IMPROVING INFRASTRUCTURE:

CORROSION PROTECTION COATINGS FOR PIPELINES AND RAIL CARS

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Wherever metal is used, corrosion is an issue, and coatings are relied upon to provide protection against such damage. Many corrosion protection coatings are also expected to be multifunctional, offering additional resistance to abrasion, impact, and chemicals, as well as aesthetics in terms of high gloss and color matching. For pipeline and rail applications of all kinds, there is also a demand for increased product life cycle performance and value in use. Coating manufacturers are responding with new liquid and powder coating technologies that are easier to apply, reduce the number of coats, require less energy, and/or have a greater application window—all with the goal of reducing the application time and cost, while still maintaining or improving the desired level of performance.

PROTECTING PIPELINES

Increasing miles of pipeline are being installed around the world to carry potable and waste water, oil and gas products, mining fluids, and other liquids and gases. The need for water pipelines is growing as emerging regions expand their infrastructure and developed regions begin to upgrade their existing and often failing systems. In addition, the shale gas boom in North America, Australia, and elsewhere is a major factor contributing to the installation of more pipelines in the energy sector.

In the U.S. in particular, the water delivery systems in most major cities are in lamentable condition and require major repairs—with costs that far exceed the budgets of these municipalities, according to Rick Bradshaw, global director of Civil Infrastructure, Protective & Marine for The Sherwin-Williams Company. In fact, in its "2009 Report Card for America's Infrastructure," the American Society of Civil Engineers gave the U.S. drinking water infrastructure a grade of D-. "With such a vast amount of investment needed to repair our water systems, it is becoming ever more important for coating manufacturers to bring greater value so that more can get done at an overall lower cost, and that has led to a focus on improving application efficiency and increasing the performance lifetime of pipeline coatings," Bradshaw remarks.

Corrosion protection of pipelines is critical, because they are often laid in challenging environments, such as the heat of the desert; the cold of the arctic; the humidity of the jungle; the pressure, salinity, and grittiness of the ocean floor; and the dampness of municipal systems.

Depending on the specific engineering requirements and the region in which the pipeline is manufactured/installed, the exterior can be protected with one-, two-, or three-layer systems. Different products are also used for different sizes of pipes. Most powder coatings are fusion-bonded epoxies, although in some cases, other materials are used. Liquid coatings tend to be epoxies or liquid polyurethanes, and most are zero-VOC, 100% solids formulations, according to Karl R. Gust, market manager for BASF's Oil & Gas--Polyurethane Solutions business.

"The preference for powder or liquid coatings differs between end users, usually based on good or bad experiences. If they have issues with one type, they are likely to investigate whether another coating technology can overcome these issues," notes Matthew Fletcher, linings sales manager, Protective Coatings for EMEA and Russia with International Paint.

Regardless of the physical form of the coating, the desire is to use as few layers as possible to increase efficiency and productivity. Direct-to-metal one-layer epoxy systems are effective in light duty applications. Two-layer systems typically include an epoxy primer and a topcoat, which can vary according to the application. For example, Axalta Coating Systems, formerly DuPont Performance Coatings, offers topcoats that resist abrasion and chipping, perform at high operating temperatures, and provide nonslip surfaces and mechanical adhesion for the concrete sleeving used on subsea pipelines for buoyancy resistance. Three-layer systems generally consist of an epoxy primer, an adhesive layer, and a polyethylene (PE) or polypropylene (PP) film. The PE systems are designed for standard operating temperatures, while the PP systems are effective for high temperatures. These three-layer systems are most popular in South America and the Middle East, according to David J. Lazzeri, Axalta's business director for Powder Coatings in North America. However, there is growing interest in and a broader acceptance around the globe of two-layer systems because they reduce application costs and increase productivity.

The need for exterior coatings to perform at higher temperatures is a result of the high demand for new pipelines for transmission and exploration in the oil and gas industry, particularly as more companies are drilling much deeper and further to reach shale deposits, according to Lazzeri. Axalta's NapGard Gold coating has been attracting interest because it is reported to be as effective up to 130°C in a two-coat system (when applied over NapGard primer) as current three-layer systems.

Other new exterior coatings recently introduced to the market include ElastoCoat AC from BASF and Nap Gard 7-2514 from Axalta. ElastoCoat AS is a new 2K (1:1 by volume) 100% solids polyurethane designed for use on the interior and exterior of potable water and other pipelines. "This product is self-formulated, with the majority of the raw materials produced by BASF, so we have control over the supply chain, and thus can guarantee high quality and performance," notes Gust. Nap-Gard 7-2514, on the other hand, is a thermosetting epoxy powder pipe coating for underground and subsea applications. Notably, according to Lazzeri, it has been designed with significant cure latitude, so that it can be applied at greater speeds and lower temperatures while still providing a coating that is free of the defects that can serve as sources for initiation of corrosion.

"Regardless of the specific coating systems, the main aim is to give long-term corrosion protection, especially in a buried environment," Fletcher says. "However, for most coatings," he continues, "once the minimum technical performance requirements are met, cost is the main driver. This market is a high volume/low-margin business." He points to recent advances in on-site application, including improvements in portable application equipment and the introduction of products requiring minimum application tools and skills, as ways the coating industry is working to help increase value for its pipeline customers.

Interior coatings, which have been seeing more use in recent years, according to Lazzeri, also face additional requirements, such as for potable water and jet fuel. For example, coatings for potable water pipelines must meet the certification requirements of either the ANSI/NSF61 or the American WaterWorks Association AWAC222 standards, according to Gust. In addition, these interior coatings typically provide more than corrosion protection; they are also used to increase flow efficiency, reduce the need for cleaning, and provide additional protection for the pipe. Polyurethanes are common in this application, although Axalta has had growing success with a new phenolic/epoxy system called Black Beauty that protects against abrasion and chemical attack.

SherFlex from Sherwin-Williams is a new, 100% solids polyurethane elastomer lining material that provides applicators and owners with quick return to service times in immersion conditions (as little as 24 hours), according to Bradshaw. With high film build characteristics of >250 mils DFT (>1/4 in.), it fills minor surface imperfections in a single application. SherFlex also offers resistance to a broad spectrum of chemicals and bridges hairline cracks that form in concrete substrates. It is primarily used in water storage and treatment applications as a result of its NSF Standard 61 approval and in severe wastewater environments due to its resistance to hydrogen sulfide gas (H_2S) and sulfuric acid generated by microbiologically induced corrosion.

One particular area that remains an issue for pipeline coatings is the performance of coatings applied to field joints, or the joint where two prepared sections of pipe are joined together out in the field. Several new powder and liquid coating products have been introduced recently

to increase both the ease of application and the performance of field joint coatings. International Paint now offers Enviroline 124, a hand-applied field joint coating that is easy to use in remote areas and requires minimal tools and skills to apply, according to Fletcher. The weld is first prepared using basic power tools and the Enviroline 124 coating is mixed by hand and applied using a brush or trowel. "Most importantly, the thick film that forms has excellent adhesion to both metal and typical pipe coatings, so it provides long-term corrosion protection," he says.

Meanwhile, AkzoNobel Powder Coatings has launched its single layer Resicoat R-726 Low Application Temperature (LAT) powder coating for field joints, with "high reactive" chemistry. Unlike typical powder coatings, which need to be preheated to 220–245°C, Resicoat R-726LAT only requires heating to 180°C. Therefore, less energy is consumed, the process is up to 40% faster, and blistering of precoated pipe sections is avoided, according to Volker Boerschel, global R&D and marketing manager, Functional Coatings. A further benefit, he adds, is that the entire pipeline can be powder coated, thus guaranteeing a consistent quality throughout. The new coating has been specified for a major liquefied natural gas (LNG) pipeline project in Melanesia and is being considered by Chevron for an LNG project in Australia.

KEEPING RAIL CARS ON TRACK

Interest in moving people and materials by train always rises when the price of crude oil climbs above $80-$90/barrel, according to Bradshaw. At that price point, rail transport becomes competitive, and as more trains run more often, the need to protect these valuable assets with corrosion protection coatings also increases.

As with pipelines, there are many different types of rail cars, and each has its own needs with respect to coating performance, appearance, and cost. Axalta Coating Systems breaks the rail sector into five major sections: locomotives, high performance cars, tank wagons, other cars, and passenger rail, which has been a particularly strong growth area. Very different resin systems are used in each of these five application areas. Exterior coatings tend to be liquid formulations— epoxy/polyurethane two-coat systems (high solids solvent-borne) for high performance applications and direct-to-metal equivalents for lighter duty performance, including waterborne acrylics, while interior applications tend to rely on powder coatings, according to International Paint's Emre Karapinar, OEM business development manager for Protective Coatings in Europe.

Locomotives represent the brand image of a railroad company and, as such, are showpieces. As a result, coatings are required that provide not only corrosion protection, but an excellent, durable, glossy appearance. "Because image is so important for locomotives, most have a two-coat system with a polyurethane clearcoat," according to Joseph W. Wood, business director for Liquid Industrial Coatings with Axalta.

High performance cars and tank wagons are generally protected on the exterior with a two coat system based on an epoxy mastic with a polyurethane topcoat. Coatings for the interior of tank wagons vary, depending on what material is being carried. The three biggest commodities that are moved by rail are crude oil, caustic soda, and corn syrup, according to Bradshaw. Each has very different properties, and in addition, there are often different standards that apply, such as those for foodstuffs and flammable materials. Thus, very different coating technologies are required to ensure not only protection of the tank wagon, but safe transport in general.

Workhorse rail cars carry coal, rock, and other basic materials. These cars need both corrosion and abrasion resistance, but there is little concern about appearance. For these applications, direct-to-metal epoxies and even waterborne acrylics are used for the exterior. "The key driver here is cost. Users are willing to paint a little more often because of the reduced expense associated with the coatings. The interiors of hopper and other cargo cars, however, are subject to a very harsh operating environment, and the coatings used must provide protection from impact, abrasion, and mechanical damage. Both two- and three-coat systems are employed depending on the specific material to be loaded in the cars."

The extreme vibration that these cars must endure poses a challenge for coating manufacturers. The intense vibrations cause cracks to form at the weld seams that are then transmitted outwards. To address this problem, Sherwin-Williams developed Carflex, a low-VOC (<100 g/l), bisphenol A-free, 100% solids epoxy with a core-shell morphology. It combines toughness and flexibility in order to absorb stress points that can cause

cracking due to the flexing of a cargo bin in a rail hopper car, according to Bradshaw. The coating can be applied in one or two coats and is heat-cured for fast return to service. It is also FDA Approved (FDA 21 CFR 175.300) for direct contact dry food products storage. "Because it is flexible and tough, the coating is longer-lasting and requires less maintenance than traditional epoxies, and can help companies strengthen the safety of their cargo transportation while lowering overall costs," he notes.

Passenger rail manufacturers—notably Siemens and Bombardier in the U.S.—are looking for both corrosion protection and appearance. Coatings for these applications must be provided in a broad color palette to enable color matching. They must also provide a glossy appearance that is maintained for at least 10 years. For these reasons, Axalta has, according to Wood, taken advantage of its expertise in the automotive coatings sector and adopted its basecoat/clearcoat 2K/2K technology for passenger rail car applications. For the interior, the company has also introduced a new polyaspartic/polyurea/mesh flooring membrane system that is more durable than conventional flooring, faster to apply, and easier to repair. The Precedium systems are installed in a three-step process involving application of the basecoat, the effect color, and then a semi-nonslip clear coating.

The focus on the development of products that are easier and faster to apply is apparent in all of the various rail car segments. "Advancements are driven by the need to meet or exceed existing durability performance at a lower cost," says Karapinar. "The ability to apply direct-to-metal (DTM), build up thickness in one coat, achieve fast dry at ambient temperature—all are main paint properties that have a direct effect on manufacturing cost efficiency." Bradshaw agrees that self curing products that do not require baking, and thus that eliminate the expense of heating large train car components, is a significant development, and adds that high solids systems that need only two coats rather than three are also important technologies for reducing the lifecycle costs of rail car coatings.

Two new DTM coating technologies from International Paint are being launched in the first quarter of 2013 for light industrial market end uses, including rail transportation. High solids Interthane 3230 polyurethane primer/finish and ultra high solids Intercure 3240 polyaspartic primer/finish are low-VOC products that can be applied direct to metal at 60–150 microns dry film thickness in one layer and can be baked at 25–40°C, increasing production efficiency and reducing energy consumption, according to Karapinar.

Sherwin-Williams has taken a different approach with the development of its <100 g/L VOC, HAPs-free Sher-Cryl SS self-stratifying coating, which forms a film containing multiple individual "micro-layers" that offer the equivalent protection of multiple coats, but with only one application. The single component water-based acrylic protects against moisture and UV degradation, resulting in excellent color and gloss retention that outperforms two-coat acrylic/acrylic clearcoat systems and extends the recoat and maintenance cycle, according to Bradshaw. "This product is the first of its kind and an indication of where efficient and effective corrosion protection technology is headed in the future," he says.

Aside from advances in coating technologies themselves, there is much that can still be done to improve the efficiency of the actual application process. "The rail industry still relies heavily on manual labor for coating applications, unlike in the automotive industry, where robotics has had a huge impact on efficiency and productivity," observes Wood. "We do note, however, that manufacturers are slowly introducing robotic technologies into their production processes. There will be a need for extensive training, but we foresee that robotics will eventually be adopted, particularly for OEM tank coating," says Wood.

WHAT'S IN STORE FOR THE FUTURE?

As with all other sectors of the coatings industry, changes in regulatory requirements will continue to drive further developments in coating technologies for pipelines and rail cars, according to Kenneth Tator, CEO of coating consulting firm KTA-Tator. "Continued compliance is assumed by rail car and pipeline manufacturers and coaters, and thus, their focus remains on getting good value over the entire coating life cycle, including application efficiency and applied performance for longer and longer periods," he maintains.

He does note that today there is recognition that performance must be paid for. "Users seem to know now that high performance paint costs more, but using premium products that cost more upfront do provide overall savings," he says. It also means that coating manufacturers that can provide technologies that offer measurable time and labor savings during the application process will have the advantage.

With respect to specific technologies, Tator believes that the major advances made in the use of nanotechnology over the last 8–10 years suggest that major breakthroughs in the performance of corrosion protection coatings for pipelines and rail cars, as well as many other applications, will be achieved using nanomaterials in the coming years. Smart coating technologies, such as those that indicate the presence of corrosion and have self-healing and other corrosion-mitigating properties, will also have a significant impact.