SHERWIN-WILLIAMS®

MARKET PULSE

ADVANCEMENTS IN COATINGS TECHNOLOGY

WHY FIREPROOFING IN THE SHOP BEATS THE FIELD

NEW WAYS TO CURB OFFSHORE CORROSION

CONCRETE TANK LININGS: FLEXIBLE OR RIGID?

BETTER SPECS TO PROTECT PROCESS VESSELS

BOOSTING PIPELINE PERFORMANCE AND SAVINGS

BEST PRACTICES FOR COATING HIGH-TEMP BULK VALVES


FROM SPEC
TO PROTECT

INSIDE

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ADVANCED COATINGS TECHNOLOGIES START WITH EXPERTISE

Technology drives success in the coatings industry. So does expertise. Advancements in corrosion protection, application windows, curing times and so much more help numerous industries extend asset lives, reduce operating costs and enable efficiencies. But it takes true experts to bring these benefits to life—experts from coatings manufacturers to asset owners, specifiers and applicators.

Advancing coatings technology and enabling better outcomes start with a focus on anticipating problems—not just solving them. For Sherwin-Williams Protective & Marine, that means keeping a pulse on the industry. Listening to stakeholders' concerns. Understanding their challenges and proactively developing technologies that improve their businesses.

We asked our dedicated coatings technology and industry experts to share some of the challenges they're helping to solve. These thought leaders, each with decades of direct field experience, have an impressively broad and in-depth knowledge of the industry. They understand your concerns. And they drive the development of new products and practices to address issues the industry may not have even thought about yet.

This publication features our experts' contributions. You'll learn how the specification of non-traditional coating systems can help the oil and gas industry better combat offshore corrosion. How dual-layer pipeline coatings enhance safety. And how to realize time, cost and durability benefits related to technology advancements in the water and wastewater, fire protection, high-temperature, rail and flooring markets.

You'll learn a lot from our experts here. And you may think of some questions along the way. I encourage you to reach out to them with your questions and share your challenges. They can help with a solution—and perhaps initiate the next coatings technology advancement for you.

Joe Laehu
Global Vice President of Marketing
Sherwin-Williams Protective & Marine

HIGH TEMPERATURE

HIGH-TEMP BULK VALVES ENCOUNTER NEW STRESSES

ADVANCED COATINGS TECHNOLOGY NEEDED FOR GLOBAL SUPPLY CHAIN THAT SHIPS COMPONENTS OVER LONG DISTANCES IN THE OPEN AIR

BY NEIL WILDS, GLOBAL PRODUCT DIRECTOR – CUI/TESTING, SHERWIN-WILLIAMS PROTECTIVE & MARINE

For many years, epoxies and epoxy phenolics were the preferred coatings for preventing corrosion under insulation (CUI) in valves and pipes. There is good reason for this. They perform well under this limited, yet challenging, set of conditions. In recent years, however, a new set of supply chain conditions has placed additional stresses on large bulk valves and pipes destined for high-temperature service in the oil and gas and power industries. Unfortunately, unmodified epoxy and epoxy phenolics were never intended to manage these new stresses.

FIGURE 1. Most oil and gas refineries are located in highly corrosive C5 environments near coastal areas.
OPLA/GETTY IMAGES

As the supply chain has evolved from local to global, bulk valves are traveling long distances from the place of fabrication and coating to the job site. During this journey, they are subjected to corrosive atmospheric conditions and ultraviolet (UV) rays, with unfortunate results.

For large oil and gas downstream projects, most bulk valves are being fabricated and painted in Spain, Italy, Germany and the United Kingdom, and then transported to refineries in the Middle East. They are painted and assembled in fully erected modules before they undergo the long voyage in the open sea air of the Atlantic and Mediterranean. In addition, they may then sit in open-air storage at the construction site awaiting installation for a considerable period of time.

This journey may extend upwards of six months to one year, during which time surface damage is exposed to extremely corrosive C5/CX environments, first in sea transport and then in the coastal areas where most refineries—and some power plants—are located ***(Figure 1, facing page)***. Incorrectly formulated epoxies and epoxy phenolics do not perform well under these conditions. The result is substantial corrosion of the valves, as well as erosion of the film base due to UV exposure. Very often, the valves must be completely re-blasted and recoated, a considerable expense for the engineering procurement companies that are responsible for the condition of the valves during their first five years of service.

Another challenge inherent in today's supply chain is that bulk valves are procured before their exact operational conditions have been fully determined. These circumstances are challenging for material engineers, coatings specifiers and paint manufacturers who are responsible for specifying coatings. On the one hand, the components may need protection from CUI and high heat at specific temperature ranges. On the other hand, they may need protection from corrosion or UV degradation in atmospheric conditions. Selection of the wrong coating system can lead not only to corrosion and damage in transit, but also to premature coatings failures, even within three years of operation.

What today's complex supply chain in the oil and gas and power industries requires is a more versatile high-performance coatings technology that is compliant with NACE SP0198-2017, "Control of Corrosion Under Thermal Insulation and Fireproofing Materials—A Systems Approach," and one that protects bulk valves from a wide range of possible performance conditions.

A NEW SOLUTION FOR RESISTING UV DEGRADATION AND CORROSION

Given the evolution of the supply chain for bulk valves, epoxy and epoxy phenolics have several shortcomings that should be explored fully:

1. They can be brittle in nature and subject to mechanical damage.
2. When damaged areas are exposed to corrosive environments, corrosion works its way under the film, causing flaking, blistering and disbondment.
3. They can suffer erosion or loss of film thickness due to UV exposure, unless top-coated.

Epoxy phenolics were originally used as tank linings because of their resistance to chemicals. For this application, there was no requirement to modify the formulation for UV exposure. Initially, the same was true as epoxy phenolics were employed in high-temperature applications. But as we have seen, the circumstances have changed and now UV exposure is a regular part of the service conditions for large bulk valves and pipes. Unfortunately, amine-cured epoxy-based technologies have subtle flaws. There is a weakness inherent in the carbon-carbon bonds, which have been shown to suffer from thermal and photo oxidation. The yellowing seen when epoxies are exposed to UV environments is an indication of the breakdown of the epoxy network. Eventually, this network falls apart, leading to heavy erosion.

Some modification of epoxy phenolics is, therefore, necessary to fortify them against UV exposure. For example, lamellar pigments, such as micaceous iron oxide (MIO), are strong UV light absorbers. The shape and alignment of MIO particles in the coating film are highly effective in deflecting UV rays, as compared to conventional granular pigments. Acting like particles of broken glass or tiny mirrors, MIO particles are reflective, but at the same time they create a tortuous path for UV rays ***(Figure 2)***. MIO particles are also chemically inert and resistant to high temperatures, and they form a physical barrier that prevents the ingress of water, oxygen and ions.

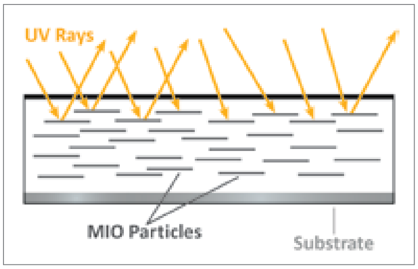

FIGURE 2. An illustration shows how MIO particles form a barrier deflecting UV rays.

When MIO particles are used as pigment in an inert multipolymeric matrix coating (IMM), the result is a film that outperforms unmodified epoxies, both in terms of erosion resistance from UV exposure and corrosion resistance from atmospheric conditions. In the balance of this article, this formulation will be referred to as MIO/IMM—as represented by Heat-Flex® Hi-Temp 1200 from Sherwin-Williams Protective & Marine.

EROSION TESTING

To test the MIO/IMM formulation for erosion under UV exposure, Sherwin-Williams employed a British standard (BS EN 927-6:2018) originally devised for wood coatings and intended to simulate weathering in a high UV environment. The standard consists of a four-step cycle involving condensation, UV exposure and a water spray ***(Table 1)***. The experiment, which consisted of 17 cycles, was conducted by a third-party lab. Results in CONT. P. 6

TABLE 1. Schedule for an erosion test from BS EN 927-6:2018.

STEP	ENVIRONMENT	TEMPERATURE	DURATION	CONDITION
1	Condensation	40 ± 3°C	24 hours	–
2	Cycle of step 3 + 4	–	144 hours consisting of 48 cycles of 3 hours	–
3	UVA–340	60 ± 3°C	2.5 hours	Irradiance set point 0.89W / (m2nm) at 340 nm
4	Spray	–	0.5 hours	61 minutes to 71 minutes, UV off

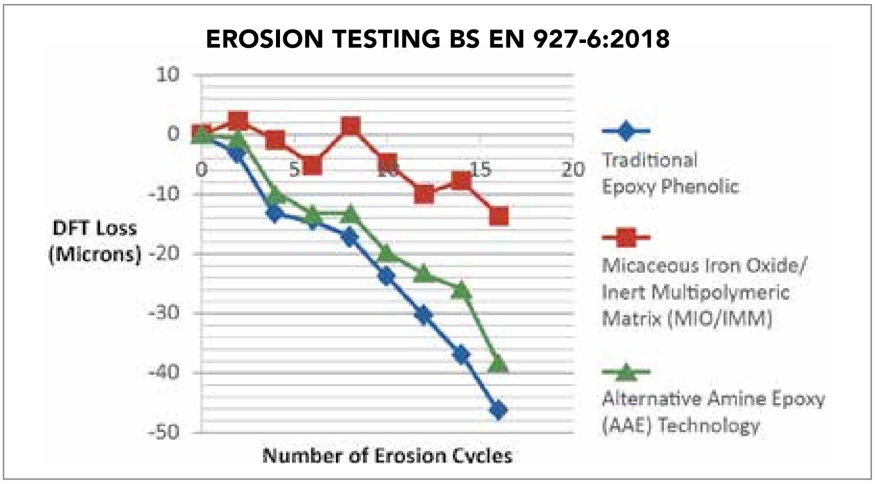

FIGURE 3. UV exposure resulted in film erosion in samples coated with traditional epoxy phenolics and the AAE technology. By contrast, the samples coated with MIO/IMM resisted erosion.

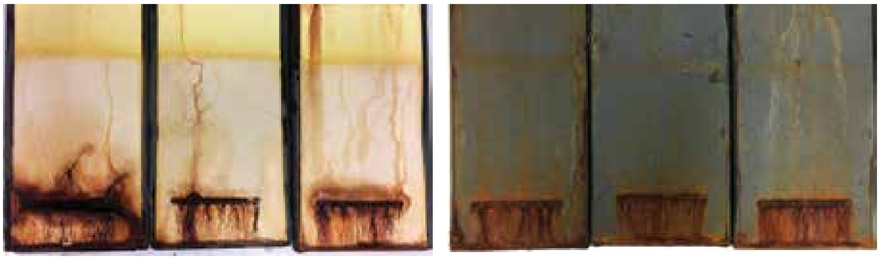

FIGURE 4. The traditional epoxy coating *(left)* shows chalking following the ISO 12944-9:2018 test protocol. By contrast, the MIO/IMM coating *(right)* shows no chalking following the same test.

CONT. FROM P. 5

Figure 3 show that while the MIO/IMM technology resists erosion, non-modified epoxy phenolics erode rapidly. The new formulation also outperforms alternative amine epoxy (AAE) technology, a newly released alternative to traditional epoxies for high-heat applications.

There are two main reasons for the superior performance of the MIO/IMM formulation. The silicon-oxygen bond in MIO/IMM coatings is much stronger than the carbon-carbon bond of epoxy phenolics. Further, the MIO particles protect the resin system from UV rays, unlike the non-filtering pigments in traditional phenolics.

In a separate experiment, Sherwin-Williams employed a third-party lab to conduct cyclic corrosion testing according to ISO 12944-9: 2018. The test consisted of wet and UV cycles over seven days, as illustrated in **Table 2**. Results showed heavy chalking and film erosion in the traditional epoxy sample ***(Figure 4)***. By contrast, the MIO/IMM sample showed no chalking.

CORROSION TESTING

The MIO/IMM formulation has been thoroughly tested in high-temperature and CUI applications, but Sherwin-Williams wanted to determine if the formulation also performs in atmospheric conditions, without heat activation or the use of an anticorrosive primer. The company therefore employed a third-party lab to test samples according to ISO 12944 C5M. The test consists of a hot salt spray for 1,440 hours.

The MIO/IMM coating system was applied direct to metal (DTM). Then, to simulate mechanical damage, lab technicians machined a scribe mark 1 mm in width. After the test, they measured creep from the scribed area on each sample. Results, which are shown in **Table 3 *(next page)***, document that under-film creep from the scribe marking was ≤ 0.3 mm. Remarkably, the MIO/IMM coating, without a primer, performed in a C5 environment according to the ISO 12944 standard.

Technicians then proceeded to carry out a still more aggressive test protocol, the ISO 20340 aging test (now ISO 12944 CX), which is usually reserved for the best atmospheric systems for offshore use. It consists of 4,200 hours of varied conditions, following the pattern of UV exposure, hot salt spray and freezing temperature shown in **Table 2**. The results, produced by a third-party lab, showed under-film creep between 1-2 mm ***(Table 4, next page)***. That result compares favorably to performance criteria used for zinc-based systems (< 3 mm) and far exceeds performance criteria for epoxy systems (< 8 mm).

TABLE 2. A seven-day testing cycle per ISO 12944-9:2018.

DAY 1	DAY 2	DAY 3	DAY 4	DAY 5	DAY 6	DAY 7
UV/Condensation – ISO 16474-3			Neutral Salt Spray – ISO 9227			Low-Temp. Exposure at -20 ± 2°C

A SINGLE-COAT TECHNOLOGY FOR THE FULL RANGE OF SERVICE CONDITIONS

CUI coatings are often tested rigorously for their performance under insulation and at high heat, but not at all for ambient corrosion protection or resistance to UV degradation. But as the industry knows, these conditions are an inevitable part of the global supply chain for bulk valves and pipes in the power and oil and gas industries. The coatings applied to these components must perform in the full range of conditions that they will be subjected to, not only after installation (at the back end), but also before installation (at the front end).

TABLE 3. Third-party test results show minimal corrosion creep of MIO/IMM samples after testing to the ISO 12944 C5M standard.

SAMPLE REFERENCE	PANEL EXPOSURE	ISO 2409 ADHESION CLASSIFICATION	MAXIMUM CORROSION CREEP (MM)	ISO 4628-2 BLISTERING (DENSITY/SIZE)	ISO 4628-3 RUSTING (RI)	ISO 4628-4 CRACKING (DENSITY/SIZE)	ISO 4628-5 FLAKING (DENSITY/SIZE)
158-16	1440 hours Neutral Salt Spray	1	0.3	0(S0)	0	0(S0)	0(S0)
158-17		1	0.3	0(S0)	0	0(S0)	0(S0)
158-18		1	0.2	0(S0)	0	0(S0)	0(S0)

TABLE 4. Third-party test results show very low levels of corrosion creep on MIO/IMM samples following the ISO 20340 aging test (now ISO 12944CX). These levels of creep are comparable to performance criteria for zinc-based coatings systems.

SAMPLE REFERENCE	PANEL EXPOSURE	ISO 4624 ADHESION (MPA)	AVERAGE CORROSION CREEP (MM)	ISO 4628-2 BLISTERING (DENSITY/SIZE)	ISO 4628-3 RUSTING (RI)	ISO 4628-4 CRACKING (DENSITY/SIZE)	ISO 4628-5 FLAKING (DENSITY/SIZE)
156-13	Unexposed Pre-Test Adhesion	1.97	–	–	–	–	–
156-18		2.59	1.8	0(S0)	0	0(S0)	0(S0)
156-19	4200 hours Aging Resistance	2.57	1.1	0(S0)	0	0(S0)	0(S0)
158-19		2.41	1.2	0(S0)	0	0(S0)	0(S0)

FIGURE 5. Severe corrosion under insultation (CUI) resulted in this instance *(above, left)* from a zinc-based primer, which is not recommended for closed, wet environments. At temperatures greater than 60°C, the zinc may undergo a galvanic reversal in which it becomes cathodic to carbon steel. The MIO/IMM coating (Heat-Flex® Hi-Temp 1200) is applied direct-to-metal to large pipes, valves *(above, center)* and tanks *(above, right)* before shipping to the construction site. The coating is effective in protecting components from corrosion in ambient C5 environments or at high heat under insulation.

The main industry document for guidance in selecting coatings for high-temperature is NACE Standard SP0198-2017. Different types of coatings are designated for different temperature ranges, which can be problematic for specifiers who cannot be sure of the precise applications their bulk valves will be placed into. For example, phenolic epoxies may be specified for -45°C to 150°C, whereas novel epoxies would be specified for -45°C to 205°C.

Fortunately, the MIO/IMM formulation, which is available as Heat-Flex Hi-Temp 1200 under the Sherwin-Williams brand, is suitable for the full temperature range, from -45°C to 650°C in ambient, open environments or in closed, wet environments. It can be applied DTM as a primer or topcoat. It resists CUI but also under-film corrosion resulting from mechanical damage in atmospheric conditions. MP

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With 33 years of technical coatings experience, Wilds is focused on developing strategies for long-term asset protection from the effects of corrosion under insulation (CUI) in the oil and gas (upstream, midstream and downstream), chemical and power industries. He also directs the development of specifications and testing programs with asset owners and operators. Wilds is a member of several coatings associations and is actively involved in developing coatings corrosion and CUI test standards with NACE International. He is also the current chairman of the North East Branch of the Institute of Corrosion. Wilds holds a degree in applied chemistry from Northumbria University. Contact: **Neil.Wilds@sherwin.com**

HOW TO GET GREEN FLOORING IN ANY COLOR

INTERVIEW WITH CASEY BALL, GLOBAL MARKET DIRECTOR – FLOORING, FOOD & BEVERAGE AND PHARMACEUTICAL, SHERWIN-WILLIAMS PROTECTIVE & MARINE

Ball has 17 years' experience focusing on the flooring market at Sherwin-Williams Protective & Marine. Previously, he served as a Project Development Manager, drawing on his experience as a Corrosion Specification Specialist and a Technical Service Rep for Sherwin-Williams. He is a NACE-Certified Coating Inspector and a Certified Concrete Coatings Inspector with SSPC: The Society for Protective Coatings. He holds a bachelor's degree in business from Wilmington College and earned his MBA in marketing from Franklin University. Contact: Casey.A.Ball@sherwin.com

MARKET PULSE: How can resinous flooring systems contribute to green building design?

BALL: Various flooring options tout a host of environmentally friendly features, including their use of recycled content and sustainable raw materials or lack of volatile organic compounds (VOCs). However, many specifiers may not realize that resinous flooring systems fit into the "green" category—and quite well—despite starting out as a liquid and curing into a solid material. In fact, many resinous flooring systems offer a lower environmental impact compared to carpet, luxury vinyl tile, hardwood and other options based on their Life Cycle Analyses (LCAs). This characteristic is becoming more important as building owners strive to differentiate their properties with greener designs.

The minimal VOC content in the Sherwin-Williams Thin-Set Epoxy Terrazzo #1100 System used for Delano High School's recent addition provided a green option that enabled applicators to install flooring while students and staff occupied the building.

How do greener resinous flooring systems perform?

Some specifiers may think green floor coatings can't perform as well as their predecessors in terms of durability, application characteristics and aesthetics. They may reason that removing solvents, for example, would negatively impact performance. This is not true. A great example is today's water-based flooring systems, which are performing just as well—if not better—than solvent-based systems, while reducing VOCs and enabling easier applications, faster returns to service and long-term performance.

What advancements are making floor coatings greener?

Removing solvent emissions while maintaining extended performance is key. For example, water-based and other low- or no-VOC floor coatings help improve indoor air quality and can enable flooring installations in occupied spaces with minimal to no containment and filtration. Such formulations exhibit low life-cycle costs due to their long-term durability. The longer the floor lasts, the lower its potential LCA based on the waste reductions gained from not having to remove the old material, and the energy and environmental savings realized by not needing to manufacture, package, ship and pour new product.

Can flooring help a building achieve LEED® status?

In the quest for Leadership in Energy and Environmental Design (LEED) status, the focus is on maximizing points. Surprisingly, the selection of resinous flooring systems can help contribute up to five LEED v4.1 points—or 12.5% of the necessary 40 points for baseline LEED certification for commercial spaces. The rules are too detailed to describe here, but stakeholders should work with suppliers to carefully specify flooring systems that take advantage of the significant potential gains toward LEED certification.

Can specifiers further enhance sustainability in their flooring selections?

LEED qualifications are helpful in taking a big step toward greener flooring specifications. However, all flooring options that meet certain qualifications have the same potential LEED point eligibility. There are no bonus points for using greener products. Yet, specifiers can take that step on their own by looking deeper into the makeup of each option. For example, details available in Environmental Product Declarations from manufacturers can help specifiers determine which among many flooring options offers the lowest environmental impact based on its LCA. Choosing the greenest options can be a point of pride for specifiers and a marketing opportunity for building owners by going above and beyond LEED. MP

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TWO LINING TYPES FOR CONCRETE TANKS: CHOOSING BETWEEN FLEXIBLE OR RIGID

BY KEVIN MORRIS, GLOBAL MARKET DIRECTOR INFRASTRUCTURE, AND
MURRAY HEYWOOD, NORTH AMERICA MARKET MANAGER–WATER & WASTEWATER,
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Specifying the optimal lining type for concrete water and wastewater treatment assets can help reduce the total cost of ownership for those assets. However, picking the right lining for the application can be tricky. The most tried-and-true types are either rigid epoxy liners or flexible elastomeric urethane liners. These two lining types greatly differ in their composition and performance, but are often misused or used interchangeably, against manufacturer guidelines.

The wrong choice can lead to failure, costly replacements, outages or overall system breakdowns. Conversely, the right choice will extend the interval between lining repairs or replacements and will increase the life of the asset itself.

Too often, municipalities make a choice between these two lining types for the wrong reasons—because they misunderstand the relative benefits of the linings; they had a previous experience (good or bad) with one of the lining types; or the applicators favor one over the other. No one lining type is better for all situations. The best choice depends on the particular application.

Let's take a look at the basic reasons why you would choose one lining over the other. This brief discussion will inform and enable you to hold more productive conversations with engineering firms, contractors and coatings suppliers about which liners will benefit all the stakeholders involved.

BASIC ADVANTAGES OF RIGID AND ELASTOMERIC LINERS

The basic advantages of rigid epoxy linings and flexible elastomeric urethane linings are easy to grasp. Epoxy linings are able to tolerate a moisture-rich environment or substrate, which is a valued quality because in existing concrete structures, moisture may be hard to avoid. Elastomeric urethane linings cannot tolerate moisture.

On the other hand, elastomeric linings have elongation properties that enable them to withstand the effects of settling, loading, expansion and contraction due to temperature. By contrast, rigid epoxy linings cannot handle movement in a concrete structure and will develop cracks under these stresses.

While these differences seem simple and clear, a final determination as to which lining type to apply to any given concrete asset can be quite complex and should be reached through consultation among the engineering consulting firm, the contractor, the supplier and the owner.

HOW DIFFERENT FACTORS AFFECT LINING CHOICE

Moisture

Many water and wastewater structures were originally placed into service without linings. Moisture penetrates deep into the capillary pores of the concrete and remains there, even when the surface appears dry—a condition referred to as saturated surface dry (SSD). Elastomeric urethanes cannot be applied over an SSD substrate because the isocyanate component in the lining reacts with the water before it reacts with the polyol resin. The result is blistering. For pre-existing concrete structures in which moisture is still present in any form, rigid epoxy linings are the better choice.

There are some water and wastewater applications that cannot be taken offline fully. Water may be diverted or the level of water may be reduced, but it is still flowing and turbulent, creating a mist. Even in these conditions, an elastomeric urethane will be problematic because of the airborne moisture. An epoxy lining would be recommended instead.

Corrosive contents can wreak havoc on concrete assets like this chlorine contact chamber in which the basin and baffles were severely deteriorated—almost to the point of crumbling *(left)*. Following surface preparation, applicators added mortar to restore the concrete to its original plane before applying an elastomeric polyurethane liner with no seams, voids or pinholes *(right)*.

Lining a concrete clarifier with either a rigid epoxy or elastomeric urethane *(left)* will prevent the severe deterioration that an unlined concrete clarifier will experience *(right)*.

Movement

The walls of many concrete structures move ever so slightly. They may shift in the earth, settle, or expand and contract due to changes in temperature. This movement is not visible to the naked eye, but it is enough to create hairline cracks in the structure. These cracks may be telegraphed through a rigid liner. With additional movement, the cracks may grow larger than a hairline. Rigid liners are not able to bridge these cracks and, therefore, are not recommended in such applications. Elastomeric urethanes, on the other hand, have elongation properties that enable them to bridge hairline cracks that may develop as the concrete substrate moves.

How does one know whether a concrete structure will move? The age of the structure is one indication. For example, a 40-year-old tank that has had time to settle in the ground—and has been loaded and unloaded many times—will be less prone to move further. On the other hand, a tank or basin that has never been loaded will be subject to significant movement as it takes on water for the first time.

Size and type of construction are other variables that determine whether a concrete structure will move. Small structures that are precast, cylindrical in shape and reinforced with small wire mesh are less prone to movement than larger structures that are poured in place and reinforced with rebar. In wastewater systems, for example, rigid epoxy liners are often applied with success to smaller structures like manholes, lift stations, wet wells and influent channels.

One category of rigid epoxy liners is referred to as “high-strength” or “semi-structural” because of its exceptional compressive, flexural and tensile strength. In addition to their other benefits, epoxies in this category may add to the physical characteristics of a concrete structure. This improvement is not drastic, but according to the research, there is a benefit in this area.

Depending on the size of the treatment facility, clarifiers, digesters and aeration basins may be candidates for epoxy linings or elastomeric linings. In addition, any structure that may be constructed with CMUs (concrete masonry units) would be subject to movement and therefore would require elastomeric linings.

In water treatment plants, as opposed to wastewater, many of the concrete structures would be considered large, e.g., 200 feet long by 100 feet wide and 40 feet deep. Structures of this size, including flocculation basins, sedimentation basins, filtration basins and ground water storage tanks, would be better served with elastomeric linings.

For heavily chlorinated water, epoxies may be preferred because they hold up better under exposure to this chemical. On the other hand, chlorine contact basins may contain baffle walls constructed of CMUs, which would argue for an elastomeric lining because the CMUs are subject to movement.

Climate

The geographic region, time of year and climate should all be considered when choosing a lining type. Urethanes cure better in colder temperatures than epoxies, but epoxies can handle airborne moisture and high relative humidity. If the project is taking place during winter in the midwestern U.S., an elastomeric urethane may be the better choice, but during the summer in the southeastern U.S., an epoxy lining may be a better choice.

Equipment and Cost

Elastomeric urethane linings are typically more complicated to apply than rigid epoxy linings. They also require plural-component application equipment that some applicators may not possess or have the means to purchase. In addition, among those applicators who have plural component equipment, some may lack the experience to anticipate or recognize complications underlying the application of elastomerics.

Some rigid epoxy lining formulations also require plural-component equipment, but there are technologies on the market now that allow for single-leg spraying of rigid epoxy liners, with results that are equal to plural-component spraying. There are still benefits to plural-component spraying, but these pertain more to the applicator, who will be able to reduce waste and the amount of solvent required for the application.

One benefit of single-leg spraying of epoxy linings is that more contractors can compete for an epoxy lining project, which may hold down costs for the owner.

SOME CONCLUSIONS

Armed with the knowledge in this overview, you should be able to enter into a constructive conversation with your engineering firm, applicator or coatings supplier about the merits of rigid versus flexible linings. These decisions are often complex—and usually involve many variables, not one. It's appropriate to ask lots of questions before deciding on a lining type.

Unfortunately, there are many shortcuts to a simple answer. For example, some specifiers may cut and paste specifications from one project to another without adequate thought about how the applications differ. Similarly, contractors may only be comfortable applying one type of lining, or suppliers may have only one type of lining available.

These are situations that you can question, raising points that argue for one type of lining over another. The best scenario is always a constructive discussion that involves all parties focused on the unique characteristics of the individual application. If cost enters the picture, as it surely will, be sure to consider not only the initial cost of the lining, but also the life cycle of that lining (i.e., how soon you will need to repair or replace it). In general, life cycle questions will make the greatest impact on your bottom line over the long run. MP

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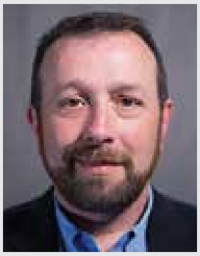

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OIL & GAS: UPSTREAM

DATA FROM NEW TESTING PROTOCOL WILL HELP ENERGY PRODUCERS CHOOSE BETTER-PERFORMING COATINGS FOR OFFSHORE PLATFORMS

GETTING AHEAD OF CORROSION OFFSHORE

BY BRUCE TOEWS, GLOBAL MARKET DIRECTOR – OIL & GAS, AND JOHNNY C. POURCIAU, OIL & GAS MARKET DIRECTOR – UNITED STATES, CANADA AND THE CARIBBEAN, SHERWIN-WILLIAMS PROTECTIVE & MARINE

Major petroleum industry stakeholders who own, operate and maintain drilling and production facilities in the Gulf of Mexico, North Sea and other offshore environments face ongoing corrosion challenges. The ocean's high saltwater content, as well as extreme atmospheric and underwater temperatures, prove hostile to platforms and topside equipment, placing stresses on the coating systems that protect steel structures above, around and below the splash zone. The constant need for corrosion prevention and mitigation makes these structures expensive to maintain.

While the corrosion precipitated by harsh sea environments is well understood, owners and operators of offshore platform equipment feel fortunate if the protective coatings on their equipment last for four to six years. Very often, however, oil and natural gas producers report that the coatings used in upstream applications are lasting only 18 to 24 months before maintenance crews must make major repairs, including blasting and recoating the steel to restore protection. These interruptions are costly and inefficient because they often slow down production rates. In addition, platform accommodations are at a premium, leaving minimal opportunities to house coating applicators onboard to perform maintenance.

To help stakeholders across the upstream, midstream and downstream oil and gas industries achieve longer service lives for their assets, Sherwin-Williams Protective & Marine began rethinking how to approach corrosion mitigation for these operating environments. Many industry players are still promoting older systems, but stakeholders in the oil and gas industries desire innovative systems that will drive operational efficiency and excellence.

To meet customers' needs to extend the lifecycle and reduce the downtime of their offshore assets, Sherwin-Williams developed an accelerated testing protocol for predicting the performance of various coating systems. The findings are revealing some surprising results that suggest the industry should consider adopting new specification strategies.

THE SEARCH FOR BETTER RESULTS

In 2017 Sherwin-Williams began work on a three-year accelerated testing protocol for offshore coatings. The company pursued the study to more effectively predict the performance of currently used systems, and to investigate non-traditional, high-performance coating systems that the industry may be overlooking. Throughout this process, the company is examining the performance of different systems over various surface preparations to find the optimal combinations for long-term corrosion protection.

Entering the third year of the testing and data collection, results are revealing new technology drivers that enable the improved life cycle performance of various coatings. As part of this initiative, technicians have also performed testing to confirm the correlations between the tests and procedures.

Traditionally, the accepted coating systems for offshore applications

"We developed an accelerated testing protocol for predicting the performance of various coating systems, revealing some surprising results that suggest the industry should consider adopting new specification strategies."

include epoxy primers, epoxy intermediates, and epoxy or polyurethane finish coats. An epoxy with glass-flake or aluminum-flake filler has been thought to be more robust, guaranteeing a longer service life for equipment. However, after two years into the testing protocol, this system typically used offshore has actually performed quite poorly. These test results are debunking prevailing assumptions, allowing Sherwin-Williams to recommend specific changes in coating specifications for customers that will improve their operating efficiencies and afford them tremendous cost savings.

COMPLETE TESTING WITH VARIED SURFACE PREPARATIONS

The types of coatings selected for the test procedure represented both "typical" and "atypical" systems for atmospheric service. The study also included a variety of substrate profiles to duplicate the angles found on offshore assets and ensure any areas vulnerable to corrosion were thoroughly examined.

For the procedure, lab technicians applied 11 coating systems to test panels featuring different surface preparations, including: grit blasting (according to SSPC-SP10) on one set of panels; grit blasting contaminated with 25 $\mu g/cm^2$ Cl- on another set; ultra-high-pressure water-jetting (per NACE No. 5 WJ-2/ Moderate Flash Rust) on a different set; and a power tool treatment (according to SSPC-SP11) before being contaminated with 25 $\mu g/cm^2$ Cl- on the last set.

Lab technicians prepared the panels (according to SSPC-SP10) contaminated to 25 $\mu g/cm^2$ Cl- by uniformly spraying them with a known volume of an aqueous solution. The panels were then flash rusted to a moderate grade (as described in NACE No. 5). The concentration of chlorides on the contaminated panels was verified to be 24 $\mu g/cm^2$,

Offshore platforms are susceptible to corrosion from the splash zone to topside equipment such as cranes.

CONT. FROM P. 13

based on a commercial, soluble salt testing kit.

The panels that received ultra-high-pressure water-jetting were left to rust in a light industrial environment for 30 days (according to an SSPC VIS-3 Condition C), after which technicians performed ultra-high-pressure water-jetting (based on NACE No. 5 WJ-2) with water at 30,000 psi. The panels were flash rusted to a moderate grade before coating.

The panels that received the power tool treatment were prepared by rusting according to the above procedure. Then technicians used a power tool to obtain a surface preparation (according to SSPC-SP11), and followed that up by spraying a salt solution on the panel, which once again resulted in moderate flash rust.

EXPOSURE CONDITIONS MIMIC OFFSHORE STRESSES

Each set of test panels was exposed to the following four conditions:

a) NACE TM0304 (i.e., cyclic weathering according to a modified ASTM D5894-16 exposure), in which the electrolyte was synthetic seawater
b) Exterior exposure at a 30-degree angle facing the ocean in a warm environment
c) Exterior exposure at a 45° angle facing south in a light industrial environment
d) Exterior exposure at a 30-degree angle facing the ocean in a cold environment

Lab technicians then subjected each coating to four types of analyses. First, a visual analysis of the exterior helped to determine evidence of damage or corrosion, undercutting and degradation of color or gloss. This analysis also looked at surface edges for blistering, rusting, scribe creepage or signs of visible breakdown. Second, technicians tested the coatings using electrochemical impedance spectroscopy. Third, they evaluated the coating's permeability before and after exposing the test panels to the above conditions. Finally, the lab tested the panels using Fourier Transform Infrared Spectroscopy before and after they were exposed to the simulated weather and temperature conditions above to analyze the coatings' chemical properties and evaluate their health.

A TOP PERFORMER EMERGES

Following 24 months of the 36-month test protocol, Sherwin-Williams has already determined there are greater benefits in specifying select one- and two-coat systems compared to the traditional three-coat systems used. At this advanced stage of the study, the application of Corothane® I – GalvaPac 1K Zinc Primer, an organic zinc-rich, moisture-cured urethane primer from Sherwin-Williams, has shown the best results to date. This and other zinc-rich primer systems are demonstrating superior corrosion resistance and have exhibited no major breakdown after 24 months into the test procedure.

Second, testing determined that a coating system's film thickness only helps prevent corrosion in offshore applications if it is extremely high. Moreover, testing also showed that a thin film of high ultraviolet-resistant fluoropolymer impedes corrosion within these contexts.

When this testing is finalized in 2020, owners and operators of oil platforms, as well as companies that transport, store, refine and distribute oil and gas, will have a clearer picture as to what systems offer the lowest corrosion potential and longest maintenance intervals. The results should also benefit contractors involved in maintenance, as well as fabricators and engineering firms.

The new testing protocol developed by Sherwin-Williams Protective & Marine is an example of the company's commitment to drive new coating technologies, systems and products that enable better coatings specifications, corrosion protection and outcomes. MP

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PIPELINES

TWO LAYERS ARE BETTER THAN THREE

BOOSTING PIPELINE PERFORMANCE AND SAVINGS WITH DUAL-LAYER BARRIER SYSTEMS

BY DR. JEFFREY D. ROGOZINSKI, GLOBAL PRODUCT DIRECTOR – FUSION-BONDED EPOXY/PIPE, SHERWIN-WILLIAMS PROTECTIVE & MARINE

Oil and gas pipelines take a beating—both before and after they're installed underground. From transportation and storage to installation and service, pipes face potential scrapes, impacts, flexions and more. These stresses threaten the integrity of the pipes themselves and, especially, the external barrier systems that protect pipes from corrosion.

Top: **The use of a new dual-layer abrasion- and moisture-resistant overcoat technology for buried pipelines can enhance moisture, gouge and impact resistance to reduce total ownership costs.** ***Bottom:*** **Inspectors subjected the overcoat to multiple tests to confirm its durability.**

Such barrier systems feature a base layer of an anti-corrosive fusion-bonded epoxy (FBE)—with some systems using just a single-layer FBE and others adding layers on top to protect that base from damage. The base layer needs to remain as intact as possible throughout a pipe's life to prevent the pipe from corroding and developing a potentially dangerous leak or exploding. Therefore, pipeline owners and operators frequently specify multi-layer systems, which can protect the base layer from damage and moisture.

Stakeholders have two primary options for that protection. The most widely used systems feature a single FBE coating topped with an intermediate adhesive layer and a polyolefin wrap, but these three-layer barrier systems aren't compatible with the cathodic protection (CP) systems commonly used as backup pipeline corrosion protection. In addition, they're particularly labile during field joint coating applications in which complex application processes are prone to errors and moisture trapping, which can accelerate pipe corrosion.

The alternative option is a dual-layer system that offers outstanding damage-resistance characteristics with added benefits. These novel dual-layer systems feature enhanced moisture, gouge and impact resistance, while simultaneously having higher dielectric strength. This increases overall pipeline integrity, reduces installation and commission times, and can reduce the long-term costs of CP systems.

NECESSARY PROTECTION TO BOOST PIPELINE SAFETY

The base FBE layer applied in single-, dual- and triple-layer barrier systems is the steel substrate's first line of defense against corrosion. However, that defense can be compromised by a single scrape that exposes the substrate. Such areas become an initiation point for corrosion to take hold and proliferate, eventually requiring the pipe to be unearthed for coatings repairs or even replacement.

The base FBE layer may be damaged due to scratches from handling, impacts from backfilling, and scrapes from underground soil movement and pipe expansion and contraction. With damage potential high, adding a damage-resistant barrier to protect the base layer is advisable.

ENHANCE DURABILITY WITH DUAL-LAYER SYSTEMS

Newer dual-layer coating systems feature a base anti-corrosive FBE layer topped with an abrasion- and moisture-resistant FBE overcoat ***(Figure 1)***. They're designed to protect the base layer from scratches caused by horizontal directional drilling and backfilling, as well as mitigate moisture penetration into the coating. Blocking moisture absorption helps to greatly reduce the potential for the coatings to delaminate due to fundamental adhesion loss or cathodic disbondment, a phenomenon that poses a greater concern with three-layer systems, which trap moisture, and a lesser concern with older dual-layer systems that only feature abrasion resistance.

Recent enhancements to dual-layer systems include adding robust moisture resistance to the coating, such as with Pipeclad® 2060 MRO Abrasion-Resistant Overcoat (ARO) from Sherwin-Williams Protective & Marine. This reformulation of the company's time-tested Pipeclad 2040 Flex ARO system marries abrasion and gouge resistance with a moisture barrier that inhibits water from penetrating the base-level anti-corrosion coating.

Together, the two layers protect the pipe substrate from being exposed to prevent pipeline corrosion. This combination offers superior performance attributes that should translate into cost savings for a variety of stakeholders.

The new dual-layer system has an inherently higher dielectric

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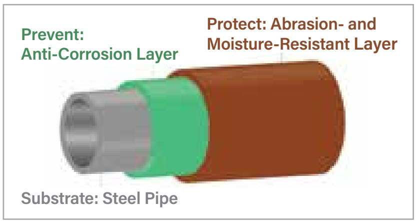

FIGURE 1. A dual-layer FBE coating system features a base anti-corrosion FBE layer to prevent pipeline corrosion and a top abrasion- and moisture-resistant overcoat that protects the anti-corrosion layer from wear.

RIGOROUS TESTING DEMONSTRATES FIELD PERFORMANCE CAPABILITIES

To confirm the performance of Pipeclad 2060 MRO ARO, Sherwin-Williams Protective & Marine sponsored extensive lab testing that attempted to damage the coating using field-scenario simulations. Findings showed that the coating's improved impact resistance eliminates the need to wrap pipes with polymeric padding, which can potentially shield cathodic protection (CP) systems before burying them to protect their barrier systems from being chipped or gouged by falling rocks and dirt. They also showed how the coating's enhanced moisture-resistance properties reduce cathodic disbondment potential to enable longer corrosion protection.

For one test (NACE TM0215-2015), technicians applied an ASTM-specified R33 drill bit to the overcoat to attempt to gouge the coating. Applying 32 kg of pressure barely affected the coating, and 62 kg of pressure illustrated a compression of the coating at the drill bit interface and not a classical "gouge" ***(Figure 2)***.

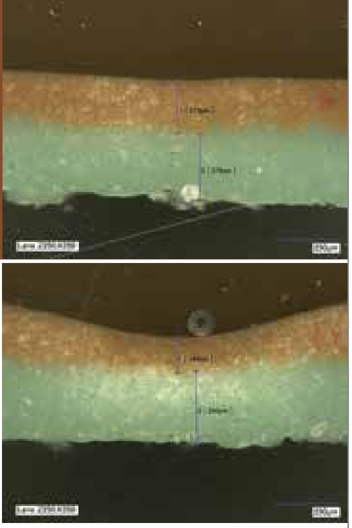

FIGURE 2. Cross-sectional microscope photos show no gouging with 32 kg of pressure applied using an R33 drill bit *(top)* and compression, but still no gouging, at 62 kg of applied pressure *(bottom)*.

During a subsequent test to evaluate the coating system's flexibility, testers bent a coated pipe, attempting to wrinkle and compromise the coating ***(Figure 3)***. Whereas the pipe itself wrinkled, the coating did not, and no holidays were formed.

The above tests—as well as impact-resistance tests involving dropping rocks and dirt onto coated pipes from several feet above ***(Figure 4)***—demonstrate that installers can cover pipes featuring the new barrier system with the same dirt that came out of the hole, provided it conforms to prescribed specifications. No additional crews are required for specialized backfilling or application of polymeric padding, speeding up installation times and, thereby, reducing installation costs.

FIGURE 3. After wrinkling a pipe coated with Pipeclad 2060 MRO ARO, inspectors found the coating to be fully intact.

The tests performed also confirm that the moisture-resistant overcoat (MRO) system not only protects pipes when being handled aboveground by cranes or chains, but also shields pipes from any damage caused by the inevitable underground shifting and movement of dirt. In addition, it can keep pipes safe from jarring and gouges that can occur during horizontal directional drilling.

Lab technicians also tested the coating system for its resistance to cathodic disbondment, which can occur when moisture penetrates the interface between the pipe and the coating, making the coating more likely to delaminate and lose adhesion. Minimizing that risk, the new moisture- and abrasion-resistant overcoat system has enhanced substrate-coating interaction, while simultaneously reducing the amount of water that can reach the pipe.

The new MRO system also demonstrated improved cathodic protection performance, as technicians observed no cathodic disbondment after attempting to peel the coating from a prepared sample that was subjected to salt water testing in an oven.

Ultimately, the comprehensive testing showed that applying the moisture- and abrasion-resistant overcoat on top of the base anti-corrosion FBE layer can demonstrably improve the ability of pipes to deliver long-term service with minimum corrosion potential.

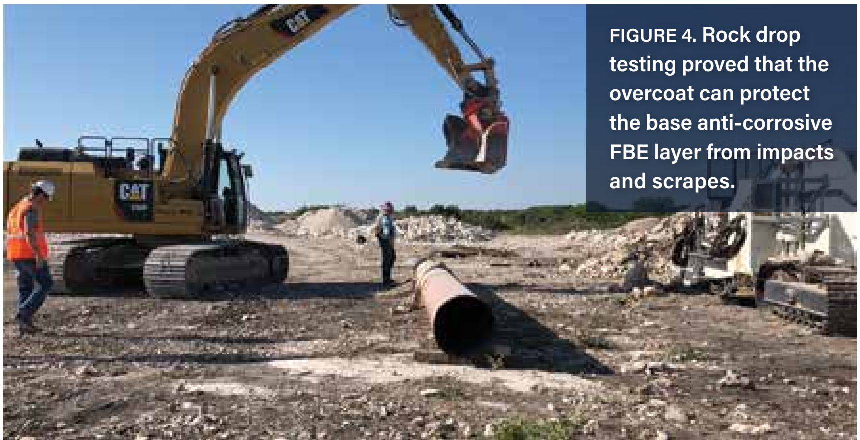

FIGURE 4. Rock drop testing proved that the overcoat can protect the base anti-corrosive FBE layer from impacts and scrapes.

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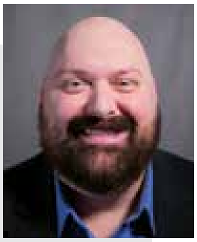
strength, which results in fewer false-positive holidays (discontinuities in the coating) during testing. This feature is associated with the system's low-moisture absorption and reduced water vapor transmission rates compared to classical FBE chemistries.

IMPROVED OPTIONS FOR PIPELINE OWNERS

Dual-layer protective coating systems are already approved external barrier system options in specific countries, and they are gaining in popularity due to their ideal combination of benefits derived from single-layer and three-layer systems. Specifically, dual-layer systems prevent corrosion, like single- and three-layer systems; they protect the anti-corrosion layer, as seen in three-layer systems; and they enable pipeline corrosion monitoring in the same way as single-layer systems.

With the availability of enhanced dual-layer coating systems that improve upon tried-and-true ARO technology, pipeline owners and operators have a new viable option to protect their critical assets. Adopting the MRO and ARO dual-layer coating system will enhance their potential to lower installation and long-term ownership costs while meeting the needs of a growing and diverse global energy market. **MP**



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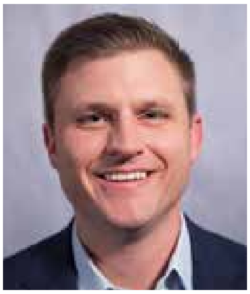
MADSCI/GETTY IMAGES

ASK THE EXPERT: RAIL

THE CALL FOR A BETTER-LOOKING RAILCAR

INTERVIEW WITH MICHAEL MANETTA, GLOBAL MARKET DIRECTOR – RAIL, MARINE AND POWER GENERATION, SHERWIN-WILLIAMS PROTECTIVE & MARINE



Michael Manetta has 15 years of experience in the coatings industry, having served in several sales and marketing roles within multiple end-use segments. He has an MBA from the Kelley School of Business at Indiana University. Contact: Michael.Manetta@sherwin.com

MARKET PULSE: What is the latest challenge concerning coatings for railcar exteriors?

MANETTA: One current challenge we're hearing a lot about is aesthetics. Everyone understands that the main role of coatings in the rail industry is durability—protection from the elements, corrosion and abrasion. But in recent years aesthetics is getting more emphasis.

Why this recent emphasis on aesthetics?

Epoxy coatings are highly effective at protection from corrosion and abrasion, but when exposed to ultraviolet (UV) rays, they will chalk and change color within a year or two. For example, black coatings will turn gray. Many railcar owners and lessees are no longer willing to accept this outcome. The lessees want a tank car that will retain its rich black color and luster. They care about what their cars look like.

Meanwhile, railcar owners do not want to have to recoat their cars for appearance purposes when it is not necessary from a protection standpoint. Their total cost of ownership improves the longer they can keep a car on the tracks without recoating. In addition, they may be able to command a higher price for a car that still looks good after many years of service.

What is the industry's answer to this call for a better-looking railcar?

Sherwin-Williams Protective & Marine embraced this challenge and explored many black pigments and epoxy formulations, looking for one that would retain its black color under UV exposure. Lab technicians subjected these experimental formulations to multiple rounds of UV testing following ASTM International protocols. The result is our new product, CarClad™ Macropoxy® HS 4200, which chalks black, not gray, and retains its luster, color and appearance much better over the full maintenance interval. It is a new and improved version of CarClad Macropoxy HS, which is a popular choice for hopper and tank car exteriors and a proven performer.

Has the new high-solids coating been tested against standard epoxies?

Yes, for example, in one third-party verified test, we exposed CarClad Macropoxy HS 4200 and a standard epoxy coating to 1,750 hours of UV light. The results in Figure 1 (*below*) show the striking difference between the two products.

From an application standpoint, what are the qualities that railcar owners value in a coatings product?

Railcar owners may coat or recoat thousands of cars per year, so speed and efficiency of the application is very important. It's all about quick returns to service. Therefore, owners need a high-solids coating, like CarClad Macropoxy HS 4200, that can be applied in one direct-to-metal coat.

In addition, railcars usually require about 4-6 mils dry film thickness, but around complex geometries, such as ladders or wheels, applicators may need to hang additional wet mils as they make multiple passes. CarClad Macropoxy HS 4200 is suited to this purpose, with the ability to hang up to 18-20 mils wet film thickness.

Finally, applicators need some latitude in application conditions, including temperature. Solvent-based coatings, such as CarClad Macropoxy HS 4200, are more flexible in this regard than waterborne epoxies. MP

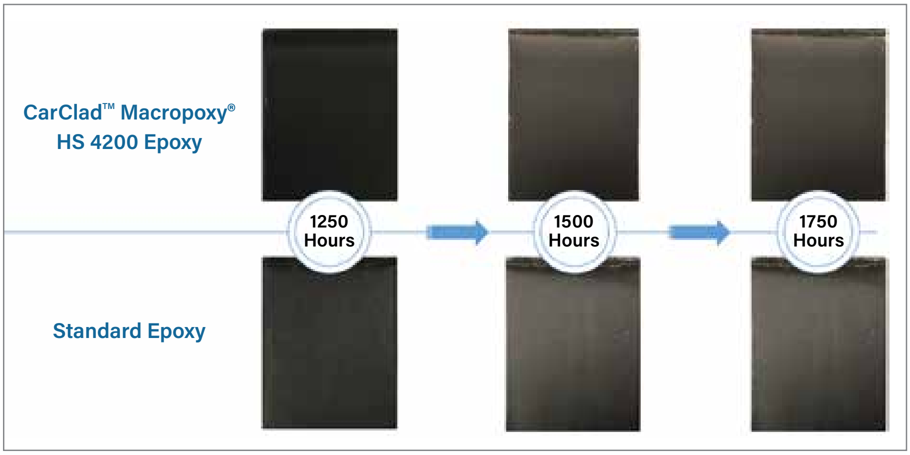


FIGURE 1. **Accelerated third-party UV exposure testing demonstrates the ability of CarClad™ Macropoxy® HS 4200 to chalk black over time—rather than turn gray like standard epoxies do.**

FIRE PROTECTION

HOW SHOP-APPLIED FIREPROOFING BEATS FIELD APPLICATIONS

Applying passive fire protection coatings in the shop can enhance the quality, aesthetics and safety of applications compared to coating steel in the field.

BY TROY MARSHALL, FIRE SEGMENT DIRECTOR – THE AMERICAS,
AND CARL BURRELL, GLOBAL PRODUCT MANAGER – FIRE,
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The practice of where and when to fireproof structural steel for buildings, hotels, stadiums and other multi-story structures has evolved significantly around the globe over the past several decades. Today, steel fabricators, general contractors, asset owners and architectural designers are realizing lower costs and enhanced safety, quality and aesthetics. These benefits can be directly tied to a shift from applying passive fire protection (intumescent) coatings in the field to applying them in a controlled shop environment. And stakeholders who have not yet made the shift are missing out on streamlined operations and lower overall costs.

REAP THE REWARDS: COST, SAFETY AND AESTHETICS

Major fabricators in the United Kingdom started applying passive fire protection coatings to structural steel within the shop environment—as opposed to within the construction zone—around the late 1990s/early 2000s. Soon afterward, the steel fabrication and construction industries began embracing fireproofing in the shop as a standard business model. It is now widely adopted in the U.K. and much of Europe, the Middle East and Asia.

Compared to the application of passive fire protection coatings in the field—which is relatively common in the United States—fireproofing in the shop enables stakeholders to reduce costs and enhance the overall quality of applications. The gains realized in the U.K. and other parts of Europe make a viable case for major U.S. fabricators to adopt a similar strategy in greater numbers, so the myriad cost, safety and aesthetic benefits derived from the shop-applied model become more widespread across North America.

IT'S ABOUT TIME

One important advantage of restricting the fire protection process to the shop environment is that it allows the construction team to complete buildings much faster, lowering costs for builders. This swifter speed-to-completion is made possible by eliminating the need for much of the equipment and hassle associated with coating steel after it has been erected within a structure.

With coatings already applied in the shop, applicators do not need to set up a full containment system around the steel structure to protect the substrate from dust, rain and snow prior to coating. Nor do they have to invest in setting up environmental controls to ensure conditions are suitable for applying coatings. The containment process alone can be time-intensive and cost-prohibitive. Plus, within the shop, applicators can control temperatures and humidity to fireproof steel during any season of the year.

In fireproofing the structurally complex Leadenhall Building in London, applicators coated the steel in the shop rather than in the field.

UP YOUR GAME: ENHANCING APPLICATION QUALITY

Applying passive fire protection within a controlled shop also improves the overall quality of the surface preparation and the coating application. To begin with, it is much easier for coating applicators to prepare each piece of steel in the shop, as opposed to the more haphazard process of coating assembled steel structures, which can contain tight corners and other difficult-to-reach areas. During field application, applicators run the risk of working with an imperfect surface preparation, which can compromise the quality of the fireproofing process.

By contrast, when spraying intumescent coatings in the shop, applicators can control the surface preparation and enhance the quality of the fire protection application, which thereby improves safety for building occupants. For example, applying fireproofing in the shop helps applicators better ensure that coatings are applied to the right thickness for each piece of steel and that the entire structure therefore conforms to the specified fire resistance rating.

Another significant benefit of applying the coatings in an indoor controlled environment—as opposed to in the construction zone—is that it removes the necessity of coating the steel while other tradesmen are working. Fireproofing in the shop reduces the number of trades that must operate simultaneously on a construction site. Doing so enhances safety for the roofers, plumbers, electricians, excavators and other tradesmen laboring at the site. When coating applicators are working simultaneously with others, the process can be inefficient and hazardous. Accidents are more likely to happen.

ADVANCING INNOVATION IN BUILDING DESIGN

Given the cost, quality-control and long-term safety benefits of using shop-applied passive fire protection coatings, this controlled application process has an added benefit for architects. It frees them up to incorporate more steel into building designs, allowing them to be more innovative. Sherwin-Williams witnessed such architectural creativity while CONT. P. 20

Iconic structures such as the 95-story Shard of Glass skyscraper in central London benefit from the practice of fireproofing in a controlled shop environment.

TABLE 1. Comparison of Shop- and Field-Applied Passive Fire Protection Coatings

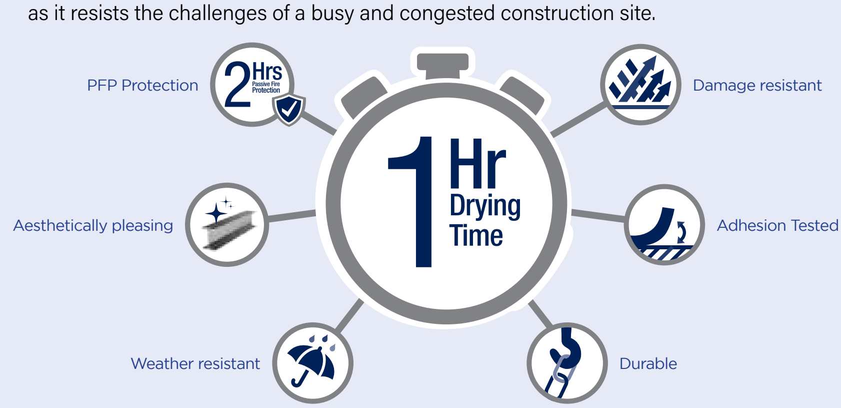
SHOP-APPLIED FIREPROOFING	FIELD-APPLIED FIREPROOFING
Controlled shop environment	Uncontrolled, variable environment
Containment inherent within shop	Containment required on site
Faster fireproofing applications	Longer fireproofing applications due to site setup
Easier surface preparation	More challenging surface preparation
Uniform coating applications and thicknesses	Potential for varied applications and thicknesses due to limited access and maneuverability when steel is erected
Faster building completion due to limited touch-up application needs on site	Longer construction timelines due to downtime for other trades working on site while applying coatings
Greater design freedom	More limited design freedom due to inability to achieve precise coating applications on site

EXTENDING THE SCOPE OF PROTECTION

Passive fire protection coatings (or intumescent coatings) from Sherwin-Williams Protective & Marine are designed to buy time for building occupants—and the steel-framed structures themselves—during a fire. Applied to structural steel, the coatings react chemically in fire, forming a char that expands with heat exposure, much like the reaction that takes place when one lights a black snake firework. Slowing that rate of heat transfer is critically important, as structural steel under load can quickly lose strength in a fire. Intumescent coatings help building owners avoid such catastrophic losses by providing fire resistance while responders work to contain a fire.

The FIRETEX® FX series is a family of intumescent coatings that allows for the flexible and creative exposure of structural steel surfaces in building design. The second generation of the **FIRETEX FX6000** series fire protection, known as **FX6002**, is an innovative patented technology. It delivers an unparalleled speed of drying, along with an extended range of approved fire scenarios and 20 years of exterior durability to support design flexibility and the architectural expression of structural steel surfaces in building design.

The FX6002 second-generation technology extends the scope of protection to lighter steelwork more than was previously possible with FX6000, while also reducing the required thickness. The ultra-fast drying feature of FX6002 removes drying bottlenecks in the paint shop and develops rapid weather resistance if applied on site. Its excellent mechanical durability minimizes transport and erection damage as efficiently as it resists the challenges of a busy and congested construction site.



working with its construction partners to fireproof the Leadenhall Building and the Shard of Glass skyscrapers in central London.

In fact, a unique fire protection challenge occurred while collaborating with architects and engineers during the construction of the Leadenhall Building, a modern glass and steel structure. Many of the iconic building's design elements—its beams, columns and large transitional nodes within a sloping mega-frame—were highly complex. The team needed to develop precise intumescent coating thickness specifications for each piece of steel, depending on its size and incorporation into the structure.

Our fire engineering team engaged in painstaking and complex fire protection analysis and coating application methodology in conjunction with the project's structural steel specialist. This process yielded specific coating thickness guidelines for each piece of steel. Then, by applying the coatings in a shop environment, the fabricator was able to ensure the Leadenhall Building's unusual design elements had the appropriate thickness of coatings applied and therefore the highest level of fire protection.

A greater percentage of construction companies in the U.S. could benefit from adopting the shop-applied fireproofing model that is now prevalent in the U.K. By embracing the shop-applied approach, major fabricators in the U.S. are sure to see a difference in the quality of the coated steel used during construction, while passing a host of benefits down the construction chain. MP

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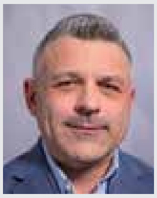
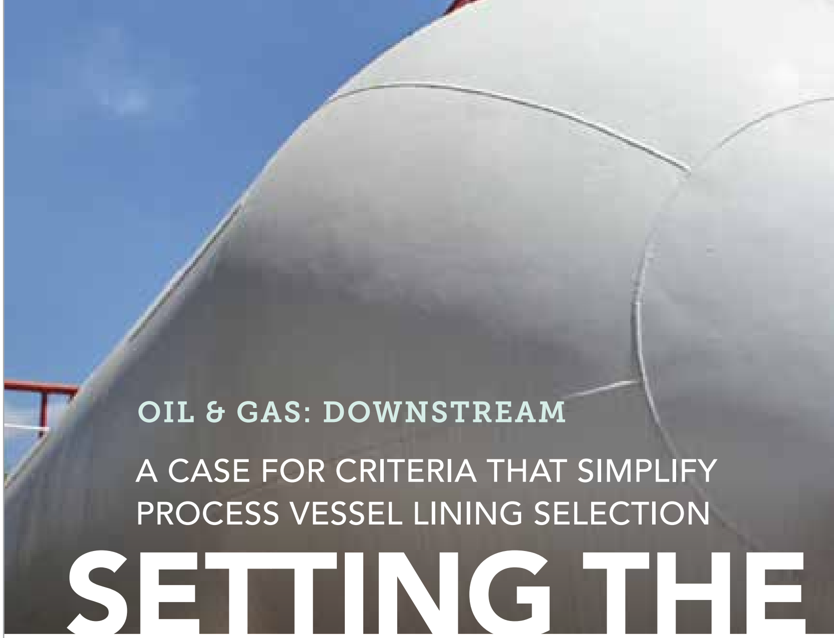


Marshall has more than 20 years' experience in the protective coatings and corrosion protection industry, including extensive experience working with contractors around the world on high-value fireproofing projects for the oil and gas and petrochemical markets. He holds a NACE Level 1 certification and is a member of NACE International and SSPC. Contact: **Troy.T.Marshall@sherwin.com**

Carl Burrell, Global Product Manager – Fire

With 21 years of industry experience, Burrell has global responsibility for the Sherwin-Williams product portfolio strategy and implementation in the areas of passive fire protection (hydrocarbon and cellulosic fire) and cryogenic spill protection. He is a nominated BSI (The British Standards Institution) national expert on the International Organization for Standardization (ISO) TC67 and TC92 committees. Contact: **Carl.Burrell@sherwin.com**



OIL & GAS: DOWNSTREAM

A CASE FOR CRITERIA THAT SIMPLIFY PROCESS VESSEL LINING SELECTION

SETTING THE

BY MICHAEL HARRISON, GLOBAL PRODUCT DIRECTOR – LININGS, SHERWIN-WILLIAMS PROTECTIVE & MARINE

Process vessels, also known as pressure vessels, deliver a critical function within oil and gas upstream operations. Subjected to elevated temperatures and pressures, these vessels are used to process hydrocarbon mixtures to remove corrosive materials from oil before transport. Asset owners and operators expect pressure vessels to remain in operation consistently, while performing over the long term to ensure productivity for hydrocarbon processing operations.

Linings are frequently used to mitigate corrosion inside process vessels and extend their service lives and maintenance cycles. Their long-term performance is important, as is the ability to return vessels to service quickly when maintenance is required. Therefore, specifiers often choose easy-to-apply and fast-curing lining technologies to reduce the time vessels are out of service.

The combined needs of long-term service and rapid service restoration require the careful selection of linings to deliver optimal outcomes. However, complicating the matter for asset owners, operators and specifiers is the dearth of available product performance and testing data and the lack of a universally accepted standard detailing how coating manufacturers should report that data.

Ultimately, all parties involved in choosing linings for process vessels would benefit from an optimized standard that offers directly comparable testing and data reporting. Achieving this goal would, in turn, help key stakeholders specify linings that maximize vessel lives and streamline operations, helping them to also reduce costs.

THE IMPACT OF OPERATIONAL STRESSES ON LINING SELECTIONS

Many different types of pressure vessels exist, and the lining demands for each type differ according to a unique set of requirements for the process and the vessel's contents. In choosing the correct lining, specifiers must consider the precise source of the crude oil being processed, as each source

STANDARD

Left: **Directly comparable testing and data reporting for process vessel linings can help stakeholders maximize vessel lives, streamline operations and reduce costs.** FUNTAY/GETTY IMAGES

has a unique temperature, acidity level and gas content. In addition, the presence of any abrasive media, such as sand, should be considered in some separators. The choice of lining type also depends on the different chemicals used during the extraction and treatment processes, as well as the different temperatures and pressures required. Due to the accelerated pace at which plant maintenance must be conducted, specifiers generally insist on procuring linings that can be applied and cured quickly.

Operating conditions in process vessels vary considerably. When selecting a suitable lining material, specifiers should consider: the composition of any oil and water inside the vessel; the vapor composition of the vessel contents; the minimum and maximum pressures; the operating temperature (and whether temperature gradients may be an issue); and the use of process chemicals and cleaning procedures, which can be more aggressive than the operation itself.

Linings inside process vessels are also subjected to different types of stresses during a plant's operation. For example, linings inside test separators experience frequent decompressions and the effects of acids from well workovers. Moreover, secondary and tertiary production separators may endure heating and temperature cycling between primary and secondary separators. Both examples demonstrate how fluctuating process vessel conditions should be considered in testing protocols to ensure the lining performs against a range of conditions.

CHALLENGES COMPLICATING LINING SPECIFICATION

Plant owners and operators face a dilemma when specifying linings for process vessels. They are often unsure which lining materials, out of myriad available options, offer the best protection for a given application and situation. During the selection process, it is imperative that owners of process vessels consider multiple factors related to the unique operational environment and field requirements.

In particular, vessel owners should make their lining selections based on likely plant conditions, which are dictated by chemical exposure, operating temperatures (including potential temperature gradients) and pressures. The lining selection may also depend on certain field requirements, in which rapid application and cure are more important than long-term, consistent performance.

To determine the proper lining material, those who specify also need to consider the design of the pressure vessel. For example, some vessels have limited access and may feature pipes and baffle plates inside, making them difficult to line. Products that are easier to apply—such as high-solids, edge-retentive coatings—should be specified in such cases.

THE NEED FOR COMPARATIVE DATA

For process vessel owners and operators, the process of selecting an appropriate lining is complicated by the lack of standardized comparative data for proposed lining solutions. In many situations, owners and operators are forced to make selections using data that are often confusing, contradictory or incomplete. In certain cases, the lining chosen may be inadequate for the required service or it may be considerably more durable than needed, thereby adding unnecessary costs.

It would behoove the coatings industry to help owners and operators make more accurate comparisons among available lining materials, so they can arrive at the optimal solution for a given application and situation. Doing so will help owners and operators optimize the costs associated with lining vessels. Of course, there will always be situations in which testing based on each project's customized needs may be required.

One appealing solution is to standardize testing and reporting data so asset owners and operators can make true, apples-to-apples comparisons among lining options. In turn, they will be better equipped to arrive at an educated final decision based on relevant, comparable data. Such standardized CONT. P. 22

This oil water separator tank features a lining created using high-solids, flake-reinforced Nova-Plate® 360 from Sherwin-Williams to mitigate corrosion and extend the tank's service life and maintenance cycle.

test results would allow end users to make proper risk assessments about the best linings to use for specific applications.

THE VALUE OF A STANDARDIZED APPROACH

There are two primary immersion standards used by lining manufacturers to simulate the corrosive conditions that occur inside pressure vessels. One is an autoclave test, which exposes the lining to selected chemicals under established temperatures and pressures, according to NACE TM0185. The second is a pressurized atlas cell test, which simulates the immersion conditions seen in a process vessel with an externally exposed wall to evaluate the chemical resistance and permeability of the coatings, according to NACE TM0174.

These standards simply detail the methods for conducting the tests, and they do not specify set exposure conditions, nor do they include pass/fail criteria. Therefore, one manufacturer may run one test for a certain number of hours, while another manufacturer could run that same test for twice as long. If each test conducted for each manufacturer's respective product results in a successful outcome, the test with the longer exposure will appear as if it is more robust. However, there is the possibility that the material tested using the shorter exposure would perform as well as—or even better than—the one tested using the longer exposure. In addition, with no pass/fail criteria in play, the reported results may be subjective.

Some national oil companies use both the autoclave and pressurized atlas cell tests to qualify linings. However, their test conditions vary considerably and may not be wholly representative of the actual process vessel conditions. Therefore, it is often difficult to translate such test results from one set of conditions to a broader set of conditions.

Consequently, there is a critical need for an international standardized approach that sets some minimum parameters to help owners and operators during the lining selection process. Such a standard would provide criteria that coating manufacturers would use for testing and reporting data. In turn, the availability of standardized reporting would make it easier for owners and operators to vet and select linings.

NEXT STEPS

Engineers from oil and gas companies already have corrosion control protocols that determine how they design and construct process vessels. Arriving at a similar selection process for linings would be beneficial. Such an initiative would require tests that demonstrate the performance of the linings, potentially divided into categories based on temperature and/or pressure. The protocols may include testing linings exposed to a variety of chemicals—such as gases, hydrocarbons and aqueous phases—under different temperatures and pressures for a standard duration. Then the lining could be tested before and after exposure to demonstrate its performance.

Abrasion-resistance testing also should be considered for certain types of process vessels, such as test and primary separators. Other types of vessels would not likely require such testing.

High-solids, edge-retentive coatings help to ensure complete coverage inside pressure vessels featuring pipes, baffle plates and other obstacles.

In addition, exposure to steam cleaning processes would need to be evaluated, as steam is often used to clean vessels between process batches. Finally, further testing should consider a vessel's exposure to process chemicals, such as amine scrubbers used to strip hydrogen sulfide (H_2S) and carbon dioxide (CO_2), at higher temperatures.

THE PATH AHEAD WITH KEY INDUSTRY STAKEHOLDERS

There will always be a need for customized testing that enables owners and operators within the hydrocarbon processing industry to suit each lining type to the unique requirements of its process vessel environment. However, data from an optimized standard would allow process vessel owners and suppliers to have a much better idea of whether a particular lining will be acceptable for their needs. Such data may also allow for greater risk management during the selection process.

Moving forward, the nature and substance of such a standardized approach will require a consensus among all industry stakeholders. Sherwin-Williams believes the hydrocarbon processing industry is ready to take this next step. The company looks forward to sharing responsibilities with all stakeholders to bring greater transparency to the testing and reporting of data, for the purpose of optimizing the lining selection process for major industry players. MP

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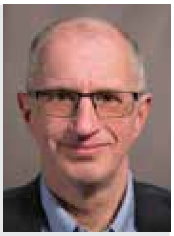

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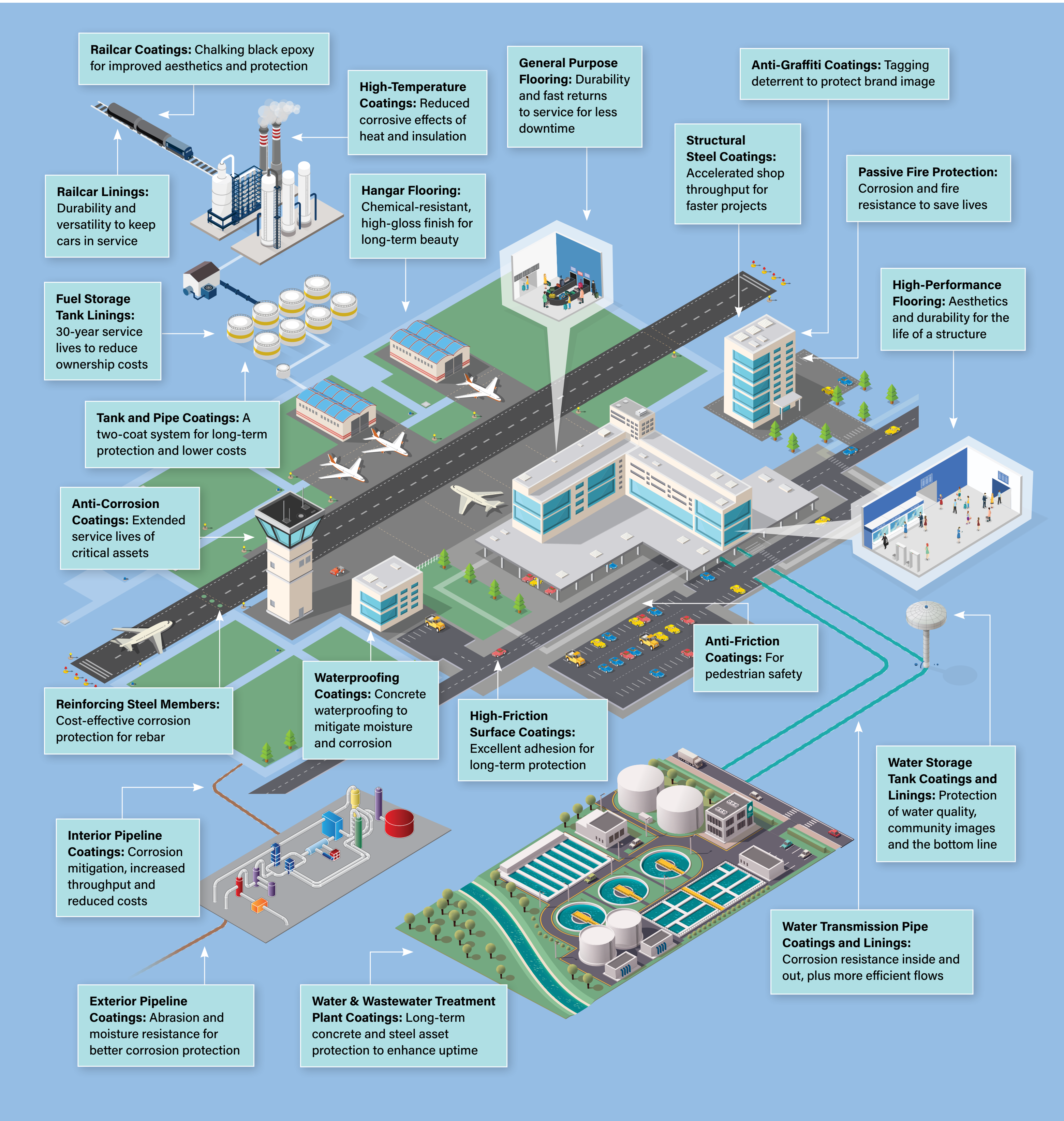

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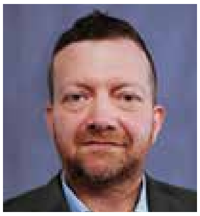

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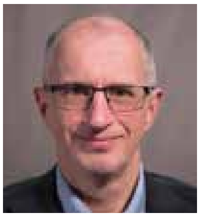

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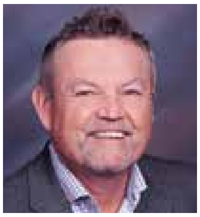

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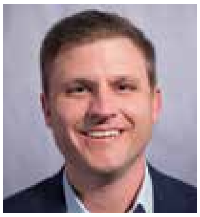

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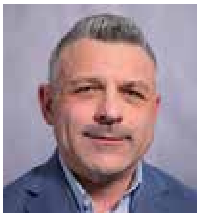

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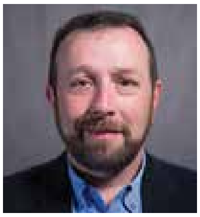

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