisture levels, and we assume that future levels will be high enough to induce a moisture-related failure.

For elevated slabs or slabs-on-

Continued

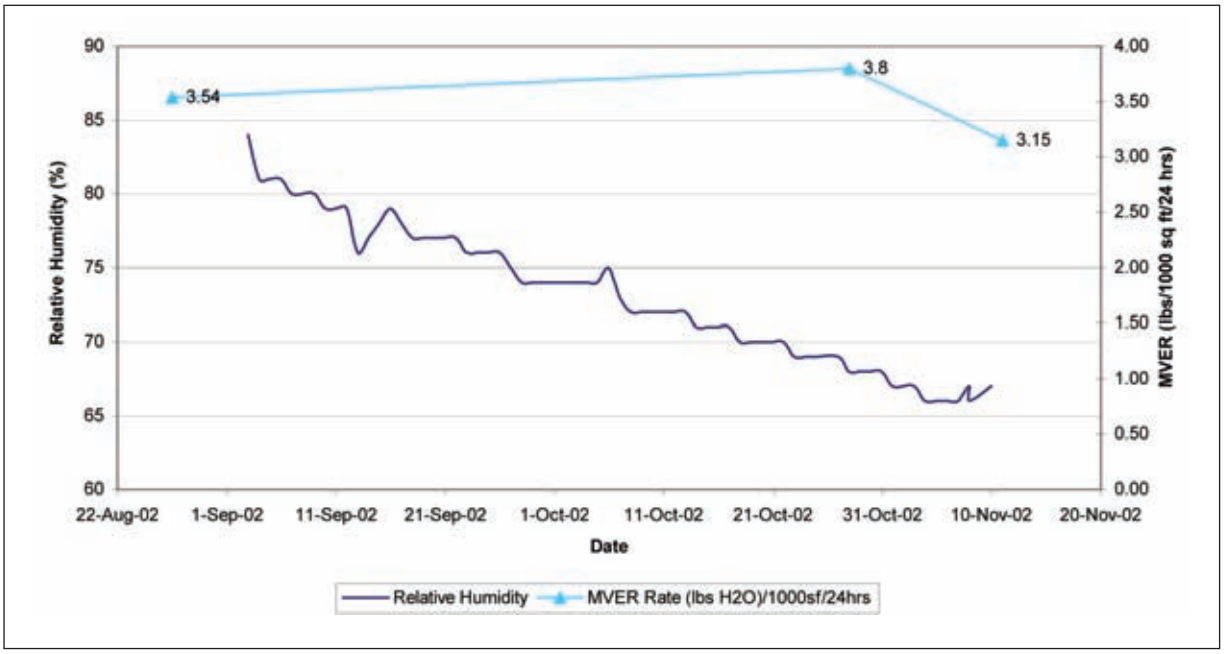


Fig. 6: Low RH and high calcium chloride results

ground with a vapor retarder, we normally conduct both the calcium chloride and the RH tests to assess a concrete floor slab's moisture content before installing a new floor finish. In general, this means we can get four different combinations of test results, which are listed on p. 64.

Continued

1. Calcium Chloride—Low; Relative Humidity—Low
2. Calcium Chloride—High; Relative Humidity—High
3. Calcium Chloride—Low; Relative Humidity—High
4. Calcium Chloride—High; Relative Humidity—Low

The first two conditions are easy to interpret. If both are low, the moisture level is low; if both are high, the moisture level is high. The third and fourth conditions require some interpretation. If the calcium chloride test is low but the RH test is high, then it is likely that the floor finish cannot be installed. The relative humidity test is detecting moisture deeper in the concrete, which the calcium chloride test cannot detect. The moisture within the concrete can redistribute after the flooring is installed and cause a failure. We see this often with lightweight concrete slabs, but we have obtained test results like this in normal weight concrete too. If the RH test indicates high levels of moisture, hold off on installing the flooring or consider a moisture mitigation system (for both normal and lightweight slabs).

If the RH test results are low and the calcium chloride test results are high (Fig. 6), then there may be a couple of reasons for this condition. The top of the slab may have been lightly wetted but not enough to saturate the slab, and the tests were run not long after. In new construction, low RH and high calcium chloride readings can also mean the slab is "almost" dry and you just need to wait a little longer. In general, this combination of test results indicates there is some level of moisture in the surface of the slab, but the "core" of the slab is dry. In other words, the slab is almost dry, but the top surface needs a little more time to dry.

Of the four possible combinations of test results, we see combinations 1, 2, and 3 most often. When the results produce combinations 3 and 4, some project-specific interpretation is likely needed, and more testing may be necessary.

> **When possible, we prefer to take core samples from the concrete slab. Core samples allow us to assess the quality of the concrete and to look under the slab.**

When possible, we prefer to take core samples from the concrete slab. Core samples allow us to assess the quality of the concrete and to look under the slab. A core hole does allow us to see if there is a vapor retarder and capillary break beneath or if there is some other material like insulation present. This information is useful in interpreting test results.

Also, consider the ambient conditions, which, as we have noted, can affect the test results. But other problems can be created by the ambient air conditions. For example, the ambient air conditions below an elevated slab could produce a vapor drive up into an elevated slab. We encountered one situation in which there was a steam generation operation under an elevated slab, and the space above was occupied. The warm moist air below the slab drove moisture up

through the perforated metal pan. Even though we obtained results that indicated the elevated slab was dry as it sat without a floor finish, we treated this particular slab like a slab-on-ground with no vapor retarder. We took this approach because, over time, moisture could accumulate in the slab from below after the floor finish was installed.

Other Moisture Tests

While the calcium chloride and RH tests currently seem to be the most popular moisture tests, there are other test procedures and equipment. Most of these are simple meters that are placed on the concrete, and the moisture level is read directly off the meter.

One proprietary unit reads the moisture level of the concrete using an electrical eddy current. By measuring changes in the impedance of the current, the meter produces a moisture reading. The scale goes from 0 to 6%, and the percentage reading is supposed to represent the moisture content as a percent by weight of the concrete.

Another type of unit has pins that are pressed into the concrete, and electrical current is passed through the concrete between the pins. Using the measured electrical resistance, the meter converts the reading to a moisture content on an arbitrary scale, such as 1 to 40. This unit is not as popular with flooring manufacturers as the meter that measures the impedance current, but we have seen it used occasionally.

A newer meter on the market uses radio waves. The meter interprets the effect on the radio waves and produces a moisture reading on a scale of 1 to 1000. In general, once readings reach the 180 to 200 range, the concrete is determined to be "wet." While the result obtained is a number, we find this test useful when used as a qualitative measure. The test is very useful in assessing what parts of a large floor are wetter than other areas, but the scale is not

Continued

always reliable in finding concrete that is too wet to receive a floor finish.

One other test that we have seen lately appears to be gaining popularity. Referred to in ASTM E1907, the test involves placing a sealed box on the top surface of the concrete floor slab. An RH probe is placed through the side of the box, and the RH change inside the box is read over time. This test has been used in other countries, but it is still not very popular in the U.S. One of the challenges faced with this test is how to interpret the results. There is some debate about interpretations. Not very many flooring manufacturers refer to the test in their data sheets, but it may become more popular in the future.

Summary

All moisture tests provide useful data, but understanding the results and their limitations is important. Based on the fieldwork we have conducted, the following summarizes some of our findings with regard to testing concrete subfloors for moisture:

- Moisture testing is necessary to determine when a concrete subfloor is dry enough to finish. The general guidelines based on time, e.g., wait 60 days after pouring concrete, are not reliable.
- Calcium chloride testing per ASTM F1869 and ASTM E1907, the most popular test methods, measures the amount of water vapor emitted from the surface of the slab over three days. The surface emission rate is not always an accurate gauge of the internal moisture content or of how fast the slab is drying.
- Internal RH testing, ASTM F2170, is gaining popularity and provides a procedure to measure the internal moisture of concrete subfloors.
- Both the calcium chloride and internal RH tests measure a moisture level at a specific point in time. However, internal RH test probes can be attached to data loggers to measure long-term changes. Seasonal differences in mois-

ture contents are not detected unless the tests are done at different times throughout the year.

- Calcium chloride tests alone are not always effective in accurately detecting moisture in lightweight concrete. Measuring the internal RH in conjunction with the calcium chloride tests can better measure the moisture in lightweight concrete.
- Calcium chloride tests are not useful in cold (refrigerated) environments.
- Neither the calcium chloride nor the RH test can predict whether moisture from other sources may enter the floor system. For instance, concrete slabs-on-grade without vapor retarders will accumulate moisture because the impermeable floor finish (vapor retarder) is installed on top of the slab.

Dennis J. Pinelle received his B.S. in chemical engineering from the University of Rhode Island in 1984. Before joining Simpson Gumpertz & Heger Inc. (SGH) in 2000, Mr. Pinelle worked as a materials engineer, a research and development manager, and a technical director in firms that manufactured construction products. At SGH, he held the position of staff consultant—materials, with particular involvement in investigating issues with coatings, concrete repair materials, and reinforcing steel corrosion. Mr. Pinelle has authored numerous papers and has given presentations at industry events on a regular basis. Mr. Pinelle is a member of the American Concrete Institute (ACI) and the International Concrete Repair Institute (ICRI), where he is a Fellow. He chairs ICRI's Corrosion Committee and currently is president of the Institute. Mr. Pinelle is also active on a number of technical committees in ACI and ICRI, including ACI 562, which is writing a new repair code for concrete repair.

Dry Ice Cleaning as Secondary Surface Prep in Ships

Editor's Note: It is common practice for many ship builders to have the steel plates blast cleaned and coated with a pre-construction or other type of primer in the shop. When the plates are then fabricated into blocks, primed areas damaged by cutting and welding in the fabrication process are repaired by blast cleaning, wire brushing, water jetting, or other conventional methods before applying the full coating system to the plates. Removal of the damaged shop-applied primer after fabrication is known as secondary surface preparation. (Intact shop-applied primer is typically overcoated with the full protective system.)

In a paper presented at the September 24–25, 2008 JPCL-PCE Marine Coatings Conference, Lars-Eric Etzold of Meyer Werft (Papenburg, Germany) describes a less common method of secondary surface preparation, the use of dry ice blasting (or cleaning). Etzold's paper is titled "Dry Ice Cleaning for the 2nd Surface Preparation." The Marine Coatings Conference was held in Hamburg, Germany, in conjunction with SMM: The Shipbuilding, Machine, and Marine Technology International Trade Fair. His presentation is summarized briefly below.

Meyer Werft in 2003
Photos courtesy of EDL, application team at Meyer Werft

Etzold, who is responsible for coating specification and deck coatings at Meyer Werft, notes in his paper that dry ice, or CO_2, blasting is not as commonly used for surface cleaning as conventional methods. However, over the past decade, Meyer Werft has started to recognize and record the possible benefits of using dry ice pellets as a secondary, efficient, and cost-effective way to clean and prepare a surface.

Before using dry ice, Meyer Werft used wire brushing or disc cleaning, but these methods created a lot of dust. Because the work was carried out in the main building hall, this resulted in time being spent cleaning the vessel and the surrounding areas. Using CO_2 cleaning reduced the dust by about 80%.

Meyer Werft, which manufactures cruise liners and special-purpose ships, started using the dry ice cleaning method in the 1990s as a secondary method for cleaning the internal areas of its ships. Since then, Etzold says, the company has successfully cleaned over two million square meters of steel.

Dry Ice: What It Is and How It Works

Etzold provides background on dry ice, noting that it is a solid form of the gas, carbon dioxide (CO_2), which comes from natural sources and arises during industrial processes where CO_2 results as a waste product.

Dry ice pellets are blasted onto the substrate via an air pressure of 6 to 12 bars. When the dry ice pellets hit the surface, several effects take place. The thermal effect happens when tension caused by thermal expansion coefficients loosen the adhesion from the base material. The sublimation effect occurs as there is an abrupt volume increase of CO_2 during the phase change that causes a type of "explosion." An impulse transfer with a dry ice hardness of 1.5 to 2.5 Mohs removes any soiling in what is known as the mechanical effect.

How One Shipyard Uses Dry Ice Cleaning

At Meyer Werft, only newbuilding is carried out and the substrate being cleaned is always steel. When Meyer Werft and contractor G.Th. Freese Bremen Company started using this cleaning method together in 1995, it was to clean the areas that would be insulated, also known as "cold steel" or "condensate" areas. The cold steel area is a non-corrosion critical area, but represents the largest area of steel on a cruise liner, as shown below in the distribution of steel surfaces.

- Underwater steel: 5%
- Vertical sides and superstructure: 20%
- Cold Steel: 40%
- Internal visible: 20%
- Tanks: 15%

The cold steel is first blast cleaned in the shop and protected with a preconstruction primer. Once the blast cleaned and primed steel is moved from the shop and assembled into the ship [block], cleaning the areas with conventional methods is not [always] practical or economical, says Etzold. Removing damaged paint by blast cleaning, water jetting, or wire brushing takes too much time and creates dust and other debris. The CO_2 method will remove paint damaged from welding or fairing work. The method will also clean off contaminants such as dirt, salt, and [weld] fume. (Removing the fume with

Top: Before the CO_2 cleaning Bottom: After the cleaning, even the burned shop primer has been fully removed.

a wire brush also increases the risk of an accident at work, says Etzold.) Because the CO_2 pellets sublimate, or turn to gas, after use, the method minimizes debris to be removed after cleaning.

After cleaning with dry ice, no wait time is necessary to start coating, says Etzold. CO_2 cleaning results in the original blast profile being exposed and slightly roughens the undamaged shop primer, so a standard coating system can be applied next, if desired and if compatible with the shop primer [before installing the insulation].

CO_2 cleaning has also been used on the vertical sides and superstructure and the interior of engine rooms.

Safety

Meyer Werft requires applicators to wear protective clothing as appropriate and to use carbon dioxide monitors with warning devices while cleaning with dry ice because as a gas, carbon dioxide above a certain level poses health risks to workers. Etzold adds that the company forbids the use of dry ice cleaning in tanks or other enclosed areas [where high concentrations of CO_2 gas could be especially dangerous].

Equipment and Costs

Etzold observes that dry ice cleaning pellets and equipment are currently available from several suppliers. The pellets are in a frozen state and require a storage box to be maintained at -79 C.

When compared to just the de-rusting and cleaning, dry ice cleaning is more expensive. However, if one takes into consideration the benefit to all parties and the ability to coat immediately, cleaning with dry ice becomes less expensive than more common methods, says Etzold.

Summary

Etzold concludes by saying that if de-rusting and outfitting work are being done in the same hall, the use of dust- or water-intensive methods will reduce the efficiency of the whole building process [compared to dry ice cleaning for secondary surface preparation].

For a copy of the paper, contact Brian Goldie, *JPCL*, at brianpce@aol.com.

SSPC Courses at PACE 2009—There's Something For Everyone!

While everyone may have a different reason for attending PACE 2009, the courses that SSPC has scheduled are sure to please all attendees—novices, inspectors, trainers, and more! The following pages provide dates, times, and course descriptions for everything SSPC is offering as of press time.

For more information on course content, prerequisites, or how to attend a course for free, visit www.pace2009.com, or call SSPC at 877-281-7772.

Blasting and Coating Fundamentals

C-1 and C-2 E-course Exam

The C-1 and C-2 E-course exam will be held on February 10 from 3:00 p.m. to 5:00 p.m. for those who have completed the 20-week online course of study for SSPC Fundamentals of Protective Coatings (C-1) and SSPC Specifying and Project Management (C-2). Those who wish to take this exam must schedule it before arriving at PACE. Dee Boyle at SSPC can be contacted for more details at boyle@sspc.org.

PCS Exam, SSPC C-1 and C-2 E-Course Exams

The PCS (Protective Coatings Specialist) Exam will be available February 16 and February 19, from 8:00 a.m. to noon. The certification program upholds the guidelines established by SSPC, and recognizes individuals who have in-depth knowledge of the principles and practices of industrial coatings technology.

Fundamentals of Protective Coatings (C-1)

The SSPC Fundamentals of Protective Coatings course takes place from February 11 to February 15, 8:00 a.m. to 5:00 p.m. each day. The C-1 course provides an overview for those who are new to the protective coatings industry. It is also a refresher on corrosion and ways to use coatings to protect against corrosion. This course is recommended for contractors, engineers, inspectors, consultants, facility owners, technical services, and sales representatives.

Courtesy of SSPC

Specifying and Project Management (C-2)

The SSPC Specifying and Project Management course will run from February 11 to February 15, from 8:00 a.m. to 5:00 p.m., including the exam. The course requires a basic understanding of topics covered in C-1, Fundamentals of Protective Coatings; the exam will cover topics from C-1 as well as C-2.

Taking the C-2 course fulfills part of the requirement for SSPC Protective Coatings Specialist (PCS) certification. Attendance is suggested for contractors, engineers, inspectors, consultants, facility owners, technical services, and sales representatives.

Lead Paint Removal (C-3)

The SSPC Lead Paint Removal course lasts from February 12 to February 15, 8:00 a.m. to 5:00 p.m. each day. The course meets the competent person training requirements for SSPC QP-2.

Attendance is suggested for anyone assigned competent-person duties on any industrial deleading project, coatings inspectors who document contractor compliance, project managers, coating specifiers, containment superintendents, and design engineers.

Lead Paint Removal Refresher (C-5)

The SSPC Lead Paint Removal Refresher course is a one-day course to be held on February 19, from 8:00 a.m. to 5:00 p.m. It provides training for those responsible for industrial deleading operations.

The course includes a review of basic

Continued

information about lead and health hazards, an update of relevant EPA regulations, a discussion of 29 CFR 1926.62, changes in the Respiratory Protection Standard (29 CFR 1910.134), and a discussion about control over emissions as presented in SSPC-Guide 6.

Those who should attend include people assigned competent-person duties on any industrial deleading project, coatings inspectors who document contractor compliance, project managers, coating specifiers, containment superintendents, and design engineers.

The C-5 course meets the competent-person training requirements for SSPC QP-2 Contractor Certification and the requirements of state programs that mandate refresher training to maintain supervisor certification.

Abrasive Blasting Program (C-7)
The Abrasive Blasting Program from SSPC will be offered on February 19 and 20, from 8:00 a.m. to 5:00 p.m. The program is designed to certify operators of dry abrasive or portable centrifugal blast cleaning equipment. There are prerequisites, which can be found on www.sspc.org/training. The program is not intended for inexperienced blasters, and it is suggested that contractors and facility owners attend.

Floor Coating Basics (C-10)
SSPC's Floor Coating Basics course is designed to meet training requirements of SSPC-QP 8, Section 4.4, which requires that each job crew chief and each QC manager complete a minimum two-day overview of concrete components, coating and surfacing types, surface preparation, and substrate repair techniques. The course will take place on February 19 and 20 from 8:00 a.m. to 5:00 p.m., including the exam. The course is worth 1.5 CEUs.

Those who attend will benefit by being able to recognize the basic properties of concrete, identify the procedures involved in inspecting and preparing a concrete installation, describe how to apply coatings to concrete floors, and evaluate contractor quality control of work. This course is recommended for concrete contractor coating and surfacing managers and related personnel.

Marine Coatings
The SSPC Marine Coatings training program takes place from February 11 to February 15, 8:00 a.m. to 5:00 p.m. each day. The program covers the use of coatings to protect structures in marine environments.

This course is suggested for contractors, engineers, inspectors, consultants, facility owners, and technical services and sales representatives.

Airless Spray Basics (C-12)
SSPC's Airless Spray Basics will take place from 8:00 a.m. to 5:00 p.m. on February 14 and 15. For the first time, SSPC has designed a program that incorporates a paint simulator for hands-on training to teach proper technique for airless spray painting. The simulation provides computerized assessments of the applicator transfer efficiency, coating thickness, amount of coating sprayed, and application time.

Topics to be covered in the course are an introduction and overview of airless spray equipment operational systems, proper mixing techniques, proper spray techniques, and troubleshooting.

This course is recommended for contractors, project supervisors, and craftworkers who use airless spray technology.

PDA's Introduction to Polyurea for the Applicator and Contractor
The Polyurea Development Association (PDA) will offer one of its most popular courses, Introduction to Polyurea for

the Applicator and Contractor, on Saturday, February 14, 1:00 p.m. to 5:00 p.m. The course is designed specifically with the applicator and contractor in mind, expanding on topics of physical properties of polyurea, testing procedures, surface preparations, application procedures and techniques, and advances in equipment.

To register for this event, contact Casey High at casey@robstan.com or 816-221-0777.

Thermal Spray Training

The SSPC Thermal Spray Training is a one-day course taking place on Saturday, February 14, 8:00 a.m. to 5:00 p.m. This course will cover the application of thermal spray coating (TSC), the equipment, inspection requirements, and more.

Students will inspect blasted surfaces for cleanliness of the panels, determine the profile, perform bend tests and inspect the bend, determine the DFT, and perform the cut test and assess the cut.

Inspection Courses

Protective Coatings Inspector Course (PCI)

The SSPC PCI Basic Inspector course will run February 10–14, from 7:30 a.m. to 6:00 p.m. Tuesday, Wednesday, and Friday; 7:30 a.m. to 6:30 p.m on Thursday; and 8:00 a.m. to 5:00 p.m. on Saturday and Sunday. The course will conclude with an exam on day five. The PCI Certified Inspector course takes place February 10–15, running the same time as the Basic Inspector course, and 8:00 a.m. to 5:00 p.m. on February 15. Check www.sspc.org/training for more information on prerequisites.

The objective of the course is to train individuals on the proper methods of inspecting surface preparation and the installation of industrial and marine protective coatings and lining systems on industrial structures and facilities.

This course is suggested for project managers, quality managers, inspectors, contractor supervisory level personnel, coating specification writers, coatings or equipment suppliers, coating consultants, or technical service representatives involved in steel protective coatings.

Courtesy of SSPC

Continued

Bridge Coating Inspector Course (BCI)

The SSPC BCI Bridge Coating Inspector Course starts on February 10 for both Level 1 and 2, and ends on February 14 for Level 1, including the exam, and February 15 for Level 2, also including the exam. The course runs from 8:00 a.m. to 5:00 p.m. each day. There are no prerequisites for Level 1, and the prerequisites for Level 2 can be found at www.sspc.org/training.

The training and certification program has been developed by an expert task group of bridge facility owners and combines lecture and hands-on instruction. The course covers topics such as how to inspect surface preparation and application of coatings on bridge steel and unique situations that will affect inspection.

This course is designed for transportation agency coating inspectors, consulting engineer coating inspectors, fabrication shop coating inspectors, contractor coating inspectors, those who want to become bridge coatings inspectors, material and equipment supplier technical representatives, program and project managers, and resident engineers.

NAVSEA Basic Paint Inspector Course (NBPI)

The SSPC NBPI course lasts from February 11 to February 15, 8:00 a.m. to 5:00 p.m. each day. There are prerequisites for this course, which can be found on www.sspc.com/training. The course was developed by Naval Sea Systems Command (NAVSEA) to train coatings inspectors to inspect critical coated areas such as cofferdams, decks for aviation and UNREP, chain lockers, underwater hulls, bilges, tanks, voids, and well deck overheads. There is a focus on ship painting issues.

The course is designed for those primarily involved in painting work on Navy ships and anyone who wants a basic certification in paint inspection.

Management and Supervision

Project Management for the Industrial Painting Industry

The SSPC Project Management for the Industrial Painting Industry is a two-day course scheduled for February 14 and 15, from 8:00 a.m. to 5:00 p.m. The program is designed to provide techniques and tools to enhance the skills of those managing industrial coating projects.

Quality Control Supervisor Course (QCS)

SSPC's Quality Control Supervisor course lasts from 8:00 a.m. to 5:00 p.m. on February 19 and 20. It is designed to provide training in quality management

for SSPC-certified contractor personnel, technical quality managers (TCM) and inspectors employed by SSPC-QP 5 inspection firms.

The course is not intended to replace the more formal quality management courses.

Applicator Train-the-Trainer

SSPC's Applicator Train-the-Trainer, a two-day course, including the exam, will be held February 14 and 15 from 8:00 a.m. to 5:00 p.m. Prerequisites for this course can be found on www.sspc.org/training.

The Applicator course is intended to meet the core body of knowledge of the SSPC/NACE Joint Standard Recommended Practice TG 320-Industrial Coating and Lining Application Specialist Qualification and Certification. The program covers an overview of the coating applicator training and certification program for two different levels. Level I is designed for entry-level employees who are new to the coatings industry. Level II is for more seasoned craft workers.

After completion of the course, the attendee will receive a CD-ROM to assist in training workers step-by-step. This course is recommended for contractor supervisory personnel interested in learning how to train workers in surface preparation and application techniques.

SSPC News Continued

More about PACE in next month's JPCL

Updated Coating Applicator Training Curriculum

Following the July 2008 launch of the coatings industry's first certification program for industrial coating applicators—the Coating Application Specialist certification program (CAS)—SSPC has expanded the integrated training curriculum of the CAS program. The curriculum, originally released in December 2007 as part of the Applicator Train-the-Trainer (ATT) program, now includes updated modules and additional specialty modules that together meet the core body of knowledge required by the joint SSPC ACS-1/NACE 13 standard for certification of coating applicators.

CAS is designed to certify individual craft workers who have experience and training in all aspects of surface preparation and coating application on complex industrial and marine structures. For the past year, training to meet the core body of knowledge has been provided as part of the ATT program as well as through public delivery of individual programs such as Abrasive Blasting (C-7) and Airless Spray Basics (C-12). Those participants learning the core body of knowledge and meeting certain prerequisites are eligible to take the CAS certification exam.

According to Bruce Henley, SSPC President, "The Applicator Train-the-Trainer program represented a great leap forward in the development of qualified applicators because it enabled low-cost, local delivery of training and allowed contractors to leverage the skills of their foremen and experienced craftspeople as instructors. This 'do-it-yourself' approach was a pioneering effort on the part of SSPC and a real departure from the concept that students must complete their training in one week. The SSPC program allows contractors to teach their workers at a pace and in a setting that provides them with immediate feedback under the tutelage of a known instructor, while disrupting the work schedule as little as possible."

With the release of this update, SSPC has added two new modules to the core body of knowledge: Safety in Painting and Process Control. In addition, seven specialty modules have been added to enable contractors to obtain training that complies with the full body of knowledge as specified by the standard.

The program provides great flexibility in the way the training can be delivered. Interested contractors can choose from three options: the ATT course, which includes instructor training for staff trainers as well as a complete set of training materials from SSPC; attendance at public offerings of individual

qualifying modules, such as C-7, C-12, Quality Control Supervisor (QCS), and Concrete Coating Basics (C-10); or a course taught by an SSPC instructor at the contractor's facility.

The updated core modules will be delivered to previous ATT participants free of charge in the next few weeks. The additional modules are available at a special introductory price for all interested parties.

SSPC also will be adding online versions of the classroom coursework in the near future.

For more information: Contact Jennifer Miller at miller@sspc.org or 877-281-7772, ext. 2221.

SSPC Announces Project Management Course

SSPC will be offering a new course, Project Management for Industrial Painting Contractors, on November 17 and 18 at its headquarters in Pittsburgh, PA.

The new course is designed to provide industrial project managers with management tools, tips, and techniques. The course will demonstrate how to define project scope, avoid bidding pitfalls, develop a preliminary schedule, optimize the project plan and budget, minimize risk by analyzing contract clauses, and make sure a project is completed successfully at a profit.

Completion of this course earns continuing education units (CEUs). Contact Jennifer Miller at miller@sspc.org or 877-281-7772, ext. 2221 for more information.

SSPC National Training Roundup

SSPC training continues to be important to many companies, both in the U.S. and abroad. The following is a brief recap of some of the courses held in the U.S. in August 2008.

Instructor Charlie Harvilicz taught eight students at a NAVSEA Basic Paint Inspector (NBPI) course held Aug. 13–17,

Continued

Students of the NBPI Course, held in Lexington, KY, in conjunction with Mega Rust 2008

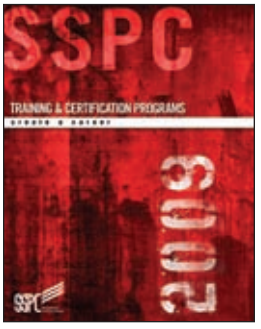
in conjunction with the Mega Rust Show 2008, in Lexington, KY. The five-day QA course teaches how to inspect critical coated areas as defined by U.S. Navy policy documents. According to SSPC, this is the 6th year in a row that NBPI has been offered at Mega Rust.

An Airless Spray Basics (C12) course with 10 students was held on August 25–26, and a Marine Plural Component Program C-14 (MPCAC) course with 20 students was held on August 27–28. Both courses were led by instructors Dan Buelk and Terry New and were hosted by QED Systems, Inc. in San Diego, CA. According to SSPC, QED is also hosting 21 SSPC classes next year in California, Hawaii, and Washington.

Said Glenn Holz of QED Systems Inc., "It was a pleasure working with the staff of SSPC in arranging and conducting both the C-12 and C-14 training courses here at our facility.

C-12 training held in San Diego, CA, hosted by QED Systems

We will benefit from these courses for a long time into the future because it expands our ability to compete for additional painting contracts with our expanded base of certified painters."



2009 Training and Certification Programs Catalog Now Available

SSPC has announced the publication of its *2009 Training and Certification Programs Catalog*. Featuring 32 pages of detailed information, the 2009 catalog is a comprehensive source for information on SSPC training and certification. Several new courses that have been added to the curriculum are featured, including the Coating Application Specialist Certification Program (CAS), Project Management for the Industrial Painting Contractor, and the Master Coatings Inspector Certificate (MCI).

To order a copy of the *Catalog*, call SSPC at 877-281-7772; a pdf version can also be downloaded at www.sspc.org/training.

SSPC Individual Member Update

Below is a list of 37 new individual members who joined SSPC in September, 2008.

If you have questions about joining, contact Terry McNeill at 877-281-7772 (U.S. and Canada) or 412-281-2331, ext. 2233.

- Albert Albrtson, Lynnwood, WA
- Magnus Andersson, Champaign, IL
- S. Arunkumar, Chennai, Tamil Nadu, India
- Bill Bendush, Blackfoot, ID
- D. Edward Blake, Manitowoc, WI
- Thomas Blaney, Posen, IL
- Matthew Burkett, Perth, WA, Australia
- Don Buwalda, Lake City, FL
- Walter Carter, Apopka, FL
- Ian G. Clark, Milperra, NSW, Australia
- Roxane Cleaves, Jefferson, ME
- Pat Coomes, Owensboro, KY
- James D. Dufour, Houston, TX
- Goh Tee Eng, Singapore, Singapore
- Robert Field, Wilmington, DE
- Manfred A. Frank, Delta, BC, Canada
- Robert Gagliano, Newark, NJ
- Ronald M. Haftl, Berkeley, IL
- Douglas Hanson, Ventura, CA
- Danielle Harrison, Alexandria, VA
- Thomas Hay, Pittsburgh, PA
- Carl Heerup, Phoenix, AZ
- Muhammad Iqbal, Batam, Indonesia
- David B. Jenkins, Maryville, TN
- Raymond Kitasoe, Menlo Park, CA
- Walter O. Lampton, Jackson, MS
- Steve McCombs, Denver, CO
- John Payne, Statesville, NC
- John M. Pence, Folly Beach, SC
- Don Pruitt, Bettendorf, IA
- Chaker Saab, Beirut, Lebanon
- Jens Saalfrank, Erlangen, Germany
- Jeremy Satterwhite, Nicholasville, KY
- Larry L. Schweinegruber, Zelienople, PA
- James D. Tallman, Seffner, FL
- Gabriel Teo, Singapore, Singapore
- Pankaj Vyas, Harwood Heights, IL

Companies

WorkBoat Show Cruises into the Big Easy

Billed as the largest commercial marine trade show in North America, the International WorkBoat Show will return again to the Morial Convention Center in New Orleans, LA, on December 3–5. Serving people and businesses working on the coastal, inland, and offshore waters, the event features a conference as well as a trade show in which nearly 1,000 companies will display products and services for commercial vessels and the companies that build, service, and operate them. The show is sponsored by *WorkBoat* magazine.

Courtesy of the New Orleans Metropolitan Convention and Visitors Bureau

This year's conference features two sessions that may be of interest to professionals in the field of industrial and marine coatings. The first, titled "Being Environmentally Responsible," will be held on Thursday, Dec. 4. Speakers Brandon Durar, Brian King, Daniel Cavalier, Robert Hill, and Sean Caughlan, P.E., will share how their companies have become more environmentally friendly through various methods, including vessel design, construction, and operation. The second session of note, "Regulations, Present & Future, Affecting Marine Industry," will also be held on Thursday, Dec. 4. Speakers Kathy Metcalf and Sean Duffy will help attendees understand the regulatory landscape and offer insights into regulatory compliance.

The intended audience for the show includes owners and operators of commercial, military, and research vessels; shipyard personnel and commercial boatbuilders; marine engineers and architects; equipment manufacturers and distributors; and port authorities and port engineers.

For more information about the show, or to register, visit www.workboat.com.

The exhibition at WorkBoat will feature many companies involved in the manufacture, supply, and application of marine and protective coatings. The following is a list of such companies known to *JPCL* as of press time.

• Calico Coatings (Booth 336) is a high-performance coating applicator and manufacturer that works with companies on friction, wear, corrosion, and heat.

• Carboline Company (Booth 2821) offers a comprehensive product line for solving marine/offshore corrosion problems through protective coatings and linings.

• CHLOR*RID International, Inc. (Booth 1171) is a leading source of products and information for soluble salt testing and soluble salt removal.

• Dalseide Inc./Rustibus (Booth 2825) is the U.S. company of the Austevoll-Norway-based Dalseide Shipping Services Group (DSS). DSS manufactures Rustibus maintenance equipment.

• Eagle Industries (Booth 176) is an international provider of products and services for containment and ventilation.

• Eureka Chemical Company (Booth 1527) manufactures the Fluid Film® product line of corrosion preventives and lubricants.

• Hempel (USA), Inc. (Booth 2530) develops and produces high-standard paints and coatings, including fouling-release coatings for the marine industry.

• Industrial Vacuum Equipment Corp. (Booth 1827) manufactures the Hurricane Line of industrial vacuum loaders. Its rental fleet is nationwide and includes vacuums, dust collectors, and steel grit recyclers.

• International Paint LLC (Booth 1630), part of Netherlands-based AkzoNobel, manufactures marine, protective, yacht, and aerospace coatings.

• Jotun Paints Inc. (Booth 3160), the North American affiliate and subsidiary of The Jotun Group, produces and supplies products to the following market segments: foreign and domestic marine and shipping, offshore, and the military.

Continued

• KMT Aqua-Dyne (Booth 1827), owned by KMT, manufactures high-pressure and ultra-high-pressure water jetting pumps, systems, and accessories.

• Marco (Booth 675) manufactures products, including industrial blast rooms, paint rooms, and blast cabinets; it also offers services, including rental and leasing.

• Mascoat Products (Booth 257), the manufacturer of Delta T Marine, Delta T Industrial, and WeatherBloc Insulating coatings, has been designing, distributing, and manufacturing insulating coatings since 1995.

• Munters Corporation—Mist Eliminator Division (Booth 3007) provides high-performance and low-pressure loss mist elimination (droplet separation) systems protecting marine air intakes from salt-laden spray.

• PolySpec LP (Booth 2660) provides specialized marine deck coating technologies designed to meet the stringent requirements and demands of offshore living accommodations and work spaces.

• PPG Protective & Marine Coatings (Booth 1431) is a supplier of high-performance coatings and fireproofing for marine and offshore applications worldwide.

• Rhino Linings USA (Booth 2863) provides industrial-strength protective coatings for marine, commercial, industrial, military, and retail applications.

• Ring Power Corporation (Booth 1827) is a Florida-based supplier of air compressors, air tools, compressor parts, and services for applications including portable or industrial compressed air and high-pressure and ultra-high-pressure water jetting.

• Sherwin-Williams (Booth 2235) is a single-source provider of high-performance coatings and equipment, with knowledgeable people and the expertise to help ensure success in all the markets served.

• Sponge-Jet Inc. (Booth 2936) manufactures Sponge-Jet® abrasive blasting systems and clean, dry, low-dust, and recyclable Sponge Media™ abrasives that allow marine personnel to accelerate maintenance activities and extend coating life.

• Wheelabrator Group (Booth 2607) manufactures a full range of wheel-type shot blast machines, air blast and painting halls, and plate and structural preservation lines dedicated to the demands of the marine industry.

• The Wooster Brush Co. (Booth 153), founded in 1851, manufactures paintbrushes, rollers, surface prep tools, and other painting equipment.

News Continued

Company Named A "Best Firm to Work For" for Fourth Year

Simpson Gumpertz & Heger Inc. (SGH) has been named a "2008 Best Firm to Work For" by *Structural Engineer* and *CE News* magazines for the fourth consecutive year. SGH is ranked the third best firm to work for among mid-sized civil engineering firms, 12th among all firms, second among large structural engineering firms in the U.S., and ninth among all structural engineering firms in the country.

Structural Engineer and *CE News* annually rank the top engineering firms that provide the best workplaces by evaluating firm culture and values, quality of leadership, compensation and benefits, recognition programs, social atmosphere, and professional growth opportunities. The rankings are determined by a corporate survey through which the firms report their employment practices and statistics, and through a confidential employee survey.

SGH is an engineering firm that designs, investigates, and rehabilitates structures and building enclosures. The company has offices in Boston, Los Angeles, New York City, San Francisco, and Washington D.C.

RPM Adjusts Full-Year Guidance

RPM International Inc. (Median, OH) announced that it has changed its outlook for its fiscal 2009 earnings to $1.75 per share, down from $1.85 for the year ending May 31, 2009.

RPM President and CEO Frank C. Sullivan made the announcement during a presentation at the Oppenheimer and Company Third Annual Industrials Conference, citing economic headwinds, sustained volatility in financial markets, weak domestic market conditions for consumers, and raw material costs as the reasons.

RPM is a holding company that owns subsidiaries in specialty coatings and sealants serving both industrial and consumer markets. Its products include corrosion control coatings, flooring coatings, specialty chemicals, sealants, and roofing systems.

Evonik Resins Renamed

Evonik Industries (Essen, Germany) has decided to rename two of its specialty resins. The name change occurred with the integration of the resins into the Tego product range in October.

Evonik Tego Chemie GmbH will supply synthetic resin under the name TEGO® VariPlus and adhesion resin under TEGO® AddBond. The specifications and quality will not be changed, according to the company.

More information is available at www.tego.de.

Bayer to Raise Prices

Bayer MaterialScience (Leverkusen, Germany) has announced that it will raise prices for coating and adhesive raw materials in the European, Middle Eastern, and African regions. The increase was slated to start October 1 and may raise prices by up to 13%, according to the company. The increase will affect aliphatic and aromatic monomeric and polymeric isocyanates and prepolymers, and some coating resin products and dispersions. The company cites rising costs of raw materials, utilities, and resources as the reason for the price increases.

PPG to Restructure Operations in Europe

PPG Industries (Pittsburgh, PA) has proposed the closure of its Geldermalsen, Netherlands, coatings manufacturing facility. Production will be consolidated with facilities in Amsterdam and Deurne-Borgerhourt, Belgium, sometime in 2009, according to the company.

The closure will be submitted to the Works Council of its Dutch subsidiary, PPG Industries Netherlands BV. The consolidation will create approximately 65 positions. There are approximately 111 people currently employed at the Geldermalsen site.

Emerald Appoints Director of Specialty Nitriles Products

Emerald Specialty Polymers LLC (Cuyahoga Falls, OH) has appointed Sara Farling as director of its Specialty Nitrile Polymers product line. The company recently combined its Nitriles and Polymer Additives divisions, which both share facility resources in Akron, OH.

Farling joined BF Goodrich, Emerald's predecessor company, in 1997 as a senior financial analyst. She also held various positions within Noveon Inc., also a predecessor to Emerald. Farling will continue to hold her position as

Continued

business director for the Polymer Additives Tire Market Segment, according to the company.

Emerald Nitrile Polymers is part of Emerald Polymer Additives, which is a division of Emerald Performance Materials. The company has been producing nitrile emulsions for over 50 years. Emerald makes products for coatings and other applications.

AkzoNobel Makes Double Acquisition

AkzoNobel (Strawinskylaan, Amsterdam) recently acquired two U.S.-based companies that it says will strengthen the company's performance coatings portfolio. The companies are Lord Corporation (Cary, NC), a floor coatings business, and Soliant LLC (Lancaster, SC), manufacturer of durable paint and bright films.

Lord Corporation is active in coatings and several other industries. The acquisition includes all resilient floor coatings business that generates revenue in the U.S., Europe, and China, the company says.

Soliant specializes in films that are used in the automotive, architectural, signage, and marine industries. Many of the films are sold under the Fluorex® name. The acquisition is expected to result in more choices for the car refinishing business, according to AkzoNobel.

Rice University Establishes Corrosion Center

Rice University (Houston, TX) has established a National Corrosion Center (NCC) to develop better technology for preventing corrosion. The development of the center is a collaboration of researchers from Rice's George R. Brown School of Engineering and Weiss School of Natural Sciences, NACE International, and other experts in the industry.

It is estimated that corrosion costs the U.S. $276 billion per year. NCC will focus on corrosion prevention and mitigation technologies. According to the university, the intentions of NCC will be to change corrosion from being an afterthought to being part of the upfront decision-making about an asset.

Due to Rice's location, a majority of the initial work will be in the oil and gas industry. Emil Peña, the executive director of the new center, is optimistic about developing superhydrophic nanocoatings that can keep water away from a steel surface.

Products

MSA Announces New Products

MSA (Pittsburgh, PA) has announced two new products, the

Continued

business director for the Polymer Additives Tire Market Segment, according to the company.

Emerald Nitrile Polymers is part of Emerald Polymer Additives, which is a division of Emerald Performance Materials. The company has been producing nitrile emulsions for over 50 years. Emerald makes products for coatings and other applications.

AkzoNobel Makes Double Acquisition

AkzoNobel (Strawinskylaan, Amsterdam) recently acquired two U.S.-based companies that it says will strengthen the company's performance coatings portfolio. The companies are Lord Corporation (Cary, NC), a floor coatings business, and Soliant LLC (Lancaster, SC), manufacturer of durable paint and bright films.

Lord Corporation is active in coatings and several other industries. The acquisition includes all resilient floor coatings business that generates revenue in the U.S., Europe, and China, the company says.

Soliant specializes in films that are used in the automotive, architectural, signage, and marine industries. Many of the films are sold under the Fluorex® name. The acquisition is expected to result in more choices for the car refinishing business, according to AkzoNobel.

Rice University Establishes Corrosion Center

Rice University (Houston, TX) has established a National Corrosion Center (NCC) to develop better technology for preventing corrosion. The development of the center is a collaboration of researchers from Rice's George R. Brown School of Engineering and Weiss School of Natural Sciences, NACE International, and other experts in the industry.

It is estimated that corrosion costs the U.S. $276 billion per year. NCC will focus on corrosion prevention and mitigation technologies. According to the university, the intentions of NCC will be to change corrosion from being an afterthought to being part of the upfront decision-making about an asset.

Due to Rice's location, a majority of the initial work will be in the oil and gas industry. Emil Peña, the executive director of the new center, is optimistic about developing superhydrophic nanocoatings that can keep water away from a steel surface.

Products

MSA Announces New Products

MSA (Pittsburgh, PA) has announced two new products, the

Continued

Altair® 5 Multigas Detector, and the AirHawk® II Air Mask. The Multigas Detector is a portable 5-gas detector with MotionAlert™, which activates a "man down" alarm when no motion is detected for 30 seconds, and InstantAlert™, which allows

users to activate an alarm to alert those around them of a potentially dangerous situation. The product also features a high-resolution color display, 17 preprogrammed languages, data logging, and a vibrating alarm.

The Air Mask offers either

the Ultra Elite® Facepiece or the industrial Advantage 4000 Facepiece, which provides adapters for twin-cartridge respirator conversion or an RD40 facepiece. The mask has an alarm and offers low- and high-pressure versions.

More information on both of these products can be found at www.msanorthamerica.com.

Stonhard Introduces Lining for Rugged Surface

Stonhard (Maple Shade, NJ) has introduced its newest lining system, Stonchem441. The system offers expanded options for protecting water and wastewater treatment facilities, chemical facilities, truck loading areas, helipads, and parking structures.

The product is engineered as a solvent-free polyurethane-polyurea hybrid coating. It has 125% elongation, chemical and abrasion resistance, dense film formation, and a water-tight finish, according to the company. UV-resistant topcoats and broadcast textured surfaces for the lining are available.

For more information, visit www.stonhard.com.

Odyssey Contracting Awarded Bridge Rehabilitation

By Brian Churray, PaintSquare

Photo courtesy of Library of Congress Historic American Engineering Record

Odyssey Contracting Corp. (Houston, PA) was awarded a contract of $6,844,466 by the Pennsylvania Department of Transportation to rehabilitate the McKees Rocks Bridge, a 7,300-foot-long, steel truss, through-arch bridge over the Ohio River. The bridge, which features a 750-foot-long, two-hinged, truss-arch span, was constructed in 1931. The project includes abrasive blast cleaning and zone painting existing structural steel surfaces. New and existing steel surfaces will be coated with an organic zinc-rich primer, an epoxy intermediate, and a urethane finish.

North Star Secures Bridge Painting Project

Photo courtesy of Jason Reighard/Structurae

North Star Painting Company, Inc. (Youngstown, OH) was awarded a contract of $4,419,930 by the West Virginia Department of Transportation to recoat approximately 6,386 tons of existing structural steel on the Jennings Randolph Bridge, an 11-span 2,024-foot-long steel truss bridge over the Ohio River between Chester, WV and East Liverpool, OH. A portion of the steel will be abrasive blast cleaned to a Near-White finish (SSPC-SP 10) and coated with an organic zinc-rich coating system; the remainder of the steel will be power tool cleaned (SSPC-SP 3) and coated with a surface-tolerant moisture-cured urethane system. The contract includes containment of the existing lead-bearing coatings.

National Park Service Awards Light Tower Painting Project

Photos courtesy of the National Park Service

The National Park Service, Midwest Regional Office, awarded a contract of $70,500 to Earl, Inc. (Negaunee, MI) to repair and recoat the interior and exterior surfaces of two steel light towers at the Munising Range Light Station in Pictured Rocks National

Continued

Lakeshore. The contract includes lead abatement and epoxy coating application.

Blastco Wins Clarifier Painting Project

The City of Garland, TX, awarded a contract to Blastco, Inc. (Houston, TX) to clean and recoat metal surfaces associated with two 110-foot-diameter secondary clarifiers. The exposed steel will be abrasive blast cleaned to a Near-White finish (SSPC-SP 10) and coated with an epoxy-epoxy-polyurethane system. The submerged steel will be abrasive blast cleaned to a White Metal finish (SSPC-SP 5) and coated with a coal-tar epoxy system. The contract, which required SSPC-QP 1 certification, is valued at $235,152.

Crosno Construction Wins Stoplog Coating Contract

The Placer County Water Agency (Auburn, CA) awarded a contract of $71,000 to Crosno Construction, Inc. (San Luis Obispo, CA) to shop-coat two 17-foot by 11-foot steel stoplogs associated with a hydroelectric facility. The steel will be abrasive blast cleaned to a Near-White finish (SPC-SP 10) and coated with a moisture-cured urethane system. The contract includes containment of the existing coatings, which are presumed to contain hazardous materials.

US Air Force Lets Fuel Tank Repair Projects

The United States Air Force Materiel Command awarded two contracts for fuel tank repair work at Eglin Air Force Base in Florida. Fuel Tank Maintenance Company, LLC (Cookeville, TN) was awarded a contract of $1,067,441 to repair a 52-foot-diameter by 40-foot-high steel tank. TolTest, Inc. (Toledo, OH) was awarded a contract of $735,178 to repair a 30-foot-diameter by 20-foot-tall steel tank. The projects include installing new steel bottoms in the existing tanks, reconfiguring appurtenances, and installing leak detection tubes and cathodic protection systems. The projects also include lining the interior surfaces of the tanks and coating exterior surfaces impacted by the retrofits.

Redwood Painting Awarded Clearwell Coating Contract

Redwood Painting Company, Inc. (Pittsburg, CA) was awarded a contract of $559,960 by the Alameda County Flood Control and Water Conservation District to perform coatings repair work on two clearwells. The project includes cleaning and overcoating the exterior surfaces of a 4.5 MG steel clearwell, cleaning and coating interior metal surfaces of a 3 MG concrete clearwell, and performing touch-up coating on the interior surfaces of the concrete clearwell's aluminum roof.

S&T Painting Awarded Tank Repair Contract

S&T Painting, Inc. (Parkton, MD) was awarded a contract of $259,000 by Harford County, MD, to repair and recoat a 1 MG water storage tank. The interior wet surfaces will be abrasive blast cleaned to a Near White finish (SSPC-SP 10) and lined with an epoxy system. The exterior surfaces, which are currently coated with heavy metal-bearing coatings, will be abrasive blast cleaned to a Near-White finish and coated with an epoxy primer and two coats of urethane finish. The concrete ring and base will receive a single coat of epoxy.

US Tank Painting to Recoat Elevated Tank

US Tank Painting, Inc. (Hillside, NJ) was awarded a contract by the Township of Moorestown, NJ, to recoat a 1.5 MG hydropillar elevated water storage tank. The interior of the tank will be abrasive blast cleaned to a Near-White finish (SSPC-SP 10) and lined with an epoxy system. The exterior of the tank will be abrasive blast cleaned to a Commercial finish (SSPC-SP 6) and coated with an epoxy-urethane system. The contract, which includes lead abatement within a Class 2A containment structure (SSPC-Guide 6), is valued at $1,095,000.

Quick Hits

Martin Painting & Coating Company (Grove City, OH) was awarded a contract of $7,925 by the City of Columbus, OH, to apply a chemical-resistant epoxy system to 1,166 square feet of ceiling surfaces and 1,296 linear feet of ductwork at a water treatment plant.

The City of West Sacramento, CA, awarded a contract of $264,900 to Olympus and Associates, Inc. (Reno, NV) to clean and recoat the interior and exterior surfaces of an existing 1.8 MG ground-level water storage tank.

E&D Coatings, Inc. (Savannah, GA) was awarded a contract of $28,000 by the City of Savannah, GA, to apply an alkyd coating system to ornamental iron fencing and handrails along Factors Walk in the city's historic district.

The City of Pueblo, CO, awarded a contract of $51,400 to Counce Kemper Specialty Contractors (Mead, CO) to perform foam insulation replacement and coatings application on four digester domes at a water reclamation facility.