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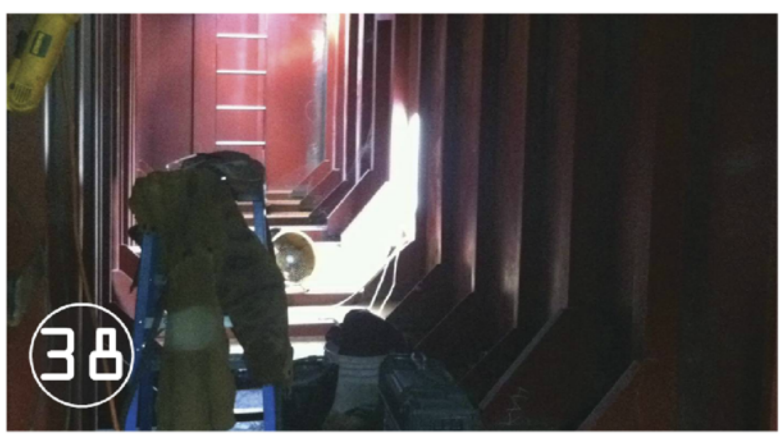
JOURNAL OF PROTECTIVE COATINGS & LININGS

The Voice of SSPC: The Society for Protective Coatings

Cover photo: Courtesy of ITW Polymers Coatings NA

FEATURES



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The Society For Protective Coatings

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Free Webinars Focus on Sewer Rehab, Coating and Lining Systems

Webinar Education Series

The 2013 SSPC/*JPCL* Education Webinar Series continues in July and August with two new free webinars.

"Sewer Infrastructure Rehabilitation," will be presented on Wednesday, July 24, from 11:00 a.m. to 12:00 noon, EST. This webinar will explain the steps required to properly rehabilitate sewer structures, including the control of inflow and infiltration, substrate repair or rebuild, and the generic types of coatings and linings that exist in the marketplace today to prevent corrosion. This webinar will also review some of the generic characteristics—both positive and negative—of these coatings and linings.

"Selecting the Proper Coating and Lining System," will be presented on Wednesday, August 21, from 11:00 a.m. to 12:00 noon, EST. This webinar will discuss the common generic chemistries in the high performance coating and lining marketplace and highlight their practical uses. It will define coatings and linings in generic categories such as thin film, medium film, self-leveling mortars, mortars, laminates, flexible systems, mortar laminates, etc., and the potential areas for use of these generic classifications. The webinar will also review the three mechanisms of how coatings protect a substrate and how surface preparation and profile play into coating and lining selections.

Kevin Morris

These webinars will both be presented by Kevin Morris, Regional Market Segment Director, Water & Wastewater, for The Sherwin-Williams Company. Morris has been employed with Sherwin-Williams for 21 years, with the past 12 years dedicated to the Protective & Marine Coatings Division. In the past, Morris has served as Protective & Marine Coatings Sales Representative and Corrosion Specification Specialist in the Southeastern United States. He is currently responsible for the North American Water & Wastewater Market Segment for Sherwin-Williams Protective & Marine Coatings Division. Morris is a NACE Level III Certified Coating Inspector, an SSPC Certified Concrete Coatings Inspector, and an instructor of SSPC's Coatings – Concrete Coatings Basics and Concrete Coatings Inspector programs. He has written and published numerous papers and articles for organizations such as Paints and Coatings Expo (PACE), International Concrete Repair Institute (ICRI), American Water Works Association (AWWA), Water Environment & Technology (WE&T), and *JPCL*.

These webinars are both sponsored by The Sherwin-Williams Company.

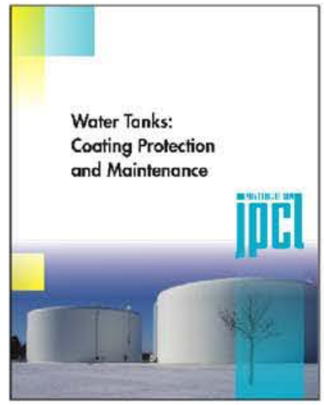
Registration, CEU Credits

These programs are part of the SSPC/*JPCL* Webinar Education Series, which provides continuing education for SSPC re-certifications and technology updates on important topics.

SSPC is an accredited training provider for the Florida Board of Professional Engineers (FBPE), and Professional Engineers in Florida may submit SSPC Webinar Continuing Education Units to the board. To do so, applicants must download the FBPE CEU form and pass the Webinar Exam, which costs $25.

Register for these online presentations at www.paintsquare.com/webinars.

JPCL Offers New Water Tanks eBook



JPCL has released a new, free eBook on coating, protecting, and maintaining water tanks, available for a free download exclusively through paintsquare.com, the online home of *JPCL*.

"Water Tanks: Coating Protection and Maintenance," is a combination of eight in-depth, technical articles written by leading industry experts that serves as a guide to protecting and maintaining water tanks and other waterworks structures. This eBook is sponsored by The Sherwin-Williams Company.

All of the articles in this eBook were originally published in *JPCL*. A copy of this eBook is available for free download at www.paintsquare.com/store.

Stars Shine at Houston Coating Society Show

Silly string and noisemakers were plentiful at the Houston Coating Society's Annual Trade Show, held April 20 in Pasadena, TX.

Among those honored were the winners of the Society's 23rd Annual Industrial Painters' Competition. The team from Infinity Construction Services of Freeport, TX, claimed the first place prize, with CB&I/Battleground (Deer Park, TX) and Brand/Lubrizol (Deer Park, TX) taking second and third place, respectively.

Kevin Kelleher of PPG Protective and Marine Coatings receives the royal treatment as he steps up to accept the David Randall Whiteman Award. Photo by Pam Simmons, JPCL/PaintSquare

Recognition for individual contributions to the Society went to several members.

Kevin Kelleher of PPG Protective and Marine Coatings received the David Randall Whiteman Award in recognition of his diligent work with the Houston Coating Society. The award is named for Whiteman, an HCS member who was tragically killed in an accident in 1976.

Mascoat Products won the William A. Wood Award for supporting the Coating Society through membership, sponsorship, and representatives. The award is named for Bill Wood, an almost 40-year veteran of Sherwin-Williams and highly revered individual in the industry.

The Ernestine McDaniel Lifetime Achievement Award, created in 2004, was presented to Wayne Pruitt, an owner of Anchor Industrial Services, in recognition of his involvement in the Coating Society throughout his career, chairing the tradeshow for the past six years, and developing the Dick Paseman Project, which chronicles the history of the Houston Coating Society. The award is named for Ernie McDaniel (GMA Garnet), whose commitment to the Houston Coating Society is longstanding and ongoing. She was the first recipient of the Award.

OSHA Targets Isocyanate Exposure

The Occupational Safety and Health Administration (OSHA) announced a National Emphasis Program (NEP) to protect workers from the serious health effects from occupational exposure to isocyanates, chemicals used in protective coatings such as polyureas and polyurethanes as well as in products such as building insulation and mattresses.

Isocyanates can cause occupational asthma, irritation of the skin, eyes, nose and throat, and cancer if workers are not properly protected while working with isocyanates or products containing them, and deaths have occurred due to asthma and hypersensitivity pneumonitis from isocyanate exposure.

For the NEP: osha.gov/OshDoc/Directive_pdf/CPL_03-00-017.pdf

For more information and standards addressing isocyanates: osha.gov/SLTC/isocyanates/index.html

Correction

In the May 2013 *JPCL*, Table 5 on p. 52 of the article, "Is Lead Dead," gives an incorrect value for the 1995–1997 allowable level of lead in dust for window sills. The correct value is 250 $\mu g/ft^2$.

The Buzz on PaintSquare.com

By Anita Socci, JPCL

HOT TOPICS:

Maintaining fire hydrants—and gun control

In the PSN story, "Seeing Red: Gun Pulled Over Paint Job," an intoxicated Washington State man became fired up after he found a note from a city employee suggesting the red fire hydrant the man recently painted be repainted in yellow, per city code requirements. The man reportedly found the note and, while intoxicated, took a loaded handgun and tracked down the worker to his home, police said.

Scan the QR code below to read the entire story and check out the comments, which are too numerous and varied to list here, and let us know what you think!

PSN TOP 10 *(As of July 5)*

- Mega-Bridge Picks Main Coating Supplier
- Bridge Projects in MO, AZ, PA Kill 3
- OSHA to Target Key Coating Chemical
- Chinese Steel Riles U.S. Bridge Group
- Plant Explosion Kills 2, Cause Unknown
- Second LA Plant Blast Claims One
- Developments in Zinc Primers For Corrosion Protection
- When in Concrete, Doing as Romans Did
- Seeing Red: Gun Pulled Over Paint Job
- Inspection Lapses at Hanford Leaked

MOST POPULAR QUIZ *(as of July 10)*

What does "theoretical coverage" mean?

Robin Hasak	21/22
Roland Peemans	21/22
John Triebe	21/22
Adam Carter	21/22
Lyudmil Yambolov	21/22

Results

MOST POPULAR POLL

How do you expect the Affordable Care Act ("Obamacare") to affect your business next year?

64% A costly nightmare from beginning to end.

13% A modest inconvenience and cost increase.

13% I already comply, or it will not apply to me.

10% I expect it to have a positive effect on my employees.

Get the coatings industry buzz at paintsquare.com, or scan the QR code with your smart phone for instant access!

Problem Solving Forum

When an IOZ Fails the MEK Test

What action should be taken if an inorganic zinc (IOZ) fails the MEK test?

From Gary Hall
Consultant

First, keep in mind how IOZ primers cure. They are based upon ethyl silicate binders. These react with atmospheric moisture producing ethyl alcohol, which then evaporates. A typical cure time for IOZ primers is seven days; however, the cure time depends on temperature, humidity, and thickness. If the humidity is too low, less than 50%, the coating may not cure fully. Generally acceptable temperature ranges run from just over 0 F to about 120 F, depending on the formulation, so the problem probably does not lie with the temperature. If the humidity is too low, it may be necessary to mist the coating during cure. (Consult the manufacturer before doing this.) If the coating is applied at a thickness greater than that recommended by the manufacturer, the coating likely will not cure throughout. If not fully cured, the IOZ will not exhibit the necessary solvent resistance.

When an inorganic zinc coating has failed ASTM D4752 (MEK—Double Rub Test), one's first impulse is to remove the failed coating and apply a new coat, an expensive and possibly unnecessary process. So before removing the IOZ and re-priming, you can take other steps to determine if removal is necessary.

Contact the coating manufacturer about the expected cure time and required cure conditions in order to pass ASTM D4752, because not all IOZs require the exact same conditions.

If the proper conditions were maintained during application and cure of the IOZ, I would give the coating a few more days to cure and then retest it in accordance with ASTM D4752.

Should the IOZ again fail the MEK test, there is a relatively inexpensive and definitive lab test for cure, and I would try it before deciding to remove the IOZ.

For *most* IOZ primers, ASTM D4752 has been shown to correlate well with a lab test called diffuse reflectance infrared (IR) spectroscopy (ASTM E1252). So if the IOZ fails the MEK test a second time, I suggest having a lab run the IR spectroscopy test. (Not all labs have the test, so you may need to call around before you find one that has it.) The IR test requires only a couple of lab hours to run, including sample preparation, and can generally be run by a qualified lab for about $300. Before considering IOZ removal based solely upon the MEK double rub, I would certainly spend the small additional amount of money to get the IR test results before removal of the IOZ.

You may even consult the manufacturer about the diffuse reflectance IR. The manufacturer may be able to run that test for you and thus save some money.

If the IR test shows the coating to be fully cured, something was done incorrectly during the MEK double rub test.

If the IR test reveals the coating to be not fully cured, then the coating is not fully cured. There are several possible causes of incomplete cure.

If the proper conditions were not maintained during application and cure, the cure rate will be affected. For example, if the coating was not cured under the correct conditions, or it was applied at a thickness that was too great, the cure will not proceed as required, and it may well be necessary to remove the IOZ.

If the conditions or thickness were marginal, the coating may partially cure. The coating manufacturer must be contacted under these circumstances to determine if the IOZ can be salvaged. Marginal curing conditions may allow the coating to be saved, but the manufacturer should be consulted before spending more money in a futile effort to save a coating that cannot be salvaged.

From Raymond Merrill
Texas Department of Transportation

An IOZ coating failing the MEK rub test is an indication that the coating is not fully cured (cured, as opposed to dried—there is a difference). IOZs, in my experience, dry relatively quickly. Curing, however, can take anywhere from 24 hours to 7 days, depending on ambient conditions. Should it fail the MEK rub test, spray with water spray and try again. Consult the product data sheet to determine about how long it should take to completely cure.

From Alan Brown
AB Independent Inspection Services

If, after one week, the IOZ has not cured, reblast and recoat under the correct conditions specified. It's the only way to go. I have done this after 4–5 days.

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

Q&A WITH PAT SWEENEY

BY CHARLES LANGE, JPCL

Pat Sweeney is the general manager of CSI Services, Inc., an SSPC-QP 5-certified coating inspection firm based in Santa Clarita, CA. Sweeney, who has close to 25 years of experience in the industry, is the chairman of the Southern California chapter of SSPC, a result of over 10 years of service on the chapter's Board of Directors. Along with having PCS certification, he is an SSPC Level 3 Protective Coatings Inspector (PCI), a NACE Level 3 Coating Inspector, an instructor of SSPC and NACE courses, and an active committee member for both organizations, as well as the American Water Works Association (AWWA). He holds a B.S. from California State University at Los Angeles.

JPCL: How did you get your start in the coatings industry?

PS: When I graduated from college, I had my choice of working for many different aerospace contractors, but around the time that I was receiving my degree, an interesting event happened: the Cold War suddenly came to an end. This resulted in an eager new graduate facing a wall of defense industry hiring freezes. Shortly afterward, a friend introduced me to a person that was looking for technical, physically capable individuals to provide coating inspection. It is hard to believe that it has been almost 25 years since I asked that person, "You want to pay me to watch paint dry?"

JPCL: Can you talk about your experiences participating in associations like SSPC?

PS: My experiences with SSPC have been invaluable to my career. It has not only allowed me to network with my colleagues, but also given me greater access to new people and technologies as they enter the industry. It has been my experience that individuals that take advantage of associations like SSPC are often the leaders and most successful people.

JPCL: Obviously, water supply is an incredibly vital issue in hot and dry places like Southern California. Can you talk about the importance of maintaining coating systems on water tanks and other water system components in your area?

PS: As I travel around the country, I am always amazed at how other regions do not value the importance of water as we do here in the arid Southwest. I always shake my head when I see rivers dumping into oceans. Any short disruption of water to customers can have a drastic result. This has resulted in water and wastewater facility owners taking a very stringent approach to maintaining their infrastructure. Complicating the role that coatings play in Southern California, South Coast AQMD was the first to implement the lowest VOC levels in the country through Rule 1113. This resulted in steep learning curves for even the best suppliers, contractors, and inspectors as the wave of new coating formulations flooded the market. After five years, it appears that the industry has evolved to meet these requirements.

JPCL: Are there any recent technological developments or new kinds of equipment that have helped make your job easier?

PS: There are two technological advances that have made my job easier. The obvious one is the current digital revolution. I remember when handwritten paperwork and one-week written responses were the norm. Today, our inspection customers expect documentation with photographs within 12 to 24 hours. The second change is the advancement and refinement of the various technical standards that are always evolving and being published. This provides for a much more sound base for providing fair and justified inspection services.

JPCL: What are some of the qualities that you look for when hiring new employees at CSI? Or, in more general terms, what are some of the qualities that are most important for someone looking to get into the coatings industry?

PS: It has been my experience that the industry needs the full spectrum of personalities. Within the inspection end of our industry, it is detail-oriented individuals with a clear understanding of the importance of coating quality that is the basic requirement. Inspectors with both of these qualities are typically the best at their job. Unfortunately, if a candidate is missing one of these characteristics, they will tend to not meet the grade.

JPCL: Is there a particular project you've worked on in the past that was especially interesting or challenging? Can you describe how you dealt with some of these challenges?

PS: My job has taken me to just about every type of project that can be imagined, and this will always keep my interest. We recently completed the inspection during the recoating of some of the Red Hill Tanks in Hawaii, and the project required critical technical and scheduling tasks. It was fulfilling to contribute to such an intriguing facility. Not many people, including Hawaiians, are even aware of this amazing place. The complex is listed by the American Society of Civil Engineers as one of the main engineering feats of the United States. It is too bad that some people forget about the amazing accomplishments that our government can achieve.

JPCL: What has been the highlight or proudest moment of your career so far?

PS: I would have to say that our company's recognition from SSPC as a -QP 5 firm was a benchmark in my career. Our firm has always felt that it provided quality services with integrity, but it was nice to be acknowledged by an impartial, respected organization that we do in fact have the qualities that are required at the highest level.

JPCL: What would you say is the best part about your job?

PS: The best part of my job is that it allows me to spend time both in the office and out in the field. Aside from managing the company operations, I am often climbing elevated tanks or crawling through pipelines. I enjoy relaying my experiences to others as a means of solving a problem, whether it is a coating, political, or personal issue. At the end of the day, I view my role as one that makes everyone else look a little better.

JPCL: What are some of your interests outside of coatings? What kinds of things do you like to do in your free time?

PS: As my two sons, Cameron and Wyatt, enter adulthood, I find that my life outside of work is built on a few passions. I enjoy spending time with my best friend and wife, Becky. I also enjoy listening to the Dave Matthews Band and downhill mountain biking with friends. Some of my favorite times are spent bike riding with Becky while my iPod plays Dave Matthews.

Why Good Housekeeping Is Important

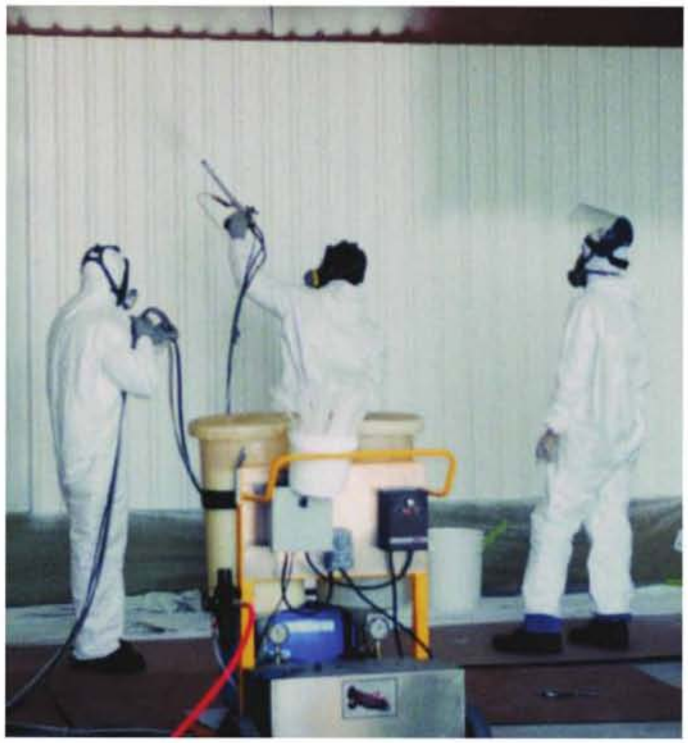
Good housekeeping during surface preparation and coating work means keeping the work environment clean; keeping equipment clean; and organizing materials, tools, and equipment so that they help rather than hinder you in your work. If you do not practice good housekeeping, you might create safety hazards that will lead to accidents, because equipment problems may slow you down; create conditions that will cause poor workmanship and possibly premature coating failure; and put workers, the environment, and the public at risk. For these reasons, you must pay careful attention to good housekeeping.

Keeping the Substrate Clean

Grease, oil, dirt, salt, and dust are among the major enemies of a good coating job. If they are not removed from the substrate before the coating is applied, then the coating is more likely to fail.

A common sense approach to cleaning the substrate requires that you clean in the proper sequence, that you be thorough in your cleaning operations, and that you eliminate sources of salt, dirt, and dust that could re-contaminate a surface after you have completed your cleaning.

Before you conduct mechanical surface preparation operations on a steel surface (e.g., hand/power tool cleaning and abrasive blast cleaning), you must remove all visible deposits of grease and oil. Otherwise, you will simply scatter and force these materials into the surface of the steel. Solvent wiping in accordance with SSPC-SP 1 is performed to remove residues of grease and oil.



Jobsite cleanliness is next to...your application success

You must use clean cloths when you are solvent wiping a surface, and use an inward circular motion when cleaning; otherwise, the oil and grease are simply spread around. A clean cloth will remain clean for only a short time; you should properly dispose of it once it becomes dirty, and use a fresh one.

Once surface preparation by blasting or power tool cleaning is finished, residual dust will remain on the surface. This dust should be removed by wiping the surface, vacuuming it, blowing it down with clean compressed air, or using another method as required. As we will discuss later, if the dust contains lead or other toxic or hazardous metals, additional requirements may be necessary when cleaning up these materials.

It is important not to re-contaminate a surface after it has been cleaned. Re-contamination can easily occur if you don't also remove dust and debris that is near the object you will be coating. If dust or dirt isn't removed, it may become dislodged by climbing, equipment or containment movement, wind, or other means.

Keeping Equipment Clean

When equipment is clean, it works efficiently; when it is dirty, it can break down and, in

Editor's Note: This article is based on the original Applicator Training Bulletin (January 1990 JPCL) and the version that was updated by the Houston Coating Society in 2005.

turn, lead to a faulty coating job.

For instance, when your work is finished, your spray gun and spray lines should be thoroughly cleaned appropriately, based on the manufacturer's instructions—usually using water or a solvent approved by the manufacturer. If the lines are not cleaned, paint left in a spray line will dry and then will crack and break free once the line has flexed. The paint particles can then travel to the spray gun and clog the tip. As a consequence, work stops until the paint particles can be removed from the system.

When you clean spray equipment, make certain that you are following the manufacturer's instructions to purge the system. Otherwise, the paint may not be completely removed, or may even set up in the lines. After cleaning, if you are immediately changing to another coating system, it may be necessary to rinse the inside of the hoses according to the instructions from the manufacturer of the new coating so that residual cleaners from the first coating do not contaminate the new material, potentially causing it to separate or gel.

It is very important to observe good housekeeping rules in the area where you mix the coating. Be sure, first of all, that the mixing area is far enough away from the cleaning and coating operation so that dust and debris do not contaminate coatings in open containers. Also, keep coating and thinning containers closed until you are ready to use them.

Do not mix coatings in containers or stir with paddles that have coating buildup on them. Even though the old coating may appear dry, it can contaminate the fresh paint you are using. It can become dislodged by the physical action of the mixing, or may even be softened by solvents in the new material. In addition, do not mix the paint from one manufacturer in the container from another manufacturer. This can cause confusion about the identity of the paint actually being used.

Housekeeping Is Important to Safety

Just as you must take care to avoid contamination of work surfaces and coatings, you must also take care not to contaminate yourself. For instance, if your work clothes are covered with dust from spent coatings, paint, or solvent, your skin can be exposed to irritant materials that may cause a rash, create an exposure through the skin, or result in allergic sensitization. The Occupational Safety and Health Administration (OSHA) has regulations for protecting workers against hazardous materials, and your employer must make sure that you are trained in hazards you are exposed to (such as lead or hazardous materials in the coating) and that you are provided adequate protection from them. Various OSHA regulations address all sorts of issues, such as the types of protective clothing you should wear; how as well as where it should be laundered; and the precautions you must follow for using, caring for, and storing your fall protection and respiratory gear. For lead, cadmium, arsenic, and hexavalent chromium, OSHA has comprehensive regulations requiring housekeeping and using HEPA-filtered vacuums.

Special Conditions

When you are dealing with cleaning or coating at a work site where there are hazardous materials or where hazardous wastes are generated, local, state, and/or federal regulations may apply for protecting the public and the environment. Some abrasives (e.g., sand), existing paint (e.g., lead-based paint), and other materials (e.g., some solvents) may be classified as hazardous materials or wastes. Regulations will apply to the removal, packaging, handling, appropriate treatment, and disposal of the materials or waste.

Keep a Clean, Orderly Work Site

It is very important, both for safety and for productivity, to keep a clean, orderly work site. If you store materials and tools properly when you are done with them, they will not clutter up the work area and they can be kept clean. In addition, they are easily accessible if they are stored in an orderly fashion.

You should also properly organize your paint storage area. For example, coatings of the same type should be stored together. Also, be sure to rotate your stock, keeping the oldest material in the front of the storage unit so you can use it first. This practice will help you make sure that none of your coatings exceed their shelf life; you will save money by not having to replace outdated material; and you will reduce the risk of premature paint failure.

Protect Materials from Weather and Vandalism

You should make sure that all equipment left overnight at the jobsite is secured to prevent damage and vandalism. Small tools should always be locked up and removed from the job site. Equipment should also be locked and secured. Coating materials should be placed in locked storage sheds in a secured area at temperatures recommended by the coating manufacturer. This may require introducing heat or cooling into storage units, and monitoring the storage temperature and conditions. While storage outdoors is not recommended, and is frequently precluded by specifications, if materials must be stored outdoors, the containers should be stored off the ground to prevent damage from water (i.e., as a minimum, on pallets), and they should be covered with polyethylene to keep them dry. Similarly, bags of abrasive should be stored off the ground and protected with waterproof coverings to prevent moisture from damaging the abrasive.

In Summary

Remove dirt, salts, dust, oil, grease, and debris from work surfaces and control the debris so that it does not recontaminate work surfaces, workers, or adjacent property.

Dust and debris that find their way into the spray pots can contaminate the paint and clog spray guns. Clogged tips require taking the gun apart for cleaning, which will slow you down. Store and mix the paint materials in accordance with the manufacturer's instructions.

And make sure that you protect yourself, the public, and the environment by following all regulations relevant to the project, thus minimizing environmental and worker health and safety risks.

Finally, keep the worksite neat and orderly. No only does this improve safety, but also it can increase productivity and the quality of the final product.

Upcoming Topics

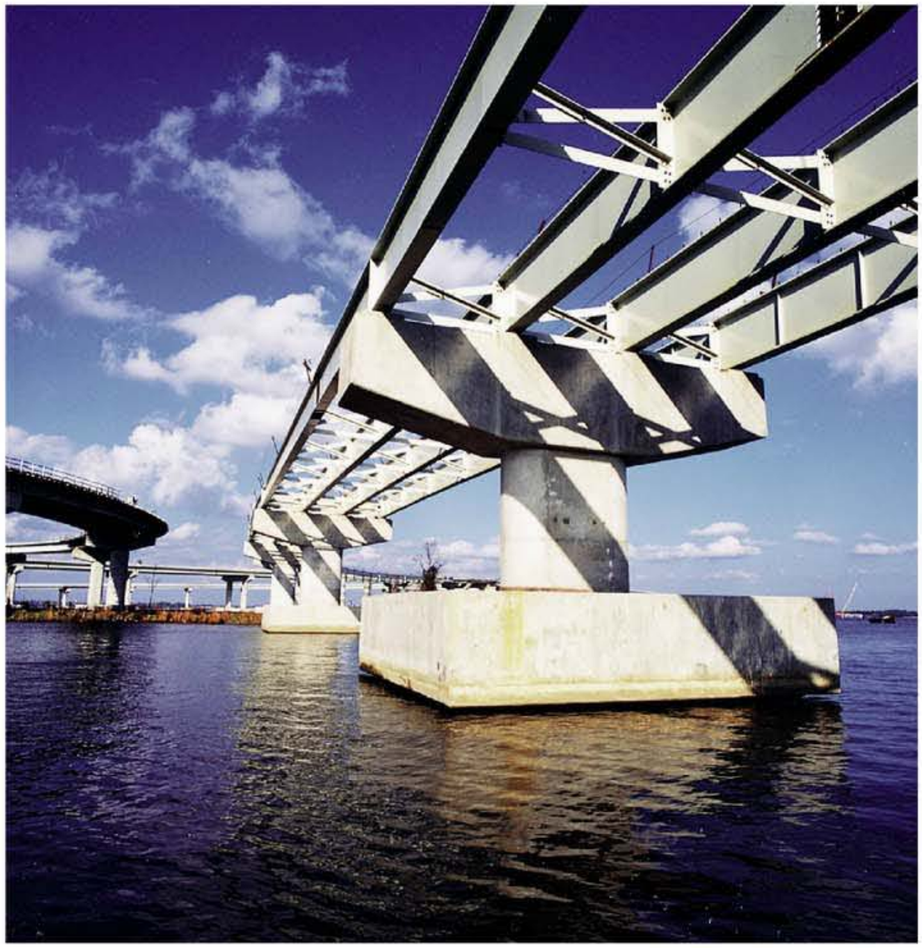
The following are among the topics covered by upcoming Applicator Training Bulletins.

Surface Preparation
- Mechanical Methods of Preparing Concrete
- Power Tool Cleaning for Steel
- Setting Up Air Abrasive Blasting Systems
- Techniques of Air Abrasive Blasting
- Using High Pressure Waterjetting

Application
- The Basics of Conventional Air Spraying
- Using Airless Spray Equipment
- Introduction to Plural Component Spraying

Quality Control
- The Effects of Weather on Coating Work
- Conforming with Job Requirements
- Records of Work and Working Conditions

Safety and Health
- Safety Considerations for Abrasive Blasting
- Anticipating Job Hazards
- Respiratory Protection



By Leo J. Procopio
The Dow Chemical Company

Waterborne Acrylics for Maintenance and Protective Coatings: Moving Beyond Light Duty

Acrylics represent one of the workhorse polymer technologies used in industrial maintenance and protective coatings. Major generic coating types utilizing acrylic technology include two-component polyurethanes, which are frequently based on acrylic polyols for the excellent durability they offer, and waterborne acrylic latex coatings, which are often relied upon for their one-component ease of use. This article focuses on waterborne acrylics, and describes their basic chemistry, the role of the latex film formation process in their performance, types of waterborne acrylic polymers and coatings, typical applications, and recent developments in enhancing their performance.[1]

Editor's Note: This article is the fifth in the 2013 JPCL series on generic coating types.

The bridge over the Neuse River in New Bern, NC, during construction in the late 1990s. The steel beams were shop-painted with a multicoat waterborne acrylic system consisting of two coats of an acrylic latex primer and two coats of an acrylic topcoat. Photos courtesy of The Dow Chemical Company

Background

Waterborne acrylic latex coatings are a broad category that encompasses a wide variety of applications and performance requirements. The first acrylic latex house paint was developed 60 years ago in 1953.[2] Since then, acrylics have captured a dominant position in the architectural coatings market, where they offer benefits such as excellent gloss and color retention and multi-substrate adhesion in exterior coatings, and good scrub and stain blocking resistance and DIY application properties in interior coatings.

Some may be surprised that waterborne acrylics have been utilized in industrial maintenance painting for nearly as long, with coatings for metal and concrete substrates being first developed in the early 1960s. During the 1970s, innovations in the polymers and other formulation additives (e.g., anti-corrosive pigments) and a better understanding of how waterborne acrylic coatings can be best formulated to prevent corrosion, led to their continued improvement.[3] Greater industry acceptance of waterborne acrylics occurred in the 1980s due to the introduction of new products with improved corrosion resistance, as well as the introduction of acrylic direct-to-metal finishes, or DTMs, which were utilized as self-priming finish coats.[4] Much of the growth in waterborne acrylics has been at the expense of another one-component maintenance coating type, solvent-borne alkyds, and has been based on the acrylics' better environmental, health, and safety profile.

Today, acrylics are heavily used in protective coatings for concrete and steel structures, typically in environments that would be considered light- to medium-duty service. They comprise approximately 15–20% by volume of industrial maintenance coatings in the U.S.[5] and are used in a variety of other industrial applications such as general industrial finishing of metal, wood and plastic substrates, traffic paints, and roof coatings.

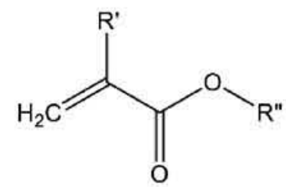
Chemistry and Production of Acrylic Latex Polymers

Acrylic polymers can be tailored to meet the needs of widely varying applications because of the many acrylic monomers available for their production. Acrylic latex polymers can be varied in hardness, chemical/solvent resistance, barrier properties, adhesion, flexibility, hydrophobicity, and other properties by manipulating the monomer composition and processing conditions.

Acrylic monomers used to produce latex polymers include the acids and esters of acrylic and methacrylic acid, which can be copolymerized with each other as well as other non-acrylic monomers. An example of a common non-acrylic monomer used in resins designed for architectural coatings is vinyl acetate, whereas those used in industrial coatings include styrene and acrylonitrile. Styrene imparts higher gloss and water resistance (but can negatively affect durability), and acrylonitrile is used for improved solvent resistance. Common acrylic monomers, shown in Table 1, are used to determine bulk polymer properties such as hydrophobicity and hardness. Various functional monomers are also incorporated at lower levels to improve colloidal stability of the latex particles, improve adhesion, or provide functionality for crosslinking.

Acrylic latex polymers are prepared by a process called emulsion polymerization. There is a large body of technical literature dealing with the process,[6] but a brief explanation is in order here. The medium for emulsion polymerization is water. Acrylic monomers typically have low solubility in water but can be emulsified into monomer droplets by using surfactant. Excess surfactant forms micelles, and it is within the surfactant micelles where the free radical polymerization process is initiated by water-solu-

Table 1: Common Acrylic Monomers and Their Homopolymer T_g Values



R"	Acrylates (R'=H) Name	T_g (°C)	Methacrylates (R'=Me) Name	T_g (°C)
H	acrylic acid	110	methacrylic acid	155
Me	methyl acrylate	8	methyl methacrylate	105
Et	ethyl acrylate	-22	ethyl methacrylate	65
n-Bu	butyl acrylate	-54	butyl methacrylate	20
i-Bu	isobutyl acrylate	-53	isobutyl methacrylate	48
2- ethylhexyl	2- ethylhexyl acrylate	-65		

ble initiators. Because they have low but finite water solubility, acrylic monomers can be transported from the monomer droplets, through the water phase, and into the micelles, where they become part of the growing polymer chain. The reaction is a free radical polymerization of the unsaturated carbon-carbon bonds of the acrylic monomers to yield a linear polymer chain (Fig. 1).

As the polymer chains grow, a colloidal particle forms, and is the ultimate product of the emulsion polymerization process. The resulting acrylic latex polymer is a stable dispersion of solid polymer particles in water. Figure 2 shows a scanning electron microscope image of latex particles, which are usually spherical and have a narrow particle size distribution. Each particle contains many polymer chains of high molecular weight (e.g., M_w of 500,000 to 1 million).

Typical solids levels are 40–55% by weight. A key benefit of acrylic latex polymers is the ability to supply a ready-to-use, high molecular weight resin at high solids. Dissolving such a high molecular weight resin in solvent would yield excessively high viscosities, or very low solids, which prevent the supply of solvent-borne resins at those molecular weights. Another major benefit of latex polymers prepared via emulsion polymerization is the use of water rather than organic solvent as the dispersing medium, which facilitates formulation of low VOC coatings.

Film Formation—A Key to Understanding the Performance of Waterborne Acrylics

Acrylic latex polymers form cohesive films through a unique process in which the colloidal particles pack tightly together and then deform as water leaves the coating; eventually the particles coalesce as the polymer chains diffuse across the particle boundaries and become entangled.[7] A diagram of the latex film formation process is shown in Fig. 3 (p. 22). This multi-step process is very different than the film formation of solvent-borne polymers, which are fully dissolved in the solvent medium and become entangled as the solvent evaporates. For waterborne acrylic latex polymers, the ease with which the polymer chains diffuse and the particles coalesce depends on several factors, including the polymer molecular weight, glass transition temperature (T_g), and the presence of coalescing solvents that increase the polymer chain mobility. Polymers with lower T_g can form films with less coalescing solvents, and facilitate the production of coatings with lower VOC.

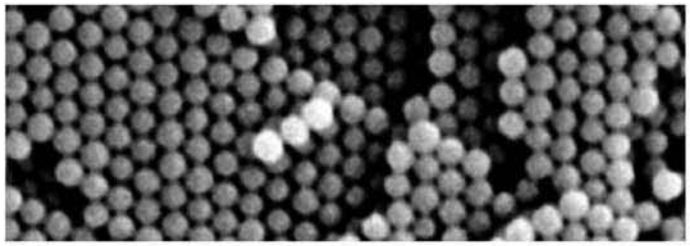


Fig. 2: SEM image of latex particles

Polymer T_g is dictated by the various acrylic monomers and their ratios in the final polymer composition. Each monomer has a T_g value associated with its homopolymer (Table 1). This T_g value dictates whether the monomer will increase or decrease the polymer T_g of a copolymer containing it. The T_g influences the film formation process and VOC content, as well as important properties such as hardness, dirt pickup resistance, and blocking resistance.

Environmental factors also have a large influence on latex film formation. If the drying temperature is below the minimum film formation temperature (MFFT), a cohesive film will not form, and in worst cases, a brittle and friable coating results. The MFFT of unformulated acrylic latex is closely related to the polymer T_g, and can be further lowered by using coalescents. So if the formulator does not use enough coalescent to depress the MFFT for the intended application conditions, or if the applicator applies at too low a temperature, poor film formation will result. Most manufacturers of waterborne acrylic maintenance coatings recommend applying the coatings above 40–50 F (4–10 C), although some claim their waterborne acrylic coatings to be suitable for application down to 35 F (2 C). Relative humidity also plays an important role because it affects the rate of evaporation of water from the drying film. High humidity retards the evaporation of water, slowing the drying process. In some cases, the volatile coalescing solvents will actually leave the film before the water, and then once the water evaporates, the particles will not coalesce properly. Again, the result is poor film formation.

The relationship between the quality of film formation and corrosion resistance of an acrylic coating has been described in numerous instances.[8] In many types of industrial acrylic coatings, corrosion resistance depends largely on the barrier properties of the coating film. Even in inhibitive primers containing anti-corrosive pigments, barrier properties still contribute greatly to the corrosion resistance. When poor film formation occurs, the presence of micro-

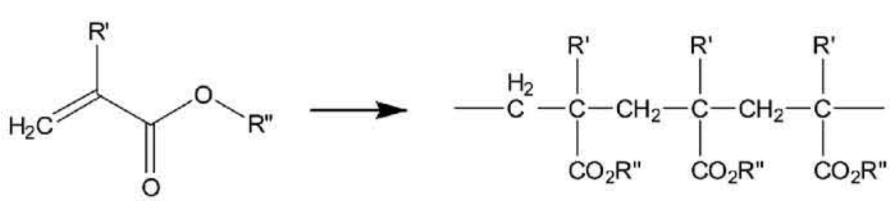


Fig. 1: Polymerization of acrylic monomers to generate linear polymer chains

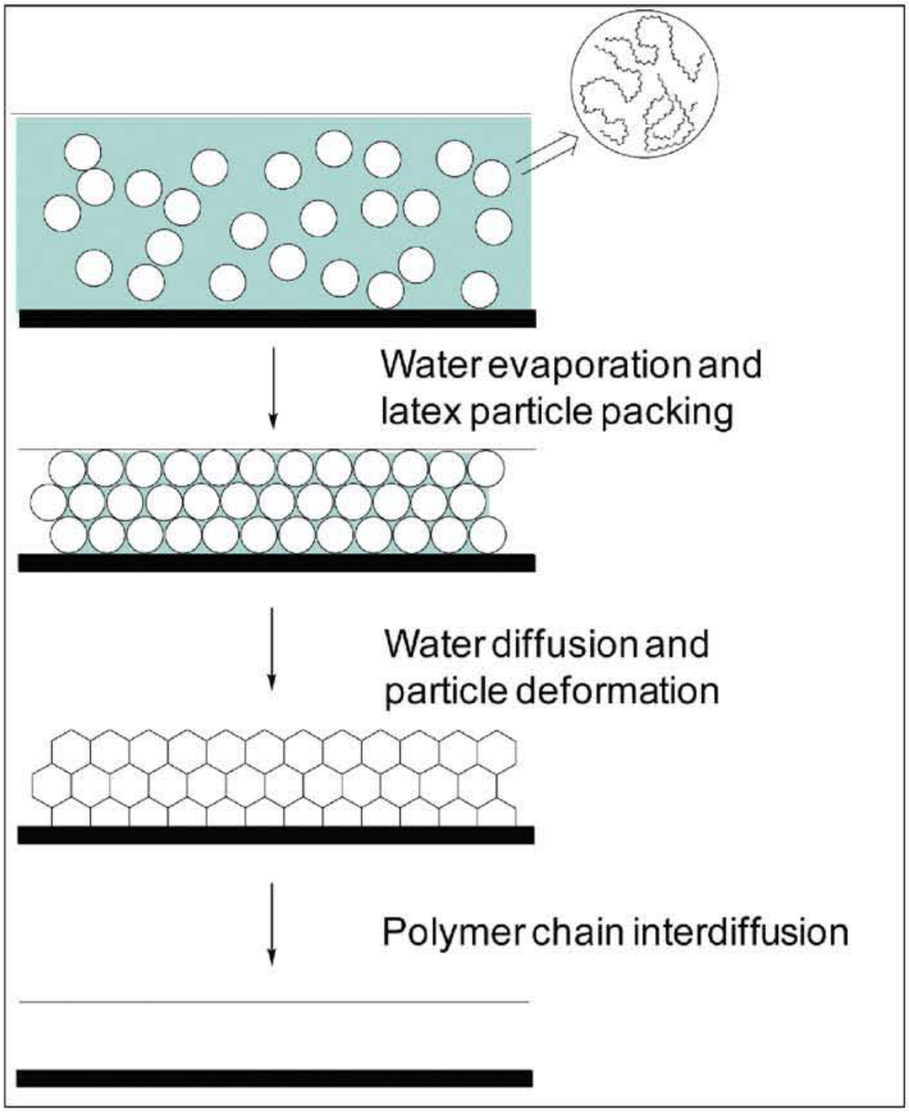


Fig. 3: Film formation mechanism for a waterborne acrylic latex polymer. Inset shows that each latex particle consists of multiple high molecular weight polymer chains.

scopic voids and channels results in a more porous film, through which water and electrolytes can more easily penetrate and reach the metal surface. Achieving good film formation and the good corrosion resistance that can accompany it is a result of proper polymer design, coating formulation, and application.

Types of Waterborne Acrylic Coatings Available

Waterborne acrylic coatings are available in both one- and two-component systems. One-component coatings are based on thermoplastic acrylic polymers, and usually rely on their initially high molecular weight for properties. Self-crosslinking versions, also available, undergo a light crosslinking after film formation to build molecular weight and further improve both chemical resistance and gloss durability.[9] Although one-component coatings are the major form of waterborne acrylics on the market, two-component systems can offer even higher performance. Crosslinking an acrylic polyol with a water-dispersible polyisocyanate yields a two-component waterborne polyurethane with excellent gloss and color durability, useful in topcoat applications.[10] Epoxy dispersions are used to crosslink carboxyl-functional acrylics; these systems offer excellent chemical resistance properties. Acrylic/epoxy coatings are often used in institutional settings (e.g., schools) requiring resistance to more frequent use of cleaning chemicals, or metal applications needing improved solvent/chemical resistance relative to one-component acrylics.[11]

For application on steel and other metal surfaces (e.g., galvanized steel), the most common formulations include anticorrosive primers, self-priming DTM finishes, and topcoats. SSPC paint specifications currently exist for latex primers (Paint 23) and topcoats (Paint 24) and describe the expected performance.[12] Acrylic primers are formulated with inhibitive pigments such as zinc phosphates for corrosion protection on steel, and some grades have excellent adhesion to difficult substrates like galvanized steel. DTM finishes are a popular type designed to give the adhesion and corrosion resistance of primers, with the aesthetic durability of a topcoat. They are applied in one or more coats directly to the metal surface or as a topcoat over another primer. Typically, waterborne acrylic coatings are applied at approximately 2–4 mils' DFT per coat, but there are also high-build versions that can be applied at 6–8 mils' DFT without mudcracking.

Recent descriptions have been given of elastomeric acrylic coatings, based on low T_g acrylic polymers, for use in even thicker films (> 10 mils' DFT) and over marginally prepared steel.[13] Recent developments in thermal insulation coatings, utilized for personnel protection and energy management, rely on waterborne acrylics as the binder for low thermal conductivity fillers.[14] The waterborne resin allows the coating to be applied to hot surfaces without posing a fire hazard. To give insulating properties, the thermal insulation coatings are applied in several coats to 80 mils' DFT or higher. Waterborne acrylic versions of wash primers are also available, and are low-solids primers designed to be applied in thin films (DFT

≤ 1.0 mil) and act as tie-coats to promote adhesion on difficult substrates such as galvanized steel, untreated aluminum, and stainless steel.

Environmental, Health, and Safety Considerations

The increased use of waterborne acrylic coatings in the past 30 years has been partly driven by increased environmental, health, and safety awareness of government agencies, specifiers, and end users. Volatile organic compounds (VOCs) and hazardous air pollutants (HAPs) have been under increased scrutiny by local, state, and federal regulators, and limitations on their use are driving the industry to the use of alternative technologies for traditional solvent-borne coatings. Waterborne coatings such as acrylic latex coatings offer one possible solution. With waterborne coatings in general, there is lower odor and less concern over worker exposure to hazardous solvent fumes, as well as less risk of fire from handling flammable solvents, which can translate into lower insurance costs. Cleanup is easy and safer, with a water rinse often being sufficient to clean brushes, rollers, and spray equipment. Waste that is generated is typically less hazardous, with less impact on the environment, and is easier and less costly to dispose of.

As with any coating, proper industrial hygiene procedures should be followed by the applicator. Proper respiratory protection should be used when spraying, and skin contact should be avoided. Manufacturer technical and material safety data sheets should be consulted before using waterborne acrylics and all protective coatings.

Performance Features of Waterborne Acrylics

In addition to the safety, health, and environmental benefits of using waterborne coatings, waterborne acrylics have some specific performance features that make them useful for protective coatings. Acrylics are known for having good resistance to ultraviolet light, which translates into excellent exterior durability, chalking resistance, and gloss and color retention. The acrylic polymers used in maintenance coatings commonly have T_g values in the range of 15 to 40 C, which leads to good flexibility and resistance to cracking. Accelerated[15] and exterior[16] weathering studies have also shown that acrylic latex coating systems can offer good corrosion resistance. Although there are limited documented accounts in the open literature, there are several that describe exterior exposures in moderately aggressive environments where waterborne acrylics performed very well compared to traditional solvent-borne systems.[16] Acrylics generally offer good chemical resistance to mildly aggressive agents like dilute acid and bases, and some one-component systems can withstand occasional contact with solvents such as gasoline. Self-crosslinking acrylics have demonstrated very good solvent resistance after curing fully.[17]

Waterborne acrylic coatings also have some disadvantages when compared to solvent-borne coatings. Depending on regional climates, the length of the painting season can be shorter with waterborne coatings because of restrictions on temperature and humidity conditions under which they can be applied (i.e., due to film formation concerns). Waterborne coatings tend to have reduced water resistance compared to solvent-borne coatings because of the presence of surfactants and salts from the synthetic process, which can lead to a greater tendency for the coatings to blister with water contact. Adhesion of waterborne acrylics often takes several days to develop, so early adhesion tests may show failures. When the coating is given time to fully dry and the film formation process allowed to progress, adhesion typically improves.

Substrate wetting is often worse for waterborne paints because of the higher surface tension of water compared to typical solvents, although this limitation can be mitigated with additives.[18] Poor wetting can negatively affect adhesion to dirty or greasy substrates, which is also difficult because water will not dissolve and remove oil and grease from the substrate. Therefore, proper surface preparation is often more critical for waterborne coatings. Solvent wiping and detergent cleansing are recommended for surfaces contaminated with oil, grease, and dirt. Abrasive blasting to a minimum of SSPC-SP 6 is often recommended to obtain the best performance with waterborne acrylics applied directly to steel.

Fig. 4: A chemical storage tank located in a chemical plant in Philadelphia, PA. The tank was coated with a three-coat waterborne acrylic system in 1986. The tank is shown here after 15 years of exposure.

Industrial Applications using Waterborne Acrylics

Waterborne acrylic coatings are being used today in a variety of maintenance and protective coatings applications on steel and other metallic surfaces, as well as other substrates such as concrete, wood, and drywall. Acrylic primers, DTMs, and topcoats are applied on storage tanks, piping, bridges, railcars, metal buildings, shop- and field-painted structural steel, and other structures to facilitate good aesthetics and prevent corrosion. Suitable atmospheric service environments range from dry interior spaces to more aggressive coastal settings. Figure 4 shows a typical application for acrylics—a chemical storage tank in a chemical plant located in the Philadelphia area. In this case, the three-coat acrylic system provided over 15 years of corrosion protection. Thermal insulation coatings based on acrylics are used on piping and other surfaces, and are recommended for continual service below approximately 325 F. Waterborne acrylics are not recommended for extremely harsh environments such as immersion service, marine splash zones, or areas in continual contact with harsh chemicals and solvents.

Acrylics have been heavily studied for use in the transportation infrastructure, specifically for use on steel bridges. Multi-coat acrylic systems have shown very good performance in both lab[15b] and exterior weathering[16a,c,19] studies designed to show their suitability for direct-to-metal applications on steel bridges. Field evaluations of overcoating maintenance systems for bridges have also demonstrated good performance for acrylics,[20] as have other studies examining their use as topcoats over primers of other technologies, so-called hybrid systems.[21] A number of state transportation departments currently specify waterborne acrylics as primers and/or topcoats for steel bridges, including California, North Carolina, Georgia, Texas, and others.

California, with the most restrictive VOC regulations in the U.S., has a waterborne acrylic coating specification for a 100 g/L gloss topcoat, demonstrating the current trend towards lower VOC levels.[22]

Recent Advances in Waterborne Acrylics

For more than 40 years, raw material suppliers and coatings manufacturers have continually made advances in the development of waterborne acrylic coatings for maintenance and protective applications. Some exciting improvements in performance have been within the past several years, lifting the corrosion resistance and durability of these systems to new heights while pushing VOC levels down to 100 g/L and below.

Several groups have reported on the use of functional monomers to improve both the adhesion and corrosion resistance of acrylic latex coatings over metal.[23] Adhesion and corrosion resistance are intimately related, so improving adhesion will often affect the protective qualities of a film. Optimizing the polymerization process has allowed the most effective use of the functional monomers, which is important because these specialty monomers are often more costly than the bulk monomers shown in Table 1 (p. 19).

As discussed above, the quality of film formation is very important in reaching the best barrier properties with a latex film. Manipulating the latex polymer morphology to optimize film formation and, therefore,

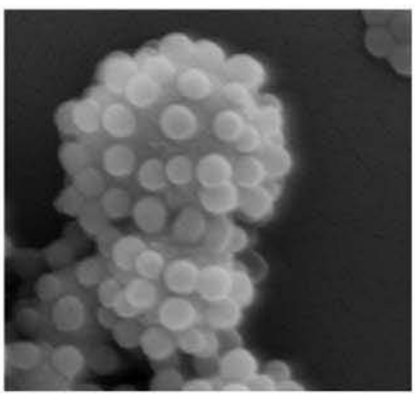


Fig. 5: SEM image of titanium dioxide pigment particles with smaller acrylic latex particles adsorbed onto their surface.

barrier properties, has recently been described by two groups.[24] Forming latex particles with multiple phases, i.e., regions of varying polymer composition and T_g, facilitates coatings with enhanced corrosion protection. One of the studies also shows how minimizing the water-soluble components via the synthetic process increases corrosion protection of the final coating.[24a]

A coating film contains both a resin phase (i.e., polymer) and pigments. Optimizing the polymer phase through improved film formation is one method to improve barrier properties. Another is to optimize the structure of the dry film by controlling how the pigment particles are distributed throughout the polymer phase. The pigment distribution in a film has a strong effect on barrier properties, and thus corrosion resistance. One technology described recently offers a new method for improving the distribution of pigment in an acrylic latex coating film.[17,25] The latex particles adsorb onto the pigment surfaces in the wet state (Fig. 5), and act as spacers to prevent pigment aggregation as the coating dries. The result is a dry film in which the pigments are more homogeneously distributed compared to a conventional acrylic, leading to greatly enhanced corrosion resistance. Figure 6 shows an example of the improved corrosion resistance in ASTM B117 salt spray testing for the new technology and a conventional acrylic DTM after 35 days of exposure. The poor corrosion resistance of the conventional acrylic after extended salt spray exposures is not unexpected, although it does have acceptable protection properties in a multi-coat system when exposed outdoors. Figure 6 shows the potential that new technologies have in extending the performance of waterborne acrylics to more aggressive environments or to longer coating lifetimes.

Finally, advances have also been made in decreasing the VOC content of waterborne acrylic coatings for metal protection. The most stringent VOC regulations are currently found in California's South Coast Air Quality Management District (SCAQMD), where

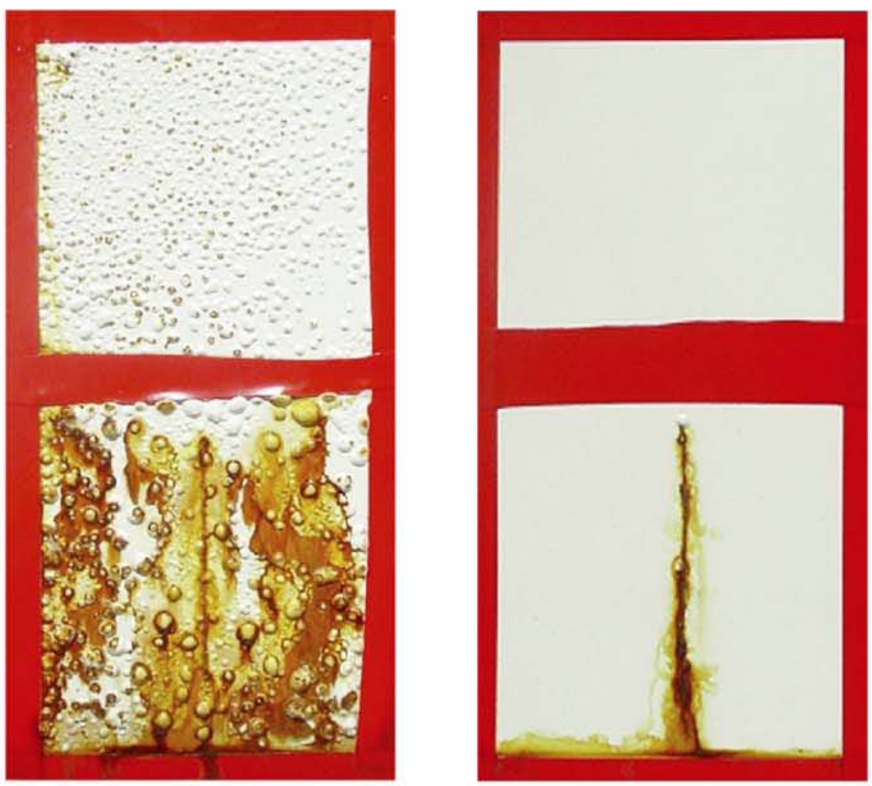


Fig. 6: Panels coated with gloss white waterborne acrylic DTM coatings based on conventional and new technology acrylic latex polymers. Panels are blasted hot rolled steel (SSPC-SP 5) with 3 mils' DFT of each coating, and shown after 35 days' salt spray exposure.

industrial maintenance coatings must be below 100 g/L. Waterborne acrylics have been developed that can meet those requirements and are currently available in the market. Several groups have also reported the ability to make waterborne acrylic topcoats and DTMs with zero or near-zero VOC content and high performance.[26]

Conclusions

Waterborne acrylic coatings for the protection of steel and other metal surfaces have been used in industrial maintenance painting for about 50 years, and in that time have undergone continuous improvement. Today, acrylic coatings are available at VOC levels below 100 g/L, and with adhesion, corrosion resistance, durability, and chemical resistance that are well beyond those properties in the original versions. Traditionally, waterborne acrylics have been an excellent choice for painting in light- to medium-duty environments because of their environmental, health, and safety benefits, and their proven performance in real world exposures. With recent advances in acrylic latex design and formulation, waterborne acrylic coatings have moved beyond the strictly light duty performance of old, and use in more demanding environments is now a reality.

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JPCL

Understanding Vinyl Ester and Epoxy Tank Lining Properties for Power Plants: Tips for Owners

By Jeff Stewart, ITW Polymers Coatings North America

In common with all downstream oil and gas plants, chemical/petrochemical plants, and production plants, power generating facilities need storage and process tanks whose internals require linings to protect against contamination of the cargoes and corrosion of the structure. This article gives an overview of the key features needed for vinyl ester and epoxy tank linings, particularly at elevated temperatures. The article is not intended to be a comprehensive guide to these two types of linings, nor is it intended to address other generic types of tank linings.

Permeation Protection

The main purpose of most tank linings is to provide a barrier to corrosion. For corrosion to occur, there must be an anode, a cathode, and an electrolyte bridge for electron transfer. Because of its heterogeneous nature, steel contains both potential cathodic and anodic sites. To prevent corrosion, a barrier (lining) must be placed to block the electrolyte bridge between these sites and any potential aggressive chemicals in the environment.

Permeation is the passage of molecules, usually water molecules, through the lining. Permeation protection is, therefore, the most critical characteristic of a corrosion barrier coating. Once the lining is permeated, water molecules have reached the substrate, and an electrolyte bridge can be established, potentially initiating corrosion. As iron forms iron oxide, the iron expands, increasing in volume several magnitudes. This expansion forces the lining off the surface and forms blisters. The loss of adhesion accelerates additional permeation and further iron oxide formation, which will eventually lead to breaks in the lining system.

The permeation rate for any tank lining should be listed on the product's technical data sheet (TDS) as perm-inch and measured in accordance with ASTM E-96. Glass flakes or other inert fillers whose permeability is lower than the resin binder are commonly added to vinyl ester and epoxy lining systems to improve their performance.

Temperature Resistance

Linings will have a glass transition temperature (T_g), the point at which the lining starts to shift from solid to liquid. The maximum temperature recommended for the lining performance will be below its T_g. Most TDSs for linings with temperature resistance report a temperature close to the T_g as the maximum operating temperature in dry conditions. Immersion temperatures are usually a function of chemical resistance and permeation resistance. There should be a maximum immersion temperature for a lin-

Lime slurry storage tanks require protection from high temperatures, caustic environments, and abrasion. Photos courtesy of ITW Polymers Coatings NA

ing based on either water or mild chemistry, or both. This temperature will decrease based on the actual chemicals and concentrations. The maximum immersion temperature is a function of the lining system chemistry and fillers. When evaluating an epoxy or a vinyl ester lining for temperature resistance, one must take into consideration the standard operating temperatures and upset conditions, which may be significantly higher or lower.

(top): FGD aux slurry storage tanks require protection against low pH, high chlorides, and abrasion due to high-solids concentration. (middle): An absorber pump agitator collects drainage from numerous sources and must resist a large variety of chemicals and abrasion from high-solids slurries.

Chemical Resistance

Chemical resistance, as noted on the TDS or Chemical Resistance Guides, will be temperature dependent. A list of chemicals expected in the tank and other process equipment should always be provided to the lining manufacturer for evaluation. The level of chemical resistance is a function of the lining's base chemistry. So, for example, Bis A vinyl ester, novolac vinyl ester, and novolac epoxy base chemistries and chemical resistances will differ from one another.

Abrasion Resistance

In some tanks, the contained liquid has no or very little suspended particles, so there is very little abrasion to be considered. In such cases, the main focus for lining selection will be on permeation and chemical resistance. In the case of high-solids content in the contained liquid, slurry abrasion protection will be an important factor.

The industry standard for measuring abrasion resistance is the Taber Wheel test, ASTM D 4060, for weight loss, which can be done with one of several different wheels. The C-17 wheel is described as more abrasive than the mildest wheel—the C-10—and normally operates with a 500- or 1,000-gram weight. While this test is used as a comparator or "yard stick" between linings, it does not provide a direct correlation of life expectancy or an accurate proportion of abrasion resistance in service. Abrasion is very dependent on the hardness of the solids, as well as the velocity, size, and angularity or sharpness of the solids.

In lining applications requiring higher levels of abrasion resistance, both epoxy and vinyl ester linings are usually modified by the addition of some form of ceramic additive, either aluminum- or silicon-based. The type, loading, and size distribution all play a part in the material performance. The abrasion protection principle is simply that the binder material will wear away faster than the ceramic portion of the lining, eventually leaving a ceramic face that is harder than the solids trying to wear it away. As the lining wears, eventually some of the ceramic will be pulled out of the resin, exposing the lining to wear. In this regard, abrasion-resistant vinyl ester and epoxy tank linings are usually applied in thicknesses proportional to the abrasiveness of the process and the desired length of service. In order to acquire longer life and allow thicker applications, these abrasion-resistant linings are usually reinforced with some form of mat or cloth to provide internal reinforcement. Without the reinforcement, the linings are prone to cracking when applied at high thicknesses.

Excellent abrasion resistance may also be achieved by softer materials with excellent tensile strength. A good example of this is urethanes, which actually absorb the impact of the solids and then rebound without any loss of material or properties.

Thickness

Specified lining thicknesses vary based on the properties of the system and may have a proportional effect on the life of the lining system. While a lining may reach the point of no return on investment or may be applied at an excessive thickness, causing physical issues such as cracking or strain on adhesion, there are benefits to additional thickness in regard to permeation and abrasion.

All linings are permeable, and if a lining is permeated at a given rate, increasing the thickness of the lining will increase the theoretical time it takes the lining to be compromised. The same goes for abrasion protection. If the lining wears at a given rate, it will take longer to wear away at a greater thickness. Increasing the lining thickness has the drawback of increasing the system material pricing and other costs.

Absorber towers offer many lining challenges in regard to temperature, low pH, high chlorides, and abrasion from direct impingement and agitation.

Material Pricing

It is a simple practice to compare the price per gallon of material A against that of material B, but the comparison may not necessarily give a true reflection of the cost of the materials or the value offered. The true cost of a lining project requires a quick analysis of the factors that make up a lining project.

In the power Industry, the number one cost associated with a lining project is usually plant equipment downtime. Downtime on the equipment, which keeps the unit off-line or derated, could easily result in a loss of $1M, where loss of generation costs could be as high as $200–300K/day. The additional expenditures to increase the lining quality or thickness could be a bargain.

The cost of a lining should be evaluated on its life cycle cost, because life cycle cost takes into account the impact of equipment downtime. A quick example would be Lining A, expected to last 10 years, vs. Lining B, expected to last 15 years. Over 30 years, a tank protected with Lining A will be relined 3 times (counting the initial lining application), while a tank to be protected with Lining B will be relined twice (counting the initial lining application). The total economic impact must take into consideration the impact of lost generation or purchasing replacement power.

Additional factors affecting the price of application include access, cleaning, surface preparation, contractor mobilization, equipment rental or purchase, and cleanup, which are all pretty close to fixed costs regardless of lining selection or thickness. Once this investment is made, it seems to make sense to purchase the best possible lining technology to provide extended service life.

Labor Costs

The two main effects on manpower costs are application method (spray, brush and roll, trowel) and number of coats. Whenever similar or like properties may be achieved by spray application rather than more labor-intensive methods like troweling, then spray application should be utilized to save on labor costs.

However, care must be taken to ensure that performance properties are not sacrificed to achieve these savings. Switching lining systems to save on labor may result in losing dollars to save pennies if the switch results in more maintenance or more frequent lining replacement. Similarly, the number of coats required to achieve the necessary build or properties must be carefully looked at to ensure that the money on the project is well spent. Does each additional coat or step achieve an added value to the total system?

In the case of applying abrasion-resistant coatings over a permeation barrier, the additional coat does add value. Abrasion-resistant epoxy and vinyl ester linings that do not offer the same permeation protection as they do when reinforced with flake glass may be prone to premature failure due to permeation, leading to undercoat corrosion. (See section on permeation.) However, one-size-fits-all designs that require a high level of hand-applied linings in non-abrasion zones or multiple low build coats are wasting money.

Warranty

When basing a cost comparison on expected performance life, one should have a high level

Outlet duct and chimney. Linings must protect against saturated environments that have high permeation potential, especially when subjected to cold wall effects.

of comfort that the material performance will be equal to the promised design life offered by the supplier. The only litmus test for promised performance is a warranty that provides for the stated life. A warranty means that the material supplier has "skin in the game," a financial interest in the performance of the lining. If a warranty is to be of value, it must offer the purchaser full replacement cost and be of a term sufficient to the owner's expectation of performance. It must also cover all key parameters, such as abrasion in the case of a lining system designed for abrasion resistance.

Be cautious of warranties that require the owner to purchase, either separately or as part of the material cost, a third-party insurance policy to cover the warranty. A third-party policy means that the obligation or future expenses for warranty repairs has been passed from the supplier to the insurer at the owner's expense and has relieved the supplier of risk and its potential costs. The advantage of such a warranty is that the purchaser has little risk that the warrantor will no longer have the assets to support a warranty claim when one occurs.

Flexibility

In active process systems, where there can be a lot of substrate movement, including vibration, the lining material must be flexible and tough. This is a key difference between novolac epoxies and flake glass vinyl esters. Novolac epoxies are highly cross-linked, which is a reason they offer such good chemical resistance. The problem is that this bonding tends to make them rigid and brittle. Vinyl ester systems reinforced with flake glass can withstand greater deflections, including dual amplitude vibrations. It is critical to understand the amount of deflection required and the limits of a lining system to withstand the deflection.

Adhesion

Adhesion is key to the long-term performance of any lining. The greater the difference in the thermal coefficient of expansion between the lining and the substrate and the greater the physical stress applied to the lining the greater the importance of adhesion. Adhesion to steel is usually measured in accordance with ASTM D4541 or the pull-off test. Approximately 1,500 psi should be seen as a minimum adhesion of an epoxy or vinyl ester lining applied to properly prepared steel.

Lining adhesion to concrete is different and is measured in accordance with ASTM D7234. Adhesion to concrete is usually specified at much lower values than adhesion to steel. This is because the adhesion testing will tend to "pull" concrete, meaning the concrete surface will come apart around 300 psi, depending on the properties of the concrete.

Cure

The vinyl ester and epoxy lining systems being discussed cure by polymerization, or a chemical reaction that causes many smaller molecules to join together in chains, forming fewer larger molecules. It is this process that results in the material changing from liquid to solid and taking on new physical properties. Because the rate of the reaction varies among linings, one must pay close attention to the recoat and cure schedules associated with linings.

Recoat windows, or the maximum and minimum amount of time in which an additional coat may be applied, may significantly affect the schedule and thus the cost of a job. Recoat windows with long minimums require lengthening of schedules and may result in paying for "dead time" while the applicator waits to apply the next coat. Short maximum recoat windows may result in overtime or shift differentials because the job may need to be manned around the clock and through weekends or holidays. Some vinyl ester systems can be formulated to offer the best of both worlds, with a two-hour minimum recoat and a ten-day open window for maximum recoat.

Final cure, which should never be confused with dry-to-touch, is the point at which the material has reached its full physical properties and theoretically is no longer undergoing any additional chemical reactions. It is important to understand whether any additional heat is required to "force cure" a lining or whether the reaction will take place at ambient temperatures. Most epoxies and vinyl esters cure at ambient temperatures (50–110 F), but some may obtain superior physical properties if they are force cured at higher temperatures.

It is also important to understand whether any outside factors will impact or inhibit the cure of the material. In vinyl esters, cure is inhibited by oxygen. This factor is actually taken advantage of to keep a broad recoat window in the build coats but is not a desirable property when waiting for final cure. An oxygen barrier topcoat can be applied to accelerate the final cure process and allow the system to reach full cure in as little as 72 hours. (Epoxy reactions are not affected by oxygen.)

An additional consideration is that all recoat and cure schedules for materials which cure by polymerization are temperature dependent, and may be subject to maximum and minimum allowable temperatures.

Closing Thoughts

Epoxy and vinyl ester immersion linings, often for elevated or cyclic temperatures, require a range of properties; power plant and other process plant owners should carefully research the characteristics of their particular process equipment and stored product both in operation and off line, and then, just as carefully, research the lining properties needed, from performance to costs, before specifying a material. Plant surveys, consultation with reliable manufacturers and third-party specifiers, and other sources can help owners select suitable linings.

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This concrete tank with one manway tank at the top is a PRCS.
Photos courtesy of the authors

THINKING OUTSIDE THE BOX:

Tips from a Painting Contractor on Working Safely in Confined Spaces

By Kyle Hough and Duane Hough, Champion Painting Specialty Services Corp.

"Safety at any cost" is frequently trumpeted by safety managers throughout the coatings industry. Ideally, every project would have unlimited funds to either ventilate, air condition, and otherwise assure worker safety in any working environment, regardless of size, or replace the structure if it could not be made completely safe and comfortable. The reality is that project owners and project scopes dictate the amount of money that can be dedicated to safety on a project, which forces contractors to make work environments, including permit-required confined spaces (PRCS) as safe as possible with the budget available. As this article will illustrate, making a PRCS safe for cleaning and coating work requires thinking about more than the PRCS and the painting contractor crew, no matter what the budget.

This article is not intended to be a complete guide to making all permit-required confined spaces safe—you must always thoroughly understand OSHA's and other relevant regulations and consult with a safety expert on each PRCS. There are many types of hazards in confined spaces. The main hazards focused on in this article are potentially hazardous atmospheres. The authors will give some insights, based on their experience with field painting, into planning how to make the work environment safe for blasting and coating operations in two examples of permit-required confined spaces: (1) a ground storage water tank; and (2) a greywater tank in a cruise ship when the ship is at sea. To this end, the article will briefly define PRCS and give tips drawn from field experience for conducting job hazard analysis, using engineering controls, and developing rescue plans. Although these tips will be illustrated through the ground storage water tank and greywater tank examples, neither example is comprehensively described. Portions of each are used for illustration purposes only. General insights into training, documentation, lighting, planning, and troubleshooting are also discussed. Examples of some of the consequences of not following safe practice for PRCS are also given.

Definitions

Although a PRCS rule for the construction industry has been proposed, it has not yet been issued. [*Editor's note: For a discussion of a proposed comprehensive OSHA regulation on confined space for the construction industry, see the April 2008* JPCL *article, "Regulatory Update for Industrial Painting," by Kaelin and O'Malley, p. 14.*]

The present article uses guidance from OSHA's general industry regulation on confined spaces (29 CFR 1910.146)[1] and other OSHA documents on confined spaces (e.g., OSHA 3138-01R[2]).

A confined space:

- is large enough for an employee to enter fully and perform assigned work;
- is not designed for continuous occupancy by the employee; and
- has limited or restricted means of entry or exit.

A confined space may include underground vaults, tanks, storage bins, pits and diked areas, vessels, silos and other similar areas.

In addition to the above features, a permit-required confined space (PRCS), which is potentially hazardous, has one or more of the following characteristics:

- contains or has the potential to contain a hazardous atmosphere;
- contains a material with the potential to engulf someone who enters the space;
- has an internal configuration that might cause an entrant to be trapped or asphyxiated by inwardly converging walls or by a floor that slopes downward and tapers to a smaller cross section; and
- contains any other recognized serious safety or health hazards.

Permits in accordance with OSHA regulation 1910.146 are typically supplied by the facility owner, who ensures that all contractors, other workers, and other persons at or near the work site understand the confined space is occupied and that all emergency personnel are aware of what work is being performed in the confined space. This process also can combat complacence, because it means that all contractors on site as well as the owner need to re-evaluate the confined space on a regular basis, as working conditions change.

One factor to understand is what constitutes entry into the confined space. Included in OSHA's definition of "Entry" into a confined space is that it starts "as soon as any part of the entrant's body breaks the plane of an opening into the PRCS" (1910.146 (b)Definitions).

Job Site Hazard Analysis: It's Not Just About Your Work

The first step to safely conducting work in a confined space is to evaluate the site and identify hazards. It is imperative that the evaluator not only identify hazards within the scope of the coating work, but also evaluate hazards presented by other trades that will be conducting work in or near the PRCS at the same time as the painting contractor. Unlike the horse on the track, blinders do not assist us in getting to the finish line, but instead leave us vulnerable to avoidable accidents. Heavy equipment, electrical hazards, hot work, noise hazards, hazardous substances, and hazardous environments must all be identified in order to create an effective site-specific safety plan. OSHA's "Permit-Required Confined Space Decision Flow Chart," reproduced in this article (p. 40) from Appendix A of 1910.146, illustrates the complexity of fully evaluating confined spaces.

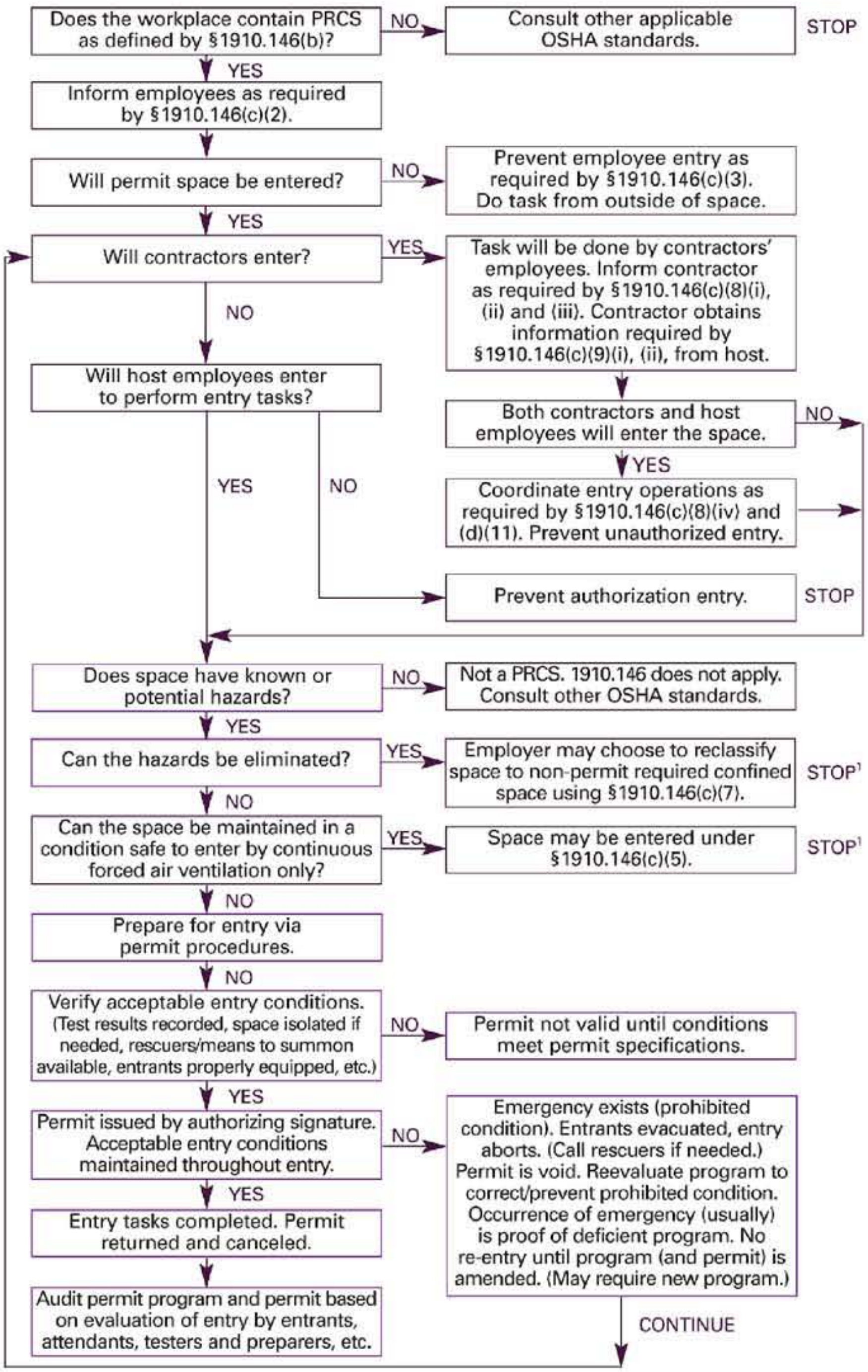
Venting explosive vapors outside of an enclosed space, using explosion-proof lighting, and constant monitoring of Lower Explosive Limits (LEL) all become moot if they are vented into the workspace of the welders replacing pipe sections on the outside of the tank. A job hazard analysis form is a useful tool, but the evaluator has to remain vigilant against the pattern of simply checking the boxes and filling in the blanks, which leads to "inattentional blindness."

"Inattentional blindness" was first, and most famously, demonstrated in the invisible gorilla study, conducted by cognitive psychologists Dan Simons and Christopher Chabris.[3] In the study, volunteers were asked to watch a short video and count how many times a ball was passed between either three people in white shirts or three people in black shirts. In the middle of the video, a gorilla (or a person in a gorilla suit) walked into the frame and began to beat its chest for several seconds. Many of the volunteers failed to notice the gorilla because they were so focused on the basketball, hence, the term "inattentional blindness," where we see only what we are looking for and can miss important information outside of the framework our minds create.

Example 1: Ground Storage Water Tank Site Evaluation

Coating and other work is required on a 30-year-old, 70-foot-diameter by 30-foot-high ground storage water tank with a riser and rafter-supported cone roof that has two

Permit-Required Confined Space Decision Flow Chart



¹Spaces may have to be evacuated and reevaluated if hazards arise during entry.

Source: 29 CFR 1910.146 Appendix A.

36-inch circular hatchways. The first hatchway is at the base of the tank next to an exterior ladder; the second is on the roof of the tank, directly in front of where the exterior ladder meets the roof. The interior of the tank is to be abrasive blasted per SSPC-SP 10, with a minimum anchor profile of 1.5 mils, and coated with two coats of polyamidoamine epoxy at a dry film thickness (DFT) of 4.0–6.0 mils. Ten feet from the ground level hatch, work is to be conducted to replace a defective underground valve connected to the tank by 6-inch pipe. Welding, excavation, and the use of heavy equipment will be needed in addition to the equipment, practices, and materials for the blasting and coating work.

In brief, the scope of coatings work has the following hazards: (1) Physical: PRCS, fall/trip, scaffolding, noise, heat stress, sparking from abrasive, static electricity buildup from hoses and equipment, fire, and explosion; (2) Chemical: paints, solvents, abrasives, dusts, fumes; and (3) Environmental (from the surrounding work): hazards from heavy mechanical equipment, hot work (welding), excavation hazards. All safety data sheets must be reviewed by the owner and the contractors, and appropriate protective measures must be put into place for coating work and for working alongside the other trades.

An example of a potential environmental hazard from the surrounding work would arise if a backhoe, which is used to excavate the valve, is parked in front of the manway and the exhaust flows into the tank, creating an oxygen-deficient atmosphere.

Example 2: Greywater Tank Site Evaluation

Another type of PRCS project involves cleaning and coating a double-bottom 233-cubic meter greywater tank having a complex multi-chambered interior with one 36-inch hatch. On the upper level, the interior is broken up into three cubes, each 9 ft x 9 ft x 9 ft, and the lower level is sloped and divided into 3-foot-long by 9-foot-wide by 6- to 18-foot-high chambers. The bottom floor of the tank is the hull of the ship. The tank is to be wet abrasive blasted and coated with two coats of novolac epoxy. The work will be done while the ship is at sea, a significant consideration when planning the project.

It is important to point out that the process of wet abrasive blasting specified for

Water treatment facilities have many structures that can meet the definition of a PRCS.

this job and its associated hazards differ from those of slurry blasting, abrasive-injected washing, and waterjetting. The wet abrasive blast equipment that is used for this project holds a mix of aggregate (e.g., garnet) and water in a pressurized pot, with blast pressure at the hose of 90 to 110 psi (not an abrasive-injected pressure wash, or a dry blast where water is introduced at the nozzle). The equipment operator has to set the water-to-aggregate ratio and the pressure to most effectively remove coatings, corrosion, and scale, as well as to get the proper surface profile. With wet abrasive blasting, ricochet as well as sparking from abrasive is possible.

(A wet Brush Blast [SSPC-Vis 5/NACE Vis 9, WAB 7] will use more water, small and soft aggregate, and a relatively low pressure. For the most efficient way to achieve a wet Near-White [SSPC-Vis 5/NACE Vis 9, WAB 10], the contractor should use a harder aggregate, greater pressure, and greater aggregate-to-water ratio. Size of aggregate will determine the profile.)

Thus, in brief again, the scope of the coating work poses the following potential types of hazards: (1) Physical: PRCS, water (drowning/engulfment), ricochet from abrasives, sparking abrasive, poor vision, fall/trip, scaffolding, noise, heat stress, fire and explosion; (2) Chemical: exposure to paints, solvents, abrasives, dusts, fumes, mists; and (3) Environmental: surface contaminants, process chemicals, ship operations/collisions, heavy seas.

When planning to operate, the evaluator must step into the shoes of the operator, and plan the safety measures from the operator's perspective, while using safety measures that are relevant to the task performed and the work environment. For example, abrasive in the water-abrasive mix can ricochet off of the walls of the tank, stinging exposed skin, and although blast-proof pneumatic lighting would be needed, the water from the blasting would mist up the chamber, obscuring the light and leaving very limited vision. The noise from the blasting and the forced air ventilation will be deafening, so working will be like walking through a harsh atmosphere on the surface of a distant planet, especially with the blast shield down and respirator on. The constant ventilation will help to prevent mist from obscuring workers' vision, but if the mist is excessive, work may need to stop periodically to let the mist dissipate.

Waterproof communication equipment is invaluable to safely and efficiently communicate with both the hole watch and equipment operator. (The 'hole watch,' technically called the 'attendant,' is defined as the person outside of the confined space responsible for continuously monitoring, and being in contact with, the entrants.) But this type of environment makes a walkie-talkie without ear muffs useless, a situation that could be easily overlooked by the evaluator when planning if he or she has not been in the environment that the crew will be operating in.

Using Engineering Controls: Different PRCSs Require Different Controls

In accordance with OSHA's prioritization of controls for work environments, hazards should be addressed first through engineering controls whenever possible, then through administrative controls, work practices, and personal protective equipment (PPE). Forced air is an often-used engineering control to eliminate hazardous atmosphere conditions, by introducing a constant flow of safe air into the confined space, and ventilating the hazardous atmosphere out of the tank. Note that pure oxygen should never be used because it creates fire and explosion hazards.

Staging area outside a greywater tank on a cruise ship.


This interior of a ballast tank on a barge is a PRCS.

The key to effective ventilation is moving air through the entire space. Simple structures, meaning confined spaces with multiple entrances and few or no internal chambers, can be ventilated by using the proper equipment for the size of the space. Complex structures, with various levels and chambers, need to have additional duct work and fans throughout the structure to ensure that air reaches all parts of the structure and pockets of hazardous atmosphere are not left to a poor ventilation plan. Moreover, no matter how good your engineering plan is for ventilation, you always need to monitor the atmosphere inside the space, before, during, and after ventilation.

The evaluator should always pay particular attention to lower chambers, depressions, and wells that can capture and hold heavier gases such as methane. The cautionary tale that is most often cited is the FACE 89-46 from the Facility Assessment and Control Evaluation Program conducted by the Centers for Disease Control (CDC).[4] In that case, five individuals died in a depression on a dairy farm that was oxygen deficient (oxygen levels below 19.5%). The manure pit had been present on the farm for 18 years, and was not seen as presenting a confined space hazard. The pit had been used over the previous 18 years without incident; however, in 1989, the farmer's son entered the area and died from methane exposure, followed by four more family members attempting rescue. As a result of the 1989 accident and ensuing CDC evaluation, recommendations for safe work in manure pits were issued, including the recommendations that they be identified as confined spaces and that because they meet the definition of confined space, entry in them should be governed by NIOSH guidelines for working in confined spaces; a special NIOSH alert on the hazards of manure pits was also called for. Unfortunately, it is this type of horrific event that has shaped the current requirements for safety; it has been a costly learning curve paid in lost lives.

Example 1: Ground Storage Water Tank

Returning to the ground storage water tank example, there are two options for engineering a safe atmospheric work environment. The best option is to cut a door sheet into the side of the tank, large enough for a manlift to enter the tank. This open door can make the tank a non-PRCS (as there is now easy access and the opening allows heavier gases to escape from the lowest level), and ventilation dangers can be reduced or eliminated. The manlift itself does nothing to eliminate confined space hazards; however, a secondary benefit of cutting a door sheet into the tank and using a manlift to conduct high work is that the lift reduces fall hazards by eliminating the need for scaffolding and rigging and therefore eliminating potential errors and injuries during assembly, use, and disassembly of scaffolding or rigging. This option is more commonly seen on new construction, when the coatings contractor is subcontracting to a tank manufacturer.

In our example, the ground storage water tank is owned by a municipality operating on a tight budget, so cutting out and replacing a door sheet is not an option. The potentially hazardous atmosphere created by blasting and coating operations would need a ventilation plan. The location of the hatches would cause an air stream to be created on one side of the tank, so an engineering solution is to force air into the ground level hatch and block off the roof top hatch, ventilating the air out of the "hat" in the top center of the tank.

Example 2: Greywater Tank

In the example of the greywater tank, it was to be cleaned and washed by the ship's crew before contractor operations. One to two weeks before the ship's crew was to conduct cleaning operations, enzymes were to be introduced to the tank to increase friendly micro-organisms. The micro-organisms would feed on raw sewage and reduce odors, making the tank biologically safer before pressure wash.

Creating the ventilation plan for the greywater tank has several complexities that need to be addressed, including multiple chambers, many sloped lower pockets, and the requirement to create an engineering plan for ventilating the tank to the outside of the ship without odors diffusing into passenger areas. The plans call for an industrial-grade pneumatic fan at the hatchway to force positive air into ducting throughout the tank. To move the air from the tank, the engineer would run an air sock down a passageway and attach it to exterior ventilation that vents off the rear of the ship.

Both examples illustrate that when it

Interior of a ground storage potable water tank completed using all required safety measures

comes to engineering plans, if you can change the nature of the PRCS, do so, but if you can't, you must ventilate.

It must be noted again that there can be much more to making a PRCS safe than ventilating potentially hazardous or flammable atmospheres. There are lockout/tagout procedures for electrical equipment, measures to be taken when engulfment is a hazard, and measures for other hazards. Contractors and owners must constantly be aware of all hazards. Again, however, this article is not intended to address every type of hazard, but to offer a sampling of insights into making potentially hazardous or flammable atmospheres in PRCS safe.

Confined Space Rescue Plan: Keep Everyone in the Loop

There are many important factors that must be taken into consideration when discussing confined space rescue operations. The first question is who will be responsible for permitting and rescue operations, the contractor or the owner? There are actually three questions within this one question.

- Who is creating the hazard?
- Who is controlling the space?
- And who is exposing his or her personnel?

The answers to these three questions generally dictate who does what. In the ground storage water tank example, the contractor will generally be creating and controlling the hazard and will be responsible for initiating the confined space permit, ventilation, and hole watch, and for arranging rescue. In the ship example (or in a plant), the owner might be the controlling employer and have an in-house trained rescue team. Responsibility is also sometimes driven by the contract and specification.

Regardless of who is responsible, the contractor and crew must review and understand

Worker preparing to enter confined space to perform degassing and cleaning

the plan and their responsibilities, even if their responsibilities are simply to move out of the way and muster to a rally point. It is imperative that duties and responsibilities are clearly documented and signed by all parties, to clarify any ambiguities that could result in delays during a rescue, where minutes can be the difference between life and death. At a minimum, everyone should know who the attendant is, who is providing rescue services and how to contact the provider, who will open and close the permit, and who will do the monitoring. And for the purposes of this article, the painting contractor should always take on the responsibility to ensure that the attendant has the proper forms and permits. Painting contractors should sign onto other contractors' sign-in sheets only after a full review of the plan and after reviewing the lock-out/tag-out procedures for the space.

It is extremely important that the entire crew working on a project be aware of their duties and responsibilities as well as all other team members' duties and responsibilities. For contractors, situations often arise that lead to mid-project personnel changes, whether because the contractor needs additional crew members to meet a deadline, a crew member quits or is fired, or the blast crew moves out and the spray crew moves in. *Every* change requires a review of the work plan by all parties involved.

It is the responsibility of the contractor to fully brief all new members of the team and to ensure that they are properly trained and that their training is documented. Even one change in personnel could lead to an injury.

All entrants, attendants, and supervisors are required to have specific training for PRCS work.

The attendant/hole watch is a key position that is often filled by the least experienced, lowest cost/production member of the team. It is of the utmost importance to thoroughly train this member of the team on the rescue plan, and to make him or her understand the potential deadliness of any inattention, including inattentional blindness.

Example 1: Ground Storage Water Tank

In this example, the contractor is the controlling employer and is responsible for confined space rescue operations. When developing a rescue plan, the contractor should first contact the local authorities, such as fire and rescue, to notify them of the project and potential hazards. The local authorities may not perform the rescue, but will be administering the care of any injured workers after they have been extracted from the space.

Within the confined space, the contractor may run into many obstacles, ranging from the means of extraction to ensuring that the confined space can be entered by the rescue team. All members of the crew will have to understand the PRCS rescue plan and be able to fill any or all rescue roles because any one member or members of the work crew could need to be rescued.

Here are two of the items to consider.

(1) Rescuing a member from elevated staging or scaffolding may require tripods, manual hoists, or additional pieces of equipment at mobilization of the project. Never use mechanical extraction equipment such as cranes because they will not stop if the injured member gets caught on an obstruction and could cause further injury.

(2) Self-Contained Breathing Apparatus ("SCBA") may need to be staged on-site to ensure the safety of the rescue team extracting members from hazardous atmospheres.

Although a mock run is not required by the regulations, we have been asked on several projects to have our site crew, under the supervision of a safety professional, perform a mock run of a rescue based on our completed rescue plan. A rescue should take no more than three minutes to avoid permanent brain damage or death. If the contractor does not have the credentials or sufficient personnel to develop a rescue plan and conduct a rescue, the contractor should hire a safety expert who also understands coating operations.

Example 2: Greywater Tank

The ship's owner, as controlling employer, is responsible for all confined space permitting, attendant duties, and rescue operations. The superintendent reviews rescue plans with the ship's bosun. The crew runs through general safety drills with the crew and passengers, and confined space drills with the ship's crew. In the event of an emergency in the tank, the attendant radios the bridge, rescue team, and the equipment operator (who is located in the engine room a deck below and approximately 200 meters away from the tank entrance). The equipment operator shuts down the blasting/airless spray unit. The owner is taking responsibility as the controlling employer. The contractor is the exposing employer.

Training and Document Management: Again, Keep Everyone in the Loop

All members of the contractor's team must be fully trained, and copies of all training and certification must be documented and on-site in the job book. Safety management through documentation is the final check for the project manager and foreman. Documentation of pulmonary function, fit test, confined space training, safety training, employee orientation checklist, and first aid/CPR forces the management to ensure that each employee is fully trained for the hazards of the job, and to review the expiration dates of certifications.

It is easy and potentially dangerous to

overlook training, documentation management, and the overall need to keep all team members in the loop, as illustrated in the following example from a 1998 worksite, in which the names of the companies involved are intentionally withheld. A new employee (with little previous experience) was hired to perform hole watch duties and came to the site with confined space training, respirator fit test, and other general industry standard training. The employee received the site-specific and company training per the contractor's safety plan and site safety plan. The employee was performing his hole watch duties when one of the workers in the tank needed a break from waste cleanup.

The foreman quickly made a change and had the new employee clean up waste; he performed his job duties and followed safety protocol. Within 30 minutes, the employee complained of shortness of breath and had to come out of the tank. A safety man quickly responded and aided in the review of the situation. The employee told the safety man that he had asthma and a history of this type of shortness of breath. The employee had not brought his respirator clearance card and he did not make his team aware of his medical condition.

Fortunately, the employee fully recovered and did not sustain a serious injury; however, the project was a $2.5 million tank coatings contract, and the safety infraction caused the coatings contractor to be removed from the site. A checklist for all safety training and medical requirements should be part of every job book and work plan.

Lighting Requirements

Lighting is an essential element in both safety and quality control planning of operations. SSPC-Technical Guide 12[5] makes recommendations about procedures and minimum foot-candle requirements for performing various tasks. One element of illuminating potentially explosive environments is to insure the use of explosion-proof lighting and connections within the hazardous area. The connections must be explosion-proof rated connections. A string of explosion-proof 110-watt LED lights, plugged into a non-rated extension cord, can cause an explosion. Pneumatic explosion-proof lighting is an expensive but safe method of lighting a confined space that has the potential for an explosive atmosphere.

Planning vs. Reality: Know and Adapt to Changing Conditions

Marine Infantry Squad Leaders learn that the most important thing about planning combat operations is the following: No plan survives contact with the enemy. The same is true with planning abrasive blasting and coating work. Regardless of how much effort and time go into preparing work plans, safety plans, and pre-project operations, the leadership must be prepared to adapt to the actual conditions on the ground. While knowing and adapting to changing conditions are true for all jobsites, they are especially critical to confined space operations because in confined space projects, a change in one work area can complicate all activities on the job, including the measures taken to make the space safe for work, the rescue plan, other safety measures needed, communications, and inspection.

Some tried and true methods of team and leadership management are realized through using a job book, intent-based troubleshooting, and the employer's providing project leaders with the power and authority to act.

The job book, when utilized properly, is the key to managing changing conditions on the job site. All project documents, specifications, plans, PDS, SDS, jobsite hazard analysis, daily reports, and daily inspection reports are contained within the job book. As changes to a project occur, such as changes in scope, specification, corrective action, and change orders, documents about the changes are submitted and approved in the office, and they should be saved in the on-site job book. Continually maintaining and updating the job book keeps the project management in the office in synch with the site supervisor. Any change in personnel, whether leadership or crew, is recorded in the job book along with full documentation of their training, qualifications, and medical clearances. The outgoing leadership, the incoming leadership, the safety manager, and QA/QC personnel all meet to discuss the project—all questions and clarifications are documented, and signed and dated by all parties. This procedure can help prevent accidents created by assumptions.

Intent-based troubleshooting is predicated on everyone's understanding of the reasoning behind planning, thus allowing decisions to be made to correct mistakes using the original intent to dictate the means. Often, project management gives a safety plan or work plan without discussing the reasoning behind the decisions. A round table discussion among the project manager, superintendent, and foreman about the planning helps everyone understand how the plan is crafted to meet project specifications safely and profitably. We often find that the discussions illuminate the flaws in our planning, whether it is an item we missed, a better method of completing a task, or simply a better way to articulate the plan.

It is important to authorize leaders with the power and authority to act. In our industry, management usually has a multitude of duties. Often, the foreman needs the power and authority to make decisions on the spot.

Conclusion

In conclusion, working safely in confined spaces can be difficult, complex, and costly. This article was written in order to provide contactors with some real-life insight into to everyday problems, especially with making potentially hazardous atmospheres safe. This article is not intended to be used as a guidance document. Be sure to read, understand, and follow all regulations and other relevant documents for confined space work.

Notes

1. www.osha.gov/pls/oshaweb/owadisp.show_document?p_table=STANDARDS&p_id=9797
2. www.osha.gov/Publications/osha3138.html
3. www.npr.org/blogs/health/2013/02/11/171409656/why-even-radiologists-can-miss-qa-gorilla-hiding-in-plain-sight
4. www.cdc.gov/niosh/face/In-house/fullq8946.html
5. SSPC-Guide 12, SSPC Technology Guide No. 12, Guide for Illumination of Industrial Painting Projects, SSPC: The Society for Protective Coatings, Pittsburgh, PA, 2004, sspc.org

About the Authors

With over 18 years of experience with protective coatings, Kyle Hough is an industry veteran. Kyle completed his apprenticeship through DC 71 and has worked his way up through the ranks to his current position as Vice President of Champion Painting Specialty Services. Kyle has a passion for the industry.

Duane Hough served as a combat decorated United States Marine before starting in the coatings world. Duane has worked in a variety of industries including nuclear, industrial, pharmaceutical, and marine. He is a certified Level 3 SSPC Protective Coating Inspector, and a Certified CAS Trainer. Duane is currently serving as Chief Operating Officer of Champion Painting Specialty Services. JPCL

Results In for SSPC BOG Positions

Jay Kranker

Garry D. Manous

Skip Vernon

SSPC has announced three changes to its Board of Governors. The Society recently held elections for two open positions on its Board. The ballot included candidates for the Other Product Suppliers demographic and the Coating Contractors demographic.

Jay Kranker, Western Region Sales Manager for DRYCO, LLC, won the Other Product Suppliers demographic, while Garry D. Manous, Senior Project Manager for Atsalis Brothers Painting, won the Coating Contractors demographic.

As per SSPC Bylaws, Manous was elected to his first full term after being appointed to complete the term of Robert Ziegler, whose demographic category changed in 2011.

Both newly elected Board members will serve a four-year term, beginning July 1, 2013, and ending June 30, 2017.

In addition, at a recent Board meeting in Herndon, VA, L. Skip Vernon of CLT Inc., was elected by the Board to be Vice President. Vernon has almost 30 years of experience in the protective coatings industry. He has served on the Board of Governors since 2010, and will serve as SSPC President in 2015–2016.

PCS Certifications Earned in Peru

SSPC has announced that 11 industrial coatings professionals in Peru recently completed the Society's Protective Coatings Specialist (PCS) Certification Program. Each has been evaluated for his mastery of coating type, surface preparation, coatings application and inspection, contract planning and management, development of specifications, and the economics of protective coatings.

The recently certified Protective Coatings Specialists are:


Luis Merino


Jose Padilla


Michael Valdez

- Jesus Agreda, CPPQ S.A., Lima
- Moises Alberca Vin, IPCC S.A.C., Lima
- Felipe Aulla, Concar S.A., Lima
- Hector Basilio, CPPQ S.A., Lima
- Giancarlo Caceres, Concar S.A., Lima
- Henry Capcha, QROMA, Lima
- Luis Merino, CPPQ S.A., Lima
- Jose Padilla, CPPQ S.A., Cañete
- Antonio Utrecho, CPPQ S.A., Lima
- Michael Valdez, COLP S.A.C., Lima
- David Vassallo, EDECO PERU S.A.C., Lima

Photos were not available for many of the newly certified PCSs.

These certifications signify further development and growth of SSPC's international training and certification programs.

SSPC Course Roundup

SSPC's Protective Coatings Inspector (PCI) course was held in Surabaya, Indonesia, May 27–June 1. Ten students attended the course, which was instructed by Muniandi Dewadas.

Houston Hosts 30th Waterjet Conference

The WaterJet Technology Association (WJTA) and the Industrial & Municipal Cleaning Association (IMCA) will hold the annual WJTA-IMCA Conference and Expo at the George R. Brown Convention Center in Houston, TX, September 9–11.

The event, in its 30th year, is the largest combination academic conference/trade show/educational program for high-pressure waterjet technology and industrial and municipal cleaning. It is comprised of research paper presentations, educational "Boot Camp" seminars, waterjet technology "Basics & Beyond" short courses, an exhibit hall, live demonstrations, an awards ceremony, and an evening networking reception.

For more information, visit the Conference and Expo page at www.wjta.org.

Schedule of Events and Technical Programs

The Conference kicks off on Monday, September 9, with a pre-conference seminar, Basics & Beyond, from 8:00 a.m. to 4:30 p.m. Several short presentations will address a variety of topics, including the history of waterjet technology, applications, equipment, and others. After the seminar, Monday's events end with a WJTA-IMCA General Membership Meeting from 4:30 to 5:30 p.m.

Tuesday, September 10, opens with live demonstrations from 8:00 to 10:30 a.m., followed by the opening of the exhibit hall from 10:30 a.m. to 5:30 p.m. Exhibit hall hours will coincide with individual Boot Camp sessions. Tuesday's Boot Camp sessions will cover hydroexcavation in the oil and gas industry, manual waterblasting, nozzle selection, industrial vacuuming, and related topics. Also, from 10:30 a.m. to 5:00 p.m., a series of papers will be presented as part of the Emerging Technology, New Applications—Papers session. Tuesday closes with the Industry Appreciation Reception and Awards Ceremony, from 5:00 to 7:00 p.m.

Wednesday, September 11, again starts with more live demonstrations from 8:00 to 10:30 a.m., with the exhibit hall open from 10:30 a.m. to 1:00 p.m. Boot Camp sessions on vacuuming and manual waterblasting run from 10:30 a.m. to 1:30 p.m., and more Emerging Technology, New Applications—Papers will be presented from 10:30 a.m. to 1:00 p.m. There will also be indoor robotics demonstrations on Wednesday at a time to be determined later.

Exhibitors

The following is a list of companies that will be exhibiting at the 2013 WJTA-IMCA Conference and Expo. This list is current as of June 26.

24 Hr Safety 207
Advanced Pressure Systems 717
BIC Alliance 119
Blasters, Inc. 619
CSM Supply 817
Carolina Equipment & Supply (CESCO) 406

Chemac, Inc. 908
CleanerTimes/IWA 1018
D&S Professional Services....919
Diesse Rubber Hoses S.p.A. 316
Dragon Products, Ltd. 100
FS Solutions 421
Fruitland Manufacturing 909
GHX Industrial, LLC 307
GapVax, Inc. 121
Gardner Denver Water Jetting Systems, Inc. 601
General Pump, Inc. 110
Giant Industries, Inc. 901
Global Vacuum Systems, Inc. 621
Guzzler Manufacturing 421
Hammelmann Corp. 309
High Pressure Equipment Co. 116
HoldTight Solutions, Inc. 416
Idrojet, s.l.r. 808
JGB Enterprises, Inc. 117
Jack Doheny Companies, Inc. 521
Jetstream of Houston LLP 421
LaPlace Equipment Co., Inc. 1013
Maxpro Technologies, Inc. 907
NLB Corp. 607
Newson Gale, Inc. 216
Parker Hannifin-EPD 917
Peinemann Equipment B.V. 201
Powertrack International, Inc. 308
Presvac Systems 721
RamVac Vacuum Excavators 321
Reliable Pump Consultants, Inc. 617
Safety Lamp of Houston, Inc. 718
Sewer Equipment Company of America 319
SPIR STAR 1011
Stewart R. Browne Manufacturing Co., Inc. 317
StoneAge, Inc. 301
Stutes Enterprise Systems, Inc. 417
Terydon, Inc. 806
Trans Lease, Inc. 209
Trillium Industrial Services 306
TurtleSkin WaterArmor by Warwick Mills 217
US Jetting, Inc. 1015
Under Pressure Systems, Inc. 407
Vac-Con, Inc. 921
Vactor Manufacturing 421
Vacuum Truck Rentals, LLC 112
Veolia Environmental Services 906
Wilco Supply, LP 1008
WOMA/Kärcher Group 107

Water Tank Quick Hits

- A contract worth $864,000 was awarded by the Fallbrook (CA) Public Utility District to Utility Service Co., Inc. (Perry, GA) to rehabilitate the Sachse Reservoir, a 10.5 MG, 208-foot diameter by 40-foot height steel water storage tank.
- George Kountoupes Painting Co. (Lincoln Park, MI) won a $1,240,000 contract from Clermont County (OH) to clean and recoat interior and exterior surfaces of two steel elevated water storage tanks and one steel ground storage tank.
- The Benton/Washington County (AR) Water Association awarded a $1,132,394 contract to Protective Linings & Coatings (Alexander, AR) to clean and recoat interior and exterior surfaces of one 2 MG water storage tank and one 5 MG water storage tank.
- Advanced Industrial Services, Inc. (Los Alamitos, CA), SSPC-QP 1 and -QP 2 certified, and the Lake Hemet Municipal Water District have agreed on a $204,000 contract to abrasive blast clean and recoat interior surfaces of a 2 MG, 32-foot height by 104-foot diameter welded steel ground storage tank.

Project Preview is compiled from Paint BidTracker reports.

Milwaukee Awards $8.6M Lift Bridge Contract

Zenith Tech (Waukesha, WI) beat out one other bidder to win an $8,682,616 contract from the City of Milwaukee to rehabilitate the St. Paul Avenue lift bridge over the Milwaukee River. Constructed in 1966, this 262-foot-long, 82-foot-wide lift bridge was named "The Most Beautiful Steel Bridge" by the American Institute of Steel Construction in 1967.

The contract calls for 14,000 square feet of the bridge's structural steel surfaces to be abrasive blast cleaned, with recycled abrasives, to a Near-White finish (SSPC-SP 10) and recoated with a zinc-rich primer, an epoxy intermediate, and a polyurethane finish. Top flanges of the bridge will also be coated. Negative pressure containment is required to capture the bridge's existing lead-based coatings.

The contract also requires 1,738 square yards of protective surface treatment application and 7,540 square feet of concrete stain application, as well as miscellaneous other bridge improvements. The project is expected to begin in September and wrap-up by June 2014.

S&K Nets Alsea Bay Bridge Overcoat Job

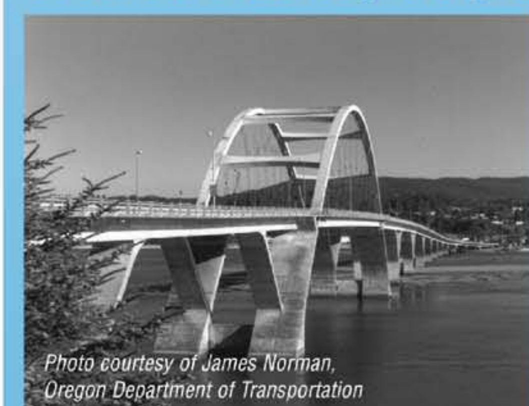


Photo courtesy of James Norman, Oregon Department of Transportation

The Oregon Department of Transportation and S&K Painting, Inc. (Clackamas, OR) have reached an agreement on a $2,543,000 contract to clean and recoat or overcoat structural steel surfaces on the Alsea Bay Bridge. Opened in 1936, this 3,011-foot-long concrete through arch bridge has a 450-foot-long main span and crosses the Alsea Bay near Waldport, OR.

The contract includes full coating removal and replacement, with containment required, as well as cleaning and spot-priming approximately 3,500 square feet of structural steel. S&K beat out five other bidders for the contract; the second-lowest bid came in at $2,967,967.50, while the highest bid exceeded $5,000,000.