Polyurethanes exhibit many characteristics that have led to their extensive use in the pipeline industry. For example, they are chemical- and abrasion-resistant, they can be applied directly to steel to form a very high-build system in a single application, and they have good corrosion resistance. “These properties, along with many others, are the reason that fast-setting, high-solid polyurethane coating systems have been used to line and coat steel pipe since the 1980s. In 1999, the first American Water Works Association (AWWA) standard for polyurethane lining and coating of steel pipe was published (referred to as ANSI/AWWA C222), with an update published in 2008. As stated by Jeff Stewart, in recent years, the use of polyurethane linings and coatings has grown substantially.

The chemistry behind polyurethanes
To understand why polyurethane coatings and pipelines are such a good match, you must first understand how the chemical composition of polyurethane defines its properties and characteristics. In terms of chemistry, polyurethane is the result of a reaction between an isocyanate and a hydroxyl terminated polyol group. Isocyanate is nitrogen, carbon-, and oxygen (NCO) based, and the polyol, which is often referred to as the resin, is a carbon chain molecule terminated with a hydroxyl group that is composed of oxygen and hydrogen (OH) groups. When these two reactive groups come together, they form polyurethane.

Despite this complex sounding chemistry, understanding polyurethane coatings is relatively simple. The word polyurethane literally means more than one urethane, which describes the polymer composed of repetitive carbon groups connected by urethane linkages. The characteristics of the polyurethane are determined by the chemical makeup of the carbon-based group that constitutes the polymer’s backbone. For example, depending on the particular polymer backbone, a polyurethane coating may be hard and rigid or soft and flexible. This explains why a roller blade wheel, lycra running shorts, “leather” car seat coverings, and the protective lining on the interior of a water pipeline can all be polyurethanes. Although polyurethanes can be flexible or rigid, they can be spray- or brush-applied, and can cure (i.e., create polymer linkages) through various mechanisms, they all display certain common characteristics. For example, they can show high impact, abrasion, and chemical resistance. Because polyurethanes are able to tolerate harsh chemicals, they are smart choices for projects such as the protection of the interior and exterior of potable and waste water pipes and tanks as well as steel and concrete in water and waste treatment facilities. “Polyurethanes are also used for secondary containment, both direct to the substrate and on a geotextile. They can be structural stand-alone liners or molded products, and they can be applied to such diverse substrates as steel, concrete, fiber-glass-reinforced paneling, and wood,” said Stewart.

Convenience, cost, and cure
Polyurethanes exhibit great resistance to chemicals, corrosion, impact, and abrasion, but this is only part of the story when it comes to polyurethane coatings and water pipelines. According to Cairns, coatings are typically applied to pipes in original equipment manufacturing (OEM) plants. “Spraying in the field requires both surface prep equipment and plural spray equipment, which also require a generator and compressor. In addition, environmental controls for temperature and humidity, along with containment and protection of the pipeline, may also be required to support the application. While welded joints and touch-ups may be done easily in the field, most coatings are applied in-plant to preserve quality and consistency,” said Cairns. Given this circumstance, polyurethanes have many characteristics that make sense for OEM application. Polyurethanes are fast-setting, are applied directly to metal without a separate primer, and are typically applied in a single high-build coat, which means that process equipment and storage areas are not tied up waiting for the coating to cure or to be quality checked. “They also offer great physical flexibility, which easily allows for 50- or 60-foot-long (15.2 or 18.3 m) pipes and fewer joints to field-apply,” explained Cairns.

Polyurethanes are also light-weight and easily in comparison with other coating systems, which allows for easier (and less expensive) transportation inside the plant and also to and at the job site. This factor, especially when combined with the other characteristics of polyurethane coatings, makes it a cost-effective choice for steel water pipelines. “Because polyurethane coatings are light in weight, they allow for less expensive and smaller equipment at the installation site,” said Stewart.

It must also be mentioned that the polyurethane coating systems used on steel water pipelines do not contain volatile organic compounds (VOCs) and are referred to as ambient cure. “Ambient cure in this instance refers to the fact that, because of the formulation, no external heat is required to cure the coating, and the material also may be applied in lower ambient and surface temperatures, stated Cairns. These characteristics make polyurethane coatings an environmentally friendly, or green, option for pipelines.
Inside and out

Another important aspect of applying polyurethane to water pipelines is the ability to use the material on both the interior and exterior of the pipe. When it comes to the exterior of a pipeline, the coating system needs to protect it from abrasion from soils, chemicals, and impacts from handling during transportation and during installation. “Polyurethane coatings are tough and impact resistant, and, once installed, they protect the exterior of the pipeline in high chloride or low pH environments. They also have excellent adhesion properties and are very resistant to soil stress,” explained Stewart. Polyurethane coatings also work well with the heat shrink sleeves that are used on the external joint completion out in the field.

As far as the interior of a steel water pipeline is concerned, it must be chemical- and abrasion-resistant and maintain a smooth low friction surface. The smooth surface created by a polyurethane lining provides energy savings in both long- and short-term water flow in the pipe. The Hazen-Williams “C” value associated with polyurethane linings is typically 150, the same as that for thermoplastic pipes such as high density polyethylene (HDPE) and polyvinyl chloride (PVC). According to Cairns, polyurethane linings used inside steel pipes are compliant with the NSF/ANSI Standard 61, which establishes minimum health effect requirements for materials, components, products, and systems that come into direct contact with drinking water, drinking water treatment chemicals, or both.

The longest pipeline

The best way to demonstrate the advantages of polyurethane coatings on steel water pipelines is to take a look at a recently extremely large — and extremely successful — project. The Provo Reservoir Canal Enclosure Project, known as PRCEP, was the longest and largest diameter polyurethane-lined and coated steel water transmission pipeline in North America and one of the longest in the world. The installation of the 21-mile-long (33,796.2 m), 126-inch-diameter (320.0 cm) pipeline will result in the prevention of approximately 2.6 billion gallons (9.8 billion L) of water loss annually through evaporation when compared with the previous open canal design.

The pipeline, which has a projected service life of 75 to 100 years, is spirally welded steel pipe with a polyurethane lining on the interior and a polyurethane coating on the exterior. Northwest Pipe was the pipe manufacturer as well as the ORM polyurethane lining and coating applicator for the job, and ITW Polyureters Coatings-Futura supplied Protec II and Protec II PW for the exterior and interior of the pipe, respectively. Both of these coatings exhibit all the high-performance qualities of polyurethane — they are high solids, fast-setting, light-weight, chemical- and abrasion-resistant, and protective against corrosion.

Prior to applying the Protec II and Protec II PW to the pipeline sections, surface preparation was done in accordance with AWWA C222 as well as the specifications particular to the project. “The surface preparation followed SSPC — SP 5, NACE 1, White Metal Blast with a minimum 3 mil (76.2 micron) angular profile,” explained Stewart.

Once the surface preparation was completed, the exterior coating was spray-applied with the pipe rotating in place and with a traveling spray gun. For the interior lining, the pipe was also rotated in place, and a spray lance was extended along the entire inside length of the pipe. Both the Protec II on the exterior and the Protec II PW on the interior were applied at a 35-mil (889 micron) dry film thickness.

On a project this large, the lightweight pipe sections and the fact that the flexibility of the polyurethane coating allowed for 40-foot (12.2 m) sections was extremely cost-effective. “Using steel pipe with polyurethane was a huge cost benefit during the transportation and installation of the pipeline. It was more economical to transport the pipeline than if another coating and lining system had been used. The longer sections allowed for fewer field joints, and the impact resistance of the Protec II meant that coating touch-ups were rarely required in the field,” stated Cairns.

It must also be noted that the PRCEP was originally scheduled to be a three-year job, but the project was finished one year ahead of schedule in the spring of 2012. According to Cairns, much of the time saved on the job can be attributed to the characteristics of the polyurethane coating and lining system and the ease with which they can be applied in-plant. And because time is money, the year saved on the project was a huge cost savings as well.

A great match

According to Cairns, the PRCEP project is just one of many examples of how polyurethanes are a cost-effective, time-saving, and long-term solution for the protection of both the interior and exterior of steel water pipelines. “Polyurethanes offer many of the characteristics necessary for water pipelines. In addition to the time and money saved during the application and installation process, polyurethane coatings do an excellent job of protecting the pipeline and extending its service life. This adds up to even more savings in the long run,” said Cairns.

By Jennifer Frakes

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