Northwest Pipe Company

Corrosion Control - Linings and Coatings

Linings and Coatings for Corrosion Protection of Steel Pipelines

Our existing water systems infrastructure is in a state of terrible disrepair because the technology of corrosion prevention was not available to our design predecessors. Today, with the use of modern protective linings, coatings, and cathodic protection, buried pipelines can achieve incredibly long lives with very little added cost.

Internal Corrosion

Steel pipe has a long history of effective internal corrosion control. For almost all water conditions, cement-mortar lining has provided high hydraulic flow capacity without the build-up of tubercles. The cement provides a high-pH environment in conjunction with a low oxygen supply, and self-healing characteristics.

Where non-potable liquids are being transported or in conditions of high velocities (over 20 feet per second), dielectric coating systems are recommended for lining of steel pipe.

External Corrosion

Preventing or greatly reducing external corrosion requires an understanding of how corrosion operates as well as the mechanisms required to perpetuate the process.

Corrosion is a process that deteriorates metallic surfaces. The systems by which this happens are both electrical and chemical. Corrosion can occur naturally or can be induced by stray currents. Naturally occurring corrosion results from dissimilar metals, dissimilar surfaces, old and new pipelines, concentration cells, dissimilar soils, bacteria, or stresses. Corrosion cells can also occur due to the introduction of electrical current into the ground (stray current). For metallic pipelines, it is critical to minimize or eliminate these corrosion processes. The methods used to combat corrosion of pipelines and to ensure a long-term performance life typically include the application of coatings and linings as well as the additional use of a cathodic protection system.

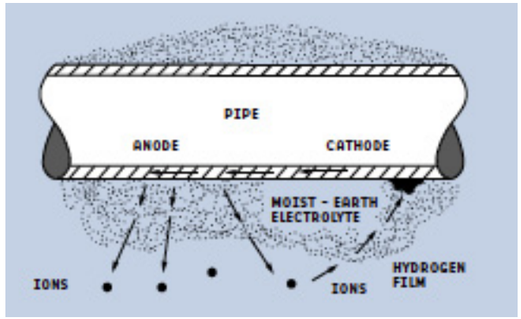
There are four requirements for the corrosion process:

1. The presence of an anode and a cathode
2. A metallic bond
3. A voltage potential between the anode and cathode
4. An electrolyte (the surrounding soil, air, and/or water) with the presence of oxygen.

An anode is the location where corrosion takes place and metal is lost. A cathode is where the lost metal migrates to, and thus, a transfer of metal ions occurs. The anode/cathode and metallic bond are always present on metallic pipelines due to the physical make-up of steel. The first two requirements of corrosion are, therefore, always going to be present.

To control pipeline corrosion, a coating system is applied to the pipe surface to reduce or eliminate the potential between the anode and the cathode, or to provide an impermeable membrane to separate the electrolyte from the metallic surfaces. The potential current between the anode and cathode can be reduced or neutralized with the use of cement coatings, a process called “passivation.” A variety of bonded dielectric coatings are available, which are designed to isolate the metallic pipeline from the surrounding environment, thus providing electrical isolation. Although coatings, by themselves, may not be the perfect answer to corrosion control in all environments, when they are used properly in conjunction with a cathodic protection system, a nearly unlimited life can be achieved.

Cathodic Protection



Cathodic protection (CP) is a method that, when connected to the pipeline, discharges an electrical current from a remote anode to the pipe. If enough current is discharged from the remote anode to the pipe, corrosion on the pipeline will not occur. Cathodic protection

External Corrosion (cont.)

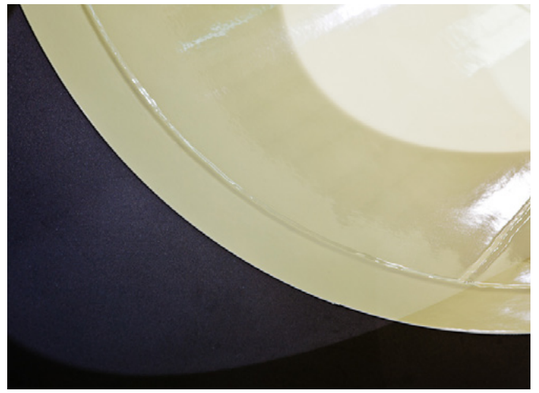
systems should be designed, taking into account the many variables that can come into play. For more detailed information on catholic protection, please refer to “Demystifying Cathodic Protection,” the Steel Plate Fabricators Association publication by Donald Waters. For proper operation of cathodic protection, each pipe must be electrically continuous and test stations installed at regular intervals. Northwest Pipe Company offers a variety of coating and lining systems. They each have capabilities and limitations that need to be carefully considered before a planned system should be specified. Our representatives can provide additional technical information and guidance regarding your pipeline system needs. There are two major categories of linings and coatings applied to steel pipe. One is cementitious materials, which neutralize the chemical process by passivation. The second is dielectric, which provides a physical barrier separating the metallic surface from the electrolyte. Both systems can be used as either linings or coatings. Example specifications are provided in this manual.

Table 1: Six Levels of Corrosion Protection

Level 1	No protection, pipe installed bare without monitoring system
Level 2	Install pipeline bare with polyethylene encasement, without monitoring system
Level 3	Add monitoring system (bonded joints and test leads) to Level 2
Level 4	Bonded dielectric coatings or cement-mortar coating without monitoring system
Level 5	Add monitoring system (bonded joints and test leads) to Level 4
Level 6	Add cathodic protection to Level 3 or Level 5

Choose a level right for you. Consult your local sales engineer or corrosion expert.

Linings and Coatings caption.



Linings

Cement Mortar Lining

Cement-mortar lining is the most commonly specified lining material in today's water transmission industry. A lean mixture of three parts sand to one part cement is centrifugally spun onto the interior surface to create a dense, smooth surface.

The actual cement application is performed by pumping or pouring a high slump cement mixture onto a slowly rotating length of pipe. The rotating speed is then increased so the proper centrifugal forces level out the wet mortar to a uniform thickness. Continued spinning removes the excess water and compacts the mixture to a dense and hard surface. After the spinning process, the lining is cured either by moist curing at ambient temperature or by an accelerated process using steam.

Like concrete, cement-mortar lining can develop drying cracks, but these cracks will self heal when the lining is wet. Wetting the cement lining also causes the lining to swell, which increases strength and adherence. Cement-mortar linings can add significant stiffness for resistance to deflection forces. The strength of the mortar lining may be added to the strength of the steel when calculating stiffness.

Soft, aggressive waters, as well as prolonged contact with heavily chlorinated water, may be injurious to cement-mortar linings. Cement-mortar linings perform best when flow velocity is 20 feet per second or less.

Paints and Polyurethane Linings

Bonded dielectric linings have been used as protective linings for above-ground applications for many years. There are two major categories of liquid film linings in the waterworks industry at this time: epoxies and polyurethane-based products.

Paints and Polyurethane Linings (cont.)

Epoxies are applied per AWWA C210 and polyurethanes per AWWA C222.

These linings have excellent water and chemical resistance properties and can be used as an alternative to cement-mortar lining. They can be applied at various thicknesses and are factory applied to provide an excellent dielectric lining. Bonded dielectric lining systems can be applied as either a single or a multiple coating process. They are tough, resilient, and extremely abrasion resistant, making them an ideal lining choice for high internal velocities. Bonded dielectric lining systems are an excellent choice for extreme conditions such as wastewater or other industrial applications, including both gravity sewer and sanitary force mains.

Epoxy and polyurethane systems do have some drawbacks that must be considered prior to application. A critical performance factor to all film linings is the surface preparation of the metal surface. In most cases, a near-white blast surface is required for proper adhesion, and this will require good inspection. Curing times and curing temperatures must adhere to critical tolerances. With proper surface preparation, controlled applications, and strict curing procedures, thin-film materials can provide a strong, resistant, long-lived lining.

Epoxies are typically solvent-based, although some 100% solids epoxies are now available. The aromatic polyurethanes are 100% solids material. The 100% solids materials contain no VOCs. The epoxies are typically mixed and then applied by airless spray or brushed on to the pipe. The polyurethanes require heated, plural-component equipment.

Epoxies typically cure in a matter of hours to days, whereas polyurethanes may be handled in a matter of minutes.

Cement Mortar Lining caption.

Coatings

Tape Coating

Modern tape coatings are the most universally specified dielectric coatings in the water industry today. The electrical resistance, mechanical strength, reasonable cost, and long performance record of tape coatings have contributed to their success in the water industry, as well as the oil and gas industry. Exterior tape coating systems are applied at the factory by the methods described in AWWA C214. The tape system consists of cleaning and blasting the pipe surface, immediately applying a primer-adhesive, and then simultaneously applying the inner dielectric tape (corrosion protection) and outer-layer tapes (mechanical protection).

Surface Preparation

The pipe surface is first cleaned and then grit blasted to achieve a surface preparation at least equal to that specified in Surface Preparation Specification No. 6, SSPC-SP 6, Commercial Blast Cleaning.

Priming

Immediately after blasting, the pipe receives an adhesive or primer coating. The primer coating is applied as recommended by the manufacturer. When complete, it will be uniform and free of sags, runs, and bare spots. The state of dryness of the primer shall also be in accordance with the recommendation of the manufacturer.

Tape Application

The inner corrosion protection tape layer is directly applied to the primed surface using a helically wound process. The minimum overlap shall not be less than 1 inch. The applied tape is tight, wrinkle-free, and smooth. The inner tape is then tested to ensure there are no flaws or holidays using 6000-volt detectors.

Outer-layer Tape

Simultaneous to the inner wrap, one or two layers of polymeric-type mechanical-protection tape is also spirally wound over the inner tape coat. The completed multi-layer tape coating system will provide a final protective encasement of between 50 and 80 mils of strong, durable, lightweight, and reliable bonded coating.

Field joints may be repaired with polyurethane tape per AWWA C209 or with shrink-wrap sleeves per AWWA C216.

Tape Coating caption.

Cement Mortar Coating

Unlike the dielectric coatings (tape, Pritec®, coal-tar and paints), cement mortar works by chemically inhibiting corrosion. The cement creates a highly alkaline environment at the interface of the pipe surface. Steel pipe, when protected by this high-alkaline environment, will exhibit no corrosion or corrosion at a reduced rate. It is critical that the cement coating be in intimate contact with the pipe surface for a long-lasting protective coating. Soil conditions play an integral role in the ability of cement mortar to provide long-term protection. Soils containing high concentrations of chlorides or soluble sulfates may adversely affect cement mortar coating protective properties.

Cement-mortar coating, although consisting of the same mixture as cement lining, is applied at a very low moisture content, or “no slump” consistency. The application procedure consists of metering the mortar between a set of counter rotating belts or impinging wheels, which accelerate the mixture to the required compaction velocity. This high-velocity stream is applied to a slowly rotating and translating steel pipe. Simultaneously with the application of the mortar, reinforcing steel wire is embedded into the middle third of the mortar-coating thickness. The pipe coating is then cured by either the moist-curing or accelerated -curing method. Cement mortar coatings are applied under the guidelines of AWWA C205.

Cement-mortar coating can be applied at various thicknesses, and it provides excellent mechanical protection for resistance to handling and installation damage. Like cement-mortar lining, mortar coatings add significant stiffness to the pipe, which resists deflection. The strength of the mortar coating and/or lining may be added to the strength of the steel when calculating ring stiffness. Deflections of cement-mortar-coated pipe must be manufactured within AWWA standard specifications to minimize cracking.

Cathodic protection systems used with mortar coatings will require significantly more current to operate than that of dielectric coated pipe.

Coal-tar Enamel Coating

Coal-tar enamel has been used to protect steel since the late 1800s. Its electrical resistance, mechanical strength, and long performance are known the world over.

Factory applied per AWWA C203, this coating system can be custom designed to fit the existing soil and laying conditions. The applied system consists of cleaning, priming, application of hot enamel, then usually a covering of a fiberglass matte and/or a felt outer wrap. Whitewash or kraft paper is then applied for storage protection.

Service Prep - The pipe is cleaned and blasted to a minimum surface equal to SSPC-SP 6.

Priming - Immediately after blasting, primer is applied per the manufacturer’s specification. When complete, the primer will be uniform and free of sags, runs, and bare spots.

Enamel **Application -** Molten enamel (450-500°F) is applied in a continuous coat with a minimum thickness of 3⁄32 inch +/- 1⁄32 inch.

Outer wrap - The outer wrap (glass or felt) is immediately applied over the hot enamel. This is followed by a layer of kraft paper or whitewash.

Electrical Inspection - Because there can be several layers of enamel and outer wrap, depending on trench conditions, it is important that the holiday-detection equipment is set up in accordance with AWWA C203. However, in no case should the operating voltage exceed 15,000 V.

Field joints may be repaired with polyurethane tape per AWWA C209 or with shrink-wrap sleeves per AWWA C216.

Cement Mortar Coating caption.

Coatings

Pritec® Coating

Northwest Pipe Company is the exclusive supplier of ShawCor Pipe Protection’s Pritec® coating for large diameter water transmission pipelines. This dielectric, side-extruded polyolefin coating is an extremely durable material when applied to pipe per the requirements of AWWA C215.

The pipe surface must be clean and abrasive-blasted to achieve a surface preparation at least equal to SSPC-SP 6 commercial blast clean standard. A compound of butyl rubber adhesive is then extruded onto the surface of a rotating pipe in a continuous operation. The butyl rubber layer is 8-mils thick. Immediately following the butyl rubber, a layer of high-density polyolefin is extruded onto the surface. Both materials are heated to a nearly molten state, thus providing a seamless, bonded, damage-resistant coating. The thickness of the polyethylene layer is 40 mils for 18- to 36-inch diameter pipe and 60 mils for diameters greater than 36 inches.

Pritec® withstands the stresses of field bending at cold temperatures and is suitable for operating temperatures up to 180°F. Field joints should be coated with polyethylene tape per AWWA C209 or with shrink-wrap sleeves per AWWA C216.

Epoxy and Polyurethane Coating

Thin-film bonded dielectric coatings have been used for many years. There are two major categories of liquid film coatings in the waterworks industry at this time–epoxies and polyurethane-based coatings. Epoxies are applied per AWWA C210 and polyurethane per AWWA C222.

Dielectric coatings have excellent water and chemical resistance properties. They are factory applied to provide an excellent dielectric coating that is very compatible with cathodic protection. These systems can be applied as either a single- or a multiple-coat process to meet AWWA standards. They are tough, resilient, and extremely abrasion resistant.

With all epoxy and polyurethane linings and coatings, a critical performance factor is the surface preparation of the metal surface. A near-white blast surface is required in most cases for proper adhesion, requiring good inspection. Curing times and curing temperatures also must adhere to critical tolerances. With proper surface preparation, controlled applications, and strict curing procedures, thin film coatings can provide a strong, resistant, long lived coating. Epoxies typically cure in a matter of hours to days, whereas polyurethanes may be handled in a matter of minutes.

Pritech® and Epoxy Coating caption.

Corporate Headquarters - 5721 SE Columbia Way, Suite 200 Vancouver, Washington 98661
Telephone 360.397.6250 Toll Free 800.989.9631 Fax 360.397.6255

www.nwpipe.com