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JOURNAL OF PROTECTIVE COATINGS & LININGS

The Voice of SSPC: The Society for Protective Coatings

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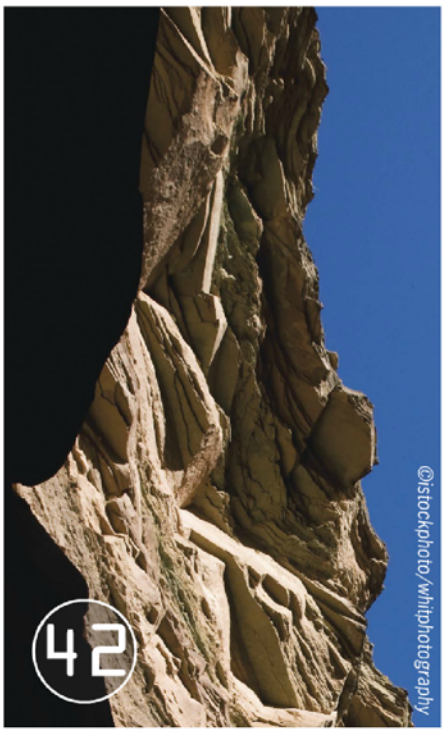
FEATURES



DEPARTMENTS

Also This Month

From the Offices of

SSPC The Society For Protective Coatings

Staff

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Hail and Farewell

This is a term we used in the U.S. Army. Every month, or at least once a quarter, the officers of the unit, usually at Battalion level, had a gathering where we would introduce the new officers who had come into the unit, giving their background and what their positions would be in the organization. After the new folks were introduced, we would then say farewell to those who were leaving. This would sometimes be an emotional event, because those in your Battalion were your family, especially when you were serving overseas. Needless to say, when you spent as much time together as we did, these particular people became your closest friends, all of the families socialized together, and there was a bond between everyone that was hard to fathom unless you lived in that environment.

In this short piece I want to say farewell to someone whom I have known 19 years and worked closely with for the past 14. Due to her role, she has been an integral part of SSPC's success and growth over that period. That person is Karen Kapsanis, who is Editor in Chief of the *JPCL*. Karen has decided to leave Technology Publishing Company and return to school to broaden her already vast knowledge base. Karen has been the editor of the magazine for over 25 years and has done a simply superb job editing and putting together a monthly periodical. The *JPCL* is seen as the benchmark magazine in our industry. This is because of her hard work and effort and her well-known perfectionist attitude that will accept nothing but outstanding work. She will be the first to tell you that she has an outstanding team, and she does. The fact remains that over her many years at Technology Publishing Company, she has ensured that the magazine is nothing short of top notch, month after month. For this, the entire staff of SSPC is grateful. The *JPCL* is our number one member benefit, and as I have traveled the world, I cannot even begin to count the number of times those members and readers of that magazine have come up to me and said that it is the best in the business. Just last month when I was in Australia, a member came up to me and told me that he had every issue of the magazine since it started and it was the best coatings magazine out there. That is because of Karen and her team. I am happy for her and, in spite of our loss, am glad she is doing what she wants to do at this stage in her life, something that she is looking forward to. We used to say, "You only go around once in life, and this is not a dress rehearsal." So as Karen goes off to further her education, I wish her much success and happiness. Most of all, I wish her good health and Godspeed as she takes this new path in her life.

Ms. Anita Socci, who is presently the Managing Editor and Directory Manager, will assume Karen's role. Anita has worked closely with Karen for over 15 years, so the transition to her new role should be seamless to the *JPCL* team and the readership. I am confident that Anita will continue to maintain the high standards set by Karen and the *JPCL* will continue to be the outstanding product that it has been since its inception in 1984.

With that, I say a hail to Anita, and I wish you the best in your new role. And lastly, I say a fond and personal farewell to Karen. I wish you happiness, prosperity, and, most of all, good health as you chart your new course in the sea of life.

Bill Shoup

Bill Shoup
Executive Director, SSPC

New SSPC Mobile App Launched

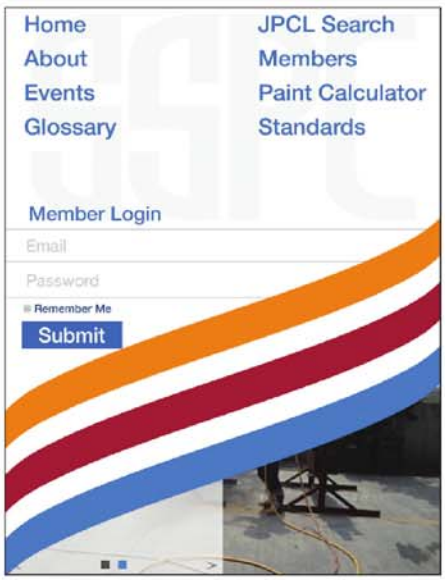
SSPC's first official app for members is now available on the Apple App Store, iTunes, and Google Play.

Developed in conjunction with Victory Apps, an experienced developer of mobile apps for non-profit organizations, the SSPC App is based on giving members mobile access to SSPC Standards and other popular SSPC information, including member contacts, the Coatings Glossary, SSPC training and events, the *JPCL* article search, and more.

The app is free to download, but in order to access all of the features, you must be a member of SSPC.

The easiest way to get started is with the user guide, posted at sspc.org/membership-mobile-app/. To navigate the app, launch it and tap on the "Menu" icon at the top left of your screen. In the text fields beneath "Member Login", enter the email address that is associated with your member account and then enter your member number in the "Password" field. If you can't remember your login email or member number, or if you have other problems with your login, please send an email to customerservice@sspc.org.

SSPC is welcoming feedback to improve the SSPC Mobile App for its members. If you would like to comment on the app or make suggestions for future versions, please send email to appfeedback@sspc.org.



The Menu page includes a login for SSPC Members to access all of the app's features

The home page shows recent SSPC news stories.

Esitmate paint consumption with the Paint Calculator.

Browse upcoming training courses and other events.

OSHA Beryllium Rule Planned for 2014

Officials with the Occupational Safety and Health Administration (OSHA) say that new federal proposals limiting worker exposure to beryllium—a particular hazard in open-air abrasive blasting—are on track to roll out in April 2014.

Details of the proposal are not yet available, but options under consideration include new Permissible Exposure Limits reducing those listed in OSHA's 1926.55 Appendix A (Occupational Health and Environmental Controls) and/or additional requirements for medical surveillance, according to a recent presentation by Tiffany DeFoe, a health scientist who is OSHA's project officer for the beryllium standard. DeFoe updated the beryllium proposal's progress in December to OSHA's Advisory Committee for the Construction Industry.

The Notice of Proposed Rulemaking for beryllium is expected to be submitted to the Office of Management and Budget in April, DeFoe said.

Beryllium, a toxic metal and component of coal, is "just a minor contaminant" in slag blast media, DeFoe said, but it can accumulate in thick blast dust to levels about the current PEL.

OSHA's current PEL for beryllium is 2.0 micrograms of beryllium per cubic meter of air (2.0 µg/m3) over eight hours. The agency is looking at reducing the PEL to as low as 0.1 micrograms of beryllium per cubic meter of air, DeFoe told Bloomberg News and confirmed in an email to *PaintSquare News*.

Other PEL thresholds under consideration are 0.2, 0.5 and 1 microgram per cubic meter, according to DeFoe's presentation.

The agency is also considering a new "short-term exposure limit to get some of those very high exposures under control," DeFoe said. Current requirements for respiratory protection, ventilation and personal protective equipment are not expected to change.

OSHA estimates that 23,000 workers in construction are "potentially exposed" to excessive levels of beryllium, putting them at risk of sensitization, chronic beryllium disease, and lung cancer, DeFoe said.

Last year, OSHA reported "potential violations" by some slag-abrasive makers about beryllium disclosures on their labeling, following a complaint by the advocacy group Public Citizen.

The path to a new federal rule on beryllium exposure began in 2002 with a Request for Information. The Small Business Advocacy Review Panel released its analysis in January 2008. JPCL

Graco Acquires Eco-Quip

Graco Inc., a leading manufacturer of fluid handling equipment based in Minneapolis, announced that it has acquired abrasive blasting equipment manufacturer EcoQuip Inc., of Chesapeake, VA. Financial terms of the transaction were not disclosed.

Founded in 2005, EcoQuip designs and produces eco-friendly abrasive blasting systems for coating removal and surface preparation. EcoQuip products will become part of the product portfolio of Graco's Applied Fluid Technologies Division (AFTD).

EcoQuip's vapor-abrasive blast equipment eliminates up to 97 percent of the airborne particles produced in typical dry-blasting applications by adding a fine mist during the spraying process. The mist minimizes the dispersal of dust and other harmful substances. In addition, the EcoQuip equipment performs at the same production rate as traditional dry-blast equipment while dramatically decreasing the blast media consumption. The products can be used in a variety of challenging conditions, such as high humidity, rain and under water. They can blast from 30 to 130 psi using all common readily available dry-blasting media.

Graco Inc. supplies technology and expertise for the management of fluids and coating in both industrial and commercial applications. It designs, manufactures and markets systems and equipment to move, measure, control, dispense, and spray fluid materials. Graco serves customers around the world in the manufacturing, processing, construction, and maintenance industries.

The Buzz on PaintSquare.com

By Anita Socci, JPCL

This month's Buzz will recap the 10 most popular and most commented on news headlines and features and the most popular quiz of 2013.

10 Most Commented on News Headlines

Seeing Red: Gun Pulled Over Paint Job
2 Burned in Tank Lining Blast
Immigrant 'Crisis in Construction' Seen
Carboline Named in BP Refinery Suit
Coating Allegedly Ruined $40M Deal
Navy to Scrap Painter-Torched Sub
Coating Firm, GC Cited in Manhole Death
2013 Corrosion Salaries Set Records
Philippines Seeks $1.5M in Reef Mishap
Painter Electrocuted on Bridge Project

10 Most Popular News Headlines of 2013

Carboline Named in BP Refinery Suit
Coating Allegedly Ruined $40M Deal
7 Workers Perish During Tank Cleaning
2 Inspectors Fall to Their Deaths
Scissor Lift Topples, Kills 2 at Port
2 Coating Company Owners Get Prison
Bridge Inspector's Fatal Fall Probed
2 Paint Plant Explosions Injure 3
Painter Electrocuted on Bridge Project
Navy to Scrap Painter-Torched Sub

Most Popular *JPCL* Features (on *PaintSquare News*)

The Case of...Bubbles, and Pinholes, and Blisters, Oh My!
(Weeks of 11/25/2013 and 12/2/2013)
Why Surface Preparation Is Important
(8/5/2013)
Developments in Zinc Primers for Corrosion Protection
(7/22/2013)
The Contractor Who Almost Got Floored
(7/29/2013)
Is Lead Dead?
(7/8/2013)
An Introduction To How Coatings Protect Concrete
(7/15/2013)
Measuring Dry Film Coating Thickness According to SSPC-PA 2
(6/10/2013)
An Introduction to the Deterioration of Concrete
(6/24/2013)
Formulating Polyureas: History and Advances
(6/3/2013)
Regulations in Coatings Work: Key Developments Over 30 Years
(10/21/2013)

MOST POPULAR QUIZ

Which of the following answers organizes SSPC abrasive blasting standards from least to most rigorous?

a. SP 7, SP 6, SP 10, SP 5
b. SP 7, SP 10, SP 6, SP 5
c. SP 5, SP 6, SP 7, SP 10
d. SP 5, SP 10, SP 6, SP 7

Answer: SP 7, SP 6, SP 10, SP 5
SP 5 is "White Wetal," SP 10 is "Near-White Metal," SP 6 is "Commercial," and SP 7 is "Brush-Off."

Results

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

On Increasing Waterjetting Pressure

There are ways to increase the pressure for waterjetting above 20,000 psi. What are the effects of different high pressures on cleaning rates?

From J. Peter Ault
Elzly Technology Corporation

Before considering the effect of increased waterjetting pressure, the user should have an understanding of the cleanliness objective—what should be removed and what should remain. Is the objective to remove pack rust, loose coating, or weakened concrete? Should tightly adherent coating or sound concrete be removed? Quite often the desired degree of cleanliness is defined using one of the Waterjetting Standards: Clean to Bare Substrate (WJ-1), Very Thorough Cleaning (WJ-2), Thorough Cleaning (WJ-3), or Light Cleaning (WJ-4).

Each of the surface preparation standards defines four different waterjet cleaning methods: low-pressure water cleaning (LP WC) is performed at pressures less than 34 MPa (5,000 psig), high-pressure water cleaning (HP WC) is performed at pressures from 34 to 70 MPa (5,000 to 10,000 psig),

high-pressure waterjetting (HP WJ) is performed at pressures from 70 to 210 MPa (10,000 to 30,000 psig) and ultrahigh-pressure waterjetting (UHP WJ) is performed at pressures greater than 210 MPa (30,000 psig). It is important to recognize that these definitions are in all four of the waterjetting cleanliness standards. Higher pressures are not intended to correlate to higher degrees of cleanliness, though it may be tempting to jump to that conclusion.

In some cases, increased pressure may result in increased cleaning rates and/or higher degrees of cleaning; however it will not always have that effect. In addition to pressure, dwell time, traverse rate, flow (gpm), stand-off distances, the number and size/type of nozzles, and rotation speed, all interact to determine cleaning rates and the degree of cleanliness. Other factors can have a greater impact on your desired objective than increased pressure. In fact, increasing pressure alone may run counter to your cleanliness objective. Appendix C of each of the waterjetting standards contains a more detailed discussion of these variables. Information is also available from the WaterJet Technology Association.

Upcoming Problem Solving Forum Questions

- Is there a definitive relationship between mechanical properties of coatings (such as elongation at break, tensile strength) and crack bridging capacity?
- What is the best way to remove thick elastomeric coatings?
- Is stainless steel banding suitable for fixing galvanized insulation cladding?

JPCL

Editor's Note: This Problem Solving Forum was posted on *JPCL*'s sister publication, *PaintSquare News*. Answers have been edited to conform to *JPCL* style and space limitations. The Problem Solving Forum is an interactive column on *PaintSquare News* and on *JPCL*. Additional answers to this month's question may be submitted to *PaintSquare News* or *JPCL*. You can also submit questions for the Problem Solving Forum on *PaintSquare News*, or you can submit questions to Anita Socci, *JPCL*, asocci@paintsquare.com.

Click our Reader e-Card at paintsquare.com/rc

Q&A with Keith Trammel

By Charles Lange, JPCL

Keith Trammel is the founder and president of Black Dog Painting, LLC, a full-service blasting and coatings contracting company based in Social Circle, GA. Before starting Black Dog in 2004, Trammel held management positions at The Sherwin-Williams Company for over 17 years. He has also completed several training and certification programs through organizations like NACE International, KTA-Tator Inc., and others. He studied at the University of Illinois at Urbana-Champaign.

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

KT: An opening as operations manager prompted me to do some studies on the then-floundering Sherwin-Williams Company. The realistic management ideals of then-CEO Jack Breen placed values at the center of every business model. The demand for a moral backbone and integrity in everything we do was too intriguing for me not to jump on board.

JPCL: What made you decide to leave such a large international company like Sherwin-Williams to start a smaller, independent, more regional company?

KT: My entrepreneurial and maverick-type drive was better utilized in creating and building up a new company. The ability to work with a major coatings manufacturer and marketer helped in enlarging my vision and gave me a very strong base of knowledge and wisdom.

JPCL: What are some of the challenges you face as president of an independent business?

KT: In your first few years, cash flow puts the worry into your nighttime. Calculated growth without a burden of debt has helped us to grow successfully.

JPCL: What advice would you give someone looking to start a new business in the coatings industry? Are there any lessons you learned during the process of starting your business that you can pass on?

KT: Develop a niche that is difficult to replicate. Learn from the mistakes of others. Don't under-capitalize your business.

There will always be competition, but the group that stays dogged with top performance, even when no one is looking, will always come out as the real winner. Running with the pack sometimes allows folks to get complacent. The view is always the same if you are not the lead dog.

JPCL: What are some of the challenges that you face when hiring new employees for your company?

KT: A lack of drive, ambition, and integrity. We seem to have dropped some of these traits in America. Behavior is very hard to change. Sometimes, senior management has done a less than adequate job by failing to take a hands-on approach with mentoring. Failing has become so much of a commonplace and acceptable practice, which is shown through poor quality workmanship and less-than-acceptable QC and QA percentages of products.

JPCL: You plan on attending SSPC 2014 in Orlando this February. As an independent business owner, can you talk a little bit about the importance of attending events like this, especially in terms networking and expanding your company's presence in the industry?

KT: The SSPC show and conventions like it allow you time to reconnect with friends in the industry. The vendor shows keep you in touch with problem solvers of the many facets of the business that we are challenged with every day. It's also important to stay on top of new solutions and cutting edge equipment and coatings.

JPCL: What do you enjoy most about attending events like the SSPC conference? (i.e., technical presentations, exhibit hall, networking opportunities, etc.)

KT: That's a tough question, as so much information is presented. It is necessary to peruse the technical presentations and select the ones that are most relevant for the company and attempt to get around to as many as possible.

JPCL: What is the best piece of advice you've received, either related to your work or just life in general?

KT: God, family and work—don't let the order of these become discombobulated.

JPCL: What is your favorite thing about the work you do?

KT: Gratification from passing on to our men that our customers have thanked us for a job well done. Highlights are being able to deliver a quality product and performance on every job we tackle.

JPCL: What are some of your interests outside of coatings? How do you like to spend your free time?

KT: I enjoy watching our children develop, and just about all outdoor sports.

JPCL

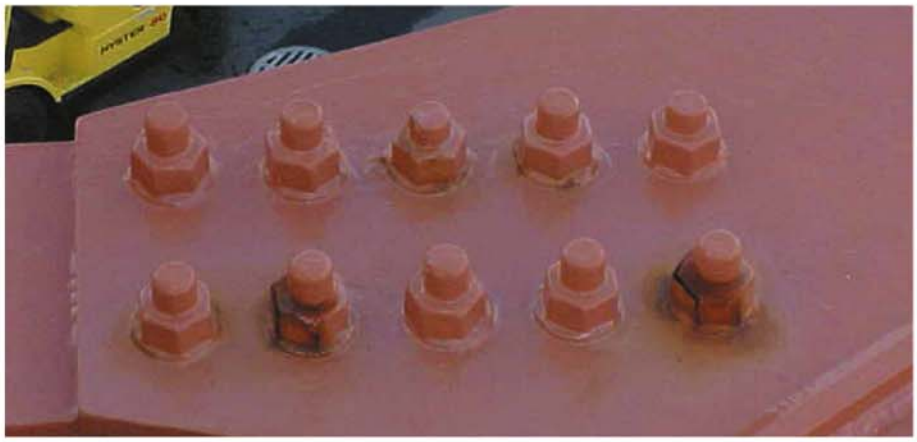
Fundamentals of Stripe Coating

Consider the following scenario, which points out one of the worst disappointments in the painting of steel structures.

The owner carefully plans a project to include a well-written specification, careful material evaluation and selection, a qualified contractor, and thorough inspection of the work. The project is done on time, within budget, and with no claims for extra work. Two years later, visual inspection of the project reveals that 99% of the painting work shows no signs of failure. Yet, essentially every edge, bolt, and weld is rusting.

What happened?

The project specification did not require "striping" or "stripe coating" of all edges and welds during the painting work. Is this the problem? Maybe...maybe not.



Paint failures on bolted connection that had not been stripe coated
Photos courtesy of Corrosion Control Consultants and Labs, Inc.

What is 'Striping' or 'Stripe Coating?'

A stripe coat is "a coat of paint applied only to edges or to welds on steel structures before or after a full coat is applied to the entire surface. The stripe coat is intended to give those areas sufficient film build to resist corrosion."[1]

Therefore, striping, as it is sometimes called, is the process of "painting the edges of a surface or welds to give them extra protection. Striping is done before priming or before the application of a full coat of paint."[1]

(In this article, the terms "stripe coating" and "striping" are used interchangeably.)

SSPC-PA 1, Shop, Field, and Maintenance Painting of Steel, includes the following advice about stripe coating.[2]

- If stripe coating is specified for a project, then all corners, crevices, rivets, bolts, welds, and sharp edges should receive a stripe coating with the priming paint before the steel receives a full coat of primer.
- The stripe coat should extend at least 1 in. (2 cm) from the edge.
- To prevent removal of the stripe coat by later application of the primer, the stripe coat should be allowed to set to touch before the full coat of primer is applied. (However, it should not be permitted to dry long enough to allow rusting of the unprimed steel.)
- Alternatively, the stripe coat may be applied after a complete coat of primer, especially if a long drying period for the stripe coat would allow the uncoated steel to deteriorate.
- Tinting of the stripe coat is advisable to promote contrast.
- Stripe coating is most effective on edges that are rounded by grinding.

The specification notes that stripe coating is advantageous in preventing coating breakdown on edges, etc., in very corrosive surroundings, but it is an expensive operation and may only be justified when it is believed that the cost will be compensated for by extra service life of the coating system.

Is Stripe Coating Necessary?

Stripe coating of edges, bolts, and welds is often specified because liquid paints tend to flow away from these parts. This is a result of surface tension in the paint film and shrinkage of the paint film during curing.

If this occurs, the paint film at or near the edges will be thinner than elsewhere on the

Editor's Note: The original ATB on stripe coating was written by Jon R. Cavallo, P.E., of Corrosion Control Consultants and Labs, Inc. (Eliot, ME) for the May 2001 JPCL. *It was slightly updated for this issue by* JPCL *Technical Editor Brian Goldie.*

Edge failure on stiffener that was not stripe coated

Edge failure evident on yellow angle

painted surface, and the result can be early corrosion failure in these areas. This can become a critical issue when the paint is failing on the nuts, bolts, rivets, and welds, because these are the items holding the structural pieces together.

The benefits of striping are two-fold. First, it tends to fill in small voids, laps, and irregularities in the substrate (such as porosity in welds). Second, if allowed to cure to the point of tackiness, striping tends to retard the next full coat of paint material from flowing away from edges.

High-solids paints are less prone to thinning at edges than low-solids paints because they generally have faster setting time, higher viscosity, and lower surface tension.

At one time, most structural steel painting work was done with low-solids, relatively slow-curing, oil-based (alkyd) materials. The fact that the industry has moved toward the use of faster setting, higher solids coating materials, which exhibit less tendency to flow away from edges after application, does not mean that stripe coating is not necessary.

The corrosiveness of the environment will often determine whether stripe coatings are needed. Stripe coating is often consid-

ered most cost-effective in highly corrosive environments such as the insides of tanks and marine or chemical exposures. In moderately corrosive environments such as those frequently wet by fresh water, coating choice and good control of the application without stripe coating may be adequate to protect the structure cost-effectively. In mild environments such as those with low humidity or indoors, striping is not necessary.

Stripe Coating Techniques

Since the original ATB on stripe coating was published in 2001, SSPC has issued SSPC-PA Guide 11, Guide to Protection of Edges, Crevices, and Irregular Surfaces. Published in 2008, the guide discusses the reasons for employing extra corrosion protection measures on edges, corners, crevices, bolt heads, welds, and other irregular steel surfaces, as well as various protection options such as edge grinding, chamfering, and application of stripe coats. Some details, including the advantages and limitations of specific methods of obtaining additional coating thickness by stripe coating, are described to assist the specification writer in assuring that the project specification will address adequate corrosion protection.

While Guide 11 should be consulted for projects that may include stripe coating application, each specifier and paint applicator must interpret the necessity, means, and methods for stripe coating for each individual project.

Therefore, the following information is provided for the reader, based on the author's experiences and interaction with various paint manufacturers, specifiers, and applicators. This information is not meant to be comprehensive; for more specific questions on stripe coating application, you should refer to Guide 11.

When Should Stripe Coating be Specified?

Stripe coating should be specified when the history of the structure indicates that edge failure of the paint system has been a problem. Consideration also should be given to specifying stripe coating in a severely corrosive environment, or if the paint manufacturer recommends stripe coating.

Is Stripe Coating an Additional Coat of Paint?

Owners and contractors have disagreed about whether stripe coating is an additional coat of paint. That depends on what the specification says. The need to cover a blast cleaned surface is paramount in corrosive environments. Therefore, the logical course is to

apply the stripe coating after the primer. In this case, the stripe coating is clearly an extra step. On the other hand, in moderate environments or if there are not a lot of edges, it may be possible to apply the stripe coat just prior to the full primer. Then the contractor may have workers applying the stripe coat in front of workers applying the primer, and both of them using paint from the same cans. This process would not necessarily be considered an extra step.

Which Generic Paints Warrant Consideration of Stripe Coating?

For the most part, low-solids/low-viscosity paints (such as alkyds) tend to benefit from stripe coating. In general, fast-setting paints (such as inorganic zincs) and high-solids/high-viscosity paints (such as epoxy mastics) do not draw away from edges. However, striping does apply additional coating thickness to edges that might not have received enough paint originally.

Which Coating Layers Warrant Stripe Coating?

Keeping in mind that the primary benefit of stripe coating is compensation for possible reduced coating thickness at sharp edges and irregularities in the substrate, it is reasonable to conclude that only the primer should be striped. After application of the primer, substrate irregularities are covered.

Applying stripe coats to all layers of paint can cause more harm than good. Too much paint increases stresses in a coating film, thereby causing cracking or peeling. The tendency of liquid paint to pull away from edges is reduced once a layer of primer has been applied. It is quite common to measure 750 micrometers (30 mils) of paint or more on a surface near edges where a three-coat system of 300–450 micrometers (12–18 mils) was specified with stripe coating of all three layers.

Should Stripe Coating Be Applied Before or After the Full Coat of Primer?

If a high degree of surface cleanliness is specified, such as SSPC-SP 10/NACE No. 2, Near-White Blast Cleaning (the equivalent of Sa 2½ in ISO 8501-1), the applicator has only a short period of time, depending upon atmospheric conditions, to prime the steel substrate before flash rusting occurs. To preclude flash rusting, the entire substrate probably should be primed first and the stripe coating applied later. The stripe coat should then be tinted so that it is obvious where the stripe coat was applied and if any areas were missed.

Is Thinning Required for the Striping Material?

If stripe coating with a particular paint material is specified, the application data sheet should be consulted for thinning instructions for the application method selected. For instance, if the stripe coat is to be applied by brush, the thinning instructions for brush application should be followed. No extra thinning should be done. Too much solvent in the paint, especially when the stripe coat is applied before the primer, will require more time for the stripe coating to become tacky. Solvent entrapment, bubbling, or pinholing can occur.

Should a Thickness Be Specified for a Stripe Coat?

Since irregular surfaces are one of the places stripe coating is used, it may be difficult or impossible to get an accurate dry film thickness reading. Nevertheless, it is important to remember that if total dry film thickness is exceeded by applying both a stripe coat and a full coat, then film defects may result. To achieve a stripe coat that is not excessively thick, the specifier may require that the paint be applied to produce a visual color change on the affected areas and not specify a particular wet or dry film thickness. It should be noted that only a portion of the paint applied directly to an edge flows away, so only a small amount of additional paint is needed to bring the coating on an edge to the same thickness as on flat surfaces.

What Application Methods Should Be Used for Stripe Coating?

The specifier and applicator must first examine the required qualities of the stripe coating to determine the optimum method of application. In general, the required qualities of stripe coating are

- filling voids and other irregularities in the affected substrate areas;
- providing a tacky surface for subsequently applied full coats of paint to adhere to; and
- not exceeding the optimum dry film thickness for the stripe coat in combination with the full coat.

Two application methods meet the requirements of these three qualities: brushing and spraying with conventional or air-assisted airless equipment. The specifier should permit all of these application methods for stripe coating, depending on specific job conditions. For instance, brushing can be used for stripe coating of small, complex shapes (such as lattice members and bolted connections), whereas conventional spraying is appropriate for the edges of large structural shapes.

Application methods that can deposit relatively high volumes of paint (e.g., rolling with a heavy nap roller or airless spraying) should be avoided to prevent excessive dry film thickness and possible film defects. (This assumes that the stripe coating or full layer of primer is being applied while the underlying material is still tacky. More latitude in application methods can be allowed if a full layer of primer is applied and allowed to cure until its dry-to-recoat time. Then, the stripe coating can be thought of as an additional coat of paint being applied to the primer.)

Edge Retentive Coatings

You have probably also heard of edge retention coatings, which claim to have an edge coating thickness similar to that of a nearby flat plate. The question you're asking is, can I use one of these coatings, or do I still need to carry out stripe coating?

The answer is simple—stripe coating still needs to be carried out, as it serves more than one purpose. In addition to increasing the film thickness at the edge of plates or beams, stripe coating carried out by brush is better at "wetting" the surface and forcing the paint into cracks and crevices, over weld beads and bold heads, and other areas which are subject to premature failure.

Conclusion

Striping or stripe coating is used to extend the life of certain paint systems in corrosive environments. It compensates for liquid coatings that flow away from edges of steel structures, thus reducing the dry film thickness. For stripe coating to be beneficial and cost-effective, the specifier must consider the configuration of the structure to be painted and the type of paint system to be applied. Stripe coating should be limited to one coat of paint to avoid overly thick coating systems. Proper stripe coating application is needed to avoid defects in the paint film that can cause other problems besides early rusting, for which the stripe coating was applied.

References

1. SSPC Protective Coatings Glossary (Pittsburgh, PA, USA: SSPC: The Society for Protective Coatings, 2011), p. 201.
2. "SSPC-PA 1, Shop, Field, and Maintenance Painting of Steel" (Pittsburgh, PA, USA: SSPC: The Society for Protective Coatings, April 2000), p. 13.

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Bolted steel bridge connections. All photos courtesy of KTA-Tator, Inc.

Understanding Slip Coefficient and Tension Creep Testing of Coatings Used in Slip-Critical Bolted Connections

By William D. Corbett, PCS,
and Carly M. McGee, PCS
KTA-Tator, Inc.

Bridges, buildings, and other structures commonly include designed bolted connections of steel beams, girders, and other structural members using connection/splice plates of various sizes and configurations. High-strength bolts are used to secure the connections. The holes in the steel members and the connection/splice plates are larger (typically $\frac{1}{16}$–$\frac{1}{8}$ of an inch larger) than the bolt shafts to enable the bolts to be inserted and tensioned against the washers and nuts. The interface of the connection/splice and the structural member is called a faying surface. Faying surfaces are not required to be coated, but are often protected to prevent corrosion at the interface and rust bleed on coated surfaces adjacent to the connection. When a designer elects to coat the faying surfaces, the coating used on these surfaces must have slip-resistant properties to reduce fatigue on the connection during loading/unloading cycles (e.g., vehicles traveling across a bridge deck). Therefore, before use, the coatings specified for these faying surfaces must be tested and classified for slip coefficient properties. Once the classified coating is applied, the connection points are masked to prevent subsequent coats from inadvertently contacting these areas.

There is no stipulation for specific coating types that must be used in these bolted connections, although zinc-rich primers are common and typically have slip resistance properties. Other generic coating types, including polyamide epoxy primers, have been tested and used. Other products, such as thermal spray coatings (various alloys, with and/or without a sealer) and roughened hot dip galvanized steel may be viable candidates, provided they have been tested and demonstrate slip-resistant properties.

The American Institute of Steel Construction (AISC) and the Research Council on Structural Connections (RCSC) publish the Specification for Structural Joints Using High Strength Bolts. The specification comprises ten sections, which only minimally address testing of coatings used in bolted joints. However, Appendix A, "Testing Method to Determine the Slip Coefficient for Coatings Used in Bolted Joints" contains four sections relating to coating testing (General Provisions; Test Plates and Coating of the Specimens; Slip Tests; and Tension Creep Tests). The focus of this article is on the testing required in Appendix A.

Essential Variables

Section A1.2 of Appendix A defines Essential Variables, which if changed, will require retesting of the coating to determine its mean slip coefficient. The Essential Variables are not dictated by the specification; rather, they are to be established by the coating manufacturer before testing. There are four Essential Variables, including the cure time (the time interval between coating application and testing), which establishes the minimum curing time prior to field assembly of the joint; any special curing procedures (when they are different from the Product Data Sheet); maximum coating thickness as measured according to SSPC-PA 2, Procedure for Determining Conformance to Dry Coating Thickness Requirements; and the composition of the coating, including the method of manufacture and the type and amount of thinner (if any) to be used.

Appendix A does not provide a tolerance for coating thickness but states only that 2 mils must be added to the coating manufacturer's maximum thickness (to ensure that a casual buildup of the coating due to overspray and other causes does not jeopardize the coating's performance). If the maximum thickness is 4 mils, the test thickness is 6 mils. However, applying exactly 4 mils of coating to a roughened surface in the shop/field (or 6 mils in the laboratory) is essentially impossible. Therefore, a reasonable thickness tolerance should be established before testing. For example, Section 9.1 of SSPC-PA 2 (2012) states, "A minimum and a maximum thickness are normally specified for each layer of coating. If a single thickness value is specified and the coating manufacturer does not provide a recommended range of thickness, then the minimum and maximum thickness for each coating layer shall be +/- 20% of the stated value." In this case, the tolerance on 6 mils would be 4.8–7.2 mils. If +/- 20% is too wide of a range, then +/- 1 mil may be a reasonable compromise. The test report should indicate the average thickness of the coating applied to each test specimen.

While the method of application is not listed as an Essential Variable, Section A2.2 (Specimen Coating) states that the coatings are to be applied to the test specimens by the same method to be used on the structure itself.

Correction of Coating Thickness Deficiencies

When coatings are applied in the shop or field and the measured dry film thickness is less than specified, it is a common practice to apply a build-up coat (within the manufacturer's recoat interval) to achieve the specified film thickness. Conversely, if a coating is applied too thick, sanding or screening is used to reduce the applied thickness, or the thickness is not corrected and the excessive thickness is accepted by the facility owner after coating manufacturer's approval. These corrective practices (sanding/screening) alter the surface of the coating or present a potentially weakened interface (build-up coat) and should not be performed on faying surfaces either in the laboratory for testing or in the shop/field during actual application. Therefore, if thickness deficiencies are found in the faying surface areas, the coating should be removed and reapplied to the correct thickness. The RCSC Standard does not currently address this potential issue.

Test Plate Design and Surface Preparation

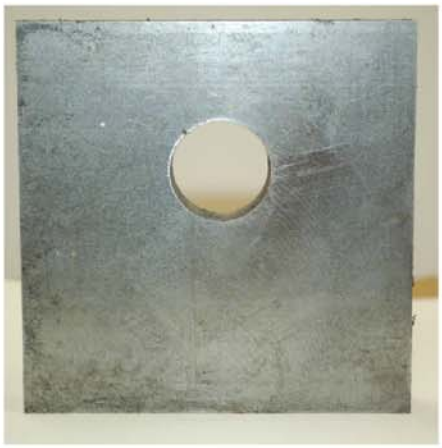
There are two test plate designs described in Appendix A, including a Slip Test Plate and a Tension Creep Plate.

The Slip Test Plate is fabricated from steel with a yield strength of 36–50 ksi (or 36,000–50,000 psi). The plates measure 4 x 4 x $\frac{5}{8}$-in. and contain a 1-in. (± $\frac{1}{16}$-in.) diameter hole centered 1$\frac{1}{2}$-in. from one edge. The top and bottom edges must be milled flat, and surfaces of the plates must be flat enough to ensure reasonably full contact over the faying surface. No burrs or other defects are permitted (Figs. 1 and 2).

The Tension Creep Test Plate is fabricated from the same type and strength steel; however, the plates are larger (4 x 7 x $\frac{5}{8}$-in.) and contain two 1 in. (± $\frac{1}{16}$-in.) diameter holes centered 1$\frac{1}{2}$-in. from both 4-in. edges. The top and bottom edges are not required to be milled flat; however, the surfaces of the plates must be flat enough to ensure reasonably full contact over the faying surface. As was the case with the Slip Test Plates, no burrs or other defects are permitted (Fig. 3).

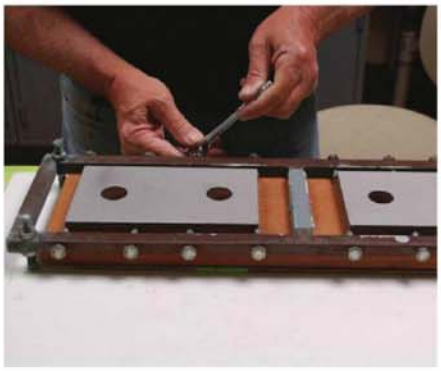
Before mechanical methods of surface preparation, the surfaces are solvent cleaned in accordance with SSPC-SP 1 to remove grease, oil, or other fabrication lubricants. The faying surfaces are subsequently blast cleaned to the required surface profile depth (e.g., 2–3.5 mils). Details related to surface preparation are undefined by the RCSC specification but must be reported by the testing laboratory. The edges of the test plates and the holes are not prepared by mechanical means, nor are they coated.

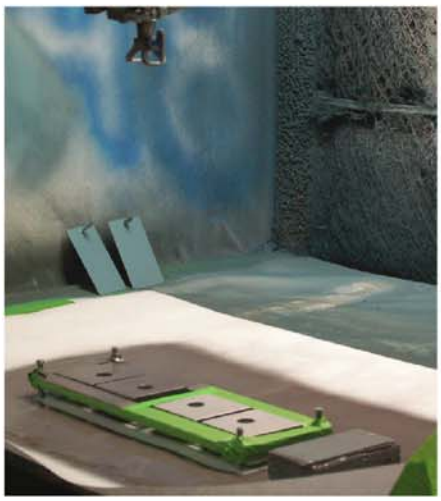
(left) Fig. 1: Slip Test Plate (front view). The hole has been deburred.
(bottom) Fig. 2: Slip Test Plate (end view). The edge has been milled flat.
(right) Fig. 3: Tension Creep Test Plate (front view). The holes have been deburred.

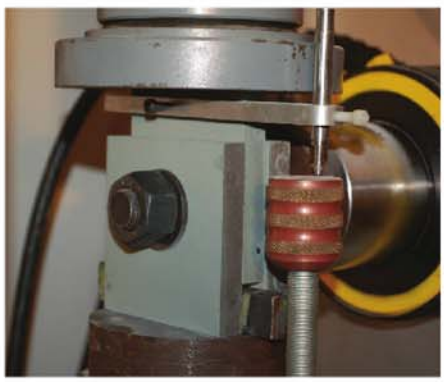


Test Plate Mounting, Coating Application, and Curing Procedures

The procedures for mounting and securing the test plates are not prescribed by the RCSC specification. However, the test surfaces must be free of surface defects so handling the freshly coated plates is problematic. Therefore special racks or trays can be used to hold the test plates in place horizontally (using compression fit along the non-milled edges) so that the faces can be sprayed and cured horizontally (and without handling), in order to prevent runs, sags and defects in the applied film (Figs. 4 and 5, p. 28). Applying the coatings to test plates mounted horizontally is especially important because the specification requires the addition of 2 dry mils to the coating manufacturer's maximum thickness (which may exceed the sag resistance thickness for a given coating). Fifteen slip test plates and nine tension creep test plates are required for testing.







(from top) Fig. 4: Mounting of tension creep plates in rack/tray
Fig. 5: Slip test plates mounted in rack/tray
Fig. 6: Application of coating to mounted test plates using semi-automated spray arm and an auto-airless spray gun
Fig. 7: Loading of assembly onto 7/8-in threaded rod

Tables 1 and 2: Slip Coefficient Calculation Sample Data

Result 1	Result 2	Result 3	Result 4	Result 5	Mean
57,028	56,626	55,118	57,028	56,276	56,415

Note: Values are "Slip Load" in pounds of force

Result 1	Result 2	Result 3	Result 4	Result 5	Mean
0.58	0.58	0.56	0.58	0.57	0.58

Note: Values are k_s or Slip Coefficient

Coating materials are applied (Fig. 6) and cured according to the manufacturer's written instructions, adding thinner if required by the manufacturer. The type and amount of thinner added is an Essential Variable and must be reported on the Certificate of Testing (described later). The batch/lot numbers of the coating components and thinner are also recorded and listed on the test certificate. An owner/specifier may require specific curing conditions (air temperature, humidity, and time). Conditions should be monitored throughout the curing period using a recording hygrothermograph or a digital psychrometer.

Coating Thickness Measurement and Selection of Contact Surfaces

Coating thickness is measured according to SSPC-PA 2. The average of the measurements for each contact surface is recorded and reported. Contact test surfaces with conforming coating thickness values (and with similar average thickness values) are selected.

Test Assemblies

A Slip Coefficient test assembly consists of three test plates: a center plate with two contact surfaces and two outside test plates with one test surface each. Five replicate assemblies must be tested. A Tension Creep test assembly is similar, but only three replicate assemblies must be tested.

Slip Coefficient Test Procedure

Once the mating surfaces are selected (based on similar average coating thickness values), the test plates are loaded onto a 7/8-in. threaded rod located in the center of a horizontal load cell (Fig. 7). The center test plate is inverted 180 degrees as it is loaded onto the rod so that the edge of the plate is higher than the two end plates. This is the plate that receives the vertical load during testing. A clamping force of 49 ± 0.5 kips (49,000 ± 500 lbf, or pounds of force) is applied to the test assembly using a horizontal calibrated ram operated using hydraulic pressure, or a ram in conjunction with a load cell. This load is maintained throughout the testing process and is monitored using a digital readout (Fig. 8, p. 30).

Once the clamping force is applied, the vertical load cell platen is lowered so that it contacts the top (milled) edge of the center test plate. After 1 kip (1,000 lbf) of load is applied to the vertical platen, slip deflection monitoring gages are attached and engaged. The vertical compression load is applied at a rate less than or equal to 25 kips/minute (or a maximum of 0.003 in. of slip displacement per minute). Each assembly takes 10–15 minutes to mount and test.

The test is terminated when 0.05 in. of slip (or greater) occurs. The slip displacement is displayed digitally and is monitored and recorded on an X-Y plotter. Typical slip responses are illustrated in the RCSC specification (Fig. 9, p. 30).

Slip Coefficient Calculation

The mean slip coefficient (k_s) is calculated as

$$k_s = \frac{\text{slip load}}{\text{2x Clamping Force}}$$

Sample data for the slip coefficient calcuation is shown in Tables 1 and 2 (p. 28).

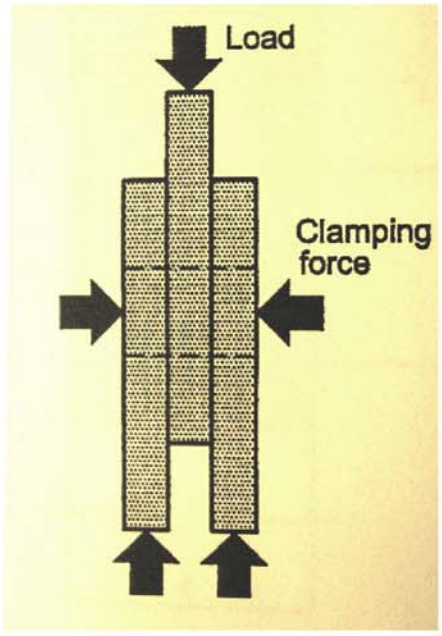
Tension Creep Test Procedure

The second phase of the testing, the tension creep test, is undertaken, provided the slip coefficient testing produces acceptable results. This test is longer (1,000 hours or six weeks) than the slip coefficient test, which takes only a couple of hours. For this phase, a "chain" of nine 4 x 7-in. test plates is assembled using A490 bolts (Fig. 10, p. 32). Once assembled, the chain is suspended from the tension creep frame, and the vertical load is applied and monitored using a load cell. The applied load is based on the specified minimum bolt pretension and the slip coefficient class established by testing (A, B or C). For example, 25.9 kips load is applied for Class A slip coefficient using A490 bolts, while 39.2 kips load is applied for Class B slip coefficient using A490 bolts. Once the prescribed tension is applied, the chain of test plates is locked in place using a large nut. This tension is maintained throughout the test period.

Movement (creep) is monitored by micrometers, which are set to "0" within 30 minutes of applying the load. The load is maintained for 42 days (1,000 hours). Any displacement (revealed by movement from the "0" position on the micrometers) is recorded.

Three replicate assemblies are tested concurrently. No single assembly can exceed 0.005 in. of displacement. After 1,000 hours, the load is again increased to the design slip multiplied by 2x the average clamping force. Once this final load is applied, the average creep displacement cannot exceed 0.015 in. for all three assem-

Fig. 8: Electronic displays of clamping force and slip deflection



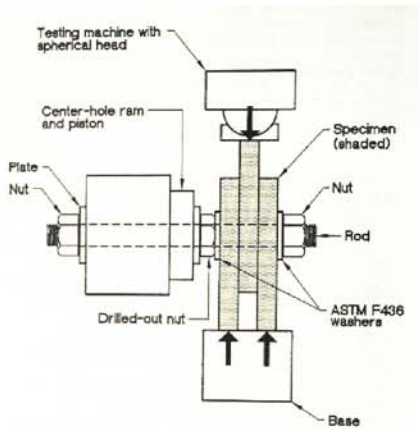


Fig. 9: Slip coefficient test in process. Figures illustrate the simultaneous application of the clamping force and the vertical load to the center (inverted) test plate. Illustrations are from the RCSC specification.

blies. Table 3 shows sample data for tension creep testing.

Once the slip coefficient and tension creep testing is complete (and the coating passes both tests), the coating is classified. According to the RCSC specification, the mean slip coefficient (μ) can be categorized as Class A, B, or C. A "Class A" slip coefficient is 0.33 minimum (uncoated, clean mill scale or coatings on abrasive blast cleaned steel); a "Class B" slip coefficient is 0.50 minimum (uncoated, abrasive blast cleaned steel or coatings on abrasive blast cleaned steel); and a "Class C" slip coefficient is 0.35 minimum (roughened, hot-dip galvanized surfaces). Note that ANSI/AISC Specification 360-10, Specification for Structural Steel Buildings, lists 0.30 slip coefficient for Class A as opposed to 0.33.

A Certificate of Testing accompanies the test report. The certificate lists

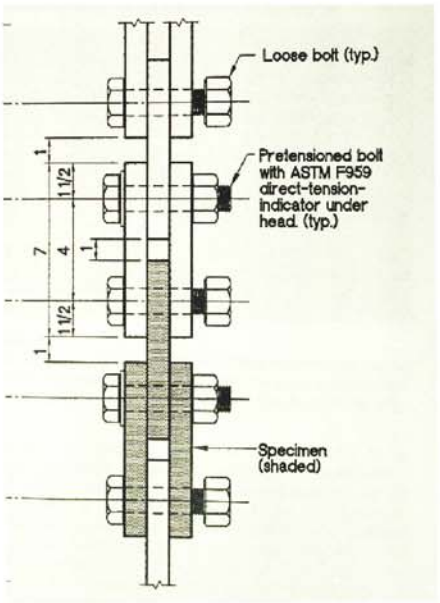
- the product manufacturer and name/no.;
- the Class achieved (A, B, or C);
- the batch numbers of the components and thinner (if used);
- the minimum cure time prior to bolt-up;
- the curing conditions of air temperature and humidity;
- the maximum dry film thickness;
- the type and amount of thinner used (if any); and
- the test period and the actual slip coefficient value.

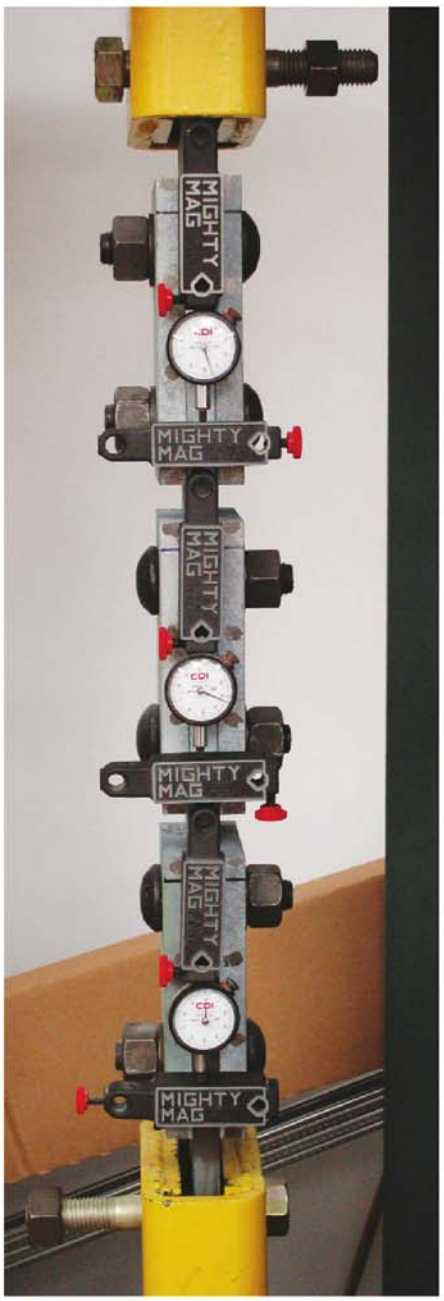
The test certificate is very important because it lists the Essential Variables under which the product was tested and classified. The certificate should be a required submittal from the coating manufacturer that has been selected to provide coatings for a project. Further, the product should be applied to the faying surfaces in the shop/field in conformance to the listed Essential Variables.

Note that surface preparation (cleanliness and profile depth/shape) is not listed on the test certificate (they are not considered Essential Variables by the RCSC specifica-

Table 3: Tension Creep Testing Sample Data

	Assembly 1	Assembly 2	Assembly 3
Initial Micrometer Reading	0	0	0
Final Micrometer Reading	0.00175"	0.0015"	0.0009"
Creep Displacement	0.00175"	0.0015"	0.0009"
Average Displacement		0.00098"	





(top left) Fig. 10: Illustration from Appendix A of the RCSC specification showing the tension creep chain assembly
(above right) Tension creep test in progress
(bottom left) Close-up of micrometer and magnets attached to assembly

tion), and the minimum dry film thickness is not listed (only the maximum). The minimum may be established by the coating manufacturer on the product data sheet.

Other Considerations

Although the testing and data management procedures are fairly well defined in Appendix A of the RCSC specification, there is a need for coatings industry research relating to the test plate preparation and coating procedures. The potential research initiatives include:

1. What is the effect (if any) of surface profile shape on the slip coefficient properties of coatings?

The shape of the surface profile generated by abrasive blast cleaning operations can be angular or rounded, depending on the shape of the abrasive used. Steel fabrication shops typically use steel shot or a blend of steel grit and shot. Field contractors typically use angular abrasives (mineral/slag or recyclable steel grit). The resulting shape of the surface profile influences the surface area of the steel. (Angular abrasives produce a denser peak/valley pattern than shot abrasive, which results in increased surface area.) It is unknown whether the texture of the steel surface influences the slip coefficient properties of the applied coating. Surface profile shape is not currently considered an Essential Variable in the RCSC standard. Note that AASHTO R31, Evaluation of Protective Coating Systems For Structural Steel, requires the use of 100% steel shot (S280) for the test "selected to create a worst-case scenario," which suggests that the surface texture may influence the slip coefficient properties.

2. What is the effect (if any) of surface profile depth on the slip coefficient properties of coatings?

The depth of the surface profile can range from <1 mil to five to six mils, depending on the abrasive size, hardness of the steel surface, and other influences. The surface profile depth is typically based on the thickness of the coating to be applied and is typically expressed as a range. While some specifications may invoke a one- to two-mil surface profile, others may invoke a three- to four-mil surface profile. It is unknown whether the depth of the surface profile influences the slip coefficient properties of the applied coating. Surface profile depth is not currently considered an Essential Variable in the RCSC standard.

3. Is there a difference in slip coefficient properties when a coating is tested over a surface that has been power tool cleaned (i.e., SSPC-SP 11 or SP 15) versus abrasive blast cleaned?

Maintenance of existing bridge structures may include replacement of connection plates. Power tool cleaning of the bridge beam connection areas is sometimes permitted to eliminate the need to mobilize abrasive blast cleaning equipment and to contain as well as properly manage a waste stream for preparation of relatively small areas. These areas may be prepared to SSPC-SP 11, Power Tool Cleaning to Bare Metal, or SSPC-SP 15, Commercial Grade Power Tool Cleaning, which allows up to 33% staining on the prepared surfaces. Both standards invoke a minimum one-mil surface profile; they do not invoke a maximum surface profile depth. The new connection plates coming from a steel fabrication shop are typically abrasive blast cleaned and primed. Accordingly, there is a potential to mate faying surfaces having two different surface textures (surface profile depth and shape). It

is unknown whether these differences influence the slip coefficient properties of the applied coating. The method of surface preparation and the degree of cleanliness are not currently considered Essential Variables in the RCSC standard.

4. Is there a curing "window" (both a minimum and a maximum set time prior to bolt-up)?

The minimum cure time, established by the coating manufacturer, is considered an Essential Variable and is listed on the Test Certificate. It is not dictated by the Standard. Organic zinc-rich primers contain an organic binder (most commonly epoxy or urethane), which can become harder over time. It is unknown whether an extended cure time prior to bolt-up (e.g., one month) influences the slip coefficient properties of the bolted connection.

5. What is the effect of using a different type of thinner (acceptable for use by the coating manufacturer) on the slip coefficient properties?

The type of thinner used to reduce the coating is considered an Essential Variable and is listed on the Test Certificate. However coating manufacturers often list more than one type of thinner that is compatible with the coating. The reasons for listing multiple thinners vary, but generally are due to different application conditions ("normal" versus "hot/windy") and environmental regulations (thinners containing exempt solvents for use in certain areas of the country). Does a coating manufacturer need multiple Test Certificates for a single coating to cover all acceptable thinners, so that the appropriate thinner can be used at the time of application? That is, it is unknown whether the type of thinner used for reduction has an effect on the performance properties of the coating (given that the thinner is compatible with the coating).

6. What is the effect of using lesser or greater amounts of thinner?

The amount of thinner used to reduce the coating is considered an Essential Variable and is listed on the Test Certificate. Thinner amounts are established by the coating manufacturer. Coating manufacturers often list a maximum amount of thinner that is acceptable for use (e.g., up to 10%) and the amount may vary depending on application method and prevailing conditions of temperature, humidity and wind. Does a coating manufacturer need multiple Test Certificates for a single coating to cover various amounts of thinner (up to the maximum allowable amount), so that the appropriate amount thinner can be used at the time of

application? That is, if "up to 10%" thinner (reducer) is permitted by the coating manufacturer and the coating is tested using 5% reducer, but 10% is used in the shop or field due to prevailing conditions, it is unknown whether the slip coefficient properties of the coating are affected by the variation in reducer amounts.

7. Five replicate assemblies are tested for slip coefficient and then averaged to generate a single slip coefficient value. Is there an acceptable standard deviation between the replicate trials? That is, what determines an "outlier"?

Occasionally, one of five replicate tests generates a slip coefficient value that is considerably different than the other four. However, the RCSC standard does not address standard deviation between test results, only that the five replicates are averaged. Accordingly, a low slip coefficient value (on one of the five replicates) could result in a Class B rating dropping to a Class A rating, or even non-classification. ASTM Standard Test Methods (methods that produce a value) are required to have precision and bias statements prepared based on interlaboratory studies that generate repeatability and reproducibility data. ASTM Subcommittee D01.46, Industrial Protective Coatings, has expressed interest in creating a Work Item and subsequently drafting and balloting a test method for slip coefficient and tension creep testing, which would address the repeatability concern. However, there are a very limited number of laboratories that are equipped to perform this test, so conducting a statistically valid study is challenging.

8. Mating of Dissimilar Coatings

Traditional slip coefficient testing mates the same coating on the faying surfaces. In some cases, there may be a need to obtain Class A or B slip coefficient certifications for an inorganic zinc primer (applied to new connection/splice plates in a shop and shipped to the field) to a field-applied organic zinc primer (on existing steel during maintenance of a bridge structure) that may have different thickness requirements. A project engineer should realize that coating manufacturers may not have this test data on hand, and that testing and certification can take two or more months to generate. Coordination with the shop (requiring them to apply the same product as the field contractor will use) will alleviate this issue, provided coating thickness is addressed.

About the Authors

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JPCL

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The demand for enhanced productivity, cost reduction, fast throughput, and optimization of life cycle costs associated with high-performance lining applications is often met using two-component, solvent-free polyurethane, polyurea, and polyurethane/polyurea hybrids.[1-3] Moreover, these thermoset technologies can readily comply with today's stringent environmental regulations, as exemplified by their low- or zero-VOC content and absence of oxygen-depleting substances (ODSs).

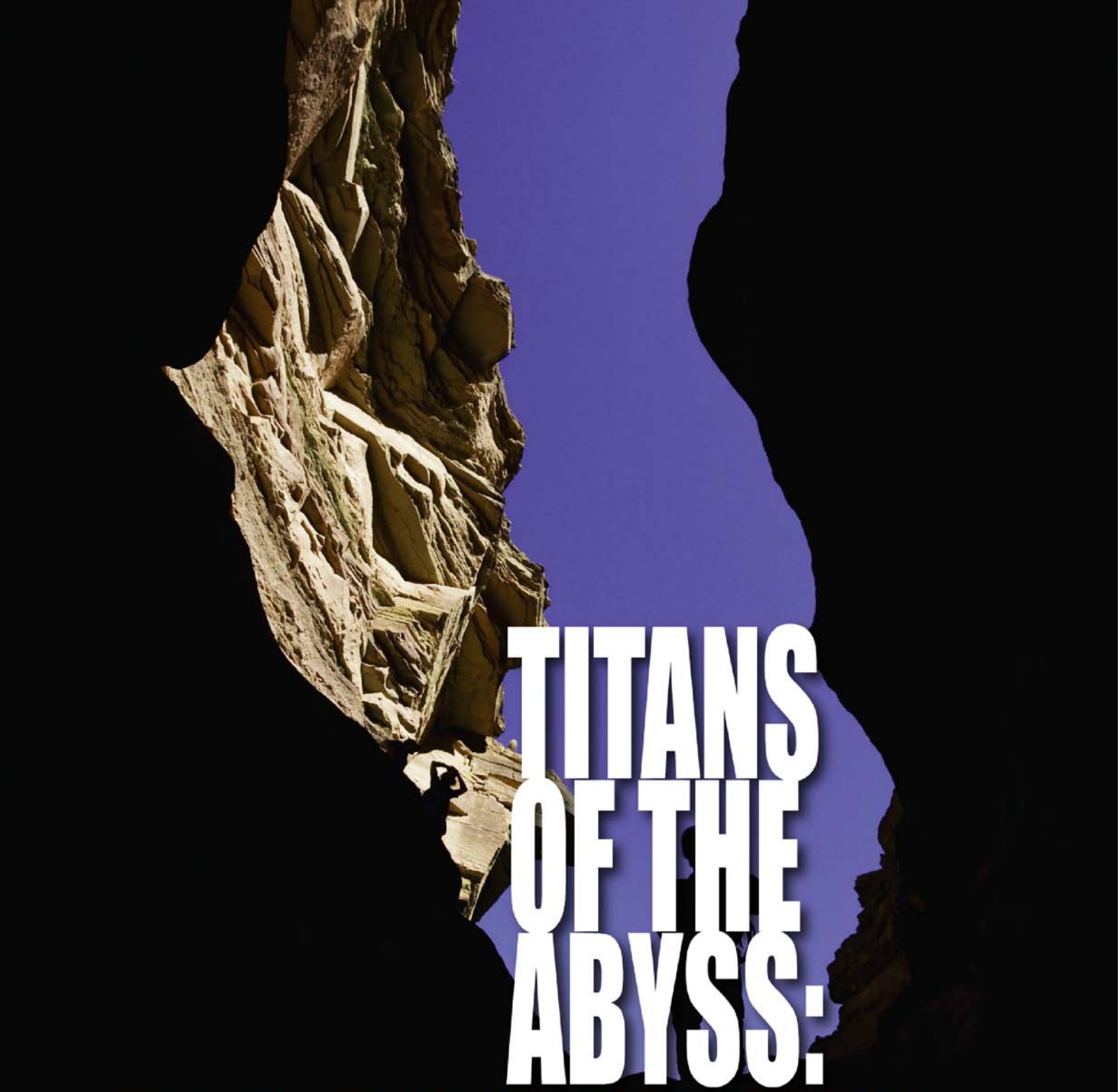
The genesis of polyurethanes hails back to the pioneering work on isocyanates by Otto Bayer in 1937. As a result of Bayer's work, thin-film polyurethane finish coats later became for decades the de facto finish coat of choice on structural steel. It was not until the early 1980s when thick-film and single-coat solvent-free aromatic polyurethane *linings* were formulated for use on girth welds, valves, and pipe. By the mid-1980s, advanced versions of these polyurethane linings were being used on large-scale pipe rehabilitation projects in Western Canada.[4] Then, by the late 1980s, an innovative generic class of thick-film and single-coat solvent-free coatings and linings emerged on the scene—polyureas.[5–7] Like their fast-reacting and fast-curing polyurethane predecessors, the even faster gel time and cure time of the polyureas necessitated that these linings be applied by plural-component spray equipment.

In the early 1990s, further advances led to new and improved polyurethane and polyurea linings in which properties could be customized. Later, various hybrids of both technologies were developed and touted by some to have a combination of the best properties of multiple technologies.[8] Interestingly, many of today's so-called polyurethanes are actually hybrids, and the implied terminology distinctions among polyurethane, polyurea, and polyurethane/polyurea hybrid descriptions has become somewhat blurred.[9] For example, a coating may be described as a polyurethane, but it is actually a hybrid.

This article will focus primarily on very fast-cure, solvent-free polyurethanes, polyureas, and polyurethane/polyurea hybrid technologies, many of which are well-suited to immersion service: the veritable Titans of the Abyss.

The chemistry, cure mechanism, safety aspects, strengths, and weaknesses of each technology will be discussed. Case histories will be provided for each technology.

In today's fast-track lining projects, the gel time and cure time of a given lining might vary from a few seconds to a few hours. Coating formulators and polymer



TITANS OF THE ABYSS:

POLYURETHANE, POLYUREA, AND HYBRID LINING TECHNOLOGY

chemists can utilize these technologies to carefully tailor elastomeric or high-tensile strength rigid linings for specific tank and pipe internals or externals. Depending on the chemistry of a polyurethane, polyurea, or hybrid, the applications for these linings are diverse.

Examples of applications include the following:

- penstocks, riveted and welded;
- potable water processing, transportation, and storage;
- aquariums;
- pipelines exposed to raw sewage and erosion degradation;
- concrete digesters;
- cooling water intakes;
- primary and secondary containment;
- rail cars;
- oilfield pipelines;
- icebreakers (underwater hulls);
- platforms;
- barges;
- syntactic foams for sub-sea projects; and
- food storage.

Each service represents conditions in which one or more factors, such as corrosion and erosion resistance, flexibility, immersion resistance, and wear resistance are important. All three lining technologies have been used on carbon steel, galvanized steel, ductile iron, and concrete substrates.

LINING SELECTION: THE INFLUENCE OF CHEMISTRY IN POLYURETHANE, POLYUREA, AND HYBRIDS

Common to the polyurethane, polyurea, and hybrid linings is the use of an isocyanate component in the cure reaction.[10]

Essentially, the film formation of a polyurethane lining stems from the reaction of isocyanate groups (-NCO) with hydroxyl groups (-OH moieties) in a polyol (Fig. 1). At least one catalyst is normally used to improve the reaction of the isocyanate and hydroxyl groups.

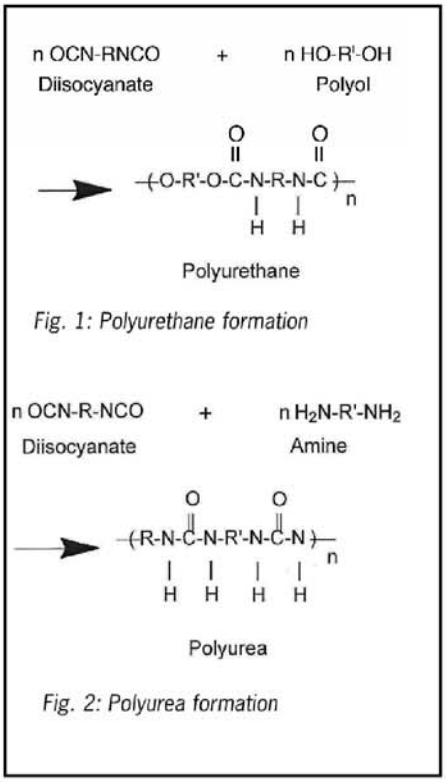


Fig. 1: Polyurethane formation

Fig. 2: Polyurea formation

In contrast, in the film formation of a polyurea lining, the isocyanate groups react with an amine group (e.g., $-NH_2$). A catalyst is not used in this reaction (Fig. 2).

As expected by the term "hybrid," in the film formation of a hybrid lining, both the isocyanate-polyol and isocyanate-amine reactions occur. The reaction rate and concentration of urethane or urea linkages depend on the proportion of polyurethane to polyurea in a given hybrid formulation as well as the usual consideration of stereochemistry of the reaction partners and number of reactive groups. As with polyurethanes, a catalyst is invariably used to control the reaction with hybrids.[11]

Because the reaction rates of water and isocyanates and of polyols and isocyanates are typically within an order of magnitude of one another, it is critical to ensure that water does not contact the isocyanate in a polyurethane lining application. Should water contact the isocyanate, a cross-interference reaction will take place and the polyurethane structure will be compromised. An unstable carbamate will form and decompose to carbon dioxide and an amine (Fig. 3). By way of comparison, the reaction rates of water and isocyanates are many orders of magnitude less than the reaction rates of amines and isocyanates; thus, polyurea and hybrid applications are far less sensitive to moisture.[5]

The chemical, mechanical, and thermal properties of each of these linings depend on the chemical makeup of the raw materials, the type and strength of the chemical bonds, the spatial configuration and steric hindrance of organic substituents on certain atoms, the resultant molecular linkages in the polymer film, and the ultimate ingenuity of the lining formulator.

Although performance in various services can vary markedly, these linings, as a whole, have excellent barrier properties and interpose a high electrical resistance into a corrosion cell circuit.

DEFINITIONS

In terms of chemistry and cure mechanism, a more thorough definition of polyurethane, polyurea, and hybrid technology is available from the Polyurea Development Association.[12]

Polyurethane: "For reference purposes, a polyurethane coating/elastomer is that derived from the reaction product of an isocyanate component and a resin blend component. The isocyanate can be aromatic or aliphatic in nature. It can be a monomer, polymer, or any variant reaction of isocyanates, quasi-prepolymer, or a prepolymer. The prepolymer, or quasi-prepolymer, will be made from hydroxyl-terminated polymer resins.

"The resin blend must be made up of hydroxyl-terminated polymer resins, being diol-, triol-, or multi-hydroxyl polyols, and/or aromatic or aliphatic hydroxyl-terminated chain extenders. The resin blend may also contain additives, or non-primary components. The resin blend will contain catalyst(s) for system reactivity."

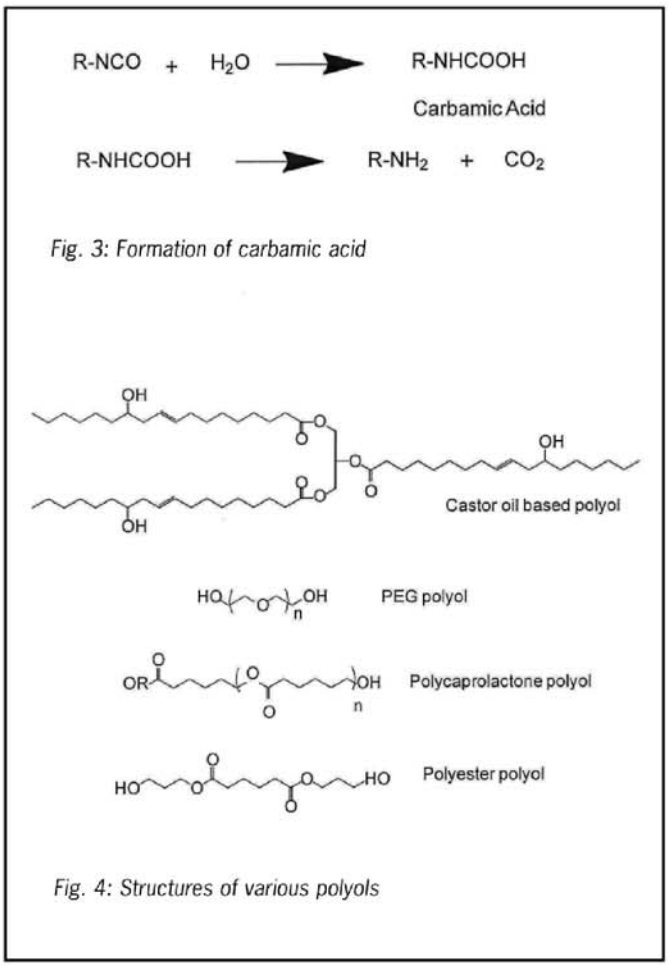


Fig. 3: Formation of carbamic acid

Fig. 4: Structures of various polyols

Polyurea: "A polyurea coating/elastomer is that derived from the reaction product of an isocyanate component (as described for a polyurethane) and a resin blend component. The isocyanate can be aromatic or aliphatic in nature.

"The resin blend must be made up of amine-terminated polymer resins, and/or amine-terminated chain extenders. The amine-terminated polymer resins will not have any intentional hydroxyl moieties. Any hydroxyls are the result of incomplete conversion to the amine-terminated polymer resins. The resin blend may also contain additives, or non-primary components. These additives may contain hydroxyls, such as pre-dispersed pigments in a polyol carrier. Normally, the resin blend will not contain a catalyst(s)."

Hybrid: "For reference purposes, a polyurethane/polyurea hybrid coating/elastomer is the reaction product of an isocyanate component (as above) and a resin blend component.

"The resin blend may be made up of blends of amine-terminated and/or hydroxyl-terminated polymer resins, and/or amine-terminated and/or hydroxyl-terminated chain extenders. The resin blend must

Table 1: Reactions of the Isocyanate Group[2]

Hydrogen Donor	General Structure	Reaction Product	Product Structure	Class
Water	H_2O	+ RNCO	Amines + carbon dioxide (leading to disubstituted urea)	$RNH_2 + H_2O$ (RNHCONNR)
Hydroxyl groups	R^1OH	+ RNCO	Urethanes	$RNHCOOR^1$
Amine groups	R^1NH^2	+ RNCO	Disubstituted ureas	$RNHCONHR^1$
Disubstituted ureas	$R^1NHCONHR^2$	+ RNCO	Substituted biurets	$R^1NHCONR^2CONHR^3$
Urethane	$R^1NHCOOR^2$	+ RNCO	Allophonates	$R^1NHCOHR^2COOR^2$
Carboxylic acids	R^1COOH	+ RNCO	Amides	$RNHCOR^1$

Isocyanates will also react well with the following less common hydrogen donors.

Imino groups	- NH	Sulfonamide groups	$- SO_2NH_2$
Substituted amine groups	- NHR	Sulfonamides	$- SO_2NHR$
Carbonamide groups	$- CONH_2$	Thioamide groups	$- SHNR_2$
Substituted carbonamides	- CONHR	Sulphonic acid groups	$- SO_2OH$
Sulfhydryls	$- R^1SH$		

contain blends of amine-terminated and hydroxyl-terminated moieties. The resin blend may also contain additives, or non-primary components. The resin blend may contain catalyst(s) for system reactivity."

Table 1 shows the reactions of the isocyanate group with various hydrogen donating groups and the resulting structures obtained.[2]

POLYURETHANES: FILM FORMATION

Figure 4 (p. 45) shows structures of polyether and polyester polyols. Some of these polyols may be used to react with an isocyanate component such as straight methylene diisocyanate (MDI) or a quasi-prepolymer derived from MDI itself. Figure 5 (p. 48) shows a typical structure of an isocyanate component used in the film formation of a solvent-free, single-coat aromatic polyurethane lining.

Figure 6 (p. 48) is an oversimplified representation of the micro-structures of polyurethane elastomers and the high-tensile strength, rigid, and hard polyurethane linings. In the polymer network, the polyurethane exhibits a two-phase morphology consisting of soft and hard segments.[13] The soft segment is because of the long-chain, high-molecular weight polyether or polyester polyols, which are relatively non-polar, whereas hard segments consist of the diisocyanate and short-chain, low-molecular weight chain extender(s), which are relatively polar.

The chemical stability and physical characteristics of a polyurethane film are derived from the chemistry of the individual components. Generally, polyester-based polyurethanes are more resistant to oil, grease, solvents, water, UV, ozone, and wear, whereas polyether polyurethanes are more resistant to hydrolysis, low temperature flexing, and microbes/fungus. Tailoring the chemical resistance and physical properties of a given polyurethane system can be accomplished by adjusting the ratio of hard and soft segments and the amount of chemical cross linking. Increasing the hard-segment concentration and cross linking of the system results in

Polyurethane lining in paper mill wastewater treatment clarifier[21] (concrete substrate)

Case History: Paper Mill Wastewater Treatment Clarifier, U.S.

In 1996, a newsprint mill in the U.S. discovered that the concrete structures of its wastewater clarifier, particularly the walls, were experiencing extensive corrosive attack from hydrosulfurous acid, sulphuric acid, and hydrogen sulphide.[21]

The corrosion had resulted in exposed rebar, and aggregate protruded up to a half-inch in certain areas. Approximately 10,000 square feet required refurbishment.

Within 72 hours, the concrete walls and steel center (including rakes) were abrasive blasted and respectively lined with 125 mils' DFT and 60 mils' DFT of a 100%-solids polyurethane lining.

After five years, the clarifier was drained, and the linings were inspected. The linings were found to be completely intact on the entire 10,000 square feet of surface (See photo above and on p. 48).

The rapid productivity associated with this one-coat lining installation, coupled with the outstanding performance in immersion, was lauded by the owner of the facility.

Advantages of Polyurethane Linings

- Rapid productivity in shop and field applications, e.g., pipelines
- Elimination of solvents and compliance with stringent air pollution regulations (VOCs)
- Single coat, high-build applications up to 250 mils (~6,000 microns)
- Formulated in a broad spectrum of cure times—minutes to hours
- Rapid curing even at sub-zero temperatures
- Formulation diversity based on vast selection of polyol and isocyanate raw materials
- Customized water and chemical resistance, flexibility, and impact resistance
- Coated pipes are readily inspected and buried within minutes of application
- Low surface friction—excellent hydraulic characteristics for pipeline internals
- Good cathodic disbondment resistance at temperatures below 50 C
- Can be used with geotextiles
- Abrasion resistance can be superior to AR steel
- Repairable by hand within minutes (kits available)

Disadvantages of Polyurethane Linings

- Moisture sensitivity—susceptibility to thickening, gelation, and foaming
- Relatively low alkali and solvent resistance
- Potential allergic reactions due to any free isocyanate content
- Susceptible to undercutting and peeling when immersed linings are mechanically damaged when not formulated properly for this service
- Poor cathodic disbondment resistance at temperatures above 50 C
- Poor hot water adhesion
- Poor color retention in aromatic polyurethanes with UV exposure

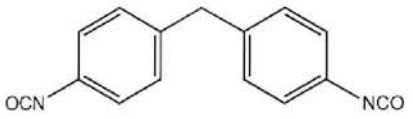


Fig. 5: Structure of isocoyanates (example: MDI methylene diphenylisocyanate)

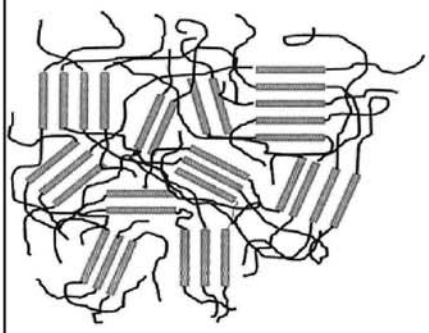


Fig. 6: Two-phase morphology: hard and soft segments in polyurethanes

Polyurethane lining in paper mill wastewater treatment clarifier[21] (steel substrate)

harder polymers that are generally more chemically and hydrolytically stable than soft polymers because the hard segment is hydrophobic and less rapidly attacked.[13,14] Conversely, a high soft-segment concentration and low cross link density will produce a softer, more elastic polyurethane.

When a polyurethane coating is engineered to be an "under cross linked" film (NCO:OH <1), the film typically will be more flexible and less resistant to solvent and chemicals. In comparison, the same system formulated to produce an "over cross linked" film (NCO:OH >1) will yield a harder and more chemical-resistant film.

Aromatic isocyanate groups are far more reactive than aliphatic isocyanate groups in polyisocyanates. Consequently, linings derived from aromatic diisocyanates, for example, dry and cure faster than comparable systems based on aliphatic isocyanates. The high viscosity of the polyol and isocyanate components, in addition to fast set times, necessitate the use of plural-component spray equipment. (However, repair kits of polyurethane linings are available for use on touch-up joints and connections).

A later development to thick-film aromatic polyurethane linings has been the advent of high-solids, aliphatic polyurethane coatings.[15]

In essence, three approaches were used to commercialize high-performance, solvent-free aliphatic polyurethane linings:

- low molecular weight compounds with lower viscosity,
- reactive diluents, and
- new polyurethane prepolymers.

While aliphatic systems are of great interest, less expensive, higher performing aromatic polyurethanes are used for immersion service.

In terms of rapid throughput of lined pipes, for example, in shop applications or pipe rehabilitation projects, the fast-set and rapid-cure characteristics of polyurethane linings are highly advantageous, saving both time and money. (Some advantages and disadvantages of polyurethane linings are listed on p. 48).

POLYUREAS: FILM FORMATION

Typical structures of amine resins are shown in Fig. 7. To form urea linkages, and thus polyurea linings, extremely fast cross linking occurs through the isocyanate/amine-terminated resin (Fig. 2.) According to the PDA, the resulting polymer is termed a "pure polyurea."

Rapid set times of less than one minute and a cure reaction largely unaffected by atmospheric moisture are features synonymous with two-component polyurea linings. Therefore, in terms of time, project costs, and overall productivity, the fast-set and rapid-cure characteristics of polyurea linings are highly advantageous, both in shop applications and field work where quick returns to service are critical.

As with solvent-free polyurethane linings, in the polymer network of a polyurea lining, there is two-phase morphology consisting of soft and hard segments. The isocyanate component is often a quasi-prepolymer derived from MDI. Given that polyurea, polyurethane, and hybrid coatings can have similar structural backbones, it is not surprising that versions of each lining type can exhibit either similar chemical resistance properties or remarkably different chemical resistance properties.

Polyurea lining in wastewater treatment clarifier[26] (concrete substrate)

It cannot be overemphasized that applying polyurea linings over damp surfaces or placing the lining in service prematurely can lead to significant loss of adhesion and early failure of the system.

Because of the fast reactivity of the isocyanate-amine reaction, special spray application equipment may be required that uses impingement mixing, i.e., the base and hardener components are mixed externally at the tip of the spray gun. Not surprisingly, this type of application invariably requires

- a fairly precise matching of base and hardener viscosities;
- heating the components; and
- ensuring the correct pressure at the tip.

Otherwise, mixing is incomplete, and the chemical and physical properties of the polymer are compromised.[16]

The rapid curing characteristics of polyureas can lead to substrate adhesion difficulties because of the limited time that is available for the films to wet the substrate. (Wetting provides an intimate degree of contact between the rapidly gelling resin and the

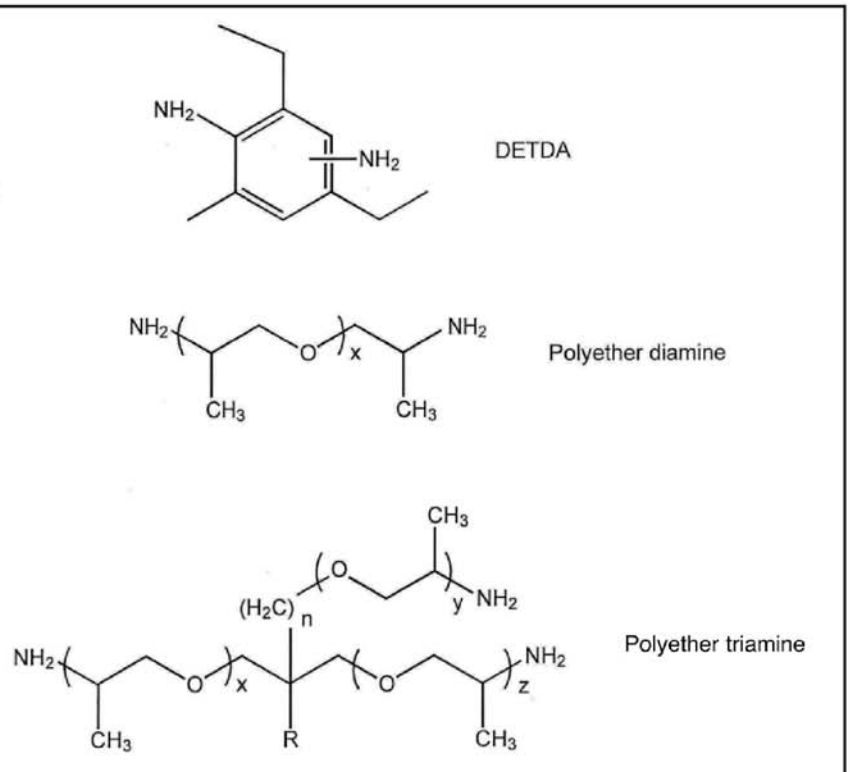


Fig. 7: Structure of amine resin in a polyurea

Advantages of Polyurea Linings

Rapid productivity in shop and field applications
Not sensitive to moisture
Fast setting and faster cure than polyurethanes, e.g., in seconds
Superior to polyurethanes with respect to application under high humidity
Customized water and chemical resistance, flexibility, and impact resistance
Low surface friction—excellent hydraulic characteristics for pipeline internals
Low VOC—compliant with stringent air pollution regulations (VOCs)
Can be applied at sub-zero temperatures
Good elongation/flexibility
High thermal stability under dry conditions

Disadvantages of Polyurea Linings

Poorer wetting out of substrates, due partly to very rapid set times
Potential allergic reactions due to any free isocyanate content
Susceptible to undercutting and peeling when immersed linings are mechanically damaged if not formulated properly for this service
Can be difficult to touch up and repair
Poor hot water adhesion
Relatively low alkali and solvent resistance
Poor color retention in aromatic polyureas subject to UV exposur
Limited raw material options compared to polyurethanes and polyurethane hybrids
Very fast cure properties reduce recoat windows, thereby increasing the risk of layering

substrate.) The limited wetting time can cause difficulties when applying polyureas over concrete, especially if it has been abrasive blasted to remove the cohesively weak, cement-rich outer layer that has developed against the formwork. In areas where the polyurea needs to be terminated, some manufacturers require a set of sawcuts (often two) into the concrete parallel to the intended edge to form a termination notch. These notches are typically about 5–6 mm wide by about 10 mm deep and provide an additional physical anchor.

Polyurea lining in wastewater treatment clarifier[26] (concrete substrate)

Case History: Wastewater Treatment Clarifier, U.S.

The eight year old concrete walls and floor of a primary clarifier in a food processing plant had sustained considerable damage by erosion and chemical attack from a solution of calcium sulphate. The owner was concerned that the concrete was in imminent danger of failure.

Given that an epoxy lining system had been used in the past and had failed in three years, the owner elected to re-line and protect the 22,000 sq ft of damaged concrete with a proprietary polyurea lining system.

All concrete surfaces were abrasive blast cleaned, followed by a spray application of a specialty concrete primer.[27]

A spray applied topcoat of .080 inches polyurea was then applied.

The project was completed in 24 hours and re-watered in two hours (See photo at left and on p. 50).

In addition, the fast reactivity makes touch-up and repair by brush application difficult on small areas. Polyurea coatings must be spray-applied; therefore, tying-in to an existing coating is difficult. Some manufacturers make special repair grades, but these are often heavily modified with diluent resins to achieve sufficient pot life and viscosity for brush application. Unfortunately, the modifications can drastically alter the repair-film properties, including loss of mechanical and chemical resistance.

With a relatively large number of isocyanate and amine components to choose from, the polyurea chemist can formulate elastomer films with various cure speeds and with good flexibility, elongation, and tensile strength properties. Depending on the amine backbone, the films can be formulated with good water resistance properties for immersion service in the wastewater industry. However, the hydrocarbon solvent resistance of polyurea linings (especially to aromatic solvents) is typically poor.

One of the very common challenges with polyureas is their very short recoat windows due to fast cure times. It is common for polyureas to demonstrate layering and poor bonding between coats because of the fast cure times.

As far as temperature resistance is concerned, while the dry temperature resistance of polyurea linings can be up to 150 C, even the most thermally stable polyurea linings will probably not survive hot aqueous immersion environments above 50 C. For oilfield services, pure polyurea products may have limited use due to their poor resistance to polar solvents.

Some of the advantages and disadvantages of polyurea linings are summarized in the chart on p. 51.

HYBRIDS: FILM FORMATION

Customized hybrid linings can be beneficial for owners and applicators. For instance, hybrid linings can be formulated to exhibit significantly harder and better damage resistance than a typical polyurea, while also

Advantages of Hybrid Linings

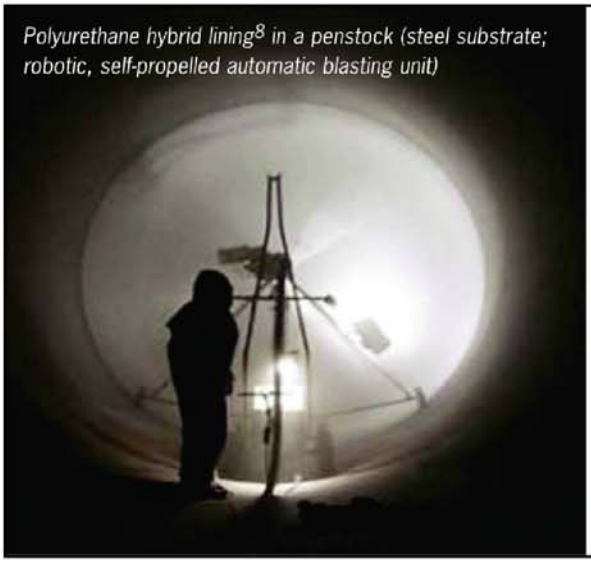
Rapid productivity in shop and field applications
Fast cure and fast return to immersion service within minutes of application
Wider range for reaction time and performance properties
Caustic resistance: 50% at 65 C—superior to polyurethane linings
Customized water and chemical resistance, flexibility and impact resistance
Generally, good cathodic disbondment resistance at temperatures below 50 C
Films are resistant to abrasion, erosion, and impact
Films that are unaffected by normal shrinkage cracks in concrete
Low surface friction that enhance hydraulic characteristics for pipeline internals
Repairable by hand within minutes (kits available).

Disadvantages of Hybrid Linings

Susceptible to undercutting and peeling when immersed linings are mechanically damaged if not formulated properly for this service
Potential allergic reactions due to any free isocyanate content
Poor color retention with UV exposure in hybrids derived from aromatic isocyanates

retaining a linear and somewhat flexible polymeric structure. By virtue of their outstanding barrier properties and elongation features, hybrid linings are well suited to protect the internals of concrete digesters.

Hybrid polyurethane/polyurea linings can be formulated to have the best combination of properties of the two technologies.[8] The hydrophobic character of some of the aromatic polyurethane-polyurea hybrids is very similar to that of high-performance, immersion-grade epoxies. Hence, the moisture



Polyurethane hybrid lining[8] in a penstock (steel substrate; robotic, self-propelled automatic blasting unit)

Case History: Penstock Internals, Australia

Since the early 1990s, some polyurethane hybrids have been used to internally line penstocks in North America.[28] The rapid productivity associated with the use of these linings and their solvent-free safety advantages made them particularly attractive for large scale penstock projects. These one-coat polyurethane hybrids have had great success protecting thousands of rivet heads in immersed conditions in penstocks.

Based on this success, in 2004, the internals of a penstock at a power station in Australia were lined with a one-coat system of a solvent-free elastomeric polyurethane hybrid. Several hundred meters of three- and four-foot internal diameter pipe were lined.

First, the carbon steel internals were abrasive blasted to SSPC-SP 10, Near White Metal, using a robot (a self-propelled, automatic blasting unit). Second, the polyurethane hybrid lining was applied at approximately 40–60 mils DFT, as shown in photo at left.

After eight years, the penstock has shown no evidence of any lining problems.

vapor transmission of the hybrids is often below a measurable quantity when tested as per ASTM E96, Method B.

Hybrid linings have the ability to incorporate geotextile fabric, fiberglass reinforcement, woven polypropylene, and polyester fabrics to produce a composite with improved properties. These include tear strength; crack-bridging capability; and the ability to cope with surface moisture and outgassing during application, and subsequent movement in a substrate such as concrete.

The longer wet time of the hybrid facilitates penetration into both the substrate and any internal reinforcement being used, thereby improving wetting and offering superior mechanical adhesion. With ultra fast-set coatings and linings such as polyureas, this type of mechanical adhesion is extremely difficult to achieve. On damp surfaces, the hybrid will still adhere to the substrate. Some pin-holing can occur in the "glue-coat" due to outgassing. Outgassing will not affect the topcoat because the outgassing will dissipate in the geotextile. On the other hand, when a polyurea lining is applied to a damp surface, it will cure very fast, so it is less likely to outgas. However, the polyurea lining also will not adhere to the substrate.

Ultra-high-build aromatic polyurethane hybrids have been shown to possess exceptional resistance to water and wastewater immersion services. Their tough, robust, and flexible films are similar to some of the best high-tensile strength polyurethane films and have been used for more than 20 years in demanding immersion exposures where abrasion and impact are additional factors of concern. Repair kits of hybrid linings are available for touch-up joints and connections.

Like polyurethane and polyurea linings, hybrids also have extremely fast return-to-service times for ambient temperature

Table 2: General Comparison of Polyurethane, Polyurea, and Hybrid Properties in the Coatings and Linings Industry

Property	Polyurethane	Polyurethane Hybrid	Polyurea	Polyurethane Hybrid Advantage
Gel time	Seconds to hours	Instant set to minutes	Instant set	Superior substrate wetting
Tack free	Minutes to hours	One minute to hours	6–30 seconds	Rapid return to service
Tensile strength	Up to 7,000 psi	Up to 7,000 psi	Up to 4,000 psi	Higher tensile strength
Tensile elongation	Up to 500%	Up to 500%	Up to 700%	Lower elongations however, significantly lower permeability
Shore hardness "D"	50A to 85D	50A to 85D	50A TO 85D	Harder, better impact resistance
Abrasion resistance	Pure polyurethanes typically have best AR props	As low as 30 mg (H18 wheel)	76 mg loss (H18 wheel)	Hybrids often have better abrasion resistance
Tear resistance	Up to 500 pli	Up to 500 pli	Up to 500 pli	Similar tear resistance
Moisture vapor transmission	Too low to detect	Too low to detect	42 g/m2/24hrs	Significantly better resistance to the passage of moisture

Polyurethane hybrid lining on steel internals of penstock[8]

water and wastewater immersion service (domestic waste and industrial waste at a pH from less than 1 to 14).

Certain hybrid linings use hydroxyl- and amine-containing resins that have very little to no oxygen atoms, or other atoms that would increase polarity in the resin backbones. This chemical make up causes the hybrids to be much more hydrophobic than polyurethane and polyurea linings. The hybrids also resist chemicals as much as, or better than, many polyurethane and polyurea linings.

GENERAL DISCUSSION

Table 2 provides a general comparison of polyurethane, polyurea, and polyurethane/polyurea hybrid properties in the coatings and linings industries.

A high degree of surface preparation must be done in order to ensure that the solvent-free and high-build polyurethane, polyurea, and hybrid linings will perform well for many years and provide the owner with a good return on his investment. For optimum results, steel surfaces should be free of surface contaminants such as soluble salts, grease, and oil; be abrasive blasted to a minimum SSPC-SP 10; and have a deep and jagged profile of 3–5 mils (75–125 microns).

By virtue of their short pot lives and fast curing properties, these linings are applied using plural-component, hot airless spray equipment. Humidity control is important, and the surface temperature should be at least 3 degrees C above the dew point.

One of the key areas where polyurethane and hybrid technology have demonstrated long-term immersion performance has been in the lining of potable water tanks and pipes. Certified to the ANSI/NSF 61 standard, these coatings have a long track record when applied to steel substrates. The same is true for polyurethane coatings applied to the interior and exterior of steel per AWWA C222-99. The rapid curing characteristics of this technology, coupled with the need to use specialized equipment, behooves owners to select qualified applicators and ensure that third-party independent inspection is provided to ensure a successful application.

Lining and relining steel penstocks is another application where polyurethane and hybrid polyurethanes excel.[14,17] Of particular note is that a single-coat application of these films can provide long-term corrosion protection to rivets in penstocks, some designed and installed in the 1940s.

Another immersion environment where polyurethane and hybrid polyurethane linings have been used is the underwater hulls of ice breakers.[18] The excellent abrasion resistance and low frictional resistance indicate that these coatings would be well suited to resist abrasion and ice impact. While these characteristics proved to be the case on many icebreakers, in more recent years, epoxy linings have become favored more than polyurethane and hybrid polyurethane linings for icebreaker underwater hulls.

The low temperature cure of some polyurethanes and hybrid urethanes is very useful in cold climates. In the Canadian oil patch, for instance, where several fast-set epoxy coatings are used for transmission pipeline externals, some owners prefer the use of fast-set polyurethane linings. Judiciously selected and qualified high-performance polyurethanes and hybrids are well suited to year-round rehabilitation of steel pipelines.[19] It should be noted, howev-

Table 3: Transmission Pipeline Coating Testing

Solvent-Free Hybrid Polyurethane: Testing in Accordance with Qualification Protocol for Liquid Epoxy Coatings		
Test	**Test Method**	**Test Results**
28 day cathodic disbondment @ 20C 28 day cathodic disbondment @ 65C 28 day cathodic disbondment @ 80C	CSA Z245.20-06 Clause 12.8	35.9 mm 1.8 mm 0.6 mm
28 day adhesion @ 65C 28 day adhesion @ 80C	CSA Z245.20-06 Clause 12.14	#2 ratings #1 ratings
1.5 J impact resistance @ -30C, -10C, 0C, 23C, 65C and 75C	CSA Z245.20-06 Clause 12.12	No holidays
1.5° flexibility @ 0C 1.5° flexibility @ -30C	CSA Z245.20-06 Clause 12.11	No cracks or stretch marks
2.5° flexibility @ 0C 2.5° flexibility @ 0C		Cracking and disbondment
Hardness (-30C, -10C, 0C and 23C) Hardness (65C and 80C)	ASTM D2240	Shore D 80 to 85 Shore D 57 to 68
Gouge Test	NACE Draft	54.1%
Electrochemical Impedance Spectroscopy	ISO 16773	Log Z > 10 (10.7 to 10.8)

er, that the service temperature for suitable polyurethanes is invariably rated up to 65°C, i.e., less than the temperature of alternative qualified epoxy coatings with high glass transition temperatures.

Considering accelerated laboratory testing, the authors have stressed, in previous work, the importance of not relying heavily on certain tests and understanding the relevance of said tests.[20] For transmission pipeline coatings, caution must be exercised in not placing too much credence in any individual pre-qualification test. Therefore, testing programs for epoxies, polyurethanes, and polyurethane hybrids typically consist of a regime that includes electrochemical impedance, cathodic disbondment resistance, wet adhesion, impact resistance, flexibility, hardness, and gouge-resistance assessments.

Table 3 shows the pre-qualification test results for a thick film, solvent-free polyurethane hybrid developed for use on a major oil company's transmission pipelines.[21] The coating's wet adhesion characteristics and its impact resistance were excellent, and it displayed good flexibility at the 1.5 degrees per pipe diameter bend, but displayed poor flexibility at a 2.5 degree bend. Gouge resistance was rated at 54.1% (average gouge depth of total film thickness). The coating showed excellent electrochemical impedance characteristics, with the log Z impedance remaining constant during 28 days of exposure to the test conditions.

In the final analysis, all the test results were excellent, except for one anomalous result in the CD test in accordance with CSA Z254-20-02. Outstanding cathodic disbondment resistance was exhibited by the polyurethane lining at elevated temperatures. At 80C for 28 days, the average disbondment radius was 0.6 mm; at 65C for 28 days, the average disbondment radius was 1.8 mm. However, at 23C for 28 days, the average disbondment radius was 35.9 mm. At first glance, this result would disqualify the coating until the coating chemistry and the relevance of the test methodology were considered in addition to other physical tests. The coating has a much higher tensile strength (6,000 psi) and elasticity at ambient temperature when compared to its tensile adhesion (3,500 psi). Therefore, in the CD test at 23 C, this polyurethane coating had a very high molecular strength, but the coating would peel when pried off in the CSA test, thereby erroneously giving the impression of poor adhesion. Elevating the test temperature to 65 C and 80 C progressively lowers the tensile strength, and the coating subsequently becomes more difficult to pry from the substrate. Hence, caution should be exercised in the disqualification criteria for a polyurethane (or polyurea and polyurethane hybrid) coating based on radial disbondment measurements obtained from CD tests.

The immersion performance of the solvent-free polyurethane, polyurea, and polyurethane hybrid linings is a function of their chemistries and the nature of their dry and wet adhesion at the polymer-substrate interface. Micro impurities (e.g., micronic backside contamination) embedded in surface irregularities and adsorbed layers of gaseous or liquid phase molecules are more likely to be problematic for the application of extremely fast-set and rapidly curing linings that have little time to wet out the surface.

In earlier work, the authors examined the influence of surface profile characteristics of steel on coating and lining performance in immersion. Failure to understand how the wetting properties of the lining as well as the adhesion forces can lead to serious repercussions for lining performance.[22] In the case of 100%-solids coatings that require heat for molecular mobility in order to facilitate mechanical and polar adhesion, it is important to have a clean and well roughened substrate with a large number of reactive sites.

The adhesion of organic coatings applied to steel surfaces is often described in terms of interfacial hydrogen bonding between polar molecules, such as -OH and -COOH groups.[2] It is reasonable to postulate that the viscous polyurethane, polyurea, and hybrid linings cure so fast that they have little time to (a) fully wet the steel surface or (b) develop the maximum number of hydrogen bonds with the iron oxide-OH groups on the steel. Adhesion viewed in terms of Lewis acid-Lewis base theory throws extra light on what is happening at the polymer-substrate interface.[23,24] This theory is especially helpful regarding the wet adhesion characteristics of these linings when subjected to water immersion. Acid-base theory envisages adhesion between acidic groups on abrasive-blasted steel interacting with basic groups on the polymer. In essence, the greater the interaction is, the better the adhesive bond will be. For instance, the basic groups on polyurethanes, polyureas, and their hybrids are weak Lewis bases, and they form bonds with the iron oxide on carbon steel. These weak bonds can readily be cleaved by water molecules when the coating is mechanically damaged in immersion.

Hence, the real world observation is that several polyurethanes, polyureas, and hybrids may peel to some extent away from carbon steel when damaged in immersed conditions. The authors are currently investigating these adhesion phenomena on steel substrates in more detail.

In the protection of new and old concrete, many polyurethane and polyurethane hybrid linings have demonstrated excellent service in a variety of municipal wastewater applications because they can protect against

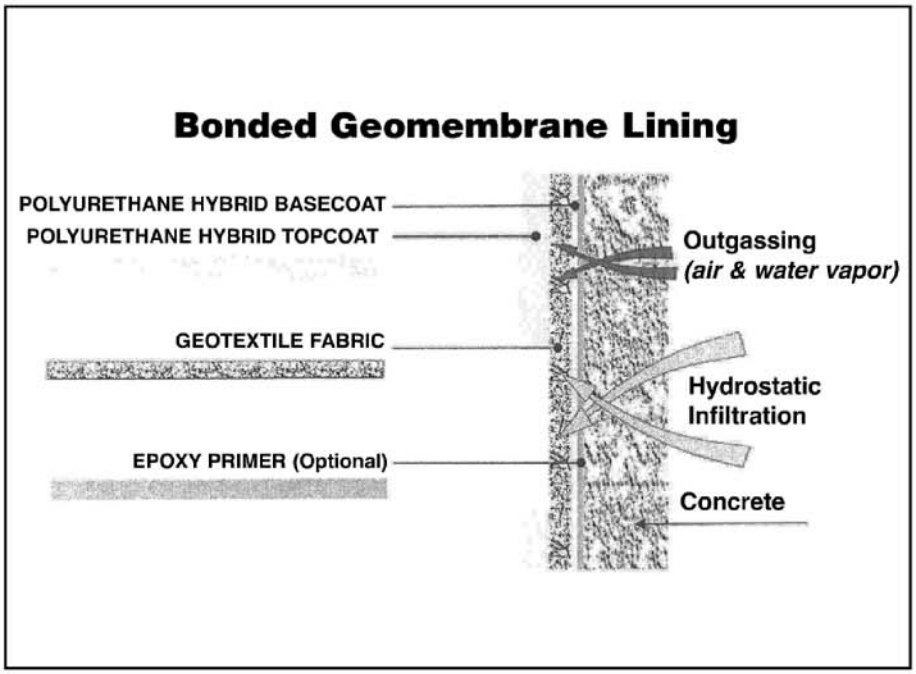


Fig. 8: Bonded geomembrane (polyurethane hybrid) to a concrete wall

microbiologically induced corrosion (MIC). Some polyurethane linings have even been formulated with special anti-bacterial additives that are said to increase resistance against MIC.[25]

Specialty polyurea linings can also provide very good protection to concrete in corrosive environments. For instance, spray applications of polyureas have been carried out inside neutralization ponds in cogeneration facilities. Often, an epoxy primer is used to aid adhesion to the concrete followed by one coat of polyurea.[26] The asset can be rapidly returned to service because of the rapid curing characteristics of the polyurea.

An innovative "bonded geomembrane" system for the application of certain polyurethane hybrids to concrete surfaces has gained acceptance and is schematically depicted in Fig. 8. The geomembrane basically consists of pre-cut, heat-set, non-woven 100% polypropylene geotextile fabric panels that are embedded between two layers of polyurethane hybrid.[8] The panels are pressed onto a still-fluid basecoat (or the concrete) and are held in place with Hilti-studs. Then, the panels are topcoated. The system is especially suited to vertical, new, or old poured-in-place concrete surfaces (walls). The polyurethane hybrid is reported to bridge bugholes and other voids in concrete as well as eliminate pinholes produced by the normal outgassing of concrete. Hence, the fabric filters and dissipates air or water vapor throughout itself. Therefore, there is said to be no way for outgassed air to blow holes through the coating when it is being applied as a topcoat onto the geotextile fabric. Once applied, (a) the embedded fabric can dissipate hydrostatic pressure and (b) remain unaffected by normal surface shrinkage cracks, most dynamic cracks and the designed movement of expansion joints in concrete.

CONCLUSIONS

Solvent-free polyurethanes, polyureas, and polyurethane/polyurea hybrid technologies have shown promise for immersion service in various market segments.

A wide array of solvent-free technologies of this type can be formulated to have a plethora of chemical physical properties by carefully selecting the amines, polyols, or a combination thereof. This is particularly true for the polyurethanes and polyurethane hybrids.

Solvent-free polyurethanes, polyureas, and polyurethane/polyurea hybrid technologies can be used in either a pure form or when slightly modified to customize required performance properties.

ACKNOWLEDGEMENTS

The authors are indebted to Dan Schneider of Polibrid, Jeff and Mark Buratto of Lifelast Inc., and Mark Dromgool of KTA-Tator Australia for their valuable insight with respect to polyurethane, polyurea, and polyurethane hybrid linings.

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Vijay Datta, MS, is the Director of Industrial Maintenance for International Paint LLC, USA. He has more than 40 years of experience in the marine and protective coatings industry.

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SSPC 2014 UPDATES

The following are updates to the SSPC 2014 Advance Program that were received after it was published in the December 2013 *JPCL*.

EVENTS

MEGA RUST FOLLOW-UP

Wednesday, Feb. 12, 2014, 8:00 a.m.–Noon

The mid-year follow up to the Mega Rust show is scheduled to be part of SSPC 2014 this year. Held this past June in Newport News, VA, Mega Rust is hosted annually by the American Society of Naval Engineers (ASNE) to provide a consolidated focus on Navy corrosion issues. The Follow Up at SSPC 2014 is designed to provide an interim update on key corrosion issues being addressed by the navy community.

Tentative Mega Rust Mid-Year Review Agenda:

8:00–8:15 a.m. Welcome & Introductory Remarks
8:15–9:00 a.m. Mega Rust 2014 Overview
9:00–10:30 a.m. Navy Corrosion Roundtable Discussion
10:30 a.m.–Noon Program Updates and Presentations

If interested in participating, please email ASNE at MegaRust@navalengineers.org. For more information, contact Mega Rust Chairman Dave Zilber, dzilber@mmm.com, or visit navalengineers.org/events/individualeventwebsites/Pages/MegaRust2014.aspx.

INTERNATIONAL SPOTLIGHT: CANADA SESSION

Tuesday, Feb. 11, 2014, 8:00–10:00 a.m.

As SSPC continues to grow, coatings professionals from around the world are discovering the value, knowledge, and resources available from SSPC and its members. To celebrate this growth and

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highlight the contributions to the industry that are coming from such a diverse group, the 2014 SSPC show will feature the 1st annual SSPC International Spotlight session. This new session will focus on issues and events affecting coatings professionals in different countries around the world. The feature country for 2014 is Canada, and the session will highlight major projects taking place around the country and the impact they have on the Canadian economy.

EXHIBITORS

Blasting Experts Ltd. is an American company that offers customers in Latin America solutions for surface preparation and cleaning, including machinery, equipment, abrasives, spare parts and technical support. Hamilton, ON; phone: 905-541-0997; blastingexperts.com. Booth 829.

Dumond Chemicals. Malvern, PA; phone: 800-245-1191; dumondchemicals.com. Booth 327.

Gill Industries, Inc. has manufactured the unique concrete admixture, Gill 33 Superbond, since 1954. Gill 33 is an all-in-one product that produces quick turnaround concrete for jobs that require early coatings plus many more benefits. Call today to learn more about Gill 33 and Gill's family of concrete repair products. Lancaster, SC; phone: 800-926-2433; gillindustries.com. Booth 519.

Graco–EcoQuip is a manufacturing company that designs and builds eco-friendly, wet abrasive blasting equipment that suppresses 95% of dust, eliminates water runoff, and minimizes media consumption. Chesapeake, VA; phone: 877-326-7847; ecoquip.com. Exhibit space M.

ITW Polymers Coatings North America manufactures a complete line of epoxy systems, including impax floor coatings, super alloy repair compounds, CWC industrial grouts, and permagile bonding patching

epoxies. Montgomery, PA; phone: 215-855-8450; itwcoatings.com. Booths 1128 and 1130.

Larson Electronics has built portable industrial lighting and power distribution solutions since 1973. With a focus on explosion proof lights, high powered LED illumination, LED area lighting, and 3-phase power distribution systems, Larson Electronics products can be found in the oilfield, paint spray booths, manufacturing facilities, and military bases around the world. Kemp, TX; phone: 903-498-3363; larsonelectronics.com. Booth 929

Luoyang Hong Feng Refractories & Abrasives Co., Ltd. (HRAC) is an experienced manufacturer of blasting media in China. Its products include aluminum oxide brown/white in macrogrits or microgrits, alumina-zirconia, general garnet material, waterjet garnet material, glass beads, glass sand, steel shot, steel grit, and silicon carbide. Luoyang, China; hongfeng-abrasives.com. Booth 927.

MONTI Tools is the North American office of the MONTI organization, proudly presenting its patented BRISTLE BLASTER® Industrial surface preparation technology. This easy-to-use, lightweight, and ergonomic designed powered tool system is capable of cleaning to a near-white finish by blasting away corrosion, mill scale, and coatings and generating a profiled finish of 3+ mils, ideal for most industrial coating applications. Houston, TX; phone: 832-623-7970; monti-tools.com. Booths 1024/1026.

Polyurea Development Association (PDA) is the trade association for the global thick-film high performance elastomeric industry. The backbone of PDA is polyurea, its development, and its application. The association also welcomes adjacent technologies like urethanes and hybrids that have similar uses, as well as related primers and topcoats. Kansas City, MO; pda-online.org. Booth 426.

Temp-Coat Brand Products, LLC has been manufacturing Temp-Coat 101, a top of the line liquid ceramic insulation, for over 20 years. La Place, LA; phone: 800-950-9958; tempcoat.com. Booth 1029.

U.S. Coatings is the fastest growing supplier of industrial coatings in the United States. It offers formulation of coatings and service to the industrial professionals field. St. Louis, MO; phone: 314-205-1500; uscoatings.com. Booth 424.

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SSPC Board Increases College Scholarship Program

SSPC's Board of Governors has increased the number of college scholarships available for the 2014–2015 school year. Beginning in January 2014, college students will be able to apply for one of six $2,500 scholarships, an increase from four the previous year.

Any student who is beginning or continuing their education at an institution of higher learning can apply for the scholarship. All educational institutions in the U.S. and Canada are now acceptable for students to receive scholarships. Scholarship funds will be applied to the direct costs of the student's courses. SSPC will work with the institution's financial aid offices to ensure proper use of the funds.

To be considered for the scholarship, candidates must be a high school senior planning to enroll full-time or a student already enrolled full-time at an accredited institution of higher learning that has a three or four-year curriculum. They also must be an SSPC member in good standing, or a child or grandchild of an SSPC member in good standing. To apply for the scholarship, candidates must submit a completed application form (available at www.sspc.org), two letters of recommendation, high school or college transcripts, and a personal letter expressing why they deserve the scholarship and what they plan to do in their field of study. A panel consisting of three SSPC Board of Governors members designated by the entire Board will choose the scholarship recipients.

Ben Fultz, SSPC President, stated, "When the scholarship program was brought up for continued funding, the entire Board agreed that this is one of the best programs we have to get young people interested in SSPC and their possible future careers in corrosion and the use of coatings to mitigate that problem."

At the Board meeting, the entire committee echoed Ben Fultz's thoughts and stated that SSPC needed to increase the funding by two scholarships, which the Board unanimously endorsed.

SSPC Releases New Standard

SSPC has announced the release of SSPC-Paint 45, "Two-Component, Thick-Film Polyurea and Polyurea/Polyurethane Hybrid Coatings, Performance-Based." The standard was crafted by the Society's C.1.9, Polyurea Coatings Committee, chaired by Dudley Primeaux of VersaFlex, Inc.

This new standard is designed to establish performance criteria for polyurea and polyurea/polyurethane hybrid coatings, and may be used by coating manufacturers and specifiers as a set of performance benchmarks. It contains minimum performance requirements for two types of two-component polyurea coatings and two types of polyurea/polyurethane hybrid coatings. Two performance levels based on resistance to deterioration by artificial weathering are provided for coatings meeting the requirements of this standard. Additional performance properties evaluated by laboratory testing include tensile

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strength, elongation, tear strength, linear cure shrinkage, abrasion resistance, permeance, and adhesion tests. In addition, coatings to be used in immersion service must also meet performance requirements for hardness retention, resistance to blistering and delamination, and resistance to mass and volume change.

The complete standard is available for purchase on the SSPC Marketplace, sspc.org/market-place.

Six New PCS Candidates Certified

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

The recently certified Protective Coatings Specialists are:

- Chen Bang Yi, Taiwan
- Rodger Hamrick, Baltimore, MD
- Murali Kurup, Sharjah, U.A.E.
- Benjamin Nicholson, St. Paul, MN
- Patrick Ricciardi, Riverside, CA
- Dan Schweizer, Colton, OR

SSPC congratulates these individuals for their achievements.

Chen Bang Yi

Rodger Hamrick

Murali Kurup

Benjamin Nicholson

Patrick Ricciardi

Dan Schweizer

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Training Courses

SSPC held its Protective Coatings Inspector (PCI) Levels 1 and 2 courses from Nov. 11–22 in Batam, Indonesia. Instructors Muniandi Dewadas and Abdul Quim (Bani) led the course's 21 students.

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Coatings Expert Leonard Phelps Promoted

Wiss, Janney, Elstner Associates, Inc. (WJE), an interdisciplinary firm of architects, structural engineers, and materials scientists that specializes in the investigation, analysis, testing, and design of repairs for historic and contemporary structures, has announced the promotion of Leonard Phelps to Associate Principal in the company's Northbrook, IL, headquarters.

Since joining WJE as a chemist in 1984, Phelps has regularly served as lead chemist on various project teams whose task is the resolution of construction-related materials problems. His work experience includes a variety of coating and materials projects involving failure analysis, condition assessment, specification development/appraisal, remedial coating recommendations, coating characterization, performance evaluation, and long-term durability assessment. He routinely consults with clients regarding material acceptability and selection, surface preparation, coating application, specification explication, resolution of disputes, and litigation. Some of his noteworthy projects include coating failure investigations at Carlsbad Caverns in Carlsbad, NM; the Denver International Airport in Denver, CO; Johns Hopkins University Applied Physics Laboratory in Laurels, MD; Northeast Ohio Regional Sewer District, Cleveland, OH; Three Lakes Water and Sanitation District in Grand Lake, CO; Ka'anapali Beach Club in Lahaina, Maui; Aloha Stadium in Honolulu, HI; and Safeco Field in Seattle, WA.

Phelps is an active member of several technical committees for SSPC, including C.1.1 Zinc-Rich Coatings, C.1.12 Painting Galvanized Steel, C.1.13 Coatings for Wastewater Facilities, and C.1.8 Fluoropolymer Coatings.

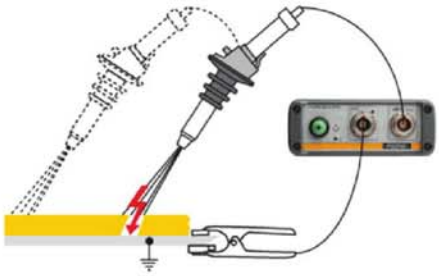
He holds a bachelor of science in biology and a bachelor of arts in chemistry from the University of Illinois. He also holds a master of science in chemistry from DePaul University.

Fischer Releases New Holiday Detectors

Fischer Technology, Inc. has released a new line of high voltage holiday detectors, the Poroscope series, to help inspectors find pores, cracks, or embedded foreign particles in a coating system.

There are three versions available, each with different test ranges: the Poroscope HV5 (0.8–5 kV), the Poroscope HV20 (4–20 kV), and the Poroscope HV40 (8–40 kV).

Once the holiday detection test voltage is determined, either according to the coating thickness or a test standard, the Poroscope adjusts to the appropriate high voltage automatically. It is equipped with two modes of pore detection—dynamic and static—with adjustable thresholds to enable measurement of these materials.



The Poroscope also fulfills the safety requirements of ISO 2746. Its low energy, high voltage is generated only in the probe head, so a high voltage cable is not necessary. The high voltage switches off automatically if the instrument is overloaded. Its insulated handle is covered with a metal housing, which is connected to the instrument ground to protect the operator. The voltage is only active as long as the instrument is grounded and the push button switch is pressed, and an integrated current limiting resistor reduces the current to non-dangerous levels. There are also various types of electrodes (Brush, Flat, Sweeper, Ring, Roller, etc.) available for application.

For more information, visit fischer-technology.com.

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How To Effectively Manage Conflict

By Warren Brand, W Brand Consulting

As a martial artist for more than 20 years, I study every aspect of conflict. When most people think of martial arts, they think of MMA, martial arts movies, and fighting. Yet, highly trained martial artists, particularly those who study combat arts, focus on the concepts surrounding conflict and how to avoid conflict whenever possible.

I've successfully used these fundamental principles of combat in business settings for the past five years. Many people consider the most fundamental aspects of humanity to be the search for food, shelter, clothing, and procreation. I believe that what has defined our existence in every dimension has been conflict.

This article will expose you to tools and techniques to better manage all types of conflict.

Background

Conflict has two components:

1. Knowing precisely what you want

If you're a coating inspector working on a tank interior and your Testex tape repeatedly shows a 1.5-mil average profile, and the spec calls for a minimum of a 3-mil profile, well, you're looking for your additional 1.5 mils.

Of course, this may require a great many things, such as the contractor restaging, blasting again, and cleaning again, or it may delay the project.

But, unless the owner advises you differently, all you want is an additional 1.5 mils.

I have a good friend who was driving in heavy traffic a few years back. Someone cut him off, and my friend responded with an impolite hand gesture. The guy became enraged, got out of the car, and started screaming at my friend to come out and fight. My friend calmly said, "I don't want to fight you, I just want you to drive better."

2. Knowing how to get what you want

The next section will include a list of techniques used by me, and my staff, to manage conflict. Conflict, whether in business or personal life is inevitable. However, developing tools, learning skills, and practicing will make you better able to manage conflict and, ultimately, get what you want.

But, there are some very basic rules from which all the others flow, and the fundamental rule that tops all others is not to get angry or upset. The moment you get upset, your body physiologically changes because of adrenaline entering your body. This is a well-established fact studied extensively in all military and martial arts circles. In Lt. Col. Dave Grossman's and Loren W.

Editor's Note: Beginning this year, JPCL *will publish a new column, "Mind Your Business," written by contributing author and consultant, Warren Brand. Brand will offer readers his advice on how to handle various business issues in the coatings and corrosion industry.*

Christensen's seminal book entitled *On Combat, The Psychology and Physiology of Deadly Conflict in War and in Peace*, in reference to getting into a heated argument with someone, "...you might as well try to argue with your dog. To connect with him, you must first calm him down." Earlier this month, I trained with a professional MMA fighter who listens only to classical music during training to stay calm.

Conflict Management Tools and Techniques

There is technique to everything, and conflict is no different. The following principles are fundamental to all conflicts, applicable to world wars, arguments with loved-ones, and customers and clients.

1. Have no ego and stay calm. Even if someone is calling you names, remember, this is their issue, not yours. Try counting to 10. Excuse yourself for a minute. Go to your happy place. Techniques for staying calm vary from person to person. Email me (warren@wbrandconsulting.com) if you'd like more.

2. Whenever possible, know exactly and precisely what you want before you are engaged in the conflict—and remember to stay focused. This is true for any type of conflict or negotiation. A boxer knows what he wants before getting into the ring, a child knows what she wants before asking a parent for dessert, and you should know what you want if, for example, you're asking for a raise. You shouldn't go into negotiations with your boss or a client (negotiating your fees) with the goal of "more money." You should go into negotiations with how much more money and why you are deserving of more money. Referring back to our example of a non-compliant blast profile, you don't want a "deeper" or "better" profile. You want, specifically, a minimum of 3.0 mils' profile based on the requirements of the specifications.

> "The supreme art of war is to subdue the enemy without fighting."
> —Sun Tzu

3. Come up with a strategy for getting what you want. Building on the aforementioned example in #2—a boxer wants to win and has a number of techniques and skills to make that happen. If he has time to prepare, you can be sure he's watched many tapes of his opponent. Likewise, a child may ask, "Dad, is this a good time to ask you a question?" And, if you're asking for a raise, you should give objective data supporting the request. If you're starting an inspection job, meet with the highest-ranking person, and introduce yourself to everyone on the site (if possible). Establish a personal connection and familiarity with the people you will be working with and, perhaps, conflicting with. Explain that you, like everyone there, have the same goals—to serve the client and to make a living. "Let's work together to get through this smoothly. After all, we want the same thing. I promise to be pleasant and professional at all times." Like a boxer studying his opponent, you are familiarizing yourself with your potential opponents so that if conflict should arise, you have some idea of their personality and needs to better get what you want.

4. Whenever possible, let the data do your talking. Refer to test results, written specifications, or anything to support your position.

5. Be empathetic and sincere. "I can see how frustrating this is." "I'm really sorry this is an issue." "What would be a reasonable course of action to remedy it?" "I'd be say-

ing the same thing if I were in your position."

6. Ask questions. (This technique works well with bullies.) "I see that you're upset and I'm sorry that I've done anything to contribute or cause that. Can you help me to understand what I've done?" "Should we take a few minutes and both catch our breath and calm down?" "Is there some way we can speak calmly and respectfully to each other to resolve these issues?" "I'm sorry I'm not seeing it from your point of view, can you please help me to understand?"

7. Be tough as a last resort. You can be kind and patient only for so long. If someone becomes overly belligerent, stay calm, but have some prepared lines at your disposal. "I can appreciate that you're upset; however, I'll need you to please tone it down a bit if you want me to participate in this conversation." "Can we please agree to stick to the issues and data, and stay away from personal remarks?" "Do you think we can agree to speak to each other calmly and professionally?" "Raising your voice or name-calling is neither necessary nor helpful to either of us." Remember to stay focused on your goals—to keep your job, to make a living, and to address the issue at hand—not the personality of the person with whom you're speaking.

8. If you're wrong, own it and own it big. "I'm very sorry. This was our fault. There was no excuse for it and we'll do what we have to do to fix it." If they continue to rant, stay calm and listen. Remember, it's not personal.

It's Worth Repeating—Let the Data Do the Talking

Many years ago, when I owned an industrial coating company, we had a coating failure in a shampoo-mixing tank. An entire batch of shampoo (about 20,000 gallons) was contaminated. The owner called me out to the job, and he was furious. He handed me an invoice for 20,000 gallons of product (which couldn't be sold) and for disposal of the product (it couldn't be used) for roughly $45,000. He also, of course, wanted the tank relined at no cost and ASAP.

I stayed calm and said, "I understand your position. And, if I were in your place I'm sure I'd be saying the same things. But, first, let's please take a look at what happened. There's no point in relining it without understanding what happened."

I entered the 40' tall tank and found the coating at the top to be soft and friable. However, as I moved down the length of the tank, from the top to the bottom, the coating became harder and harder until about 10 feet from the bottom, where it was perfect. The hardness

tester was right where it needed to be.

It turns out that there was a small amount of bleach in the product, which we were told about, and which our coating was designed to withstand.

Our client had told us that the tank operated at no more than 90 F. However, when we went back and looked at the operating engineer's notes, it turned out that the bottom of the tank was operating at 90 F while the top half of the tank reached temperatures as high as 145 F. We had designed the system for 90 F, not 145 F, which is what caused the failure.

When we sat down to discuss this, the client was steamed. And, when I showed him the data and my conclusion he became even angrier. But I stayed calm, and I did not take his anger personally. My goal was to pay nothing, and, perhaps, to have my client pay us to repair the coating. His goal was to have me pay $45,000 and reline the tank for free.

I kept calm and said, "Jim, I understand your frustration. But I can only design a coating system based on the information you provide to me." Finally, I said, "Jim, let's be honest for a moment. How would you be responding in my position?"

Jim finally calmed down, and we had a productive meeting. I paid nothing. He paid me to have the tank relined, although we did so at a discount. And he remained a good customer (but was much more careful about the data he provided.)

Most reasonable people, even if they're angry, will tend to calm down if you remain calm, focused, professional, and use the tools and techniques outlined above.

But, what do you do when you come across someone who is unreasonable and is a bully?

There was a property manager we were dealing with who was dissatisfied with some work we had done on a swimming pool. She angrily asked the same questions and made the same comments in person and via email. "Why did this happen? What are you going to do about it? When are you going to fix it?" "Why did it happen in the first place?" "You said you were good at this kind of work." "I'm sorry we ever hired you in the first place." "You and your company are a joke." "I don't know how you stay in business."

I responded to all of her issues in a lengthy, professional email. I apologized for the inconvenience, and I told her we would make repairs—at no cost and at her convenience. Yet, every time I spoke with her, she was antagonistic and asked the same questions and made the same comments. I was starting to lose my cool.

She scheduled an onsite meeting with the board. I knew she was going to be very hostile. I had found myself getting upset in anticipation of the meeting.

I came up with a plan. First, I printed up the email with my detailed answers to all of her questions. Then, I made copies for everyone who was going to be present at the meeting.

When the meeting started, I began by saying, "Angela, I know you and the board are disappointed. And we're sorry about that. I have, however, provided you with all of the answers to all of your questions repeatedly in phone calls and emails. And, as you know, we've offered to come back, at our own expense, to make repairs. I would respectfully ask that you please keep the tone of the conversation professional and refrain from making antagonistic, unproductive comments and personal attacks towards me or my company."

She became enraged and, of course, started asking the same questions. I answered each question once and when she asked the same question again, I said, calmly, "We've already gone over that." As

she continued, I simply smiled pleasantly and pointed to the email, "It's in the email."

Finally, I interrupted her and said, "Is there anything else? It seems like we covered everything. And, my contract with you does not include suffering verbal abuse." She was getting nothing from me, and she sat down as I packed up. I ignored Angela and thanked the board for their time and told them not to hesitate to contact me if there was anything more I could do.

Her goal in the meeting was to vent and, I believe, humiliate me and build up herself in the eyes of the board. We made repairs to the pool, which is what the board wanted. But she simply wanted to be abusive.

My goals were to not waste too much time in the meeting and to not become angry. When I did not respond to her and did not get upset, she had nothing. The meeting was over in 10 minutes. I kept my cool, and I found out later that the board terminated the property manager specifically for the way she handled our situation.

Conclusion

Some of our best, longest, and most loyal clients were those with whom we had problems. Although we work to avoid failures and problems, when they do arise, we view them as opportunities to re-earn our clients' trust by doing whatever we need to do to make the situation right.

About the Writer

Warren Brand is the founder of Chicago Coatings Group, LLC, a technical consulting firm he formed in 2010. In 2013, Brand started W Brand Consulting, focusing on business consulting within the coating industry. Before opening his consultancies, Brand was president and owner of Chicago Tank Lining, Inc. He has more than 25 years of experience as a coatings contractor, is an SSPC-certified Protective Coatings Specialist, and a NACE-certified Level 3 coatings inspector. Brand holds an MBA and a BA in Journalism. He has studied a variety of martial arts for 20 years and volunteers as an instructor at Northwestern University teaching combat jiu-jitsui. Mr. Brand welcomes questions, comments, and criticism at warren@wbrandconsulting.com.

Abhe & Svoboda Wins Phase II of Huey Long Bridge Contract

Abhe & Svoboda, Inc. (Prior Lake, MN), SSPC-QP 1 and -QP 2-certified, won a $21,874,935 contract from the Louisiana Department of Transportation and Development to repair, clean, and recoat railroad approaches on the Huey Long Bridge, a 5,879-foot-long continuous steel truss through deck bridge over the Mississippi River in Baton Rouge, LA. Not to be confused with the Huey Long Bridge in Jefferson Parish, LA, this bridge opened in 1940 and carries four lanes of US-190 traffic and a Kansas City Southern rail line over the river.

Photo courtesy of Wikimedia Commons

The contract includes cleaning and recoating a total of 590,000 sq. ft. of steel on the eastbound and westbound approaches (250,000 sq. ft. and 340,000 sq. ft., respectively). Most of the steel will be abrasive blast cleaned to a Near White finish (SSPC-SP 10) and recoated with an organic zinc-rich system. A 100%-solids epoxy penetrating sealer will be required for coating the existing steel. The contract also includes shop-priming new steel with an inorganic zinc-rich primer.

Some of the bridge's existing coatings contain lead; containment according to SSPC-Guide 6 and waste disposal according to Guide 7 are required. The contractor will employ a NACE-certified inspector to perform coatings inspection services.

This contract will cover Phase II of the bridge rehabilitation project. The contract for Phase I, awarded to Liberty-Alpha III J.V., LLC (Campbell, OH), included recoating approximately 3,676,000 sq. ft. of structural steel surfaces (2,935,631 sq. ft. on the main span, 230,000 sq. ft. on the east approach, and 510,000 sq. ft. on the west approach).

Water Tank Quick Hits

- Utility Service Group (Atlanta, GA) won a $691,300 contract from the City of Galveston (TX) to abrasive blast clean and recoat interior and exterior surfaces of a 1 MG steel elevated water storage tank.
- A $149,936 contract was awarded by the City of Olathe (KS) to Worldwide Industries Corp. (Butler, PA) to abrasive blast clean and recoat interior surfaces of a 1.5 MG standpipe water storage tank.
- The City of Winter Haven (FL) and Razorback, LLC (Tarpon Springs, FL) have agreed on a $197,000 contract to abrasive blast clean and recoat interior and exterior surfaces of a 150,000-gallon steel elevated water storage tank.

PennDOT Awards $11.8M McCall Bridge Contract

A contract worth $11,827,600.35 was awarded by the Pennsylvania Department of Transportation to J.D. Eckman, Inc. (Atglen, PA) to rehabilitate the Thomas J. McCall Memorial Bridge, a 16-span, 1,539-foot-long bridge over the Lehigh River. Constructed in 1938, the bridge was last rehabilitated in 1981.

The contract includes cleaning and recoating a total of 187,521 sq. ft. of structural steel surfaces with an organic zinc-rich coating system. The existing coatings contain toxic metals, including lead, chromium, cadmium, and arsenic. Containment according to SSPC-Guide 6 and waste disposal according to Guide 7 are required. The contract also includes a total of 1,991 sq. yds. of penetrating sealant protective coating application for reinforced concrete superstructure and substructure surfaces, 37 sq. yds. of membrane waterproofing application installed on other surfaces, and 5,469 sq. yds. of hydrodemolition of existing bridge surfaces.