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The Society for Protective Coatings

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COMBATTING LOCALIZED GALVANIC CORROSION AT BOLTED CONNECTIONS IN GRAVITY SLUDGE THICKENERS AND CLARIFIERS

By R. A. Nixon, Corrosion Probe, Inc.; Corrosion Testing Laboratories, Inc.

Localized galvanic corrosion of coated carbon steel rake mechanisms at stainless steel bolted connections can result in significantly high corrosion rates, particularly when connections are overtightened in gravity sludge thickeners and clarifiers. This article explains this issue and presents a typical case history to demonstrate successful measures that can be taken to prevent this prevalent problem.

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OAP COATING AND LINING SYSTEMS FOR PETROLEUM AND WATER STORAGE TANKS

By Deborah Simmons (Retired), Johnny Pourciau and Murray Heywood, Sherwin-Williams Protective & Marine

The use of coating systems formulated with optically active pigments can help to ensure correct application and inspection of interior linings for petroleum and water storage tanks. This article explains how OAP technology can help identify pinholes, eliminate holidays and reduce premature failures often caused by inadequate film thickness on angles, edges or areas that are difficult to inspect.

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FIELD TESTING FOR SOLUBLE SALTS: A PROBLEM TO BE AWARE OF

By Simon Hope, Auquharney Associates Ltd.

The presence of soluble salts on a surface is a major factor in premature breakdown of protective coatings, and resultant increased maintenance costs for the asset owner. This article explains why the presence of salts are a problem, how to measure for salts on a surface, industry standards on the subject and the results of a case study involving salt detection and removal.

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COATING APPLICATION IN WASTEWATER TREATMENT AREAS

What Does the Applicator Need to Know?

BY DUSTIN YOUNG, PRODUCT DEVELOPMENT MANAGER, SSPC

Each new environment that coating applicators work in brings its own unique set of challenges. Coating application done in wastewater treatment areas is no different. Wastewater treatment plants are constructed of both steel and concrete, and often coatings are applied to both substrates to control corrosion and deterioration. This article focuses on the challenges of coating concrete in wastewater areas as the concrete in these environments is exposed to severe conditions that include chemicals that can quickly deteriorate the concrete. This is why these areas *must* be coated with systems that can withstand these severe exposures in order for the coating to last its intended service life. So, what should coating applicators be aware of when applying coatings in wastewater treatment areas?

When applying coatings start-to-finish in wastewater areas, good painting practices must be applied under the specific conditions faced in such a corrosive environment. For instance, making sure the surface is properly prepared is always going to be critical for successful coating application, regardless of the environment. But what makes coating application in wastewater treatment areas unique? We should start by thinking about the environment itself. Understanding the service conditions that the coating will be exposed to will only aid coating applicators performing the work.

Wastewater treatment areas are often associated with microbial-induced corrosion (MIC). Do coating applicators need to thoroughly understand MIC? Do they need to know how sulfur oxidizing bacteria metabolizes the H_2S to form sulfuric acid or H_2SO_4? Probably not, but they should understand that if the coating applied has pinholes in the film this will lead to acid (by way of low pH) quickly deteriorating the concrete paste, thus initiating deterioration of the concrete and compromising structural integrity.

In terms of health and safety, outside of the normal safety procedures and personal protective equipment associated with coating application, applicators may be required to work in confined spaces and should be trained in confined space entry as defined in the U.S. OSHA Confined Spaces in Construction, Final Rule. There are many other health and safety factors associated with wastewater treatment areas such as exposure to toxic gases and biological hazards, potential for slips and falls in a wet environment, unguarded tanks, electrical hazards and moving parts that are not locked/tagged out. While health and safety is not the primary focus of this article, it should always be the primary focus for applicators, and other field personnel on any coating project. After understanding the environment and being trained on project-specific safety procedures, it is time to assess the surface.

> Understanding the service conditions that the coating will be exposed to will only aid coating applicators performing the work.

There is plenty to assess on concrete prior to coating application. One of the primary concerns, if not the main concern, is moisture. Coating applicators should test for moisture transmission using ASTM D4263, Standard Test for Moisture in Concrete Using the Plastic Sheet Test or other moisture tests that are allowed by the specification and drawings. Such tests will provide results indicating whether the moisture present in the concrete can potentially cause outgassing after the coating system has been applied, which can cause blistering or even pop off the coating.

Concrete also has physical properties that can cause issues when coating over it. For example, coating applicators should know how to recognize air voids—those "shelled-over" areas in formed concrete surfaces that are also called "bugholes." These voids must be opened up for resurfacing prior to coating application. If they are not opened, applicators run the risk of leaving areas that are prone to air entrapment within the coating film. This is why it is also important for applicators to be familiar with application materials for filler/surfacer products and with the methods used to fill those air voids to ensure no air outgassing occurs in coating films.

Other properties include fins or protrusions. Applicators should know that formwork fins in new or replacement concrete needs to be removed by grinding or chipping before abrasive blast cleaning or waterjetting. If these conditions are not removed, they can cause issues within the coating film as coatings do not adhere well to and often not cover sharp edges or protrusions.

Applicators should also know that joints and cracks are common to concrete and that they are likely to move when the tank or structure is in service. Therefore, the coatings applied over them should be designed to bridge such movement. Coating applicators should be familiar with crack and joint treatment details provided in the design

COURTESY OF SAM SCATURRO, ALPINE PAINTING AND SANDBLASTING CONTRACTORS

documents (drawings and specifications). This includes expansion joints, construction joints, control joints and cracks.

After assessing the concrete, the next step is to prepare the surface for coating application. Surface preparation in wastewater treatment is normally performed by abrasive blasting or high-pressure waterjetting. Coating applicators performing surface preparation should be familiar with industry standards associated with these methods. For concrete, the key standards are SSPC-SP 13/NACE No. 6, as well as the new SSPC-CAB standards for abrasive blasting. When assessing surface preparation, applicators should be familiar with the Concrete Surface Profile numbers and use the benchmark profile panels for visual comparisons of concrete surface profile per ICRI 310.2. It is critical that the surface be prepared according to the project specification, which should coincide with the product data sheet recommendations for the application to be successful, assuming the correct coating is chosen for the service environment. After successful surface preparation, application and cure come next. Note that application should occur as soon as possible after surface preparation to ensure the concrete remains cleaned to the level specified or noted in the PDS.

Many think that if you have properly assessed and prepared the surface, then application should be a breeze. It should be that simple. The coating applicator still needs to know a myriad of technical details prior to, during and after application. For example, application of coatings over concrete outdoors presents risks. Application should not occur in direct sunlight when ambient and substrate temperatures are rising. Application is best performed away from direct sunlight, when substrate temperatures are falling or when both conditions prevail. This prevents outgassing caused by the concrete's porosity, which can cause forming of pinholes in the coating film.

Applicators should test the surface and air temperatures, relative humidity and dew point to ensure conditions are acceptable for application. After they confirm the proper ambient conditions, they can move on to the means and methods of coating application. Applicators must be familiar with brush, roller and trowel application methods for various coating and associated resurfacing projects. In addition, they should be trained in using airless spray equipment (single-leg) and plural component spray equipment (two-leg) for 100%-solids, thick-film coatings. In terms of the coating itself, coating applicators should understand that coatings must be applied at the manufacturer's recommended wet and dry film thickness ranges. This is essential because applying excessive coating beyond the maximum recommended thickness, besides wasting expensive coating, may cause it not to set properly; applying less may lead to holidays that expose the bare concrete. Note that the coatings used in wastewater treatment are often applied at a very high number of mils (for example, 60–125) when compared to other service environments due to the severe exposure conditions.

After the coating has been applied, applicators must know that proper cure has been achieved. This requires an awareness of the expected properties (hardness or flexibility) of the properly cured product which can be checked by the solvent rub test method for solvent resistance. If coating in a confined space, cure can be checked with a coin rub test as a safer alternative.

A pinhole- or discontinuity-free coating system is the key to successful performance in wastewater environments. Pinhole and discontinuities allow acidic gases and sulfuric acid formed by bacteria in wastewater headspaces to attack the concrete and affect coating system adhesion. For more information on pinholes in concrete, refer to SSPC-PA 19, Visual Evaluation of Pinholes in a Concrete or Masonry Coating.

In this article, we have discussed the primary issues involved with a concrete coating project within a wastewater treatment area. Health and safety, concrete assessment, surface preparation, and coating application all have unique challenges in these severe environments. It is important that applicators know how to handle everything that they will encounter throughout the project. Although we did not discuss each and every item applicators should know, they should be confident that if they are properly trained and certified in good painting practices, aware of applicable industry technical standards and trained in the contents of the project-specific safety and health program, that they are that much closer to successfully completing a coating application project in a wastewater treatment area. **JPCL**

It is important that applicators know how to handle everything that they will encounter throughout the project.

COURTESY OF SSPC

The Importance of Certification

BY MELISSA PINOLINI, TRAINING AND CERTIFICATION SPECIALIST, AND SILVIA PALMIERI, INDIVIDUAL TRAINING SPECIALIST, SSPC

Certification is a popular topic that can be found in almost every trade/education industry throughout the world. There is an especially heavy emphasis of certification-based education and maintenance throughout the industrial job field. Individuals often find themselves carrying multiple certifications covering specific skills important to their daily job functions. With the ever-changing work force, certification can be used as a tool to advance professionalism, creating a foundation for excellence blased on standard requirements for best results. In a competitive job market, having and maintaining the proper certifications creates opportunity and can be a fast track to showing specialized skills.

Keeping steadfast and continuing to move forward in a competitive and challenging industry is a must. Employers throughout the industry use certification as a valuable tool to create a strong workforce. Individuals who hold and maintain their certs will have increased job opportunity. Standard-based certification can be used by management teams when analyzing job performance or evaluating employees. New hires in the coatings industry are often trained to eventually become certified, creating personal advancement in the workplace. Industry contractors hold their teams to these specified requirements to create increased job opportunities.

SSPC has been a leader in providing the industry with, skilled, experienced and knowledgeable professionals with quality certification programs. SSPC has been proud to provide specialized education in coatings, corrosion and inspections throughout industrial environments in fields such as protective and concrete coatings, abrasive blasting, spray application and marine plural component application.

"During my 15 years with SSPC, I have had many professionals reach out for guidance to gain more knowledge, education and expertise in the industry," says Silvia Palmieri, SSPC Certification Specialist. "Many will challenge themselves to push hard to gain multiple certifications. They know that their achievements will result in positive gain—not only with their employer, but for the work they perform, knowing it meets specifications and confident that it is done the right way."

Achieving individual certification is a way to define your path, and enhance your skills, while gaining valuable knowledge. Keeping your certifications current and up-to-date is more than just a formality and an industry requirement. Current certification can be essential to your personal career advancement opportunities and is an asset to your organization's success.

At SSPC, we encourage individuals in the industry to define a path and take advantage of the opportunities to become certified. We do our absolute best to help everyone of our members and customers to maintain their personal achievements, with dedicated individuals on staff to answer questions and personalize the path to individual and industry excellence. We encourage you to explore the individualized educational and certification tracks customized to areas throughout the industry, available at sspc.org.

Reasons to Pursue and Maintain Industry Certifications
Certification gives you confidence in your personal skills as a professional.
Achieving and maintaining certifications at increasing levels helps create a strong career path.
Certifications create opportunity to gain higher income, have stronger employment demand and better job stability.
Certification maintenance opportunities allow you to stay at the top of your game with the latest news, research, trends and best practices in your area of expertise.
You will be maintaining a high level of credibility with employers, peers and colleagues.

Through the use of certification programs, the workforce can also prepare itself for employment. Recognition of competency can show elevated commitment to your profession and individualized excellence. This is just another example of the determination to be the best in your field. The work you perform will show expertise, excellence, confidence, skills and knowledge as a result of your maintained education. Through the pursuit of education and advanced skill, individual workers become the testament of quality performance and results on the job.

Do not miss the opportunity to gain a valuable certification that can set you on a path to personal success. Also, always try to maintain the certification that you worked so hard to gain. Being a certified individual requires dedication, and SSPC is here to assist you along the way.

For more information on individual training and certification or registration, please visit sspc.org. If you have questions about certification maintenance or recertification, contact Silvia Palmieri, SSPC Individual Certification Specialist, at palmieri@sspc.org.

SSPC, NACE Announce Town Hall Schedule

SSPC: The Society for Protective Coatings and NACE International, The Corrosion Society have unveiled a schedule and registration info for a slew of town hall meetings that the organizations say are meant to keep members informed about the ongoing steps to combine into one organization.

"Because we serve a diverse group of members around the world, we have scheduled the meetings to accommodate as many people as possible," the organizations noted. "If you cannot attend a live town hall event, all meetings will be recorded and posted at sspc.org and nace.org. The August 5 town hall meeting is now available for those who missed it."

The town hall schedule is as follows:

- Oct. 13, 6 a.m. CT;
- Oct. 14, 2:30 p.m. CT;
- Nov. 10, 6 a.m. CT;
- Nov. 12, 1 p.m. CT;
- Dec. 14, 10:30 a.m. CT; and
- Dec. 17, 6 a.m. CT.

Registration is free and can be completed online at sspc.org/sspc-and-nace-town-hall-meeting-schedule-and-registration-info/. After registering, you will receive a confirmation email containing information about joining the webinar.

For more information about the committees or the SSPC-NACE decision to combine, please visit sspc.org/sspc-nace-updates.

Please direct any questions to cooperation@sspc.org or cooperation@nace.org. **JPCL**

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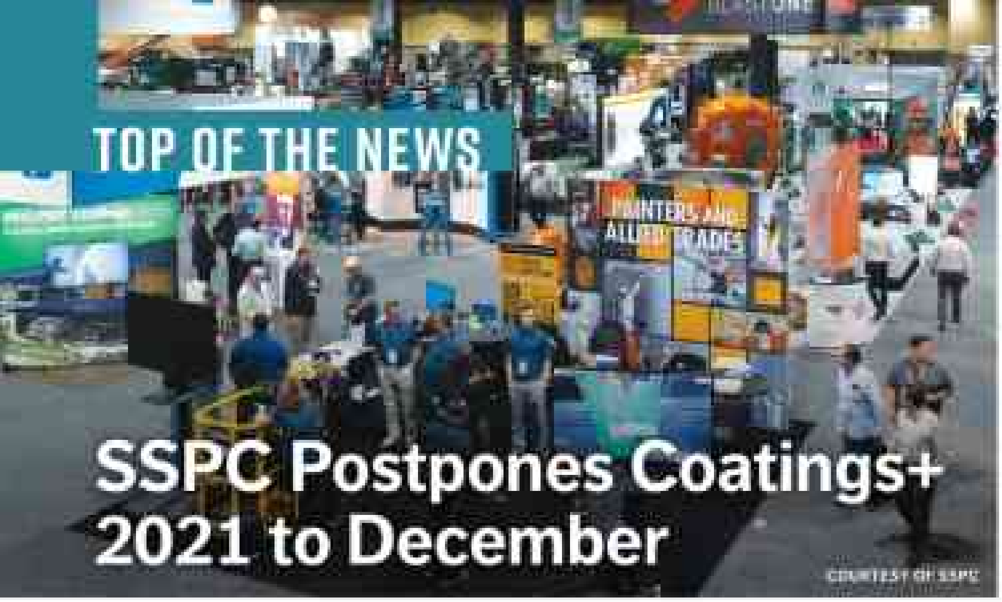

SSPC Postpones Coatings+ 2021 to December

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SSPC: The Society for Protective Coatings has announced the postponement of its Coatings+ 2021 conference slated to be held at the Phoenix Convention Center in Phoenix, Arizona.

In an emailed press release, the organization said that the conference, which was originally scheduled for Feb. 1-4, 2021, will now be held Dec. 13-16, 2021. SSPC cited COVID-19 as the reason behind the move.

"Over the past few weeks, leaders at SSPC and NACE have deliberated over the most appropriate path forward for SSPC's Coatings+ 2021 conference scheduled to be held in Phoenix, Arizona, this coming February," the organization said. "It became apparent that attempting to hold the event at the same standard we have in the past in the midst of the ongoing COVID-19 pandemic is just not feasible, nor would it be safe for our members, attendees or staff."

SSPC noted that exhibitors, sponsors and speakers will receive separate communication regarding how the date change could impact them. "With the ongoing combination of SSPC and NACE, we expect Coatings+ 2021 to remain a prime opportunity to showcase the new organization and share our vision with members," SSPC added.

The organization noted that the Coatings+ postponement does not mean that NACE's annual CORROSION conference will be impacted. CORROSION 2021 is still scheduled for April 18-22, 2021, in Salt Lake City, Utah. "We hope you all will be able to join us next December when we can once again meet face to face in a safe, and productive manner," SSPC said.

For more information, visit sspc.org/coatings-2021.

OSHA Issues Final Construction Beryllium Standard

The U.S. Department of Labor has issued its Final Beryllium Standard for Construction and Shipyards. While no major changes are reported in the rule, the DOL did include changes that it says are designed to "clarify the standard and simplify or improve compliance." The ruling comes about a month after the agency released the final rule for General Industry.

In a press release issued Aug. 18, OSHA notes: "The final rule amends the following paragraphs in the beryllium standards for construction and shipyards: Definitions, Methods of Compliance, Respiratory Protection, Personal Protective Clothing and Equipment, Housekeeping, Hazard Communication, Medical Surveillance, and Recordkeeping. OSHA has removed the Hygiene Areas and Practices paragraph from the final standards because the necessary protections are provided by existing OSHA standards for sanitation."

This rule, according to OSHA, impacts approximately 12,000 workers employed in nearly 2,000 establishments and OSHA maintains that the standards are estimated to yield $2.5 million in total annualized cost savings to employers. The compliance date is Sept. 30.

On Aug. 31, the Abrasive Blasting Manufacturers Alliance—an organization representing some suppliers of blasting abrasives—released an emailed statement on what the finalization means for workers. "While as an organization we don't agree with all of the provisions, because they impose burdensome costs on all abrasive blasters without any scientific data that shows it will increase worker safety, abrasive blasters will still be able to continue using the best media based on their needs," ABMA said, reaffirming the industry point that all abrasive materials contain trace amounts of beryllium.

The email continues: "Blanket statements from OSHA about specific abrasive materials containing more or less beryllium than other abrasives are irrelevant under this rule and have caused unnecessary confusion in the industry. Again, a jobsite is only exempt if exposures will remain below the very low action level under any foreseeable conditions, and no manufacturer can guarantee that. This means that the choice of blast media is not affected by the rule and abrasive blasters remain free to use the media that best serves their job.

"With the issuance of these final rules, it is time for the industry to recognize that the Beryllium Rules impact each of us equally and come together to champion sensible regulations that ensure worker health and environmental protection while preserving abrasive blasters' freedom to operate." **JPCL**

COMMENTS IN RESPONSE TO:

"QA-ing the QC From a Distance"

From JPCL June 2020

This JPCL feature article from Troy Fraebel of ABKaelin, LLC and Jerrith Hodskins of J.I. Hass, Inc. used a repainting project at a fertilizer distribution facility to discuss how the owner, contractor, QA consultant and paint manufacturer achieved a successful end result—even at a distance.

PHOTO COURTESY OF TROY FRAEBEL, ABKAELIN, LLC, AND JERRITH HODSKINS, J.I. HASS CO., INC.

Gordon Kuljian:

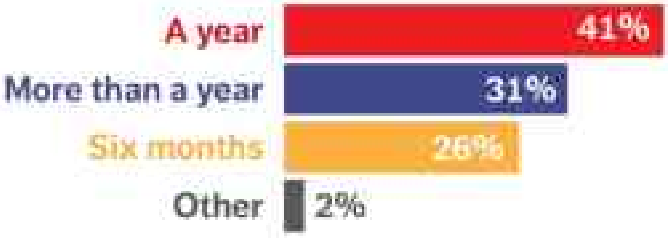
"This is a good article; it shows how the expertise of a QA consultant can greatly improve upon the QC (and overall quality) of the job, without the costly expense of full time on-site QA."

IGOR KUTYAEV / GETTY IMAGES

PAINT POLL

From paintsquare.com/poll

Quarterly earnings reports were released in late July (including those from the top coatings companies such as Sherwin-Williams, PPG, AkzoNobel and RPM), with the first wave of COVID-19 impacts on revenue. How long do you think it will take for these top companies to recover?



Michael Beitzel:

"Not sure COVID-19 has had a significant impact on the coating industry. We have continued work on all our painting projects."

PROBLEM SOLVING FORUM

From paintsquare.com/psf

When is it cost-effective to use thermal spray in petrochemical facilities?

Jaime Marcos:

"Without more data, it is not possible to know when it is better to apply one treatment or another ... The choice of a coating depends on resistance to the exposure environment and working conditions; desired durability; permissiveness with environmental conditions; time available for the execution of the work; and commissioning period (surface preparation, application and curing). Other things being equal in the possible coatings, the cost is important."

PAINTSQUARE DAILY NEWS TOP 10

From paintsquare.com/news, Aug. 3–Sep. 6, 2020

1. EPA Finalizes Plans for Sherwin-Williams Site
2. NY Execs Face Charges, Sentencing
3. None Injured in AZ Partial Rail Bridge Collapse
4. Baltimore Gas Explosion Kills 2, Injures Several
5. $1.97B Vegas Stadium Now Complete
6. PPG Inks Home Paint Deal
7. Study Looks at Painting Turbine Blades Black
8. $1.6B NV Sphere Extends Sched, Begins Structure
9. FIGG Files Against FHWA Suspension
10. 1 Body Recovered from NOLA Hard Rocke

THE NEW PAINT THAT WOULDN'T STAY "PARKED"

BY RICK A. HUNTLEY, PCS, KTA-TATOR, INC.

Concrete parking structures are frequently painted for aesthetics, improved illumination (when light-colored coatings are used) and protection. Older structures are frequently repainted during rehabilitation or expansion projects. Unfortunately, surface preparation and paint application may be a simple note on a drawing since it may be considered cosmetic. In this article, the preparation and paint system for a parking garage renovation project was proposed by the contractor and accepted by the owner. Not long after the project was completed the coating began to crack and delaminate. Here's the background, the investigation, the conclusions and recommendations, along with lessons learned.

BACKGROUND

A multilevel parking garage in an east coast city was recently renovated. The concrete parking garage had previously been expanded at least twice, with the oldest section being over 30 years old. Part of the project included painting all concrete surfaces within the garage. Reportedly, no painting specification was prepared for the project, but the painting contractor proposed the following methods for painting the interior concrete surfaces:

- Pressure wash all ceiling and wall surfaces;
- Scrape and remove any loose or peeling existing paint from wall and ceiling surfaces;
- Prime required areas with a 100% acrylic primer/sealer; and
- Apply two coats of acrylic topcoat paint to all walls and ceilings.

All of the interior concrete surfaces were pressure washed at 3,000 psi with a 0-degree rotating head. According to the contractor, the primary purpose of the pressure washing was to clean the surface because there was noticeable soot from car exhaust. The acrylic primer was applied to areas where pressure washing removed the coating. The primer was overlapped onto the intact existing paint. Sometime after the primer dried, the acrylic latex topcoats were applied.

The product data sheet for the primer stated that it was recommended for application on various surfaces including concrete. It had a recommended dry film thickness range of 1.2–1.5 mils. The product data sheet for the primer contained no specific instructions for surface preparation or application to previously painted concrete.

Fig. 1: Delamination of coating that was not previously removed during the cleaning and painting process. PHOTO COURTESY OF KTA-TATOR, INC.

The product data sheet for the acrylic latex topcoat had no specific instructions for application of the coating over previously painted concrete, but it did state that it could be used on properly prepared and primed new and previously painted exterior siding, doors, trim and windows. It had a recommended dry film thickness of 1.5 mils per coat.

Sometime after application of the coatings, cracking and peeling of the coating occurred. The coating failure was investigated to determine the cause.

EXAMINING THE PROBLEM

A site visit was conducted to help determine the cause of failure. The concrete surfaces in the garage were accessible from the garage deck and from a 6-foot step ladder. The following observations were made.

The concrete surfaces, including the ceiling, walls, columns and barricades were coated with a white paint. Certain areas of the garage had extensive peeling of the coating, mostly on the ceiling "T" sections. Peeling was minimal on columns, barricades and walls. The garage had been constructed in three sections. One of the sections was constructed approximately 30 years ago, and the extent of the peeling was noticeably greater on that section. Peeling was minimal on the newest section. The middle section had some areas of severe peeling, but not as much as the oldest section.

In most cases, the peeling was occurring down to bare concrete, often with some coating residue left on the surface. The pattern of peeling was somewhat similar throughout the facility. In many areas, it was evident that there were areas where the old coating had been removed and the new coating was applied both to bare concrete surfaces and to old intact paint. This was evident because the edge of the intact layer of paint was clearly visible. Typically, a relatively thick layer of paint was visible that terminated at a visible edge, and thinner paint was on the adjacent concrete surface. It was clear the paint was thinner because the texture of the concrete surface was more pronounced. When the coating was picked and probed in these areas it was found that the old paint had extremely poor adhesion and could be easily removed, and the paint that was applied to the bare concrete had markedly better adhesion.

In other areas, the coating appeared to crack and peel with the edge of the peeled paint loose and somewhat curled. The coating usually was peeling off to bare concrete in these areas, with some paint residue left on the surface of the concrete. On some levels of the facility the coating delamination was more severe around possible sources of moisture intrusion, including expansion joints and drains.

Regardless of whether the peeling paint was in an area where coating had previously peeled or an area where it had not, the back of the delaminated coating chips was consistently chalky and, in some cases, there were visible islands of crumbly old paint attached to the back. The front surface of the delaminating paint was not noticeably chalky or deteriorated.

The adhesion of the paint was assessed in many areas in accordance with ASTM D-3359 "Measuring Adhesion by Tape Test," Method A (X-cut).

The adhesion was rated 0A in areas where the old paint was still intact and some of the adjacent paint was peeling. The coating could be easily peeled from the surface by tugging at the edges. Generally, in areas where there was no peeling, the adhesion rating ranged from 1A to 4A.

There were many areas where it was evident that the old coating had delaminated or been removed before the new coating was applied. At a few of these areas the remaining old coating was lifted somewhat at the edge where it bordered the previously delaminated area. The new coating was well adhered to the previous delaminated spot, but some overspray was present underneath the lifted edge of the old paint, indicating that that edge had lifted before the new paint was applied.

The relative moisture content of the concrete was measured in numerous locations using a moisture meters that employs radio frequencies to measure the moisture content on the top ¾-inches of the surface. In most the areas measured on the older section of the parking garage, the meter indicated that there was excessive moisture (beyond the detection limit of the meter). In other areas, where there was no peeling of the paint, the meter still showed high moisture levels but within the range of the meter.

LABORATORY ANALYSIS

Samples of the coating removed from the concrete surfaces of the parking garage were examined by a forensic coatings laboratory. The laboratory analysis consisted of a microscopic examination and Fourier transform infrared spectroscopy. Microscopic examination confirmed what was found during the site visit. There were multiple coats of paint in the areas of poor coating adhesion and delamination; the back coat was soft, powdery, discontinuous and full of voids.

Fourier transform infrared spectroscopic analysis revealed that the newly applied topcoat was an acrylic, as reported. In one area, there was evidence of some vinyl modification. It was difficult to determine the generic identity of the old layers of paint that were overcoated during the renovation since they were so severely deteriorated that there was not enough resin remaining to make a positive identification. In other areas where there was more resin still present, it was determined that the formulation of the old layers of paint was based on vinyl (polyvinyl acetate, or PVA) resin.

CONCLUSIONS AND RECOMMENDATIONS

The site investigation and the forensic laboratory evidence indicated that the cause of the peeling of the paint applied to concrete surfaces in the parking garage was the presence of a previously existing coat that was not removed adequately before application of the new paint system. The new coating was applied over an old, weak layer of paint, and the additional stress of the newly applied paint caused the poorly adhered old paint to delaminate. It appeared that the newly applied paint had satisfactory adhesion to the old paint, but the old paint had poor adhesion to the concrete substrate.

The contractor reportedly cleaned the previously painted concrete surfaces with 3,000 psi water pressure; however, the purpose of the pressure washing was to remove soot from car exhaust. Although water at 3,000 psi pressure will remove loose paint, it is frequently ineffective in removing paint that has poor adhesion but has not yet broken loose. A close examination of many of the areas of delamination indicated that some of the

Fig. 2: Close-up of weak, crumbly coating left on surface after the newly applied coating delaminated

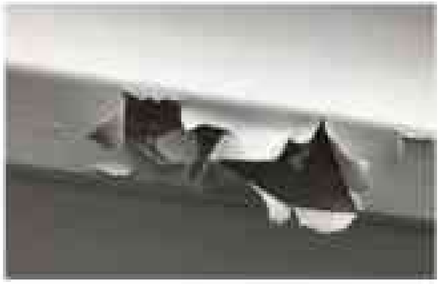


Fig. 3: Spots of tightly adhered coating within the area of delamination

Fig. 4: The coating was partially removed during the cleaning and painting process. The edges of the intact coating lifted as a result.

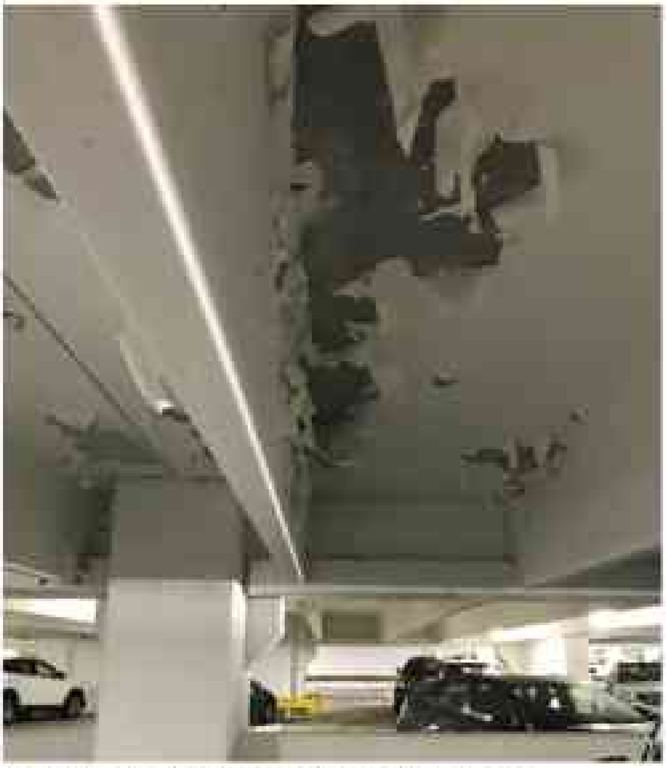


Fig. 5: The coating failures were widespread in many areas

coating, undoubtedly already loose, had been removed by the pressure washing, while the adjacent coating remained even though it had extremely poor adhesion.

The old coating that remained on the back of the delaminated coating chips was chalky and/or crumbly. When delaminating paint was removed by hand during the site visit, a considerable amount of chalk was transferred to the investigator's fingers. In many areas of delamination, a non-continuous layer of crumbly old paint was left on the concrete surface. The presence of the weak layer of old paint on the back of the newly applied paint was confirmed by the laboratory microscopic examination.

Testing during the site visit indicated that much of the concrete in the garage had a high moisture content. The investigator's experience using a radio frequency-type moisture meter to test for moisture in concrete was that relatively dry concrete will yield a reading of approximately 200 or less on the meter (higher numbers indicate more moisture). Many areas in the parking garage revealed readings of 999 (the highest reading that can be revealed by the meter, so moisture levels may have been in excess of this value).

The presence of water in the concrete creates two problems. Very high moisture content in concrete can cause coatings to delaminate—although typically not to the extent found in the parking garage with relatively thin latex coatings. The second problem is that it leads to the deterioration of the paint. Testing of the paint on the back of the chips that were removed from the parking garage indicated that the resin in the old paint was PVA (or was deteriorated to the point that the resin could not be identified). PVA coatings hydrolyze and deteriorate upon extended exposure to water.

There was some indication that not all the loose paint was removed before application of the latex acrylic paints. This was obvious because on a few spots the edge of the old paint had lifted and there was some dry spray or overlap of the new paint on the bare concrete under the lifted old paint. Although this occurred, it was discovered only occasionally and was not believed to be a significant contributing factor to the delamination problem.

It was recommended that the surface be "probed" using high-pressure water cleaning (between 5,000 and 10,000 psi) using a 0-degree rotating tip to intentionally remove poorly adhered and/or deteriorated paint. However, since pressures at the upper end of the range may damage the concrete, it was recommended that the contractor start at the lowest pressure and gradually increase the pressure until some concrete damage occurs in a small area. The pressure is then reduced until no damage occurs, but the pressure remains high enough to remove compromised coating. Once the poorly adherent coating was removed, it was recommended that the entire surface be coated with an acrylic primer and topcoat, subject to coating manufacturer recommendations.

LESSONS LEARNED

It is not uncommon for this type of coating delamination to occur when overcoating existing coatings that already have compromised adhesion. Simply removing paint that is already loose, then overcoating what is remaining often leads to further delamination of the old paint. Care must be taken to remove all old paint that has poor adhesion or has deteriorated to prevent delamination of both the old and newly applied paint.

Recall in the background of this case that there was no specification prepared addressing surface preparation and painting of the concrete, nor was there an assessment of the condition of the existing coatings (i.e., adhesion testing to determine the integrity of the existing coating layers) or concrete moisture content measurements. When a facility owner is considering maintaining an existing paint system, two of the most critical steps are:

1. Determining whether the existing system can withstand the stresses of additional coating layers; and
2. Determining the extent to which the existing coating must be removed.

If an assessment of the existing coating condition had been performed, it would have likely revealed that overcoating the existing system was not an option and total removal and replacement was necessary. Hopefully, that would have triggered the development of a specification detailing the requirements for surface preparation, maximum moisture levels in the concrete prior to coating, and the recommended coating system including application requirements. **JPCL**

[illegible] GETTY IMAGES

COMBATTING LOCALIZED GALVANIC CORROSION
AT BOLTED CONNECTIONS IN GRAVITY SLUDGE THICKENERS AND CLARIFIERS

BY R. A. NIXON, CORROSION PROBE, INC.; CORROSION TESTING LABORATORIES, INC.

Localized galvanic corrosion of coated carbon steel rake mechanisms at stainless steel bolted connections can result in significantly high corrosion rates particularly when connections are overtightened. This issue occurs routinely in gravity sludge thickeners and clarifiers.

Most epoxy coatings used for effective rake mechanism corrosion protection are quite brittle once cured. So, if stainless steel cap screws or bolts and nuts are over-tightened at mechanical connections, coating damage occurs at the areas of fastener or washer contact. This exposes small areas of bare carbon steel, which behave anodically to the larger cathodic surface area of the stainless steel fasteners. The bare carbon steel also actively corrodes due to oxygen-driven pitting and under-deposit corrosion. Hence, the corrosion rates are very high at the edges and near faces of the bolt holes. This electrolytic corrosion exacerbated by the galvanic couple promotes undercutting corrosion that causes further coating failure followed by more widespread steel corrosion damage. In this scenario, more often than not, the main problem is corrosion-driven widening of the bolt holes. This results in loosening of the bolted connections and ultimate failure of those connections. This leads to the rake components coming loose and causing mechanical damage to the sludge concentrator or truss arms.

This article will describe this commonplace corrosion problem associated with protective coating damage at dissimilar metal bolted connections and present a typical case history. The article will go on to explain why slotted bolt holes are more susceptible to more aggressive corrosion damage than round bolt holes. In addition, the article will present successful measures that can be taken to prevent this prevalent problem. Those measures include proper coating system selection, the use of non-metallic washers with stainless steel washers, reducing the number of bolted connections, and application of a flexible polysulfide sealant to seal bolted connections following proper coating application.

BACKGROUND

Gravity thickeners and clarifiers typically consist of a center influent pipe, a center stilling well with or without turbulent flow reducing baffles, truss arm type rake mechanisms for pushing sludge to the center of the tank, and a launder system for clarified water removal including scum baffles and weirs. It is an understatement to say that these mechanisms are difficult to properly coat. Coating the truss arms and center well bracing and supports, in particular, is onerous due to the geometry. Multiple angle and channel shapes replete with thin edges and corners and plate-to-plate interfaces make these structures challenging on which to achieve good protective coating film quality. These mechanisms are typically shop fabricated and field erected using both welding and bolted connections. Figure 1 (p. 17) shows the typical gravity thickener rake arm configuration. Achieving good coating film quality at bolt hole edges is especially difficult, making these locations vulnerable to corrosion once the rake mechanisms are placed into service.

Localized galvanic corrosion at bolted connections is commonplace on rake mechanisms in gravity thickeners and clarifiers. This occurs where stainless steel fasteners are used for coated carbon steel connections. Stainless steel bolts, nuts, and washers are routinely used to assure ease of disconnection and re-tightening for mechanism connections whereas carbon steel fasteners tend to corrode readily. This requires cutting those fasteners off during future maintenance work. Because the stainless steel fasteners are more noble electrochemically than the carbon steel mechanism components, any breach in the protective coatings on the carbon steel results in localized galvanic corrosion. Bear in mind that when two metals having diverse electrical potentials, are electrically continuous and immersed in a common electrolyte, galvanic corrosion generally occurs. This is regularly the case at bolted connections in gravity thickeners and in wastewater clarifiers. Such coating breaches are commonly created when bolted connections are tightened to the extent that the protective coating is damaged exposing small bare carbon steel areas. Because the carbon steel areas exposed are small in area relationship to the exposed surface area of the more noble stainless steel surfaces, significant galvanic corrosion rates are experienced.

This problem is exacerbated by three key issues. First, the most commonly used coatings for steel mechanism protection are epoxy based. These coatings tend to be quite brittle once cured. This makes these coatings susceptible to fracturing when bolted connections are tightened. Second, it is typical for these connections to be over-tightened as recommended torque procedures are not generally followed during rake mechanism or center well field erection. And third, coating film build at the bolt hole edges is often inadequate. The small bare carbon steel areas degrade in immersion service due to various corrosion mechanisms. These include oxygen-driven electrolytic corrosion, under deposit microbiologically influenced corrosion (MIC), and corrosion associated with reducible sulfur species. Once actively corroding, the bare carbon steel corrosion is enhanced by the dissimilar metal contact with the more noble (cathodic) stainless steel. In addition, the cathodic to anodic area relationship is large in this galvanic couple. This drives the galvanic corrosion rate up especially where the bare carbon steel surfaces are in immediate proximity to the stainless steel cathodic surfaces. This results in high corrosion rates at bolted connections.

This corrosion damage is most commonly manifested at the edges and near-surface areas at bolt holes in those mechanical connections. Figure 2 shows the result of this galvanic corrosion causing bolted connection failure. Rake arm components come loose and end up in the bottom of the tank. Figures 3 and 4 depict this typical galvanic corrosion problem at bolted connections on rake arms. Bear in mind that gravity sludge thickeners are essentially small versions of circular clarifiers designed to thicken sludge via settling of the biosolids.

Fig. 1: Damaged gravity thickener rake arm mechanism. PHOTOS COURTESY OF THE AUTHOR UNLESS OTHERWISE NOTED

Fig. 2: Damage to clarifier bottom

Fig. 3: Galvanic corrosion on rake arm mechanism

Fig. 4: Galvanic corrosion at bolted connection

As this localized corrosion proceeds, undercutting of the coating system occurs exposing more bare carbon steel to the corrosive conditions. More often than not, this corrosion causes widening of bolt holes. This widening of the bolt holes often leads to loosening of the bolted connections followed by failure of those connections. This can result in rake arm and other mechanism components coming loose and causing mechanical damage to the sludge concentrators and to rake arms.

GRAVITY THICKENER CASE HISTORY

A new gravity thickener was installed in a large New England wastewater treatment plant in 2015. This sludge thickener went into service in the Spring of 2015. In 2016 and 2017, this thickener was drained and cleaned for annual maintenance and inspection. No failed or loose rake mechanism components were identified at those times. It was documented that loose bolts were discovered and were tightened during those maintenance efforts. In 2018, the unit had to be taken out of service due to over torqueing of the rake arm drive. Once dewatered and cleaned, inspection revealed that rake arm components (scraper blades) had come loose and had caused mechanical damage to the mechanism. The sludge concentrator had been twisted and broken. This allowed sludge to build-up in the bottom of the tank. In addition, many loose bolted connections

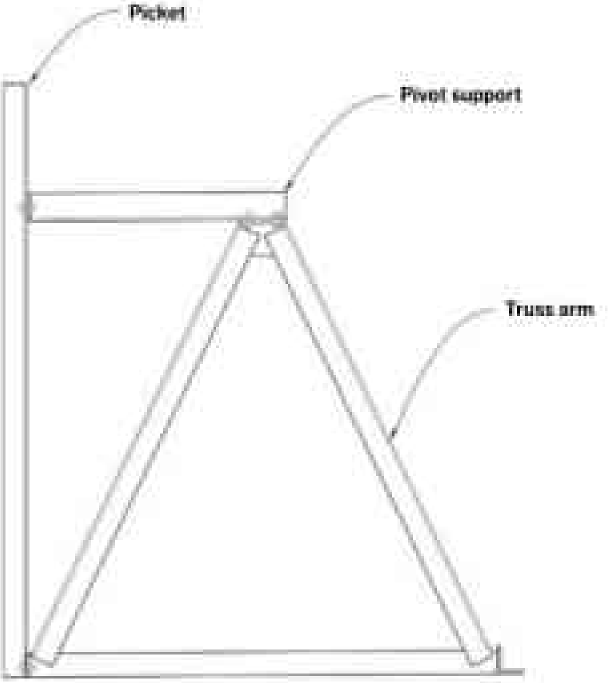


Fig. 5: Diagram of a typical sludge thickener rake arm configuration

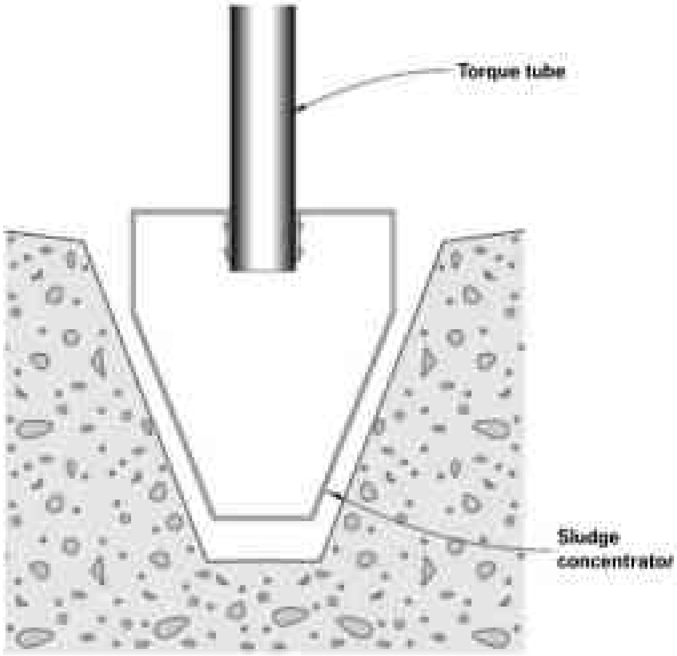


Fig. 6: Diagram of a typical sludge concentrator configuration

were discovered at pickets and scraper blade rake arm connections. Figures 5 and 6 (p. 18) depict the typical sludge thickener rake arm (with pickets) and sludge concentrator configuration.

The rake mechanism in the gravity thickener was constructed from coated carbon steel. Type 316 stainless steel hex cap screws, nuts and washers were used for the various bolted connections including picket to pivot supports and for picket-to-truss arm (rake arm) connections. Figure 7 shows the rake arms in 2015 prior to the unit going into service. This clearly shows that washers were deformed from overtightening of some of these bolted connections.

The carbon steel rake arms, center influent well, and other larger mechanism components had all been abrasive blast cleaned and primed in the shop. Following field erection, the equipment was field top coated with an epoxy coating. The shop primer was a zinc-rich polyurethane with a long recoat time. The total coating system thickness was found to be widely varied between 4 and 15 mils, dry film thickness. This coating system is considered by this author to be generally too thin to achieve good edge retention on rake mechanism truss arms and associated components. Except at the edges and flat member faces near bolt holes, the coating system was found to be performing well.

Figure 8 depicts the presence of substantial corrosion losses at 5/8-inch x 1 1/4-inch slotted bolt holes for the pickets where

Fig. 7: Rake arms in 2015, prior to entering into service

Fig. 8: Slotted bolt hole in Sample 2. The bottom image shows the smooth attack in the width of the slot. There is cracking of the coating and the attack is undercut beneath the coating. The red outline in the top image shows approximate original dimensions of the bolt hole.

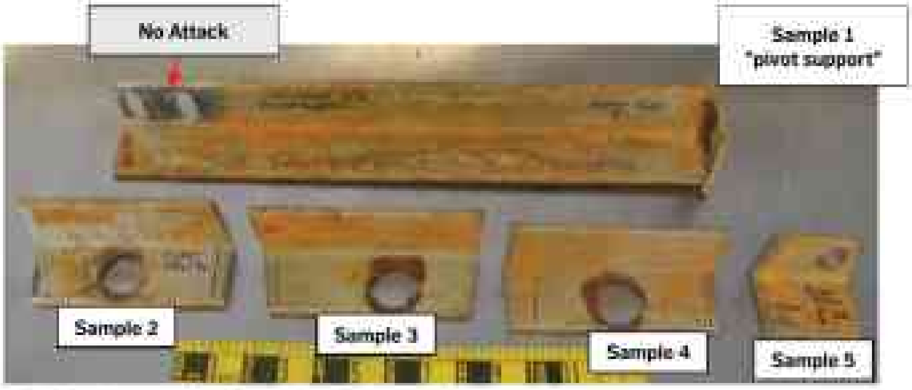


Fig. 9: Sections provided from the rake arm members.

Fig. 11: Corroded condition due to overtightening of connections

connection to the truss arm pivots takes place. Note the corrosion damage and widening of these slotted bolt holes.

Interestingly, the double bolted slotted holes (1/2-inch diameter x 1-inch long) at the ends of the pivot supports at the connection to the truss arms were found to have no corrosion damage. These connections are more solid due to double bolting. Figure 9 shows this condition.

At most round bolt holes (generally 5/8-inch diameter), little corrosion damage was observed except where deformation of the stainless steel washers was evident due to over-tightening of the connections. Figures 10 and 11 show the lack of attack at round holes and corroded condition due to overtightening, respectively. Figure 12 reveals the typical undercutting of the coated member and widening of the bolt hole edges due to corrosion.

Examination of the various stainless steel fasteners in the rake mechanisms showed no evidence of pitting or crevice corrosion of the stainless steel even at threads (Fig. 13).

Figure 14 (p. 21) shows clear evidence of galvanic corrosion of the carbon steel at bolt holes where the stainless steel fasteners connected the scraper blades to the rake arms. These were round bolt holes before edge corrosion losses widened the holes.

Corrosion damage and widening of slotted bolt holes where fasteners were overtightened were found to be greater than at round bolt holes. Figure 15 shows a typical finding where the corrosion wastage was greater at the open edges of the slotted hole. The more extensive damage is related to greater

Fig. 10: Lack of attack at round holes

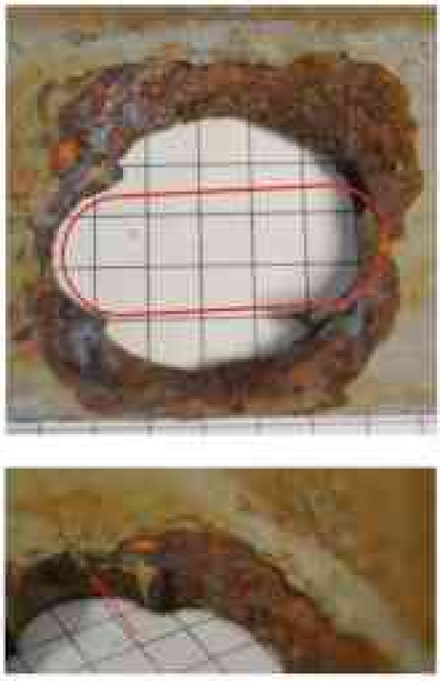


Fig. 12: Slot in Sample 3. A close-up shows the intact coating on the ends of the slot (red arrows). The corrosion is in the middle of the slot. The red outline in the top image shows approximate original slotted hole dimensions.

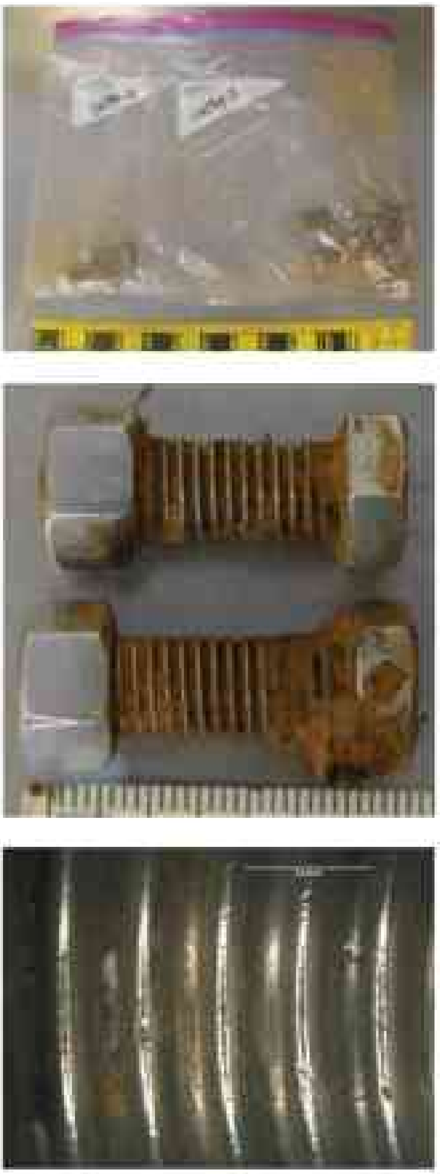


Fig. 13: The two sets of bolt samples are shown in the upper upper image. The middle image shows typical bolt samples with adhered deposits as-received. The bottom image shows one of the bolts after cleaning, which was free from obvious stainless steel corrosion.

Fig. 14: Clear evidence of galvanic corrosion of the carbon steel at bolt holes where the stainless steel fasteners connected the scraper blades to the rake arms. These were round bolt holes before edge corrosion losses widened the holes.

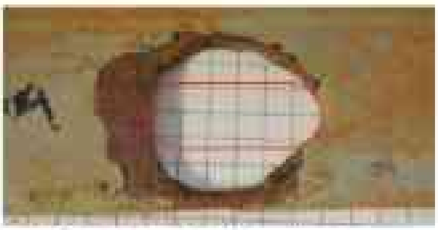


Fig. 15: Slot in Sample 4. Red outline shows approximate original dimensions.

Fig. 16: Washers as viewed in profile showing a distinct bend/distortion from over-tightening.

fracturing of the coating along the exposed edges of the slotted holes.

Laboratory examination of the corroded bolt holes and thickener components revealed that enlargement of the bolt holes was mostly oriented perpendicular to the long dimension of the slotted holes. This indicated that the corrosion progressed in the direction away from the covered area of fastener contact (Fig. 15). Other laboratory examination showed the following.

- Deformation of the stainless steel washers was evident as shown in Figure 16.
- Corrosive attack of the middle of slotted bolts indicated the attack tapered from the two surfaces toward the middle of the wall thickness of the carbon steel member (Fig. 17, p. 22).
- Energy Dispersive X-Ray Spectroscopy (EDS) on a scanning electron microscope (SEM) was conducted on the corrosion deposits from the carbon steel to determine if chlorides or sulfur corrodents drove the observed corrosion. While these corrodents were present, it was concluded that oxygen driven corrosion exacerbated by galvanic corrosion was the main driver (Fig. 18, p. 23).

TECHNICAL DISCUSSION

The corrosion of bare carbon steel in the sludge thickener was mainly driven by electrolytic corrosion influenced by oxygen reduction and to a lesser extent by

microbiologically influenced corrosion or MIC in under deposit conditions. Corrodents that further affect the corrosion severity include reducible sulfur species as well as chlorides. Both were present in the corrosion products analyzed. Neither corrodent was found to be unusually high.

Where protective coatings fail, the carbon steel's corrosion rate will be enhanced by dissimilar metal contact with more noble metals such as stainless steel. This galvanic corrosion occurs where a difference in electrical potential exists between the more active (anodic) carbon steel and the more noble (cathodic) stainless steel when the two metals are electrically connected and immersed in a common conductive electrolyte (sludge in this case). These conditions exist at bolted connections where the epoxy coating has been damaged. The pH of the sludge or electrolyte in the gravity thickener studied (reported to be in the 5.3 to 5.6 range) is conducive to all of the corrosion mechanisms mentioned above. The main factors influencing corrosion in this case include pH, dissolved oxygen concentration, dissolved ion concentrations, temperature, active bacteria of various types under biosolids deposits, and other factors including rake velocity and concentration cells associated with differential oxygenation.

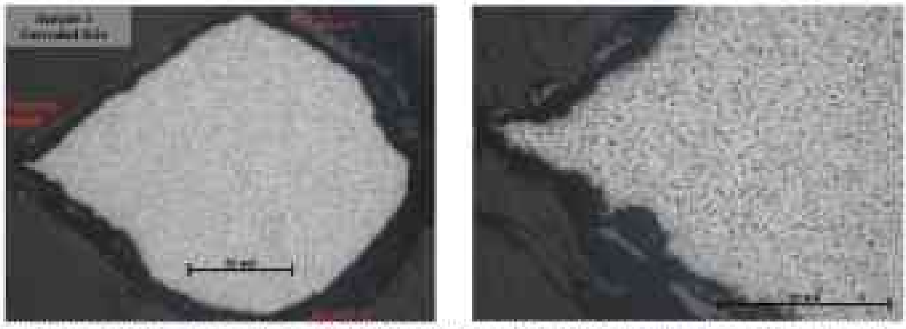


Fig. 17: Attacked surface at the middle of the slot in Sample 3. Oxidation was present, as is typical. The attack tapered from the two surfaces toward the middle of the wall thickness.

It is notable to point out that the original coating system applied to the carbon steel components was performing very well where no mechanical damage to it had occurred and where no discontinuities existed in it from the onset. Such problems on both counts were found to be minimal on the mechanism during the field inspection.

Evidence from both the field and laboratory evaluations demonstrate that corrosion wastage is present at both slotted and round bolt holes in the rake or truss arm assembly. These corrosion losses, which began with protective coating damage, were more severe, pronounced and prevalent at the slotted bolt holes at the top of the pickets than at the bottom round bolt holes for the pickets or at the double slotted holes at the pivot support-to-trust arm connections. Corrosion losses were also observed at some connecting bolt holes between flights and truss arms and elsewhere in the mechanism.

Coating damage caused by over-tightening stainless steel fasteners has exposed bare carbon steel to the normally corrosive sludge. Once that corrosion was initiated, the small surface area of the carbon steel behaved anodically to the more noble stainless steel fasteners (nuts, hex cap screws and washers) and galvanic corrosion exacerbated the corrosion damage. At the early stage of carbon steel corrosion, there was a larger stainless steel or cathodic area relative to the smaller anodic surface area of the carbon steel at bolt holes. This intensified the corrosion damage which occurred closest to the dissimilar metal contact. This caused enlargement of the bolt holes and undercutting corrosion, which expanded the area of coating delamination.

The extent of corrosion damage and undercutting of the bolt holes was greater at the slotted holes at the top of the pickets.

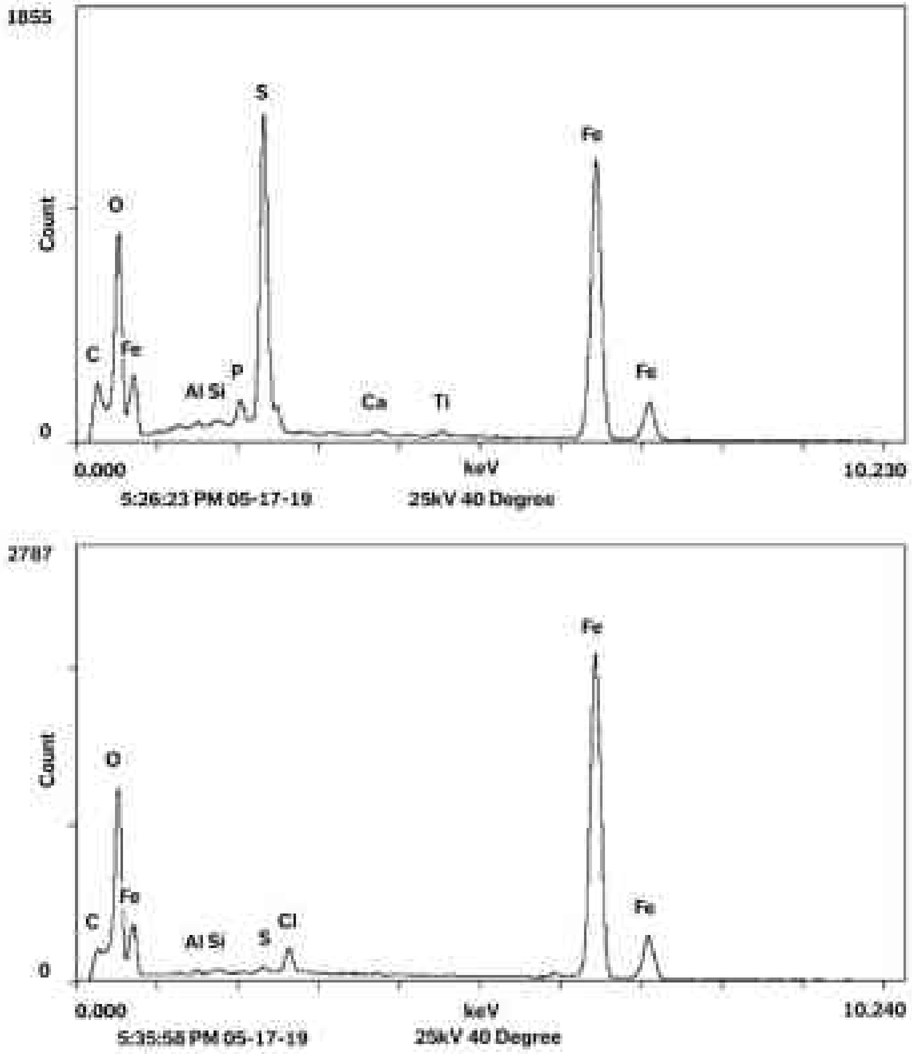


Fig. 18: Examples of the EDS spectra generated for analysis of deposits taken from corrosion sites of Samples 1 and 2.

This was the result of coating damage under the fasteners and at open edges of the holes on which the coating had been fractured. While corrosion related to coating damage was also observed at round bolt holes, the damage was mostly limited to the area beneath the hex head or washer or nut. This minimized widening of those bolt holes. Perhaps of equal importance, over-tightening of threaded fasteners is generally more likely at slotted bolt holes than at round bolt holes. This is an experience-based observation. Furthermore, the galvanic area relationship explained above would have been more influential at the slotted holes. As the fasteners were tightened, the coating along the slotted hole edges would crack. This would have resulted in larger cathode to anode area relationships than at the round bolt holes where coating damage was covered. Hence, the corrosion damage at the top of the picket slotted holes was greater.

On the subject of the pivot support-to-truss arm connection, here a pair of bolts and nuts are used. This is a more secure connection than the slotted holes at the top of the pickets. Little corrosion damage was observed at these connections. Original photographs of the rake mechanisms from 2015 show that washers were used at these connections. Those washers appear to cover the one-inch-long slotted holes at these locations. Also, the double bolted connection averts point loading on the coated carbon steel evident at single bolted connections.

Examination of the washers removed from gravity thickener exhibited significant deformation characteristic of over-tightening of the bolted connections. By contrast, stainless steel fasteners, which were used for rake arm connections in two adjacent primary clarifiers, did not reveal similar evidence of over-tightening or corrosion problems during recent inspections.

CONCLUSIONS

Based on all field and laboratory findings, the following conclusions can be drawn.

The failure of various bolted connections in the rake mechanism in the gravity thickener was corrosion related. The corrosion wastage occurred at the bolt holes where the protective coating system was damaged by over-tightening of the stainless steel fasteners. The corrosion wastage at bolt holes was more pronounced and prevalent at slotted bolt holes than at round bolt holes. This occurs because more damaged coating area became exposed to the corrosive sludge and galvanic couple at slotted holes.

The corrosion mechanisms involved include normal oxygen-driven electrolytic corrosion and MIC of the carbon steel. The aggressiveness of the corrosion damage was exacerbated by galvanic corrosion associated with the potential difference between the more noble stainless steel fasteners and the more active or anodic bare carbon steel at areas of coating damage. The greater cathodic (stainless steel) area relative to the smaller (anodic) carbon steel area increased this galvanic corrosion rate.

While the sludge in the gravity thickener has an acidic pH, which makes it more corrosive to carbon steel than a near neutral pH sludge would, the sludge chemistry was not the root cause of the corrosion damage.

The originally specified and applied coating system has performed well in the gravity thickener service and exhibits no evidence of chemical attack or degradation except at edges and bolt holes. The coating system thickness did vary quite widely near and at bolt holes which is typical for the coating products specified. Neither the primer nor the top coats are particularly thick films and neither provide good edge film build or edge retention.

All evidence demonstrates that the sequence of the bolted connection failures was as follows.

1. Certain connections were over-tightened at the time of the original 2015 erection or were tightened further during subsequent maintenance intervals. This overtightening caused fracturing of the protective coating system exposing bare carbon steel to sludge immersion.
2. Corrosion of the carbon steel proceeded and was exacerbated by the galvanic drive created by the electrochemical potential difference in the dissimilar metals and a high cathodic to anodic area relationship.
3. Widening of slotted bolt holes occurred due to aggressive corrosion as undercutting damage of the coating system exposed more carbon steel near the dissimilar metal contact area.
4. Once bolt holes were sufficiently wide and expanded, the fasteners became loose and connections of the steel components were no longer tight. Some of these bolted connections failed and steel components came loose and detached from the rake arm assembly.

RECOMMENDATIONS FOR PREVENTATIVE ACTION

The following are recommendations for preventing these corrosion problems.

Electrical Isolation at Bolted Connections: Isolation kits are available for bolted connections. However, the sleeves used are plastic or based on reinforced phenolic resins. In CPI's experience, making connections properly torqued and sufficiently tight for mechanical purposes on rake arms tend to cause cracking of these sleeves. Also, the thickness of the connections are too thin (flange to flange) for sleeves to be used. This, in turn, short circuits the electrical isolation. The use of nonmetallic washers under stainless steel washers are recommended for bolted connections to prevent or minimize damage to the coating system on the mechanism members. This practice combined with sealing the bolts and nuts as recommended below significantly minimizes galvanic corrosion at the bolted connections where bolted fasteners are really necessary.

Reduction of Bolted Connections: Based on this author's experience, many bolted connections on rake mechanisms can be eliminated. The connections are there to simplify shipping, field erection and future maintenance (change-out of worn components). However, components that do not require frequent replacement and are not susceptible to wear should have their connections welded. This can be performed in the field and greatly reduces the opportunity for coating damage and associated galvanic corrosion at bolted connections. For instance, in the gravity thickener, the picket and pivot supports rarely require replacement. These connections could easily be field welded. Proper post-weld removal of weld spatter and removal of slag and rough areas is required to assure good coating system film quality. Minimizing bolted connections also reduces future ongoing maintenance. The bolted connections for the flights to the truss arms and for squeegees to the truss arms as well as other more maintenance intensive component connections require fasteners. The use of stainless steel fasteners is appropriate at these locations. Provided some added care is taken not to over-tighten those fasteners, the problems experienced with the gravity thickener evaluated here can be averted. In addition, non-metallic washer use and sealing of bolted connections with a flexible polysulfide sealant has been shown to reduce corrosion problems at these connections.

Sealing Bolted Connections: Sealing the bolts, nuts and washers with a two-component polysulfide sealant is a good practice. This is done using a caulking gun and gloving of the sealant over the fasteners and onto the connected member surfaces. Coating the bolted connections with the field-applied epoxy coating system is also recommended prior to the sealant application. All bolts, nuts and washers should be solvent-cleaned and dried prior to installation to remove cutting oil from these fasteners. The epoxy coating systems should be brush-applied over all bolted connections when stripe coating is performed at member edges and corners and during application of each of the field coating applications. (Stripe coating refers to coating member edges and corners once before the overall member surfaces receive each coat of the coating system.) Once the coating has cured properly, the sealant can be applied. Coated carbon steel fasteners have been used on rake mechanisms for many years. The coating on the bolts generally fails when the connection is made and hence the bolts corrode readily in service. The bolt removal at such connections becomes problematic during the maintenance cycles. Therefore, the author does not recommend using carbon steel fasteners.

New Protective Coating System: It is recommended that the rake mechanisms in gravity thickeners be abrasive blast-cleaned and recoated using a different protective coating system than was originally utilized in the case given above. The recommended coating system will be as follows.

- Abrasive blast-clean to a near white metal degree of cleanliness per SSPC-SP 10 and shop or field prime with 3–5 mils DFT of an organic zinc rich primer with a long recoat window.
- Once primer has sufficiently cured, coat all surfaces including all bolted connections with a high-build epoxy coating designed for excellent edge retention and film build, or equal, applied by either single-leg or plural-component spray equipment. This coating should be applied over all welds and bolted connections so it can be worked into and over these connections. It should be used to spray and stripe coat all edges as the work proceeds. A DFT of 30–40 mils of this coating should be applied over all metal surfaces. This can be achieved in one or two coats.

Component Replacement for Gravity Thickeners: All badly corroded carbon steel members (pickets, pivot supports, etc.) for corroded gravity thickeners should be replaced prior to the recommended recoating work and connection sealing work. Where practical, replace bolted connections and associated bolt holes with welded connections as discussed. **JPCL**

ABOUT THE AUTHOR

Randy Nixon is president and founder of Corrosion Probe, Inc., which has been in business for more than 35 years, specializing in corrosion and materials engineering, consulting, testing and inspection. Nixon has more than 40 years of experience and has published over 65 technical papers and articles through SSPC, NACE, WEF, AWWA and TAPPI. He is widely recognized in the water/wastewater industry for his expertise in piping corrosion, concrete degradation evaluation, protective coatings and linings, and overall materials performance. He is also president and owner of CTL, which provides corrosion and materials testing services.

CALENDAR

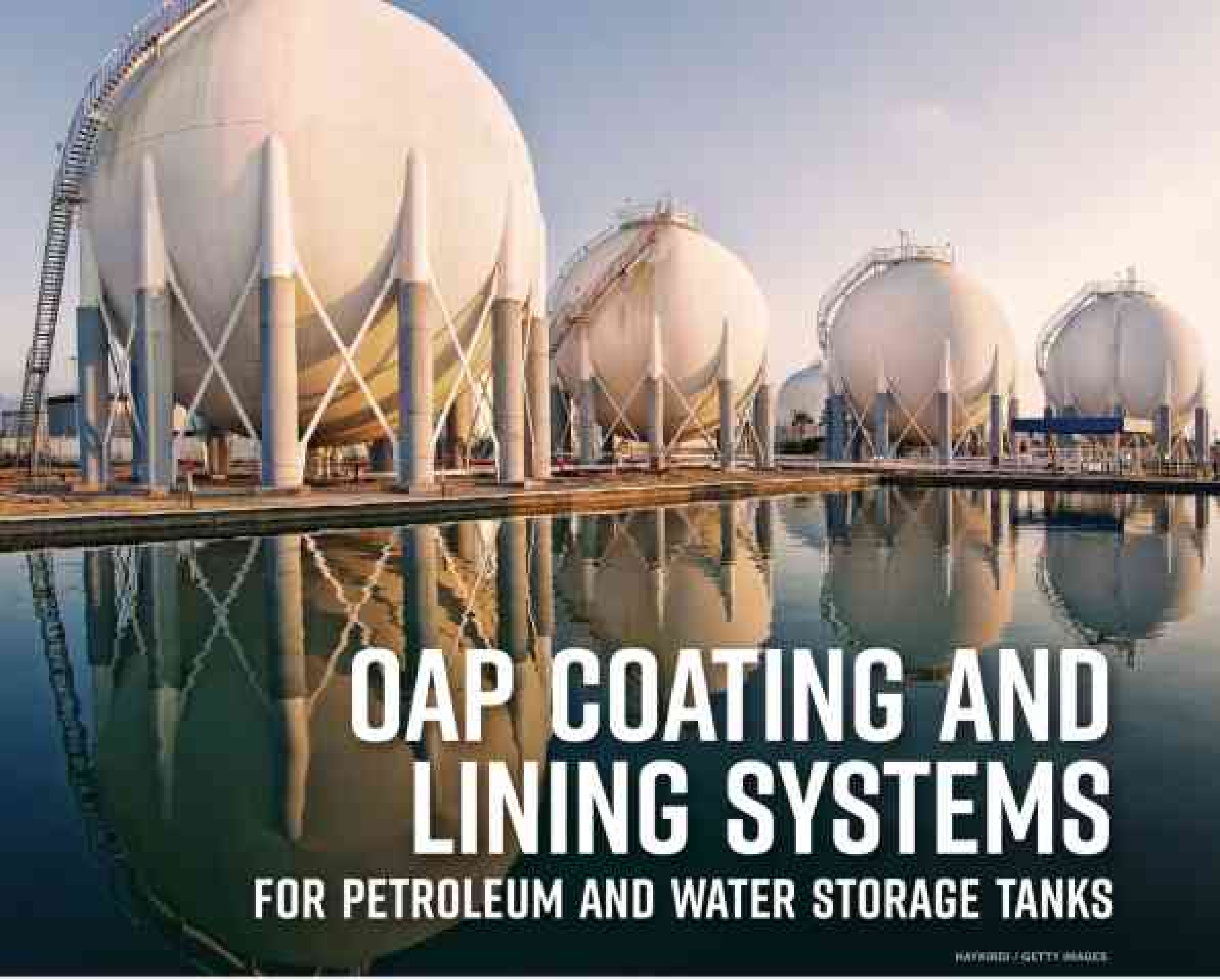
OCTOBER 2020

SSPC COURSES: *Course information available at sspc.org*

Oct. 5–9	CCAS Conc Ctg App Spclst, Glendale Heights, IL
Oct. 5–9	CCI Conc Ctg Insp, Manila, Philippines; Anaheim, CA
Oct. 5–9	NBPI NAVSEA Basic Pt Insp, Seattle
Oct. 5–10	BCI Bridge Ctgs Insp, Pittsburgh
Oct. 5–17	PCI Prot Ctgs Insp, Batam, Indonesia
Oct. 7–8	C14 Marine Plural Comp App, San Diego
Oct. 12–15	C3 Lead Pt Removal, Daytona Beach, FL
Oct. 12–16	C1 Fundamentals, Santa Fe Springs, CA
Oct. 12–16	NBPI, San Diego
Oct. 12–16	C2 Plan/Spec, Grand Rapids, MI
Oct. 12–18	PCI, Houston; Norfolk, VA
Oct. 13–16	CCAS, Portland, OR
Oct. 15	Thermal Insp, St. Petersburg, FL
Oct. 15–16	ACAS Aerospace Ctg App Spclst, Pittsburgh
Oct. 15–16	C6 Power Tool, Columbus, OH
Oct. 16	Lead Pt Refresher, Daytona Beach, FL
Oct. 17	PCS Prot Ctgs Spclst, Grand Rapids, MI
Oct. 19–20	C7 Abrasive Blast, Portland, OR; Zephyrhills, FL; San Diego
Oct. 19–22	C3 Lead Pt Removal, Hayward, CA
Oct. 19–23	NBPI, Jacksonville, FL
Oct. 20–21	C7 Abrasive Blast, Pittsburgh
Oct. 21–22	C12 Spray App, Pittsburgh; Portland, OR; Zephyrhills, FL; San Diego
Oct. 21–23	CAS Ctg App Spclst, Pittsburgh
Oct. 23	C5 Lead Pt Refresher, Hayward, CA
Oct. 23–24	C6 Power Tool, Pittsburgh
Oct. 26–30	NBPI, Newington, NH
Oct. 26–Nov. 1	PCI, Pittsburgh
Oct. 27–28	C7 Abrasive Blast, Houston
Oct. 27–30	CCAS, Paterson, NJ

CONFERENCES & MEETINGS

Oct. 5–9	WEFTEC Connect Virtual Conf, weftec.org
Oct. 7–9	Virtual CONSTRUCT Show, constructshow.com
Oct. 13–22	ICRI Virtual Fall Conv, icri.org
Oct. 25–29	ACI Virtual Fall Conv, concrete.org
Oct. 27–29	SPE Virtual ATCE, atce.org
Oct. 28–30	Virtual ASCE Conv, asceconvention.org



OAP COATING AND LINING SYSTEMS

FOR PETROLEUM AND WATER STORAGE TANKS

HAYKIRDI / GETTY IMAGES

BY DEBORAH V. SIMMONS (RETIRED), JOHNNY C. POURCIAU AND MURRAY HEYWOOD, SHERWIN-WILLIAMS PROTECTIVE & MARINE

The tank painting process for the interior of a petroleum and/or water storage tank requires proper coating selection, product application and inspection to achieve long-term service life. The primary cause of early coating failures in a painting project is often application related. The use of coating systems and linings formulated with optically active pigments can help facilitate correct application and inspection of the tank linings. OAP technology can help identify pinholes, eliminate holidays and reduce premature lining failures often caused by inadequate film thickness on angles, edges or areas that are difficult to inspect.

COMMON CAUSES OF PREMATURE COATING FAILURES IN STORAGE TANKS

Insufficient coating film thickness, improper coverage of stripe-coated areas, poor edge coverage on structural supports, welds and sharp angles, pinholes and holidays are contributors to premature coating failures in petroleum and water storage tanks. Common causes of premature coating failure in storage tanks are uncoated, exposed substrates or areas of exposed zinc-rich primer (for water storage tanks) that go undetected during the inspection process. Pinholes and holidays, low film thickness and improper coverage of stripe-coated areas are potential coating problems that can be indicated by OAP technology.

Insufficient Film Thickness

Many failures in petroleum and water tanks can be attributed to insufficient or low dry film thickness. The permeability of a tank lining is directly affected by film thickness—if the coating film is too thin it may not close properly, creating issues. Performing random checks of the DFT using magnetic gauges is the only assurance available.

Coating film thickness and uniform coating thickness concerns are traditionally determined using SSPC PA-2 dry film readings and averages. SSPC PA-2 only registers DFT in the specific areas that are checked. In general, this paint application standard is designed to provide a procedure of averaging DFT to determine an acceptable product application thickness.

Stripe Coating

It is difficult to determine DFT on the edges and radius of a support, weld or angle. These are often sites of corrosion failures and early corrosion. Stripe coating is often incorporated into a painting specification for interior surfaces of a petroleum or water storage tank to address these areas where low coating film thickness is often an issue. Project inspectors are unable to ensure that a stripe coat has been successfully applied without observing the stripe coat process or inspecting the tank prior to overcoating the stripe coated areas.

The use of 100%-solids epoxy coatings that offer edge retentive characteristics can ensure that sufficient DFT is achieved on edges that are often left with insufficient DFT when using standard epoxy linings. Although edge retentive coatings offer great corrosion characteristics, for optimum performance these products should be spray applied and brushed out to work into welds, angles and sharp areas.

Pinholes and Holidays

Basic corrosion theory tells us that any pinhole, holiday or discontinuity exposing ferrous metal substrates will result in pinpoint rusting, undercutting of the coating around the pinhole, and, ultimately, rapid coating failure and corrosion of the steel. A pinhole-free film, free of defects or holidays, is a must in an immersion environment.

Holiday testing is designed to identify pinholes, thus allowing the applicator to address the uncoated areas. Traditional holiday detection methods using low-voltage sponge testers and/or high-voltage spark testing holiday detectors, as referenced by NACE RP-0188 recommended practice guidelines, identify holidays or pinholes that penetrate to the steel substrate. These methods are not designed to detect insufficient film thickness of a multiple coat system. OAP technology does not replace the need for holiday detection as per NACE RP-0188. However, when used properly, OAP technology can result in a tremendous reduction in holidays detected during traditional testing procedures and can detect low-film build between coats. Care must be taken when choosing the proper voltage to be used during high-voltage holiday detection to avoid potentially damaging the lining during the procedure. Visual inspection of holidays is often distorted and masked by glossy coatings, shadows and lighting reflections.

Failures resulting from pinholes and holidays are amplified if the pinhole is present over one of the zinc-rich primers commonly used in the fabrication of today's water storage tanks. Zinc is a highly reactive metal and when the pinhole is exposed to water, zinc hydroxide and hydrogen gas are produced. Blisters and coating failures caused by the reaction process are frequently in areas that are difficult to reach for coating application and that can be difficult to inspect and perform using traditional NACE RP-0188 holiday detection. The use of linings containing OAP have proven to be an excellent complement to traditional holiday detection when inspecting difficult access areas.

OAP TECHNOLOGY OVERVIEW

OAPs are materials that, when added to a coating formulation, make the coating react to ultraviolet light. The effect enables quick, non-invasive inspection of very large coated areas during the application process, allowing the coating inspector to identify and concentrate on defective areas, thus reducing the inspection time while assuring the probability of good application and coverage. The OAPs, like a color pigment, will not have a detrimental effect on the coating, the application method typically used for applying the coating or its desired performance. OAPs work by highlighting holidays and pinholes and areas of over and under application.

SSPC Technology Update No. 11: Inspection of Fluorescent Coating Systems

Fluorescent coatings, visually inspected with ultraviolet and/or violet light, assist in quickly identifying holidays and areas with low film thickness. They can be used as both

Fig. 1: The interior of a storage tank during inspection using an eye-safe LED light.
COURTESY OF SHERWIN-WILLIAMS UNLESS OTHERWISE NOTED

Fig. 2: Pink-colored areas that illuminate under eye-safe LED lighting (right) show where the film thickness is insufficient. Areas of insufficient coating thickness commonly appear around weld seams and edges, where it is difficult to ensure proper coating thicknesses.

primer and finish coats. Fluorescent coatings were originally for use in ballast tanks in large ocean-going vessels to assist in the inspection of applied coatings for holidays both during and after application. The proper use of this technology gives the ship owner further assurances that the coating system has been applied correctly and will provide the expected service life. The U.S. Navy took a leading part in the advancement of this technology when in 2003 it included ultraviolet fluorescence as a requirement for Type VII (solvent-free) tank linings meeting MILPRF-23236. Virtually any type of coating can be made to fluoresce with the addition of fluorescent pigments or OAPs. Visible light is generally considered to be between approximately 400 and 760 nanometers of the electromagnetic radiation spectrum. The UV-A range is between 315 nm and 400 nm, which serves as the typical UV range for fluorescent coating inspection.

ASTM E2501-11 is the standard specification for light source products for inspection of fluorescent coatings. It provides the requirements for light source products intended for excitation of fluorescent materials used as a system for detection of defects in industrial coatings. This includes the examination of both longer wavelength fluorescing primer coatings as well as non-fluorescent top coatings. This specification establishes the radiometric requirements of the light source in terms of required wavelength range and minimum irradiance. The specification also establishes safety requirements for the light source product necessary to ensure the product will not pose a threat to visual health.

SSPC-TU 11 also discusses training requirements as it pertains to inspecting fluorescent coating systems, suggesting that applicators and inspectors examine sample panels used to perform inspections so they can learn to recognize film defects. It also addresses PPE requirements as it pertains to eye and skin protection. The document also highlights post-application inspection of three distinct visual effects, including: fluorescent coating over non-fluorescent substrate or coating; non-fluorescent coating over fluorescent coating; and fluorescent coating of one color over a fluorescent coating with a different fluorescent color.

INSPECTION ADVANTAGES OF OAP COATING SYSTEMS

Using traditional electric low-voltage wet sponge testers and high-voltage spark testing holiday detectors in petroleum and water storage tanks can create some concerns as discussed below. Coatings systems and linings formulated with OAPs have enhanced the visual inspection of the materials by enabling the use of eye-safe UV lights to identify defects, holidays, pinholes and low film thicknesses, as well as to verify stripe coating.

Visual Inspection of Fluorescent Coatings

Coatings formulated with OAPs can be made to fluoresce simply by illuminating the appropriate lamp or LED. Coating inspectors can use commercially available LED inspection flashlights to enhance safety and workflow, as these flashlights are small enough to inspect behind stiffeners. They are also compact, rugged and lightweight. OAP coatings illuminated before top coating will show defects in application and in film coverage. Pinholes, holidays or low film thickness will either appear black in contrast to the fluorescing coating, or not as bright due to insufficient film thickness. OAP coatings illuminated after top coating will allow the glowing film to telegraph through the finish coat to show pinholes, holidays or low topcoat film thickness. OAPs will illuminate even in a wet film as the coating film does not need to reach cure before checking for holidays.

Traditional Holiday Detection Issues

Coating inspectors are guided by NACE RP-0188 to address holiday testing of coatings on conductive substrates. Electric low-voltage wet sponge testers are typically used on linings applied at DFTs below 20 mils for holiday detection. For low-voltage wet sponge testing, "the sponge shall be moved over the surface of the coatings at a moderate rate of 1 ft/s (0.3 m/s), using a double pass over each area." Depending upon the size of the sponge being used, the rate would allow for 30 sq. ft. of coverage per minute, not counting the time to mobilize and move through the tank and keep the sponge in direct contact with the coated substrate. In addition, the instrument needs to be grounded to the conductive substrate during use, which could prove to be difficult and create further mobilization issues, as it may be difficult to locate a bare surface for the grounding requirement.

In the case of using high-voltage spark testing holiday detectors for linings applied at DFTs above 20 mils, care must be taken to ensure the high-voltage tester is adjusted to the proper voltage for the coating thickness being tested to avoid damaging and/or producing a holiday in the lining.

Because holiday detectors generate high voltage and create sparks, there are important safety concerns that must be addressed. One should never use a holiday detector in a flammable or otherwise hazardous atmosphere as fire or explosion could occur.

BENEFITS OF OAP COATING SYSTEMS

Fluorescence of coating systems and linings enhances visual inspection methods, finds defects that are invisible under ambient inspection and replaces situations in which traditional UV lamps are not appropriate. Inspectors report improved productivity in terms of the inspection area covered by minute by 50–70%. Coatings systems and linings formulated with OAPs have allowed coating inspectors to find approximately 25% more defects during the application process. The ability to inspect while the coating is wet, allowing for repairs to be done despite the required cure to service time, is an advantage. Pinholes as small as 0.25 mils to 0.50 mils can be identified and corrected before a water storage or petroleum storage tank is placed into service. Low film thickness on edges are easily identifiable by using an inexpensive ASTM E 2501 approved light source.

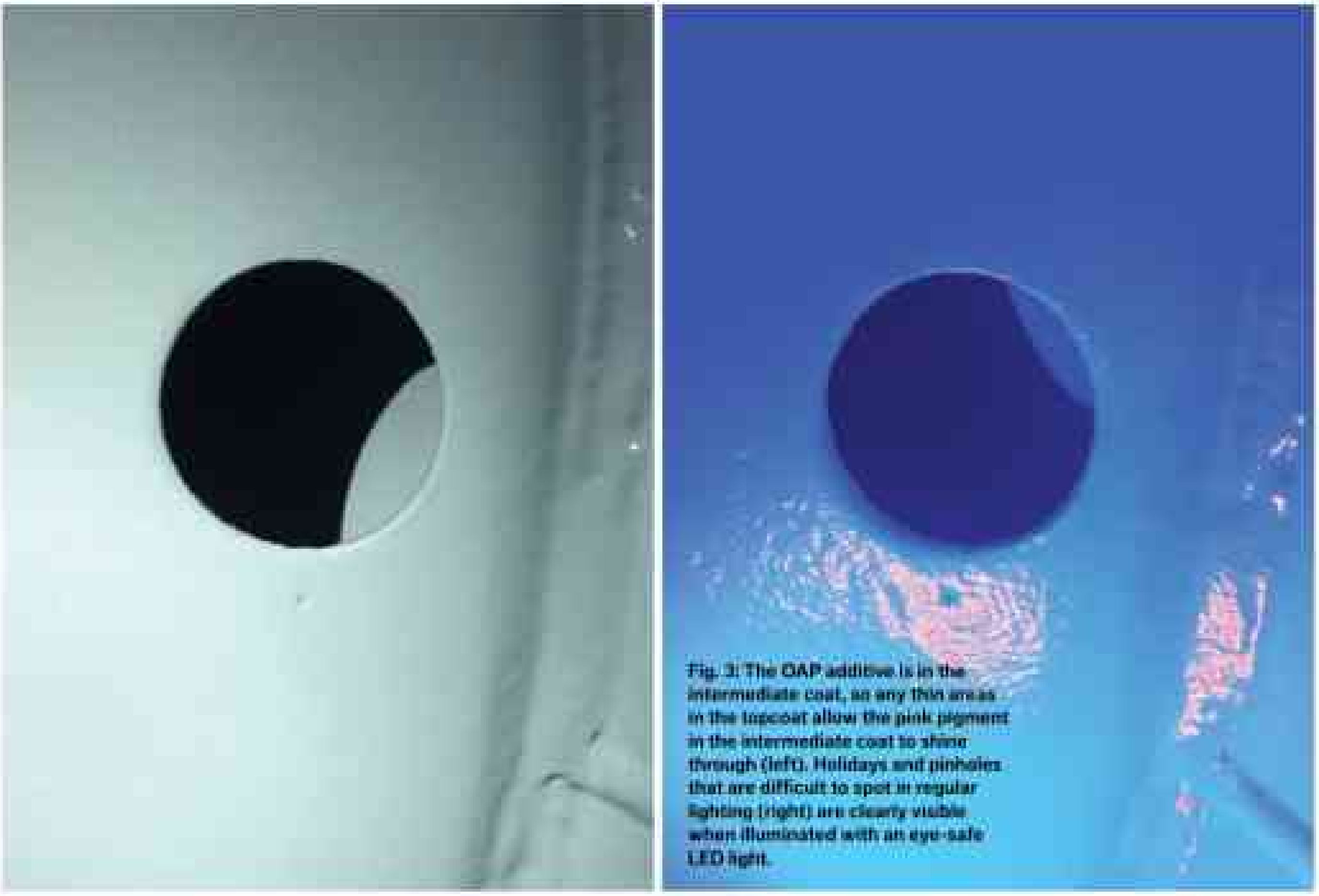


Fig. 3: The OAP additive is in the intermediate coat, so any thin areas in the topcoat allow the pink pigment in the intermediate coat to shine through (left). Holidays and pinholes that are difficult to spot in regular lighting (right) are clearly visible when illuminated with an eye-safe LED light.

Periodic inspection of coatings systems or linings could show early topcoat wear, intercoat blistering and peeling, or breaks in the topcoat film that exposes the OAP material beneath. Easy determination and detection of premature coating wear or breaks in the film are not possible with traditional means of inspection. Early identification of coating failure allows owners and consultants to quickly remedy the situation before further loss of substrate and corrosion occurs. By specifying the use of OAP coatings and linings, greater quality assurance can be attained on a project and the service life of the system can be met or extended. **JPCL**

ABOUT THE AUTHORS

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FIELD TESTING FOR SOLUBLE SALTS

A Problem to Be Aware Of

T_KIMURA / GETTY IMAGES

BY SIMON HOPE, AUQUHARNEY ASSOCIATES LTD.

It is well recognized by our industry that proper surface preparation prior to the application of a protective coating is paramount in ensuring good long-term corrosion protection of steel substrates. The amount and type of this preparation depends on the state of the existing surface, the particular coating to be used and its application method.

However, in all cases, the primary objective is to get the surface as clean as possible, and in compliance with the specified standards.

The contaminants on a surface that can affect the coating's adhesion, and hence performance, can be split into those visible to the naked eye (for example, oil and grease, mill scale, old coatings, dust and detritus and rust) and those that are not (soluble salts and micro particulates). To further ensure good adhesion of a coating, the steel substrate is normally roughened to significantly increase its surface area and hence improve the surface for bonding of the coating. The most common method of carrying this out is by abrasive blasting.

Painting specifications normally include a requirement for precleaning of the surface to be carried out before any surface roughening, to ensure that any contamination present is not spread across the surface, or driven into it, and hence not removed. Typically, this cleaning involves solvent washing, fresh water washing with or without detergent, or a combination of these, and this step is covered in various standards.

However, by far the most difficult contaminants to detect and remove are soluble salts. The presence of these is a major factor in premature breakdown of protective coatings, and resultant increased maintenance costs for the asset owner.

In the context of surface contamination of steel surfaces before coating, these salts are typically chlorides, sulphides/sulphates and nitrates of calcium, magnesium and sodium, which are commonly found in the atmosphere and environment, and although they are termed "soluble," this is not true in all cases, as otherwise they could be simply washed away easily. The solubility of a salt depends on both the cation and anion present, as well as the concentration and the temperature, but, put simply: Nitrates are soluble, most chlorides are soluble, as are most sulphates; however, carbonates, hydroxides and sulphides tend to be mostly of low solubility.

Of particular concern for maintenance painting are the salts that can be deposited on a steel surface by acid rain, or by exposure to a marine or chemical processes environment.

WHY SALTS ARE A PROBLEM

As corrosion is an electrochemical process, the rate of reaction is heavily influenced by the conductivity of the surrounding electrolyte. It is well known that these soluble salts, particularly chlorides and sulphates, can initiate and accelerate corrosion of steel due to the high conductivity of their aqueous solutions.

Over time, soluble salts can be trapped, along with the products of corrosion, on the steel surface or, more seriously, in pits. They are therefore the prime candidates responsible for causing coating breakdown due to osmotic blistering, which subsequently leads to coating disbondment and ultimate failure. Osmotic blisters form due to the semi-permeable nature of the applied coating, when a strong solution is on one side and a weaker solution on the other, nature likes equilibrium, so solvent (in this case water) migrates through the membrane (coating) until equal concentrations are on each side. Osmosis can create huge pressures as is seen by the osmotic pump in trees that moves water from the roots to the leaves, which on a 100-foot pine equates to over 3 bar. They can also produce areas of different concentration, and hence areas of different potential, which allows a corrosion current to flow, and in addition certain salts can lower the pH at the coating/steel interface, resulting in acid attack.

Where owners suspect that a surface may have been contaminated by salts, the painting specification will quote a level of salt, generally always specified as chloride ion, which is acceptable before the coating is applied. There are two common sets of units used to describe soluble salt levels, namely milligrams per square meter (mg/m^2) or micrograms per square centimeter (µg/cm^2). It is important to note that these units are NOT equivalent. Any numerical value expressed as mg/m^2 is a factor of 10x the value expressed as µg/cm^2.

These levels differ between existing standards and specifiers, as there is no consensus as to what level is safe. For example the maximum levels, quoted as sodium chloride, vary from <15 to <70 mg/m^2, and a typical figure would be < 20 mg/m^2, as given by the NORSOK M-501 and ISO standards (ISO 8502, parts 6 and 9).

HOW TO MEASURE SALTS

One of the most common tests used to measure the presence of soluble salts is the Bresle test (ISO 8502-6). This involves injecting distilled water into a patch placed on the steel surface. This water dissolves any salt present to form an electrolyte, and the conductivity of this can be measured with a standard conductivity meter. It must be remembered that it is the total salts and materials present (which are dissolved, depending on their solubility in distilled water) and the nature of the salt that will determine the conductivity. As it is generally not known which salts are present, to arrive at a result to compare with a specification, a very naive and dangerous assumption has to be made. The conductivity is through this assumption interpreted as being due solely to sodium chloride, and a correction factor is applied to the conductivity measured to give a result equal to 'x' mg/m^2 of sodium chloride. This value is then compared to the specification, and if found to be equal to or below this, then it can be said that the surface is acceptable for coating. But what if the value is higher than the specification, does this mean it has automatically failed? If a higher reading than the specification is recorded, then normal practice is to repeat the washing stage and re-blast to the specified standard. However, if the re-test still gives a higher than acceptable result, competent inspection would deem that further investigation should be carried out to determine the source of the raised conductivity. This situation is demonstrated in the case study described later.

Under laboratory conditions the Breslé method is an excellent test for the detection of water soluble ions on metal surfaces, but in the field, there are several ways in which the reading obtained by this method can be influenced by other sources of electrolytes. The main examples include:

- Using contaminated distilled water;
- Contaminated calibration solutions;
- Inadequate flushing of the meter;
- Poor cleanliness (i.e., not wearing clean gloves throughout the entire process);
- Leaving test kits unsecured and unattended where third parties can interfere;
- Continually re-using syringes and needles from previous tests;
- The quality of the "patch" used for the extraction;
- The temperature and relative humidity when the test was carried out; or
- Simply the conductivity of the water used to carry out the initial surface washing.

From a general safety and quality perspective, this method of testing can be unreliable as it assumes that the operative is fully trained and competent to undertake the testing and then report/record the results accurately, also many sites do not like

Fig. 1: Example of salt-induced corrosion on a steel surface.
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Fig. 2: The latex sleeve testing method starts by attaching the sleeve to the surface and rubbing the solution against it for about two minutes before the sleeve is removed.

Fig. 3: Next, the sleeve is then inserted into the test kit for analysis.

"sharps" at the workplace, let alone hypodermic needles being carried around, often in someone's pocket.

There are several other conductivity-based methods available to the industry (often proprietary) for field measurement. Proprietary "soluble salt meters" are available, which also use the conductivity method to measure salt concentration, but these hand-held devices are different from the Breslé method in that they perform both the taking of the sample and its analyses automatically. Measurement is faster as the number of steps is fewer, thus reducing the possibility of error, and they are claimed to have more reliable and repeatable performance.

Paper extraction methods, which remove the need for patches, use filter papers onto which a measured amount of water is added, this in theory absorbs any soluble salts present, and the conductivity can then be measured by a modified meter.

However, these methods still have most of the drawbacks of the Breslé method, and can also introduce other errors.

There are alternatives to the use of conductivity to determine the presence of soluble salts, however these methods are generally more suitable for use in a laboratory. These include titrimetric determinations, a highly accurate method and ion specific, i.e., it can measure the chloride ion concentration alone. Other laboratory methods use ion selective electrodes and spectrophotometry to determine individual salt concentrations and these are also highly accurate and specific quantitative test methods.

One method that does not rely on conductivity, and that is suitable for field use, involves ion exchange technology, and is described in ISO 8502 Part 5. For example, one proprietary system uses a calibrated titration tube containing a silver chromate solution which reacts with any sodium chloride present in an extract from the surface to form a white precipitate, following the chemical equation:

$$2NaCl\ (aq) + Ag_2CrO_4\ (aq) \rightarrow 2AgCl\ (s) + Na_2CrO_4$$

A major benefit of this method is that each test is stand-alone and cannot be contaminated by earlier tests. Simply, a known area is washed with a correspondingly known volume of a specific reagent, to create a solution that is drawn up into the titration tube which is calibrated in ug/cm^2. The color change upon reaction with chloride is from pink to white, and the concentration of chloride can be read directly on the tube at the interface of the two colors. However, it should also be noted that the presence of other halides (bromides, iodides and fluorides) and sulphide ions (which produce a brown stain) will give positive, bogus readings that should be taken as indicatives of other contaminants that may need investigation. Kits are also available for the specific determination of sulphates and nitrates.

SURFACE CLEANLINESS STANDARDS

Surface cleanliness is defined under the ISO 8502 series of international standards, along with equivalent standards from organizations such as NACE and SSPC.

ISO 8502 consists of the following parts, under the general title, "Preparation of steel substrates before application of paints and related products — Tests for the assessment of surface cleanliness."

- Part 2: Laboratory determination of chloride on cleaned surfaces;
- Part 3: Assessment of dust on steel surfaces prepared for painting (pressure-sensitive tape method);
- Part 4: Guidance on the estimation of the probability of condensation prior to paint application;
- Part 5: Measurement of chloride on steel surfaces prepared for painting (ion detection tube method);
- Part 6: Extraction of soluble contaminants for analysis — The Bresle method;
- Part 9: Field method for the conductometric determination of water-soluble salts;
- Part 11: Field method for the turbidimetric determination of water-soluble sulphate; and
- Part 12: Field method for the titrimetric determination of water-soluble ferrous ions.

In addition, new ISO standards are under development to describe some of the other commonly used methods for determination of soluble salt levels.

CASE STUDY

The following case study demonstrates the possibility of other sources of electrolyte affecting the result from a Breslé test, and the resultant increase in (unnecessary) surface preparation costs.

Fig. 4: The ends of the test tube are removed with a metal tube breaker.

Fig. 5: The tube is then placed into the solution-filled sleeve for analysis.

During maintenance painting of areas of an offshore structure, Breslé patch salt testing was carried out on two random areas after abrasive blasting. A very high reading for "sodium chloride" was obtained and the surface was washed further. Subsequent testing also produced a high result. The surface was then reblasted and rewashed, but the measured salt concentration was still too high.

The coating that was being removed had been in situ for a period of around 25 years and had been exposed to a C5M environment, and was generally in fair condition with only breakdown where mechanical damaged had occurred. This was interesting, because if the contamination was on the steel from the initial manufacture as it had originally been thought, then why hadn't the coating failed catastrophically within a short period of the original application? The readings indicated levels of contamination nine times higher than acceptable to NORSOK M-501 and over three times the maximum acceptable to the manufacturer. So, this should have precipitated a train of thought to wonder what was really going on.

An independent inspection was then carried out for further testing, this time using a proprietary ion detection tube method, alongside a direct comparison Breslé patch test. The results of which showed that no chloride was present by the chloride specific test but the Breslé test still gave a very strong positive test.

The problem, when analyzed, was attributed to the dissolution into the distilled water of zinc salts (from the very finely dispersed metallic zinc within the original primer used) being driven into the surface during blasting which created an electrolytic solution mimicking the conductive behavior of sodium chloride. If an ion selective test had been carried out initially, it would have shown that the surface had minimal chloride level and was perfectly satisfactory and compliant for coating. This would have saved the time and cost of the (ineffectual) re-washing and blasting.

It should be noted that ion-specific test kits are also available for the determination of sulphate and nitrate soluble salts, which can be just as damaging to coating adhesion. However, in this case, as there had been little or no failure of the original coating, which was thought to have been caused by the presence of salts beneath the coating, these other contaminants could not be present either.

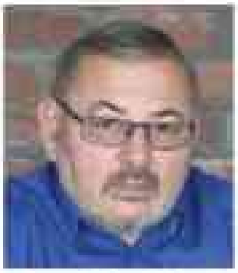
The biggest problem in the inspection of a surface prior to coating is in knowing what is being checked for. Soluble salts are not just sodium chloride as often defined in specifications. As noted above, any salt or other contamination on the surface can contribute to the overall conductivity and hence the potential for osmotic blistering and coating failure. Test results between conductivity and ion specific methods can lead to large differences and any anomalies should be investigated further to find the root cause of the problem.

Breslé patch and any other tests that rely purely on conductivity need to be treated with caution; negative readings are fine and can be used as a definitive guide but "positive" readings need to be treated as "non-negative chloride" until it is confirmed as being the source of the conductivity.

One wonders how often major cleaning and surface rejections of a substrate have taken place that, with a bit more investigation, were perfectly fit for purpose, and what the cost and time implications of this have been.

Perhaps also the definitions of soluble salts in specifications need to be reviewed and tightened up, but that is for another article. **JPCL**

ABOUT THE AUTHOR



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6

The number of virtual town hall meetings regarding the ongoing merger between SSPC and NACE scheduled through the end of 2020. *See p. 9*

67%

The percentage of PaintSquare Poll respondents who believe that top coating companies will financially recover from the impacts of the COVID-19 pandemic within the next year. *See p. 11*

5,000 TO 10,000 PSI

The recommended pressure range for high-pressure water cleaning, which can be used to remove poorly adhered and/or deteriorated coatings. *See p. 12*

3 YEARS

The period of time that a wastewater gravity thickener had been in service before having to be removed from service after corrosion caused mechanical damage to rake arm components. *See p. 16*

SSPC-TU 11

SSPC's technical update standard governing inspection of fluorescent coating systems, which can aid when inspecting OAP coating and lining systems in petroleum tanks. *See p. 26*

<15 TO <70 MG/M²

The range of maximum allowable levels of sodium chloride according to different industry standards, highlighting the differences in levels between specifiers and standards. *See p. 32*