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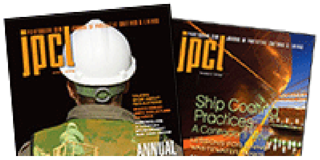

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The Buzz

From *JPCL*, August 2012 | Free Product Information

Most Popular Poll Questions

Anita Socci
JPCL

Some owners have begun to require an individually certified coating inspector for projects, rather than a certified firm. Is this necessary?

> **90% Yes, inspectors should be individually certified.**
>
> **6% As long as the firm is certified, the individual will be qualified enough.**
>
> **3% No certification is needed, as long as the inspector is experienced.**

Michael Hewins: “Does it make a difference? You can get an inspector with or without certification or a firm and still get a bad inspector. What needs to happen is the implementation of a system that monitors inspectors and has the ability to weed out the incompetent ones. The other requirement should be on the owner to specify training and experience levels of inspectors.”

Francis Goss: “Yes it is necessary. Just because a firm is certified does not mean that the persons doing the work actually know what they are doing.”

PSN Top 10

Bridge Painter Loses Lead Case Appeal
Coating Fumes Shut Down National Park
314 TX Painters, Blasters Win Back Pay
Navy Contractor Admits Minority Fraud
Union-Only Bridge Work Draws Fire in MA
Asbestos Contractor Gets 10-Year Term
Firm Fined $200K in 4 Scaffold Deaths
WI Mill Fly Ash Leaves 1 Dead, 1 Burned
Unpainted Tower Zapped with $20K Fine
Infrastructure Giant to Swallow Rival

MOST POPULAR QUIZ Results
What coating property is evaluated with the tape test?

As of Aug. 10
Michael Beitzel 22/22
Edward Van der Wilk 22/22
Shabbir Hussain Shah 22/22
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Willem van Gent 22/22

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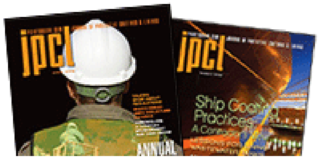

Absolute power leads to corruption absolutely

From *JPCL*, August 2012 | Free Product Information

Bill Shoup
Executive Director, SSPC

Bill Shoup

As everyone knows, Judge Louis Freeh’s independent report was very damaging to the reputation of Penn State and its legendary coach of over four decades, Joe Paterno. ESPN had its normal college football “experts” giving their opinions of what should be done to Penn State, from sanctions to the NCAA giving the school the “death penalty” in college football. Sportscaster Brent Musburger then came on and made disparaging remarks about “his friend” Joe Paterno, and he used the phrase, “Absolute power leads to corruption absolutely.” This phrase refers to that of John Emerich Edward Dalberg-Acton, otherwise known simply as Lord Acton, when he said, “Power tends to corrupt, and absolute power corrupts absolutely. Great men are almost always bad men.”

Because SSPC is located in Pittsburgh, we have had a great deal of local coverage on the Penn State scandal, and I thought to myself, “What are the lessons to be learned?” Here is what I have taken from the entire situation:

1) Remember to whom the true empathy should go, which is to those who are the victims of the convicted pedophile, Jerry Sandusky, not the members of the institution that tried to hide the truth.

2) No organization or any person is above the law. How can anyone think they can circumvent the system or get away with anything in the modern age of the Internet and social networks like Facebook and Twitter? Even before we had such prevalent use of social media, we had the disclosure of Watergate in the 70s. We also had the scandal in the Catholic Church, the wrongdoings at Enron Corporation, and Bernie Madoff’s Ponzi scheme. How can anyone be so naïve that they think they can get away with crime?

3) Report incidences of immoral, unethical, or illegal activity to the appropriate authorities immediately, whether it is the law or not. If the allegation is against your boss, go to the level above him or her, or the HR department, and report it. Then, follow up to ensure appropriate action has been, or is going to be, taken. This is a tough thing to do, and a person has to have the moral courage to do this. I worked as an Inspector General in the U.S. Army, and we had a hotline that many soldiers would call. They would make all types of allegations. We took each allegation seriously and investigated every one. Most ended up to be frivolous because the person making the allegations did not know the facts, but we still looked into them all.

5) Don’t get “too big for your britches.” No one is irreplaceable, and everyone answers to someone. Even the President of the United States answers to the American people every four years, and he has far more responsibility than any official in a university, including the football coach.

6) Opinions are just that—opinions. The thoughts that the folks on ESPN give on what should happen now at Penn State are no smarter than when they predict who will win games during college football season. I get very annoyed by people who get on the Internet and put forth their thoughts, and others take them as facts. Know the facts before you say anything. If you are in a position of leadership, do not cave in to taking actions driven by opinions. Gather the facts, and make an informed decision based on the evidence, not the emotion of the situation.

7) Lastly, no one has absolute power, and if they think they do, replace them. The athletic director at the University of Arkansas did that when he fired Bobby Petrino, the school’s winning football coach, when Mr. Petrino had indiscretions and lied about them.

At SSPC, I cannot change what happened in the past; however, I can learn from others, either their successes or failures, and change what happens tomorrow. Eventually all the facts will come out at Penn State, and I hope we can all learn from this tragedy. Right now, if I were a university president, or an official at an institution or other entity where the same situation might occur, I would conduct internal checks and establish processes to ensure that I had no victims because of my lack of due diligence and, most importantly, my utmost vigilance.

Bill Shoup
Executive Director, SSPC

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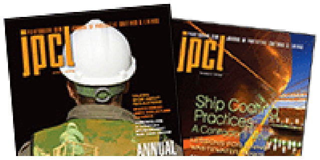

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Top of the News

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jpcl SSPC The Society For Protective Coatings
Webinar Education Series

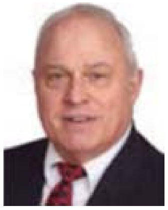
SSPC/*JPCL* Education Series Webinars in September and October will discuss conducting and controlling the quality of plural component spraying operations and below-ground pipeline inspection and repair.

Plural Component Spraying

Art Webb of the Naval Research Laboratory will present the webinar “Applying Plural Component Coatings” on Sept. 26 from 11:00 a.m.–Noon, EST.

Contractors apply plural-component coatings to various surfaces, giving unprecedented substrate protection and creating new application challenges to contractors and equipment manufacturers. This webinar will discuss how advances in high-solids/short pot life materials have seemingly outpaced equipment that can properly apply them, forcing contractors to carefully assess application methods, including static mixing and mechanical proportioning. The webinar is sponsored by WIWA.

Inspecting and Repairing Pipeline Coatings



E. Bud Senkowski

E. Bud Senkowski of KTA-Tator will present the webinar “Field Inspection and Repair of Transmission Pipeline Coatings” on Oct. 25 from 11:00 a.m.–Noon, EST.

Below-grade pipe coating systems are subject to accelerated deterioration and potential section loss of the pipe wall if the coating system is not maintained. When coating damage is found, the affected pipe must be excavated and repaired. This webinar will discuss the methods and materials used to repair pipeline coating systems and it will also describe the field inspection techniques used to evaluate the condition of coatings exposed during routine pipeline maintenance operations. The webinar is sponsored by Canusa-CPS, A ShawCor Company.

The SSPC/JPCL Education Series Webinars provide continuing education for SSPC re-certifications and technology updates on important topics.

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

Four Waterjetting Standards Replace Joint Standard

Four new waterjetting standards will replace SSPC-SP 12/NACE No. 5, the joint standard, Surface Preparation and Cleaning of Metals by Waterjetting Prior to Recoating, according to SSPC. Both organizations have withdrawn the original joint standard. The 2012 revision of the 2002 version changes the single standard into four separate standards, each addressing a different level of surface cleanliness.

The organization of the four resulting standards has been revised to more closely follow the organization of the dry abrasive blast cleaning standards, and allows specifiers to specify levels of cleanliness for waterjetting by use of separate standards, as is done when specifying levels of dry abrasive blast cleaning, said Michael Damiano, SSPC Director of Product Development.

The titles of the new standards are:

- SSPC-SP WJ-1/NACE WJ-1, Waterjet Cleaning of Metals—Clean to Bare Substrate (WJ-1);
- SSPC-SP WJ-2/NACE WJ-2, Waterjet Cleaning of Metals—Very Thorough Cleaning (WJ-2);
- SSPC-SP WJ-3/NACE WJ-3, Waterjet Cleaning of Metals—Thorough Cleaning (WJ-3); and
- SSPC-SP WJ-4/NACE WJ-4, Waterjet Cleaning of Metals—Light Cleaning (WJ-4).

Although now contained in separate standards, the definitions of the four surface cleanliness levels have changed very little from the definitions in the 2002 version of the standard. Clarification that permissible staining or tightly adherent matter must be evenly distributed over the surface has been added to WJ-2 and WJ-3. In addition, a clarification of “tightly adherent” (cannot be lifted with a dull putty knife) has been added to WJ-2, WJ-3, and WJ-4 definitions, according to SSPC.

Vulcan Painters Names New President

David Boyd

Vulcan Painters Inc., (Birmingham, AL) has announced the appointment of John Dempsey as company president, succeeding David Boyd, who will continue as chairman of the board of directors.

Founded in 1952, Vulcan Painters specializes in industrial and commercial painting projects, blasting and coating of structural steel and sewer pipe, electrodeposition, and powder coating. The business has three companies.

Boyd, who has led the company for 30 years, is one of 24 coatings industry “thought leaders” being honored this year as a *JPCL* Top Thinker: The Clive Hare Honors. The honorees are profiled in the supplement to this month’s *JPCL*.

A longtime member of SSPC, Boyd was the recipient of SSPC’s John D. Keane Award of Merit, which honors outstanding leadership and significant contributions to the development of the protective coatings industry and to SSPC. He was a founding member of the committee that established SSPC’s Painting Contractor Certification Program in 1986. He also is a member of NACE and the Associated General Contractors of Alabama.

John Dempsey

Dempsey has been with Vulcan Painters since 1983, holding various positions within the company and its subsidiaries. In 1986, he became a supervisor, and in 1989, he went to work at Vulcan Pipe and Steel Coatings, a wholly owned subsidiary of Vulcan Painters. In 1993, Dempsey became plant manager at Vulcan Electro-Coating, another company division. In 2002, he returned to Vulcan Pipe, where he was named president in 2009, as well as vice president of Vulcan Painters.

As in the original standard, descriptions of three degrees of flash rusting are provided in each of the revised waterjetting standards.

These descriptions are based on the degree to which the rust obscures the carbon steel substrate and the degree of adhesion to the substrate. The color of the rust is no longer addressed.

Lydia Frenzel of the Advisory Council chaired the Special Task Group committees working on the standards, and Rich Burgess of KTA-Tator was vice-chair.

Frenzel said, “My heartfelt thanks to the task group members. It is the support of Rich Burgess and Kat Coronado that helped assure this final publication. Thanks to the volunteers from NACE and SSPC."

Burgess said, "I applaud all of the Committee members that contributed their time, knowledge and stayed the course. I believe each of us would also acknowledge that the success of the committees in having the new waterjetting standards published was fueled by the efforts of Lydia Frenzel."

The standards were released on July 9, 2012 and are available from both associations. SSPC members can download them for free from sspc.org.

On July 9, Burgess presented an SSPC/JPCL webinar on the new WJ standards, and the webinar is archived on paintsquare.com.

Most of the stories on pp. 6 and 7 and more news can be found on *PaintSquare News*, *JPCL*'s sister publication, a free daily e-newsletter. To sign up for the newsletter, go to paintsquare.com/psn.

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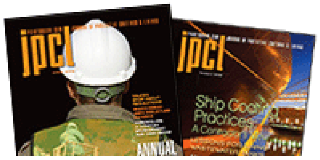

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Corrosion Protection of Cargo Tanks in Crude Oil Carriers: The New IMO Regulations

From *JPCL*, August 2012 | Free Product Information

More items for **Quality Control**

Brian Goldie
JPCL

Samco Raven, a crude oil tanker, which had an epoxy cargo tank coating applied 15 years ago; recent inspection rated the performance as "Good." All photos and figures courtesy of International Paint.

As a result of incidents of structural failure of vessels due to corrosion causing loss of life, IMO passed amendments to the SOLAS (Safety of Life at Sea) regulation II-1/3-11 requiring that adequate corrosion prevention measures be taken by owners. The first area of a vessel deemed to cause potential problems was dedicated sea water ballast tanks, and guidelines were proposed for improving the type of coatings used for corrosion protection. The guidelines were superseded by the Performance Standard for Protective Coatings (PSPC) regulation for sea water ballast tanks mandating the degree of surface preparation and type of coating used at new building. IMO has now developed requirements for corrosion protection of cargo tanks in crude oil carriers—MSC.291(87), part of which is a new PSPC. This new legislation covers new crude oil tankers of 5,000 dwt or greater, and, as usual for these types of regulations, has staggered introduction dates. First, it relates to new vessels with a contract date of 1 January 2013, a keel laying date of 1 July 2013, or delivery after 1 January 2016.

The extension of the PSPC to crude oil carriers coincides with the adoption by the Maritime Safety Committee (MSC) of IMO, at its 87th session in May 2010, of a major change in the way international standards for ship construction are to be determined and implemented in the future, i.e., as " goal-based standards." The adoption of these standards for oil tankers (and bulk carriers) by the MSC means that newly constructed vessels of these types will have to comply with structural standards conforming to functional requirements developed and agreed to by the Committee. Therefore, for the first time in its history, IMO will be setting standards for ship construction. The MSC also adopted guidelines that, also for the first time, give the Organization a role in verifying conformity with SOLAS requirements. Since the beginning of the millennium, governments and international organizations have been pressing for IMO to play a larger role in determining the structural standards to which new ships are built. The reasons for IMO's larger role are that ships should be designed and constructed for a specified design life, and that, if properly operated and maintained, they should remain safe and environmentally friendly throughout that period.

Just as the concept of "goal-based ship construction standards" was introduced several years ago in IMO (89th session of the Council in November 2002), the pressure to develop a "standard" for corrosion protection of crude oil tanks also goes back to the early 2000s. Both of these

measures should markedly increase the safety of double-skinned crude oil carriers.

The need for a standard for coating crude oil tanks goes back to 2004, when a working group was set up to look at any potential problems arising with double hull tankers in the future. Several recommendations were made, including the need to coat the under deckhead and tank bottoms to reduce corrosion risk. A performance standard for coatings was also recommended. Following this, the International Association of Classification Societies (IACS) set up a joint working group with representatives from several industry bodies including INTERTANKO, tasked with developing such a standard. The resulting regulations, the Performance Standard for Protective Coatings for Cargo Oil Tanks of crude oil carriers (PSPC COT), were incorporated into the Corrosion Protection of Cargo Oil Tanks of Crude Oil Tankers, accepted by IMO and adopted by the MSC 87 meeting in May 2010 (Resolution MSC.291). This article reviews the PSPC COT.

The Corrosion Protection of Cargo Oil Tanks

Changes in designs and building methods of ships over the past decades, together with increased environmental regulations, have not necessarily been beneficial on the impact of corrosion. Vessels are also getting larger and more complex, resulting in increased surface areas, often difficult to access, for application, inspection, and maintenance of protective coatings. These new corrosion protection regulations are aimed at improving the corrosion protection and thus maintaining the structural integrity of crude oil tanks. In general, the areas to receive better protection now are the under deck tank top (ullage space) and the cargo tank bottoms, or, more specifically, the following:

- deckhead and structure, including brackets connecting to longitudinal and transverse bulkheads;
- longitudinal and transverse bulkheads to the uppermost means of access level;
- areas with no uppermost means of access (The coating must extend to 10% of the tank's height at the center line but need not extend more than 3 m down from the deckhead.); and
- flat inner bottom and structure to height of 0.3 m above inner bottom.

The reasons behind protecting these specific areas can be seen in Figs. 1 and 2.

According to the regulations, the requirements can be achieved by different means. The three options are by use of coatings, by alternative means, or by exemption.

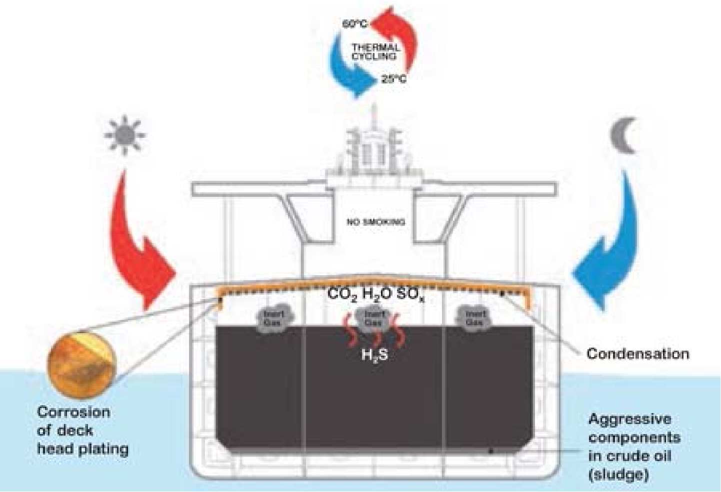
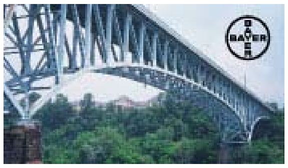


Fig. 1: Loaded–corrosion potential from "thermal cycling"



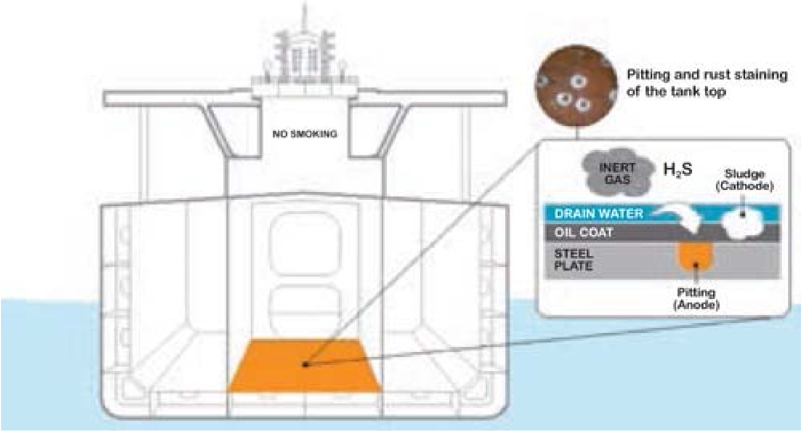


Fig. 2: Unloaded–corrosion potential from 'pitting' in tank bottom

Coatings

This option requires the coating of new tanks in accordance with the PSPC for Cargo Oil Tanks of Crude Oil Tankers (PSPC COT), Resolution, MSC 288(87). The coatings should have a useful life of 15 years in "GOOD" condition. The coating to be used should be tested according to Annex 1 of this Resolution, or its suitability should have been established by at least five years of in-service exposure, with a final rating of its condition of at least "GOOD." Compatibility of the coating with any pre-fabrication should be demonstrated and recorded on the system Type Approval Certificate. The conditions laid-out in the PSPC COT are the same as those in the ballast tank PSPC: control on application; inspection by qualified coating inspectors; data collection requirements; and inclusion of the information on the crude tank coating system, etc., in the Coating Technical File (CTF).

One of the coating testing protocols, and the most controversial, is that of crude oil immersion testing. The composition of crude oil varies markedly with the source, so it would be impossible to select just one to test coating compatibility. The compromise was that a "model" crude would be used to reflect the different components in a crude oil. However, the naphthenic acid content of the "model" selected has a relativity high acid value of ~2.5 mg KOH/g (the amount of potassium hydroxide [mg] required to neutralize one gram of oil), and most epoxy coatings do not have the required chemical resistance for this level. In fact, the majority of current epoxy cargo tank coatings used could not meet this requirement. A Type Approval Certificate could, however, be obtained on the basis of the coatings' good performance in practice, but any new coating introduced would have to meet the new protocols.

Since the introduction of the PSPC COT, paint manufacturers have been carrying out their own testing on new products before having them tested externally and Type approved. Earlier this year, one manufacturer announced that its principal anticorrosive primers and shop primers had successfully passed the very demanding IMO PSPC COT laboratory tests in accordance with the IMO MSC.288(87) SOLAS regulations for cargo oil tankers. The products passing laboratory tests include key ones from the company's epoxy and primer lines for marine application. Approved laboratories carrying out the testing included COT bv, based in the Netherlands. COT bv was the first laboratory in the world with specific Lloyd's Register approval to carry out testing in accordance with the IMO MSC.288(87) regulations for Cargo Oil Tankers. Class Society Type Approval Certifications will be issued in due course.

Proof that an epoxy cargo tank coating can have the required performance to meet this standard can be seen from an inspection of the cargo oil tanks of the 'Samco Raven' after 15 years (Fig. 3). This 301,653 dwt crude oil tanker had the upper and lower areas of her cargo oil tanks coated with an abrasion-resistant, aluminum pure epoxy coating immediately after delivery in June 1996. At her third special survey and planned maintenance at Yiu Lian Dockyard (Shekou), China in 2011, nine of her fifteen cargo oil tanks were assessed and the coating condition was rated as excellent throughout. In addition, the coating manufacturer reported that very little breakdown was observed on edges, weld seams, cut-outs and scallops throughout the tanks, with only a small number of minor, isolated spots of corrosion present. No break-down was visible directly above, at, or below the cargo load lines, and the coating was in excellent condition in areas surrounding bell-mouths and on sharp edges around cargo wells.

Another coating manufacturer has also announced that its protective coating systems, including a range of epoxy products and shop primers for marine applications, have passed the laboratory tests required by the IMO performance standard for PSPC COT. The testing was also carried out by COT bv in the Netherlands. The coatings were applied on panels and subjected to a 90-day, gas-tight chamber test, which simulates the cargo tank environment in loaded and unloaded condition, and a 180-day immersion test, which simulates conditions in a loaded crude oil tank. The test panels were then examined for blisters, rust, and other defects.

Fig. 3: Abrasion-resistant, aluminum pure epoxy coating "after 15 years in service. Removal of the residual oil layer reveals the excellent condition of the coating and tank top beneath," according to the manufacturer.

Alternative Means

A second method of meeting the regulation allows cargo tanks to be protected by what has been defined as "Alternative Means." An example of this would be the use of corrosion-resistant steel, which could meet the required structural integrity for at least 25 years according to MSC 289(87), Performance Standard for Alternative Means of Corrosion Protection for Cargo Oil Tanks of Oil Tankers.

Exemption

There is also a third option contained in the regulation: a vessel's flag state can choose to exempt a crude oil carrier from the requirements if the vessel is solely for carrying cargoes, or performs cargo handling operations (such as floating production, storage and offloading [FPSO] units) with cargoes that do not cause corrosion. What these cargoes are still has to be decided by and agreed upon by IMO.

Conclusions

The PSPC COT regulation is obviously going to put more pressure on owners, shipyards, and coating suppliers for what they need to do to be ready by January 2013 to meet the requirements, especially in the current economic climate.

At this time, the regulations only cover new buildings, but the writing is on the wall for IMO to extend them to crude oil tanks on existing vessels.

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Comment from massimiliano Lo Re, (9/8/2012, 4:40 AM)

Actually how is perfermed and designed this IMO regulation left many dark side and free interpretation for other type of vessel than oil tanker and bulck carrier, still remain not clear if the regulation include on that ship where the ballast tanks area used and designed also as grey/back water tank. Perphaps e a special charpters should be dedicated for each class of vessell: such as cruise ship etc. - The MSC 289(87) show also some incompatibility or interferences with iso

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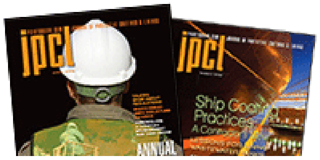

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Durability Assessment of Foul-Release Coatings

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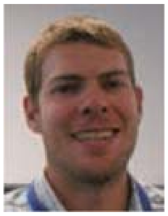
David Tordonato PE

David Tordonato is a Materials Engineer with the U.S. Bureau of Reclamation and works in the Technical Service Center's Materials Engineering and Research Laboratory. He holds BS and MS degrees in mechanical engineering and a Ph.D. in materials and metallurgical engineering. He is a SPRAT-certified engineer and frequently performs engineering assessments and other work on the inaccessible features of Reclamation Dams and equipment using Rope Access methods.

Allen Skaja PCS

U.S. Bureau of Reclamation, Denver, CO
Allen Skaja joined the U.S. Bureau of Reclamation as a Coatings Specialist. His experience is in evaluating coatings for corrosion protection and testing coatings to deter the attachment of zebra/quagga mussels. He has a BS in chemistry and a Ph.D. in coatings and polymeric materials.



David Tordonato, PE

For the U.S. Bureau of Reclamation (USBR) and other water management agencies, fouling control is becoming more important due to the recent introduction of hard macro-fouling organisms such as zebra and quagga mussels in various water bodies across the United States. If left unchecked, mussel infestation could threaten the safe and reliable operation of hydroelectric generation and pumping facilities by restricting flow through cooling lines, fire suppression lines, and other vital systems. Foul-release coatings are seen as the preferred environmentally friendly alternative to biocide-containing antifouling products to control this problem.

Commercially available foul-release (FR) coatings are being tested at Parker Dam to gage real-world foul-release performance. The results of the field-testing are presented elsewhere.[1] This article details the results of laboratory tests of foul-release coatings conducted by USBR.

Most of the commercial products being tested are marketed to the shipping industry. However, the service environment that hydraulic equipment is subjected to at USBR facilities presents unique challenges that warrant consideration; water quality is highly variable, and rivers can carry high sediment loads, woody vegetation, ice, and other debris. Hence, durability has always been a concern when foul-release coatings are considered for use in USBR facilities.

Furthermore, facility owners are typically reluctant to remove intact and functioning coatings from equipment, so the ability to apply FR coatings over materials such as coal tar enamel (overcoating) is desirable.

It is standard practice for USBR to test coatings for corrosion protection, resistance to weathering, and cathodic disbondment using ASTM tests such as ASTM D870,[2] ASTM D2794,[3] ASTM D5894,[4] ASTM D4587,[5] ASTM G8.[6] While these tests are necessary to verify acceptable corrosion performance, they are unlikely to provide an accurate prediction of service life for foul-

release coatings, which are expected to fail due to mechanical damage. To address this issue, USBR has developed new (additional) test protocols to evaluate foul-release coatings. The results from these tests are detailed in the following sections.

Allen Skaja, PCS, U.S. Bureau of Reclamation, Denver, CO

Methodology

- Test Sample Selection and Preparation: Several commercially available foul-release coating systems were selected for testing, including seven silicone-based systems, two silicone-epoxy hybrid systems, and one fluorinated polyurethane system. In addition, three non-foul-release control systems were also evaluated: a polyamide epoxy, a fluorinated polyurethane architectural coating, and a polyurea-polyurethane hybrid system to provide a baseline to compare foul-release coatings against conventional coatings.

  Product samples were provided by the manufacturers and applied at USBR's Materials Engineering Research Laboratory (MERL) in accordance with the manufacturers' application instructions. Each system contained a primer (typically epoxy) and a foul-release topcoat. (Typical foul-release systems utilize a conventional primer system to provide corrosion protection.) Some systems required an intermediate tie coat, and several systems required a "wet on wet" application. Coatings were applied to 3 x 6-inch steel substrates that were cleaned to SSPC-SP 5, White Metal.

- Brush Abrasion Test: Erosion and abrasion durability tests were performed on all of the foul-release coatings under consideration at the time of testing. Abrasion testing was performed using a reciprocating Linear Abraser test machine equipped with an extra-coarse abrasive bristle brush purchased from a local hardware store. A 3 x 6-inch panel was submerged in 10 oz. of filtered water in an acrylic tub and held in place by two C-clamps (Fig. 1). Weights were placed on a splined shaft connected to the brush to control the normal force exerted on the coated surface. The brush was cycled back and forth 1,500 times at a speed of 75 cycles per second, creating a wear track on the coating. The test panel was then removed from the solution and allowed to dry overnight. Following drying, the coating was weighed to determine material loss due to abrasion. This process was repeated for 4,500 cycles. Three wear tracks were created using three different weight levels: 0, 500, and 1,000 grams. For the latter two levels, 500- and 1,000-gram weights were added to the splined shaft (4,500 cycles per track). The weight of the splined shaft assembly was approximately 380 grams.

- Erosion Testing: Reclamation's erosion test for coatings is based on ASTM C1138,[7] an erosion resistance test for concrete that involves circulating steel ball bearings in water. Three coated 3 x 6-inch samples were fastened to the base of an 11.5-inch cylindrical tank shown in Fig. 2.

  The tank was then filled with approximately 5 gallons of water and 900 grams of sieved sand (#16–#20), instead of steel ball bearings, which are typically used. A vertically oriented motor was connected to a helical paint-stirring rod. Clearance between the rod and tank bottom was 3⅜inches. The tank was then sealed and the slurry was agitated vigorously at 1,140 rpm for 48 hours. The samples were then removed, dried, and weighed.

- Assessing sample weight loss: It was necessary to allow each freshly applied coating to reach equilibrium with the surrounding air. This was accomplished by using a convection oven set to 50 C to accelerate the curing process. Next, the coated samples were hung on a drying rack in front of a large fan for the moisture content to reach equilibrium with the surrounding air. The samples were weighed every 24 hours, and equilibrium was deemed when no significant weight change occurred within two consecutive measurements.

  Once a coating has cured completely, it's weight will continue to vary with temperature and relative humidity. Consequently, each set of samples was also assigned an identically coated control substrate. The weight of the control was recorded at the same time as the test sample weight. The final weight change for each test substrate was then adjusted by subtracting the weight change of the control. In this way, it was possible to adjust the readings for any changes in weight due to humidity variations in the laboratory.

  After testing was completed, samples were also equilibrated using the fan/drying rack. The length of time required for equilibration depends on the length of time the sample was submerged. For abrasion testing, samples were immersed for approximately 25 minutes and were allowed to dry overnight before mass measurements were made. Initial testing showed this drying time to be sufficient for achieving a stable sample weight. For the erosion testing, equilibrium was deemed when no significant weight change occurred after 24 hours. This time typically ranged from 7 to 10 days following the conclusion of the test.

- Deionized Water Immersion Flow Test (DIFT): A high flow rate test using deionized water was conducted using a reservoir tank, PVC piping, and a 7.5 hp pump (Fig. 3) to produce flow rates of 95 gallons per minute. Details of the test configuration are presented in Table 1.

The water velocity will vary inversely with the cross sectional area and will accelerate in locations where the pipe is partially obstructed due to the presence of samples. The velocity across the samples was estimated to be between 25 and 30 ft/s. This test simulates the flow rates seen in penstocks, outlet works, and various pipelines found throughout USBR infrastructure.

High-flow immersion tests were performed on four of the most promising coating systems, which are shown in Table 2. Samples are 1 x 6-inches in length ⅛-inch thick steel. Two panels were coated with 1/16–3/32 inches of a coal tar enamel in accordance with AWWA 203 Type II. The coal tar enamel was prepared using a sweep blast, SSPC-SP 7 technique with a coal slag abrasive to provide a 10-mil (approximate) profile adequate for over-coating. A third panel was prepared to SSPCSP 5, White Metal, with a 3 mil surface profile. The samples were coated with 1 to 2 coats of primer, tie coat(s) (if applicable), and a foul-release topcoat in such a manner as to leave approximately 1 cm of each coat exposed.

The pump on the high-flow immersion test was run each day for approximately 2 hours. The water temperature in the DIFT test ranged from 65 F to 105 F. On a few occasions, the pump was run longer and the water temperature was allowed to reach 118 F.

Fig. 1: Abrasion test setup

Fig. 2: Erosion test configuration

Fig. 3: High flow water test set up. Samples were placed inside 1.5-inch PVC pipe.

TABLE 1
High Flow Test Parameters

Pump	**Piping**	**Test Conditions**	**Test Duration**
7.5 HP 3,450 RPM 3-inch discharge Flow rate: 95 gallons per minute (measured)	1.5-inch schedule 40 PVC	Velocity: 25-30 ft/sec Temp: 75–115 F Deionized, filtered water	Alternating 2 hrs flowing/22 hrs static immersion (approx) Total: 196 hrs flowing, 2,928 hrs static

TABLE 2
Systems Tested for Overcoating Coal Tar Enamel

System	Existing Substrate	Primer	Tie Coat	Top Coat
1	Coal Tar	97% Solids Epoxy	Silicone Tie Coat	Silicone Foul-Release (Si-9)
2	Coal Tar	100% Solids Epoxy	Silicone Tie Coat	Silicone Foul-Release (Fl-Si)
3	Coal Tar	100% Solids Epoxy	N/A	Silicone Epoxy Hybrid (SiEp-3)
4	Coal Tar	87% Solids Epoxy 85% Solids Epoxy	Silicone Tie Coat	Silicone Foul-Release (Si-3)

Results

- Abrasion Resistance: The abrasion test produced visible scratching on nearly all of the samples. On the control samples (epoxy, fluorinated polyurethane architectural coating, and polyurea hybrid), the scratches appeared to be fairly superficial on each of the test tracks. There was no significant difference in damage as additional weight was added to the brush. The weight losses were negligible for each of control samples, i.e., less than 10 mg.

  The hard foul-release coatings resisted abrasion damage effectively and showed only slightly more physical damage and weight loss compared to the control samples. These coatings included two silicone epoxies and a fluorinated polyurethane system. There was a clear distinction between these coatings and softer silicone foul-release coatings, which all underwent damage to a much higher degree with weight loss that ranged from 17 to 37 times greater than the best performing silicone epoxy.

  In general, the harder coatings were far more durable than the softer coatings. However, one notable exception was the polyurethane-urea hybrid control sample, which was both soft and durable. The abrasion test results for the more durable coatings are given in Fig. 4a results for silicone-based coatings are shown in Fig. 4b.

- Overcoating Coal Tar: All four coating systems used to overcoat coal tar experienced failures in the high flow test. Typically, the coal tar showed disbondment from the metal substrate on the overcoated portion (Fig. 5). Neither static immersion in a dilute Harrison solution or in deionized water produced catastrophic failure, but cracking was observed in several samples along the interface between the coal tar enamel and the primers. It is believed that internal stresses, perhaps due to expansion and contraction of the primer and subsequent layers, caused the low strength coal tar enamel to fail. It is unlikely this problem is unique to foul-release coating systems, but the extra coats that were required may have aggravated the effect.
- Erosion Resistance: The most notable physical change observed on the samples was a loss of gloss. It was difficult to gage the damage using visual inspection, so the samples were weighed to quantify the damage (Fig. 6). In general, silicone foul-release coatings exhibited excellent erosion resistance. One notable exception was silicone FR#8, which showed damage far greater than any other coating system and also felt oily compared to the other samples. It is worth noting that this product also per-formed poorly in the UV accelerated weathering test. Exposure to ultraviolet light caused the coating to dry out and crack before completion of the test.

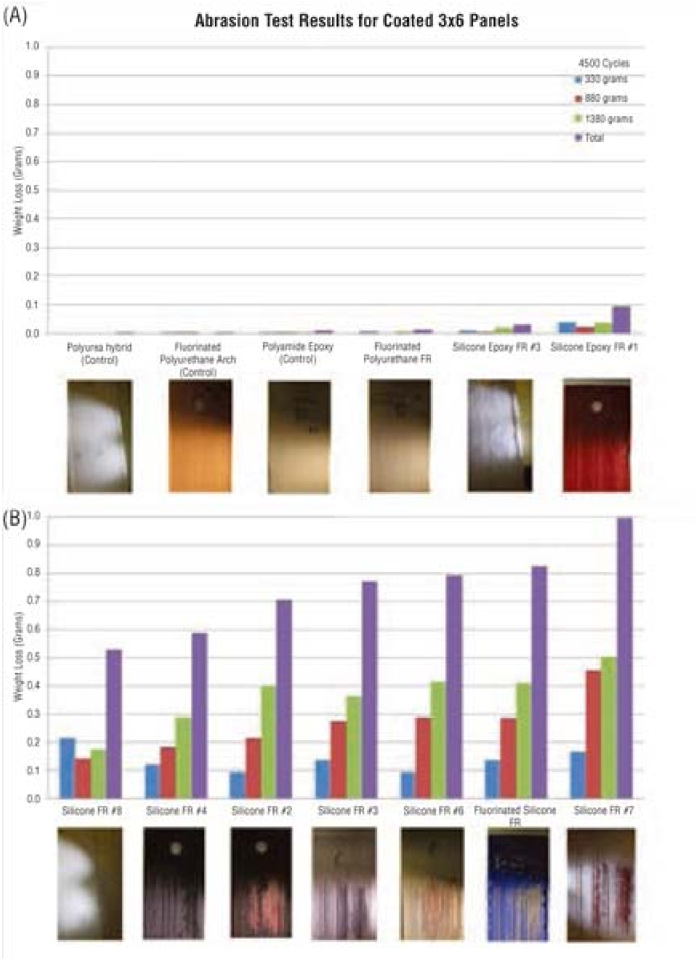


Fig. 4: Abrasion test results for (a) control samples and hard foul-release coatings and (b) silicone foul-release coatings

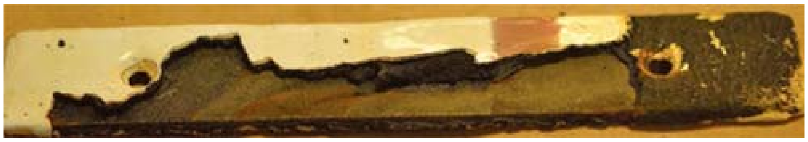


Fig. 5: Failure of overcoated coal tar during a high flow test

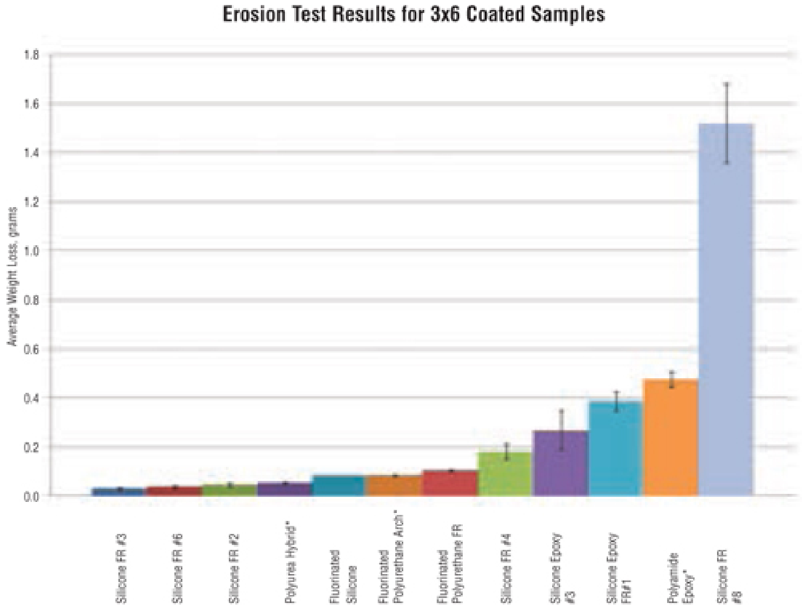


Fig. 6: Erosion test results for foul-release coatings and controls.
****denotes the non-foul-release (control) systems.***

Discussion

The tests used to evaluate the foul-release coatings in this study were developed by the Materials Engineering Research Laboratory at the Bureau of Reclamation. The tests were intended to simulate and accelerate the effects of a severe environment that a foul-release coating may be subjected to while in service. The brush abrasion test may represent cleaning of a trash rack/intake grating or contact from debris at the waterline of gates or trash racks.

The erosion test is intended to simulate the erosive action of water flow with entrained solid particulates. These results are most relevant to applications with water flow such as intake structures, piping, turbines, and pumps.

A polyamide epoxy is a commonly used coating system for the immersion environment. The expected service life of an epoxy will depend on a variety of factors but is estimated to be about 20 years. Ideally, a successful foul-release coating would last as long as an epoxy or longer. Hence, durability test performance should exceed that of the control for the application.

Several foul-release coatings outperformed the epoxy controls in erosion testing, but abrasion resistance was much lower.

Failure of one of these tests does not automatically eliminate a coating system from consideration, but it is important to recognize each product’s limitations when developing project specifications. Successful deployment of a silicone-based foul-release coating will depend strongly on the service environment. Environments where contact with equipment or floating debris is likely should be avoided. Silicone-epoxy coatings appear to be more resistant to this type of abrasion damage. None of the coating systems are recommended for application over coal tar enamel.

Conclusions

- Foul-release coatings are an important tool in mitigating impacts to hydraulic equipment caused by macrofouling organisms.
- Brush abrasion, slurry erosion, and high flow immersion are three new test protocols developed and used by USBR to evaluate the durability of foul-release coatings.
- These tests are intended to simulate the unique service environment that equipment may be exposed to at USBR facilities.
- Testing shows that several silicone-based foul-release coatings may work as well as (or better) in applications where sediment loading is high.
- The use of silicone-based coatings should be avoided in applications where contact with equipment or floating debris is likely. Durable foul-release coatings with acceptable foul-release performance may be more appropriate in such an environment.
- Overcoating coal tar is not recommended for any of the systems that were tested.

Editor’s Note: This article is based on a paper given at SSPC 2012 featuring GreenCOAT *in Tampa, FL, January 30-February 2, 2012.*

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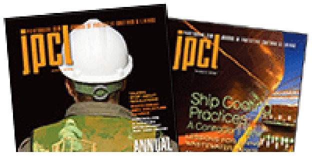

Influence of UHP Waterjetting on Shop-Primed Steel in New Construction, Part 3

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Philippe Le Calvé is responsible for R&D, paint technology, for DCNS, a military shipyard in France, where he has worked for 25 years. For the past 10 years, he and his co-workers have been involved with, and have written articles on, the use of UHP waterjetting as a surface preparation technology.

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Surface preparation processes influence the performance and lifetime of coating systems applied to steel substrates. The state of the steel surface immediately before painting is crucial. The main factors influencing the performance are the presence of rust and mill scale; surface contaminants including dust, salts, and grease; and surface profile. For aggressive environments such as marine atmospheres of C5M corrosivity category and for high-performance coatings that require cleaner and/or rougher surfaces, blast cleaning is often the preferred method of surface preparation. However, it is well known that abrasive cleaning can produce a considerable amount of waste, mainly containing blasting media, old removed paint, and rust products. As an alternative to abrasive cleaning for maintenance work or complete renovation, ultra-high-pressure (UHP) waterjetting is becoming common as long as the performance of the coatings on steel structures is not affected. UHP waterjetting technology has been described intensively in previous papers.[1-6] There are, however, questions about its suitability for new (naval) constructions.

Courtesy of DCNS.

Due to these questions, a project was started with the purpose of reinforcing the knowledge about the behavior of different paint systems for highly corrosive marine environments (C5M) and, more particularly, for assessing UHP waterjetting performance in relation to abrasive blasting on steel coated with a zinc-rich shop primer (ZRP).[7-10]

All other images and figures are courtesy of the authors.
Courtesy of DCNS.

In the first stage of the study, the characterization of surfaces after UHP waterjetting of shop primed steel surfaces was reported in the April/June 2011 issue of PCE as well as the May 2011 *JPCL*, and in the second part (reported in July/Sep 2011 issue of PCE and September 2011 *JPCL*), the performance of seven paint systems applied on UHP (DHP4) treated ZRP-coated steel flat panels and welded panels was studied in laboratory and field tests.[10] The results were compared with conventional abrasive blasted (Sa 2.5 MG) surfaces. It was concluded that UHP waterjetting was a promising technique for steel surface preparation within the scope of new constructions (on ZRP-coated steel). The results showed behavior of UHP waterjetting comparable to standard surfaces after abrasive blasting. Despite a slight difference in the roughness compared to abrasive blasting, coating performance did not seem to be affected. However, some results remained inconclusive regarding welded panels as a consequence of inhomogeneous weld area.

In this article, the authors describe the third and final part of the study, which involved testing three paint systems over UHP waterjetted ZRP panels, including more representative welded panels, compared to conventional grit blast-treated panels.

Experimental Conditions

In this study, an effort was made to design an appropriate welded sample, including a mixed zone at the periphery of the weld seam cleaned by UHP waterjetting to get a surface cleanliness DHP4. Partially cleaned ZRP-coated steel flat panels, treated with UHP to get a DHP1 cleanliness, were also considered. These were compared to conventional blasted surface (Sa 2.5 MG). Three different paint systems were applied on the various panel designs and roughnesses, and they were exposed to cyclic corrosion tests and natural weathering.

Test Panels, Surface

Preparation, and Coating Test panels of DH36 steel, commonly used in naval constructions, with different surface preparations representing the different practices used on a newbuild structure, were selected. As shown in Table 1, the steel plates had first been grit blasted (metallic abrasives) to grade Sa 2.5 and coated with a zinc-rich shop primer (zinc silicate, 10-15 µm) to create the initial conditions (i.e., steelmaker delivery standard). Two designs of test panels were considered: flat panels (100 x 175 mm) and welded panels (320 x 250 mm).

TABLE 1
Description of Steel Samples

Test Piece Reference	**T1**		**T3**
Steel Grade Initial State	DH36 Cleaning up to Sa 2.5 (grit and shot mixed) + zinc rich primer (10-15 µm)		
Test Piece Configuration	Welded panel (320 x 250 mm, 10-mm thick)		Flat panel (175 x 100 mm, 5.5-mm thick)
6-Month Natural Aging	Yes	Yes	Yes
Surface Preparation	Grit blasting Sa 2.5 (ISO 8501-1) ; MG (ISO 8503-1)	UHP waterjetting DHP4: complete ZRP cleaning and oxide removal in the mixed zone at weld area periphery	UHP waterjetting DHP1: partial ZRP cleaning

The flat test pieces were then cleaned by UHP waterjetting on only one side, to treatment degree DHP1, light cleaning according to NF T 35-520 standard (“surface shall be free from oil, mud, grease, caking, poorly adhering former paint, poorly adhering rust and mill scale, former coatings and any foreign matter. At this treatment degree, 70% of the surface is still partially covered by former coatings”). Details on the UHP waterjetting parameters are given in Table 2.

TABLE 2
Selected UHP Waterjetting Parameters (According to NF T 35-520)

UHP Waterjetting – Requirement NF T35 520	**DHP4**	**DHP1**
Test Piece Configuration	Welded test pieces	Flat test pieces
Cleaning Parameters	Pressure: 2400 bars Progression: 1 m/min Distance: 50 mm Rate: 13 l/min	Pressure: 1125 bars Progression: 1.5 m/min Distance : 70 mm Rate: 17 l/min

The welded samples consisted of two panels assembled by conventional welding for ship construction. At the center of the welded panels, a 120-mm-wide strip at right angles to the weld was machined, as shown in photographs in Fig. 1. Then, in order to mimic shipyard conditions when the ZRP is depleted during construction phases, the welded panels were exposed outdoors for six months in the shipyard at Lorient before secondary surface preparation and painting (The site is classified C2 on steel: corrosion rate, 195.8 +- 4.6 g/m^2 per year, i.e., 24.9 +-0.6 µm/year).

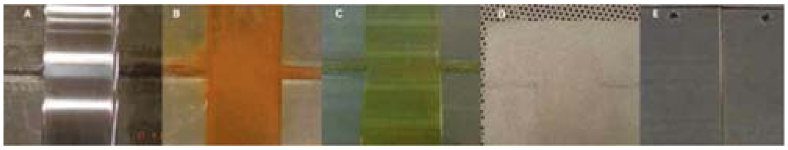

Fig. 1: Photographs of the welded panels (A-D) as a function of surface preparation stages and flat test panel DHP1 (E). (from left to right) Welded test piece before natural aging; Welded test piece after outdoor exposure; Welded test piece after DHP4, OF1 UHP cleaning; Welded test piece after grit blasting Sa 2.5; and Flat test piece DHP1 A B

Then, half of the panels were abrasive blasted to Sa 2.5 grade while the other half were cleaned by UHP waterjetting on one side to get a surface cleanliness DHP4, OF1 according to the NF T 35-520 standard (“surface shall be free from oil, mud, grease, caking, poorly adhering former paint, poorly adhering rust and mill scale and any former coatings or foreign matter. The exposed steel must be uniform and have an “original metallic colour”). Photographs of the different steps in the preparation of welded samples are shown in Fig. 1.

The roughness of the different areas of the welded panels was measured after the UHP waterjetting (DHP4) and is summarized in Table 3. It should be remembered that after abrasive blasting to Sa 2.5 MG, the measured roughness Ra ranged from 9 to 12 µm while the machined area roughness (after machining and before rusting) was from 0.3 to 0.7 µm (Ra).

TABLE 3
Surface Roughness of Pre-Rusted Welded Panel

Location on Welded Panel	Ra (µm)
Area 1: Machined steel (central section)	4.4 ± 1.1
Area 2: ZRP DHP4	7.1 ± 0.9
Area 3: Machined weld	6.4 ± 1.9

Once cleaned by either UHP waterjetting or blasting, the flat and welded samples were painted using three different commercial paint systems selected from the preliminary phase of this study.[10] As indicated in Table 4, two of them were based on an inhibiting protection mechanism, while the other operated on the barrier effect.

TABLE 4

Paint and Category Protection System

Primer Nature	Protection Category		Dry Film Thickness, µm
	Barrier Effect	Inhibitor Effect	
S1		X	350
S2	X		350
R		X	240

Before testing, scribes down to the steel substrate were made using a scribing tool equipped with a rectangular blade of 0.5 mm. On flat samples, a vertical scribe parallel to the longest side of 100 x 0.5 mm was made in compliance with the previous phase of the study.[10]

For the welded test panel, several areas were considered, and, therefore, a scribe was made in each of the five areas being considered (Fig. 2).

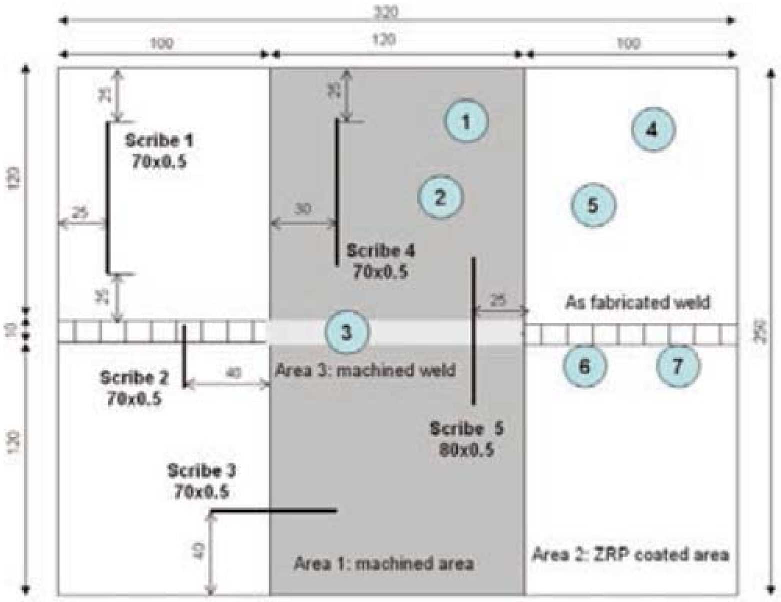

Fig. 2: Position of the scribes and pull-off test dollies on the welded test panel (dimensions are given in mm)

Artificial Ageing Test and Field Test

The corrosion performance of the paint systems as a function of surface preparation was carried out in the laboratory according to the C5M test cycle described in Fig. 3, a test that was implemented during the study preliminary phase.[11] The duration of the test was 4,200 hours.

Day 1	Day 2	Day 3	Day 4	Day 5	Day 6	Day 7
UV/Condensation ISO 11507		Neutral Salt Spray Test NaCl 1wt% - 35°C			Ambient 22°C, 55%RH	Low Temperature -22°C

Fig. 3: Basic artificial weathering cycle used in the study

Outdoor exposure was carried out at the marine site at Brest (classified C5M on steel, according to ISO 9223). Two duplicate samples per system, except abrasive-blasted welded samples, were exposed at 45 degrees facing south. The minimum duration of the test will be four years with intermediate inspections, and, at the time of writing this article, two years' evaluations were available.

Assessments

Visual Assessment

ISO 4628-2 to -6 standards have been used to assess paint defects, such as blistering, rusting, cracking, and chalking. For delamination measurement from the scribes, two methods have been used as described and illustrated in Fig. 4.

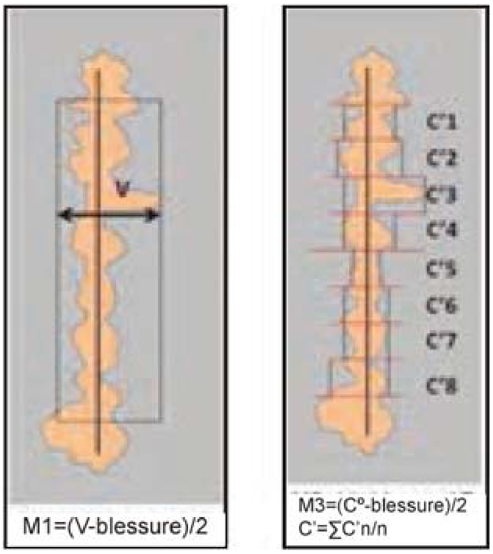

Fig. 4: Assessment of scribe creep.
Left: M1=(V-scribe width)/2 This measurement method has been used for intermediate measurements in particular.
Right: M4=(C'-scribe)/2 where C' = ΣC'n/n This measurement has been used after removal of the coating once C5M test was completed.

Pull-Off Adhesion Test

The pull-off adhesion tests were carried out according to ISO 4624 standard using a hydraulic pull-off device on unexposed references and after completion of the C5M cycle. Twenty-millimeter diameter dollies glued to the coating were used, and the tests were carried out in laboratory conditions (23.8 C – 45.1% RH). Figure 2 indicates the position of the dollies as a function of the area on the welded test pieces.

Assessment Requirements

For accelerated corrosion tests, the assessment of test pieces cleaned by UHP waterjetting was carried out according to the acceptance requirements defined in ISO 20340 (Table 5) and compared to abrasive blasting performance.

TABLE 5
Assessment Criteria According to ISO 20340

Criteria	**Standard**	**Acceptance Thresholds Established at the End of the Ageing Cycle (ISO 20340)**
Defects before and after aging	ISO 4628-2 ISO 4628-3	0 (S0) Ri 0
Peeling-corrosion around the scribe	ISO 4628-8 and ISO 20340	Max < 8 mm for the coating system with zinc-free primer
Adhesion before C5M weathering test	ISO 4624	Minimum pull-off test value: 4 MPa for the coating system with zinc-free primer No adhesion defect between the substrate and the first layer except if pull-off values exceed or equal 5 MPa
Adhesion after C5M weathering test	ISO 4624	Minimum pull-off test value=50% of the initial value with a minimum value of 2 MPa No adhesion defect between the substrate and the first layer except if pull-off values exceed or equal 5 MPa

Results

Cyclic Corrosion Test C5M

Flat test panels: No degradation such as blistering, rusting, cracking, and chalking was observed on any of the paint systems. However, a loss of brightness was seen on S2 paint system. Visible degradations for all test pieces were red rust runs from the scribes.

Regarding flat test panels of DHP1 surface preparation grade, a variable degree of creep from the scribe line was observed with the different paint systems, as shown in Fig. 5. Thus, paint system S1 was clearly less efficient than the other two systems, S2 and R. This has already been observed in a previous study where the same system (except for the first layer) was tested.[10] For the other two paint systems (S2 and R), the results were comparable between UHP-treated DPH4 and grit-blasted Sa 2.5 surface states.

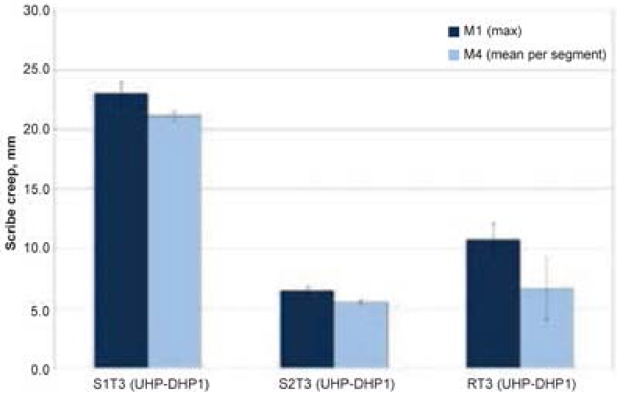

Fig. 5: Delamination from the scribes on flat test pieces after 6 months of C5M test.

Paint system adhesion results are summarized in Table 6. These show satisfactory behavior of paint systems S2 and R on a ZRP UHP-waterjetted DHP1 surface state. The behavior was the same as for the abrasive-blasted surface (data from a previous study), indicating no alteration of the coating performance on ZRP completely (DHP4) or partially (DHP1) cleaned steel surfaces. Nevertheless, the results highlighted the poor behavior of system 1.

TABLE 6
Pull-Off Test Values on Flat Samples after Six Months of C5M Cycle Corrosion Test*

Paint System	**Pull-Off Test Value, MPa**	
	T1 (Sa 2.5)	**T3 (DHP1)**
S1	15.7±1.1	11.0±2.3
S2	12.2±3.2	14.6±1.2
R	12.8±1.9	9.4±1.9

**T1: Sa 2.5, T3: DHP1. Data on T1 surface state from Ref 10*

Welded test panels: As with the flat test panels, no degradation such as blistering, rusting, cracking, and chalking was observed on any of the paint systems. Only corrosion from the scribes was present. Figure 6 (p. 50) presents the scribe creep measured on the welded test panels after six months of C5M test for both Sa 2.5 abrasive-blasted surface (T1) and DHP4 UHP-treated samples (T3). As mentioned in the experimental section regarding the design of the welded samples, five scribe lines were applied to assess the coating performance on the surface properties. From the results, abrasive blasting gives satisfactory behavior whatever the locations on the welded sample, in particular when considering systems S2 and R. It is interesting to note that the weld area periphery (scribes 2 and 5) or machined area (scribe 3, 4, and 5) are not significantly more affected than the reference surface (scribe 1).

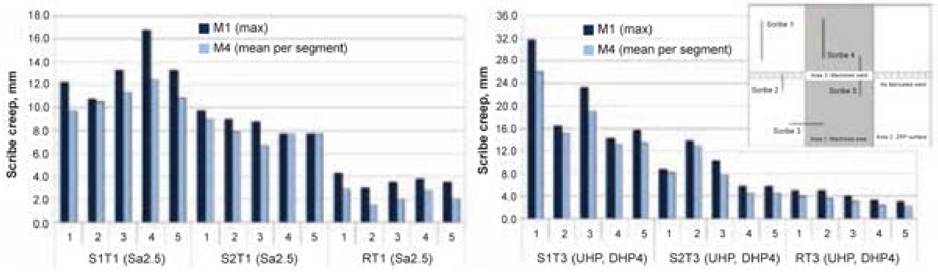

Fig. 6: Influence of surface preparation (left: abrasive blasting Sa2.5 - T1; right: UHP watterjetting DHP4 – T3) of welded test pieces on the delamination from the scribes after 6 months of C5M cycle test. The labels 1 to 5 refer to the 5 scribes as shown on the scheme in the right-hand

graph.

This test also clearly highlights the difference in behavior between the three paint systems applied on abrasive-blasted samples. Only system S1 did not satisfy the aging resistance criteria defined in Table 5. Indeed, the average scribe creep after coating removal of the five scribes gives the following values per paint system: S1 = 11 mm; S2 = 7.8 mm; S3 = 2.2 mm.

Regarding UHP-waterjetted (DHP4) samples, system S1 again gave unsatisfactory results, even worse than the abrasive-blasted surface. Nevertheless, for the two other paint systems, S2 and R, there was no significant difference between the two surface preparation modes. The average scribe creep after coating removal of the five scribes was the following: S1=17.4 mm; S2=7.6 mm; S3=3 mm. It should be noted, however, that on paint system S2, an unsatisfactory value of scribe creep was measured at scribe 2, located on the as-fabricated weld area with an average value of 13 mm. This may be observed on the photographs in Fig. 7. They also clearly highlight the degree and extent of corrosion upon the surface state, with an obvious remarkable behavior of the UHP DHP4 machined area in the center of the samples.

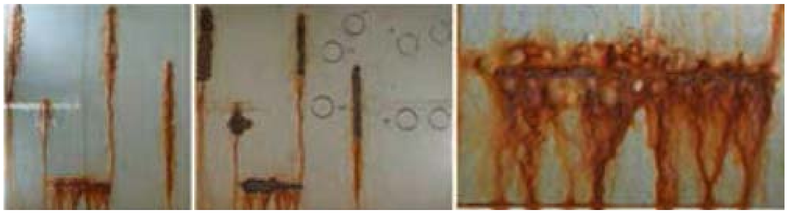

Fig. 7: Photographs of test panels S2T3 (DHP4) after six months of C5M test – (left): before coating removal around the scribe, (center): details of scribe 3 and (right): after coating removal.

Paint system R presented a marked and constant behavior regardless of the scribe location, whereas extremely different roughness and surface profile levels were tested. The scribe creep was far below the requirements (<8 mm).

As with the flat samples, adhesion properties were investigated in accordance to ISO 4624 in different areas of the welded panels, which differ in their surface roughness and profile. These areas were labelled as follows: area 1 corresponds to machined steel surface, area 2 to ZRP-coated steel surface (not machined) and area 3 to machined welded area. The adhesion was also investigated in the vicinity of the as-fabricated weld (dollies 6 and 7 in Fig. 2). However, due to the deformation of the weld, the results were very scattered and thus not conclusive. However, for the other locations on the test panels, the results indicated no adhesive failure. Figure 8 presents the adhesion strength as a function of the paint system and surface preparation, where satisfactory results can be observed regardless of the paint system and the surface roughness and cleanliness. In particular, it is interesting to note that despite the low roughness (Ra 4.4 µm) obtained on the UHP-waterjetted (DHP4) pre-rusted machined area (central section), adhesion properties comparable to the abrasive-blasted surface can be seen. This result obviously underlines the importance of the surface cleanliness level achieved after UHP waterjetting to level DHP4.

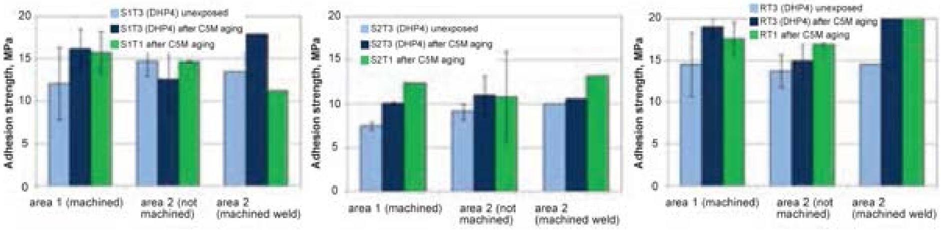

Fig. 8: Influence of surface preparation on coating adhesion before and after six months of C5M corrosion test for paint system (left): S1, (center): S2 and (right): R. Surface state: T3=UHP DHP4, T1=abrasive blasting Sa 2.5.

The different tests carried out on the welded test pieces, having roughness and surface profile levels not covered by any standards, gave the following results.

- For all tested configurations, including test piece types and UHP waterjetting cleaning requirement (DHP4), no blistering, rusting, cracking, or chalking defects were observed. These results constituted an important point demonstrating that the relative level of performance of the tested paint systems could be judged only by the corrosion creep at the scribe and adhesion.
- Paint system 1 did not meet the requirement of ISO 20340 of <8 mm creep, and this occurred after only a 4.5-month aging on Sa 2.5. Systems S2 and R showed satisfactory behavior. S2 had results close to the value of 8 mm and on average below the requirement. All these remarks are valid for all scribe locations on the welded test piece.
- Pull-off adhesion tests in seven different locations revealed variations in system behavior according to the different surface profiles. However, due to the study conditions, the adhesion results do not make it possible to define the roughness and the proximity to the weld area that produce a weak point for tested systems. The behavior of test pieces cleaned with the UHP

waterjetting method was rather similar to that obtained after abrasive blasting (Sa 2.5), where all surface irregularities have been evened-out by abrasive blasting.

Such behavior confirms the conclusions of the previous study and thus gives credibility to the thesis that surface cleanliness quality level associated with a roughness level is a key element to guarantee the performance of paint systems. The cleanliness level required is indeed obtained using UHP waterjetting. Specific work on required roughness levels will be undertaken in the ongoing program, “Anticor.”

Natural Aging

After 2 years of natural aging in a marine atmosphere, the inspection revealed no blistering and rusting defects—only delamination from the scribe line as shown in Fig. 9, which presents the maximum scribe creep on flat and welded samples. In good agreement with the results from the accelerated corrosion test, more severe breakdown was generally observed on paint system S1 for both DHP1 and DHP4 surfaces, compared to systems S2 and R. With paint system 1, increased scribe creep was formed with ZRP-coated steel DHP4 (scribe 1 and 3) in comparison to machined surface (scribe 4 and 5). The extent of scribe creep was between 1 and 2 mm for paint system 2 with no major difference upon the surface roughness. The same observation may be drawn for paint system R with however less scribe creep (below 1 mm). Thus, these observations are quite consistent with artificial aging trends and demonstrate the necessity to carry out specific additional work on paint system roughness and stability.

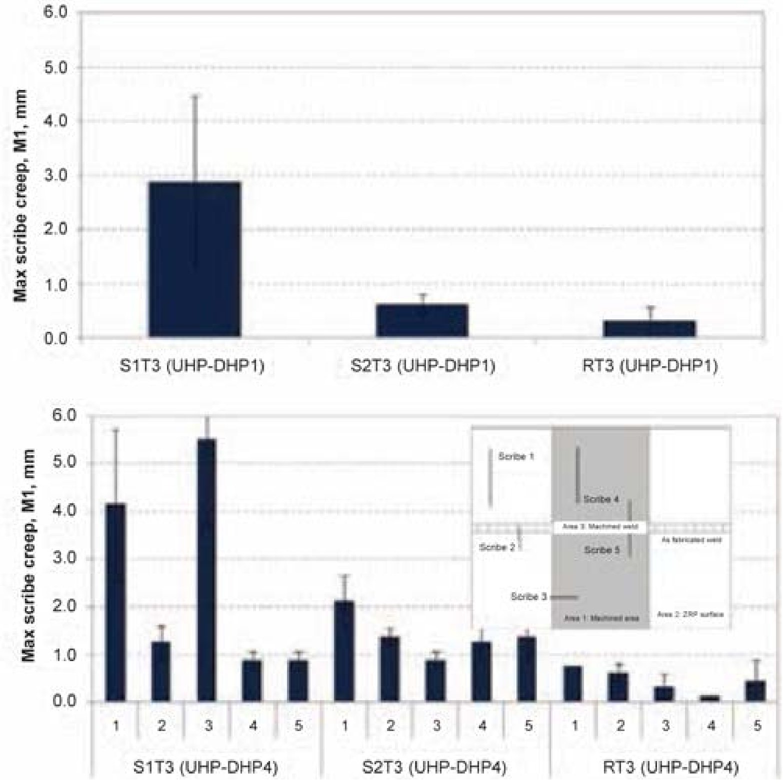

Fig. 9: Influence of surface preparation (top: flat test panels UHP-DHP1; bottom: welded test panels UHP DHP4) on the delamination from the scribes after 24 months of exposure in marine atmosphere.

Conclusions

The aims of the study were to assess the performance of three different coating systems applied on UHP-treated zinc-rich shop primer-coated steel (in new construction configurations) by considering different surface states (roughness and cleanliness DHP1 and DHP4). Thus, in addition to conventional flat panels, welded panels were included to represent fabricated and machined welded areas. The results were compared with classical grit blasted Sa 2.5 surfaces. A cyclic corrosion test based on C5M corrosivity was carried out to evaluate the performance of the coatings. The results were compared to field data obtained on a natural aging site that qualified for a C5M corrosivity category.

From the results, the following conclusions were drawn:

- Flat panels, DHP1 cleaning: On the basis of corrosion from scribe and pull-off adhesion results, UHP waterjetting on ZRP was efficient for S2 and R paint systems, showing behavior comparable to abrasive blasting. Both ZRP complete (DHP4) or partial (DHP1) cleaning generated satisfactory results.
- Welded panels, DHP4 cleaning: For paint systems S2 and R, UHP waterjetting (DHP4) gives behavior comparable to that of conventional abrasive blasting on a surface, with an optimized

performance in the low roughness area (machined area and machined weld).

Comparable observations may be drawn from 24 months of natural aging in a marine C5M atmosphere. The results will, however, be consolidated after longer exposure durations in the coming years.

The conclusions were in good agreement with a previous study for maintenance situations where a reinforcement of the surface cleanliness obtained after UHP waterjetting in relation to the abrasive blasting was noticed. One of the major advantages of UHP waterjetting is the complete removal of non-visible contaminations. They include water-soluble substances such as salts (chlorides, sulphates, soluble iron oxides); alkaline residuals (from lyes); welding fume deposits; and water-insoluble matter such as oils, greases, silicones, dust, and abrasive material inclusions. This good performance level was obtained in previous investigations with controlled flash rusting levels (<1 g/m^2) where the surface cleanliness level was found to be a key parameter in the paint durability.6 It is undeniable that this approach can include an important notion relative to roughness. Within this scope, a new study has begun, taking into account both surface preparation types and associated cleanliness levels, particularly reached using UHP waterjetting.

Editor's Note: This article, by Philippe Le Calvé and his co-authors, is part of the series of Top Thinker articles appearing in *JPCL* throughout 2012. Mr. Le Calvé is a recipient of *JPCL*'s 2012 Top Thinkers: The Clive Hare Honors. Mr. Le Calvé's profile and professional profiles of all of the award winners, as well as an article by Clive Hare, appear in the accompanying supplement to the August 2012 *JPCL*.

This article is based on a presentation given at EuroCorr 2011, Stockholm, Sweden. Parts 1 and 2 were also given earlier: Part 1 was also published in the April/June 2011 PCE *and the May 2011* JPCL; *Part 2 was also published in the July/September 2011* PCE *and the September 2011* JPCL.

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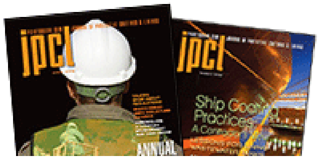

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Going global: OSHA revises hazard communication standard

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On March 28, 2012, OSHA issued a final rule on the sweeping changes to the Hazardous Communications Rules for the General Industry, Construction Industry, and Maritime Industries to correspond to the United Nations' Globally Harmonized System of Classification and Labeling of Chemicals (GHS). GHS is being implemented throughout the world by countries including Canada, the European Union, China, Australia, and Japan.

The revised Hazard Communication Standard (HCS) includes revised criteria for classification of chemical hazards; revised labeling provisions; a specified format for safety data sheets; and revisions to various definitions and terms used in the standard. The revision also introduces six (6) new appendices covering:

- Appendix A–Health Hazard Criteria (Mandatory),
- Appendix B–Physical Hazard Criteria (Mandatory),
- Appendix C–Allocation of Label Elements (Mandatory),
- Appendix D–Safety Data Sheets (Mandatory),
- Appendix E–Definition of Trade Secrets (Mandatory), and
- Appendix F–Guidance for Hazard

Classification Re: Carcinogenicity (Non-Mandatory).

Nearly every employer will be affected by this rule change related to employee training content, signs, labeling, and programs. Chemical manufacturers, importers, and distributors will have additional responsibilities related to hazard evaluation, development, and updates to safety data sheets and labels. (For example, in Appendix D, the safety data sheets (SDS), which are mandatory, contain largely the same information as material safety data sheets (MSDS), but the SDS has a different and "globally harmonized" format.)

When Does the Revised HCS Go into Effect?

The HCS revisions became effective May 25, 2012. This rule will phase in over four years with full implementation required by June 1, 2016. Table 1 summarizes the phase-in dates required under the revised HCS.

TABLE 1
Phase-In Dates under the Revised Hazard Communication Standard

Effective Completion Date	Requirement(s)	Who
December 1, 2013	Train employees on the new label elements and safety data sheet (SDS) format	All employers
June 1, 2015	Compliance with all modified provisions of this final rule, except: *Distributors may ship products labeled by manufacturers under the old system until December 1, 2015.	Chemical manufacturers, importers, distributors, and employers
June 1, 2015	Update alternative workplace labeling and hazard communication program as necessary, and provide additional employee training for newly identified physical or health hazards.	Employers
June 1, 2016	Update signs based on other standard revisions Full Implementation	All

OSHA has stated in the preamble to the revised hazard communication standard that "the [label and SDS] training needs to be completed by the time employees begin to see the new labels and SDS rather than waiting until after the transition has been completed." Therefore, prior to or as soon as employers start to receive the new GHS-compliant labels and SDSs, they should start training employees on how to read and interpret them.

The first effective completion date affecting all employers, December 1, 2013, requires all employers to provide training in the new label elements and SDSs. It should be noted that this training will continue to evolve as chemical manufacturers, distributors, and importers evaluate their materials and develop new labeling and SDSs through June 1, 2015.

Safety Data Sheets (Formerly Material Safety Data Sheets)

The revised HCS (29 CFR 1910.1200(g)) requires that the chemical manufacturer, distributor, or importer provide SDSs for each chemical to users to communicate information of any hazards. OSHA defines "chemical" as "any substance or mixture of substances." The information contained in the SDS is largely the same as the MSDS, except now the SDSs are required to be presented in a consistent user-friendly, 16-section format. OSHA requires that SDS preparers provide specific minimum information as detailed in Appendix D of 29 CFR 1910.1200.

The SDS includes information such as the properties of each chemical; the physical, health, and environmental health hazards; protective measures; and safety precautions for handling, storing, and transporting the chemical. The information contained in the SDS must be in English (although it may be in other languages as well). The SDS preparers may also include additional information in various section(s).

MSDS (HCS 1994) vs. Safety Data Sheet (HCS 2011) – Section by Section Comparison

Section 1: Identification

HCS 1994	HCS 2011
• Product identity same as on label and common names **(g)(2)(i)(A) - (C)** • Name address and telephone number of the manufacturer, distributor, employer or other responsible party **(g)(2)(xii)**	(a) Product identifier used on the label; (b) Other means of identification; (c) Recommended use of the chemical and restrictions on use; (d) Name, address, and telephone number of the manufacturer, importer, or other responsible party; (e) Emergency phone number.

Section 2: Hazard(s) Identification

HCS 1994	HCS 2011
• Physical	(a) Classification of the chemical in accordance with paragraph (d) of

hazards **(g)(2)(iii)** • Health hazards **(g)(2)(iv)**	§1910.1200; (b) Signal word, hazard statement(s), symbol(s) and precautionary statement(s) in accordance with paragraph (f) of §1910.1200. (Hazard symbols may be provided as graphical reproductions in black and white or the name of the symbol, e.g., flame, skull and crossbones); (c) Describe any hazards not otherwise classified that have been identified during the classification process; (d) Where an ingredient with unknown acute toxicity is used in a mixture at a concentration ≥ 1% and the mixture is not classified based on testing of the mixture as a whole, a statement that X% of the mixture consists of ingredient(s) of unknown acute toxicity is required.

Section 3: Composition/Information on Ingredients

HCS 1994	HCS 2011
• Chemical and common name of ingredients contributing to known hazards **(g)(2)(i)(A), (B)** •For untested mixtures, the chemical and common name of ingredients at 1% or more that present a health hazard and those that present a physical hazard in the mixture **(g)(2)(i)(C)(1),(3)** • Ingredients at 0.1% or greater, if listed carcinogens **(g)(2)(i)(C)(2)**	Except as provided for in paragraph (i) of §1910.1200 on trade secrets: **For Substances** (a) Chemical name; (b) Common name and synonyms; (c) CAS number and other unique identifiers; (d) Impurities and stabilizing additives which are themselves classified and which contribute to the classification of the substance. **For Mixtures** In addition to the information required for substances: (a) The chemical name and concentration (exact percentage) or concentration ranges of all ingredients which are classified as health hazards in accordance with paragraph (d) of §1910.1200 and (1) are present above their cut-off/concentration limits; or (2) present a health risk below the cut-off/concentration limits. (b) The concentration (exact percentage) shall be specified unless a trade secret claim is made in accordance with §1910.1200(i), when there is batch-to-batch variability in the production of a mixture, or for a group of substantially similar mixtures (See A.0.5.1.2) with similar chemical composition. In these cases, concentration ranges may be used. **For All Chemicals Where a Trade Secret is Claimed** Where a trade secret is claimed in accordance with paragraph (i) of §1910.1200, a statement that the specific chemical identity and/or exact percentage of composition (concentration) has been withheld as a trade secret is required.

Section 4: First-Aid Measures

HCS 1994	HCS 2011
• Emergency and first-	(a) Description of necessary measures, subdivided

aid procedures **(g)(2)(x)** • Signs and symptoms of exposure **(g)(2)(iv)**	according to the different routes of exposure, i.e., inhalation, skin and eye contact, and ingestion; (b) Most important symptoms/effects, acute and delayed. (c) Indication of immediate medical attention and special treatment needed, if necessary.

Section 5: Fire-Fighting Measures

HCS 1994	HCS 2011
• Physical hazards (potential for fire, explosion) **(g)(2)(iii)** • Emergency procedures **(g)(2)(x)**	(a) Suitable (and unsuitable) extinguishing media. (b) Specific hazards arising from the chemical (e.g., nature of any hazardous combustion products).

Section 6: Accidental Release Measures

HCS 1994	HCS 2011
• Procedures for cleanup of spills and leaks **(g)(2)(viii)** • Protective measures during maintenance and repair of contaminated equipment **(g)(2)(viii)**	(a) Personal precautions, protective equipment, and emergency procedures. (b) Methods and materials for containment and cleaning up.

Section 7: Handling and Storage Measures

HCS 1994	HCS 2011
• Precautions for safe handling and use, including appropriate hygienic practices **(g)(2)(viii)**	(a) Precautions for safe handling.

Section 8: Exposure Controls/Personal Protection

HCS 1994	HCS 2011
• General applicable control measures, such as appropriate engineering controls, work practices, and personal protective equipment **(g)(2)(ix)** • Protective measures during maintenance and repair of contaminated equipment **(g)(2)(viii)** • **(g)(2)(ix)** • Permissible exposure levels, threshold limit values, listed by OSHA, ACGIH, and other limit recommended or used by the MSDS preparer **(g)(2)(vi)**	(a) OSHA permissible exposure limit (PEL), American Conference of Governmental Industrial Hygienists (ACGIH) Threshold Limit Value (TLV), and any other exposure limit used or recommended by the chemical manufacturer, importer, or employer preparing the safety data sheet, where available. (b) Appropriate engineering controls.

The SDS must also state that no applicable information was found when the preparer does not find relevant information for any required element.

Section 9: Physical and Chemical Properties

HCS 1994	HCS 2011
• Physical and chemical properties such as vapor pressure, flash point, etc. **(g)(2)(ii)**	(a) Appearance (physical state, color, etc.); (b) Odor; (c) Odor threshold; (d) pH; (e) Melting point/freezing point;

	(f) Initial boiling point and boiling range; (g) Flash point; (h) Evaporation rate; (i) Flammability (solid, gas); (j) Upper/lower flammability or explosive limits; (k) Vapor pressure; (l) Vapor density; (m) Relative density; (n) Solubility(ies); (o) Partition coefficient: n-octanol/water; (p) Auto-ignition temperature; (q) Decomposition temperature; (r) Viscosity.

Section 10: Stability and Reactivity

HCS 1994	**HCS 2011**
• Physical hazards (potential for fire, explosion, reactivity) **(g)(2)(iii)** • Organic peroxides, pyrophoric, unstable(reactive), or water-reactive hazards**(g)(2)(iii), definitions in (c)**	(a) Reactivity; (b) Chemical stability; (c) Possibility of hazardous reactions; (d) Conditions to avoid (e.g., static discharge, shock, or vibration); (e) Incompatible materials; (f) Hazardous decomposition products.

Section 11: Toxicological Information

HCS 1994	**HCS 2011**
• Health hazards, including signs and symptoms of exposure, and any medical conditions which are generally recognized as being aggravated by exposure to the chemical **(g)(2)(iv)** • Primary routes of entry **(g)(2)(iv)** • Whether the hazardous chemical is listed in the National Toxicology Program (NTP) Report on Carcinogens (latest edition) or has been found to be a potential carcinogen in the International Agency for Research on Cancer (IARC) Monographs (latest editions), or by OSHA. **(g)(2)(vi)**	Description of the various toxicological (health) effects and the available data used to identify those effects, including: (a) Information on the likely routes of exposure (inhalation, ingestion, skin and eye contact); (b) Symptoms related to the physical, chemical and toxicological characteristics; (c) Delayed and immediate effects and also chronic effects from short- and long-term exposure; (d) Numerical measures of toxicity (such as acute toxicity estimates). (e) Whether the hazardous chemical is listed

	in the National Toxicology Program (NTP) Report on Carcinogens (latest edition) or has been found to be a potential carcinogen in the International Agency for Research on Cancer (IARC) Monographs (latest editions), or by OSHA.

OSHA will not enforce the content of these sections because they concern matters handled by other agencies002E

Section 12: Ecological Information (non-mandatory)

HCS 1994	HCS 2011
• No present requirements	(a) Ecotoxicity (aquatic and terrestrial, where available); (b) Persistence and degradability; (c) Bioaccumulative potential; (d) Mobility in soil.

Section 13: Disposal Considerations (non-mandatory)

HCS 1994	HCS 2011
• No present requirements	Description of waste residues and information on their safe handling and methods of disposal, including the disposal of any contaminated packaging.

Section 14: Transport Information (non-mandatory)

HCS 1994	HCS 2011
• No present requirements	(a) UN number; (b) UN proper shipping name; (c) Transport hazard class(es); (d) Packing group, if applicable; (e) Environmental hazards (e.g., Marine pollutant (Yes/No)); (f) Transport in bulk (according to Annex II of MARPOL 73/78 and the IBC Code); (g) Special precautions, which a user needs to be aware of, or needs to comply with, in connection with transport or conveyance either within or outside their premises.

Section 15: Regulatory Information (non-mandatory)

HCS 1994	HCS 2011
• No present requirements	Safety, health and environmental regulations specific for the product in question.

Section 16: Other Information

HCS 1994	HCS 2011
• Date of preparation of MSDS or date of last change **(g)(2)(xi)**	The date of preparation of the SDS or the last change to it.

A section-by-section review and comparison of the MSDS versus SDS content appears throughout this article.

Manufacturer/Importer Responsibilities Related to SDS

Chemical manufacturers and importers must evaluate and classify each of their chemicals based on the new criteria, definitions, and guidance provided in the HCS and its appendices. This will require them to deter-mine the hazard classes and categories applicable to their products. They are specifically required to apply the health and physical hazard criteria presented in Appendices A and B to their evaluation and to “identify and consider the full range of available scientific literature and other evidence concerning the potential hazards.”

Each chemical or product must first be “classified” based on 16 physical hazards, 10 health hazards, and 1 environmental hazard. Classification means to identify and evaluate any relevant data regarding hazards. If the chemical or product does not meet the criteria in Appendices A and B, it is not classified.

Flammable materials are further broken down into four subcategories based on their flashpoint (Table 2).

TABLE 2
Flashpoint Subcategories and Criteria

Category	Criteria
Category 1 Extremely flammable liquid and vapor	Flash point < 23 C (73 F) and initial boiling point ≤ 35 C (95 F)
Category 2 Highly flammable liquid and vapor	Flash point < 23 C (73 F) and initial boiling point > 35 C (95 F)
Category 3 Flammable liquid and vapor	Flash point ≥ 23 C (73 F) and ≤60 C (140 F)
Category 4 Combustible liquid	Flash point ≥ 60 C (140 F) and ≤ 93 C (200 F)

Related changes to the health-based general industry standards (as part of the HCS revisions) specifically require that the classifications of hazards address the following.

- Inorganic Arsenic–cancer, liver effects, skin effects, respiratory irritation, nervous system effects, and acute toxicity effects
- Lead–reproductive/developmental toxicity, central nervous system effects, kidney effects, blood effects, and acute toxicity effects
- Chromium VI (Hexavalent Chromium)–cancer, lung effects, kidney effects, and acute toxicity effects

The change in definitions, creation of the new hazard classes and categories, consideration of specific hazards, and the results of new scientific research to certain chemicals will likely result in changes to the information (and controls) presented on updated SDSs compared to previous versions of the MSDS. For flammable liquids, the changes in flashpoint and boiling point definitions will likely shift some liquids from lower to higher categories.

The revisions also require that those responsible for SDSs who becomes aware of any new and significant information regarding the hazards of a chemical, or ways to protect against the hazards, assure that the new information is added to the safety data sheet within three months.

Employer Responsibilities Related to SDS

Employers should review all new SDSs received for existing materials to determine if the reclassification process under the revised HCS for SDS has changed any of the information related to its use, controls, storage, or disposal.

Employers must ensure that the SDSs are readily accessible to employees for all hazardous chemicals in their workplace. During the phase-in period, the employer will need to track receipt of SDSs for existing materials and may need to maintain dual records of MSDSs and SDSs until the rule is fully in effect.

Container Labels and Pictograms

Under the HCS all labels must be revised by the manufacturer to include the following:

- a product identifier,
- a standardized signal word (Warning, Danger, Caution, or Notice),
- a hazard statement(s),
- a pictogram,
- a precautionary statement, and
- name and contact information for the manufacturer.

A major reason for the labeling changes is to improve the under-standing of non-English speaking and low-literacy workers. The pictograms are expected to improve overall recognition and comprehension of hazards. OSHA has developed a QuickCard depicting a sample label (Fig. 1, p. 18). Specific pictograms apply to each physical, health, and environmental hazard class (Figs. 2–4.

OSHA QUICK CARD

Hazard Communication Standard Labels

OSHA has updated the requirements for labeling of hazardous chemicals under its Hazard Communication Standard (HCS). As of June 1, 2015, all labels will be required to have pictograms, a signal word, hazard and precautionary statements, the product identifier, and supplier identification. A sample revised HCS label, identifying the required label elements, is shown on the right. Supplemental information can also be provided on the label as needed.

For more information:

OSHA Occupational Safety and Health Administration

(800) 321-OSHA (6742)
www.osha.gov

SAMPLE LABEL

Product Identifier

Supplier Identification

Hazard Pictograms

Signal Word
Danger

Hazard Statements

Precautionary Statements

Supplemental Information

Fig. 1: OSHA QuickCard of a sample label

ENVIRONMENTAL HAZARD CLASS

1. Hazardous to aquatic environment

Fig. 2: Physical Hazard Class pictograms

10 HEALTH HAZARD CLASSES

1. Acute toxicity

2. Skin corrosion/irritation

3. Serious eye damage/eye irritation

4. Respiratory or skin sensitization

5. Germ cell mutagenicity

6. Carcinogenicity

7. Reproductive toxicity

8. Specific organ toxicity - Single exposure

9. Specific organ toxicity - Repeated exposure

10. Aspiration hazard

Fig. 3: Environmental Hazard Class pictograms

Fig. 4: Health Hazard Class pictograms

Effect on Other Standards

The revisions to the HCS resulted in several revisions to health-based standards that include labeling, signs, or training requirements, and still other regulations related to substances such as hazardous materials and flammable liquids. Affected standards of interest to the coatings industry include the following.

- 29 CFR 1926.62/1910.1025, Lead
- 29 CFR 29.1118/1910.1018, Inorganic Arsenic
- 29 CFR 29.1126/1910.1026, Chromium (VI)
- 29 CFR 1926.1127/1910.1027, Cadmium
- 29 CFR 1926.65/1910.120, Hazardous Waste Operations and Emergency Response
- 29 CFR 1926.152/29 CFR 1910.106, Flammable Liquids
- 29 CFR 1926.155/1910.155, Fire Protection and Prevention—Definitions

Language on Signs in Substance-Specific Health Standards

The HCS revisions modify the language used on signs and labels related to health-based standards to include use of the words “Danger” or “Warning” and to include specific references to key health effects.

Under the HCS revisions, changes in sign language started on May 25, 2012, through June 1, 2016, and changes in warning labels started on May 25, 2012, through June 1, 2015. The language for signs for contaminated clothing and equipment will change (Table 3).

TABLE 3

Language Changes for Contaminated Clothing and Equipment

Title/Part/Section	Labels Current until 6/1/15 Signs Current until 6/1/16	Labels after 6/1/15 Signs after 6/1/16
	INORGANIC ARSENIC	
1910.1018(j)(2)	CAUTION: CLOTHING CONTAMINATED WITH	DANGER: CONTAMINATED WITH INORGANIC ARSENIC.

1926.1118 Labels on contaminated equipment and clothing	INORGANIC ARSENIC; DO NOT REMOVE DUST BY BLOWING OR SHAKING. DISPOSE OF INORGANIC ARSENIC CONTAMINATED WASH WATER IN ACCORDANCE WITH APPLICABLE LOCAL, STATE OR FEDERAL REGULATIONS	MAY CAUSE CANCER. DO NOT REMOVE DUST BY BLOWING OR SHAKING. DISPOSE OF INORGANIC ARSENIC CONTAMINATED WASH WATER IN ACCORDANCE WITH APPLICABLE LOCAL, STATE OR FEDERAL REGULATIONS
1910.1018(p)(3) 1926.1118 Precautionary labels on shipping and storage containers	CONTAINS INORGANIC ARSENIC CANCER HAZARD HARMFUL IF INHALED OR SWALLOWED USE ONLY WITH ADEQUATE VENTILATION OR RESPIRATORY PROTECTION	PER HAZARD COMMUNICATION STANDARD
1910.1018(p)(2) 1926.1118 Signs	INORGANIC ARSENIC CANCER HAZARD AUTHORIZED PERSONNEL ONLY NO SMOKING OR EATING RESPIRATOR REQUIRED	DANGER: INORGANIC ARSENIC. MAY CAUSE CANCER. DO NOT EAT, DRINK OR SMOKE. WEAR RESPIRATORY PROTECTION IN THIS AREA. AUTHORIZED PERSONNEL ONLY
LEAD		
1910.1025(g)(2)(vii) 1926.62(g)(2) Labels on contaminated equipment and clothing	CAUTION: CLOTHING CONTAMINATED WITH LEAD. DO NOT REMOVE DUST BY BLOWING OR SHAKING. DISPOSE OF LEAD CONTAMINATED WASH WATER IN ACCORDANCE WITH APPLICABLE LOCAL, STATE, OR FEDERAL REGULATIONS	DANGER: CLOTHING AND EQUIPMENT CONTAMINATED WITH LEAD. MAY DAMAGE FERTILITY OR THE UNBORN CHILD. CAUSES DAMAGE TO THE CENTRAL NERVOUS SYSTEM. DO NOT EAT, DRINK OR SMOKE WHEN HANDLING. DO NOT REMOVE DUST BY BLOWING OR SHAKING. DISPOSE OF LEAD CONTAMINATED WASH WATER IN ACCORDANCE WITH APPLICABLE LOCAL, STATE, OR FEDERAL REGULATIONS
1910.1025(m)(2) 1926.62(m)(1) Signs	WARNING: LEAD WORK AREA POISON NO SMOKING OR EATING	DANGER: LEAD MAY DAMAGE FERTILITY OR THE UNBORN CHILD CAUSES DAMAGE TO THE CENTRAL NERVOUS SYSTEM DO NOT EAT, DRINK OR SMOKE IN THIS AREA
HEXAVALENT CHROMIUM		
1910.1026(h)(2)	PER HAZARD COMMUNICATION	PER HAZARD

1926.1126 Labels on waste, scrap, debris, bags, containers, personal protective equipment, and clothing	STANDARD	COMMUNICATION STANDARD
CADMIUM		
1910.1027(m)(3) 1926.1127(m)(3) Labels for containers, shipping, and storage containers	PER HAZARD COMMUNICATION STANDARD	CONTAINS CADMIUM MAY CAUSE CANCER CAUSES DAMAGE TO LUNGS AND KIDNEYS AVOID CREATING DUST
1910.1027(m)(3) 1926.1127(m)(3) Labels for contaminated protective clothing, equipment, waste, scrap, or debris	DANGER: CONTAINS CADMIUM. CANCER HAZARD. AVOID CREATING DUST. CAN CAUSE LUNG AND KIDNEY DISEASE	CONTAINS CADMIUM MAY CAUSE CANCER CAUSES DAMAGE TO LUNGS AND KIDNEYS AVOID CREATING DUST
1910.1027(m)(2) 1926.1127(m)(2) Signs	DANGER: CADMIUM CANCER HAZARD CAN CAUSE LUNG AND KIDNEY DISEASE. AUTHORIZED PERSONNEL ONLY. RESPIRATORS REQUIRED IN THIS AREA	DANGER: CADMIUM MAY CAUSE CANCER CAUSES DAMAGE TO LUNGS AND KIDNEYS WEAR RESPIRATORY PROTECTION IN THIS AREA AUTHORIZED PERSONNEL ONLY

Training

Employee training programs will need to be updated to include the newly added health considerations for inorganic arsenic, lead, and chromium as discussed above.

29 CFR 1926.152/29 CFR 1910.106, Flammable Liquids

The revision to the HCS has the most collateral impact on the flammable liquid standards. This is due to the change in the definitions of flashpoint and boiling point and the introduction of the four categories for flammable liquids. While the author has not completed a full analysis of the impacts on the Flammable Liquid standards, a few key changes (based solely on the new categories) include the following:

- Changes in vent and piping design, location, and requirements;
- Maximum allowable size of containers and portable tanks for flammable liquids (Table H-12);
- Maximum capacity of storage cabinets 1910.106(d)(3)(i);
- Location and maximum capacity of indoor container storage (Table H-14);
- Ventilation (various references throughout standard);
- Location and maximum capacity of indoor portable tank storage (Table H-15);
- Criteria of outdoor container storage (Table H-16);
- Criteria of outdoor portable tank storage (Table H-17); and
- Allowable quantities located outside storage areas (paragraph e).

Conclusions

This revised Haz Comm Standard is a major revision to a sweeping regulation affecting nearly every employer in the United States. Despite the four-year phase-in period, revised regulations are currently in effect, and changes have already begun related to training requirements, hazard evaluations, labels, signs, and SDSs.

Our first overall compliance deadline requires employee training in labels and SDS by December 1, 2013. Employers will want to evaluate flammable and liquid storage areas based on the new categories. Employers (and/or their health and safety representatives) should critically review new SDSs and labels for materials for changes and new information related to health hazards, worker and engineering controls, etc. as the mandatory SDS' requirements come into effect. Haz Comm has changed; are you ready?

Editor's Note: Alison Kaelin is one of 24 recipients of *JPCL*'s 2012 Top Thinkers: The Clive Hare Honors, given for significant contributions to the protective coatings industry. Professional profiles of all the award winners, as well as an article by Clive Hare, appear in the accompanying supplement to the August 2012 *JPCL*.

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