PROTECTION OF WASTEWATER STRUCTURES WITH POLYMER COATINGS AND LININGS

Differences, considerations, and performance expectations

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Over the last 40 years, many exceptional polymer chemistries were developed to protect concrete and steel. Typically, the design and formulations focused on specific market segments facing corrosion problems that created escalating maintenance and safety issues. Although many polymer coating technologies are very good, not one of the generic product types fits every environment. This article will discuss polymer coating and lining materials for cementitious surfaces, as well as explore considerations and performance expectations of each product.

The basics of polymer coatings and liners

What is a polymer?

A polymer is a substance made up of molecules that link together to form larger molecules. Polymers are everywhere. Plastic is a synthetic polymer and rubber is a natural polymer, both used in our everyday lives. Polymers are used from simple home furniture, to looming skyscrapers. Their superior adherence and ability to protect substrates from corrosives allow them to be frequently used in water and wastewater collection and treatment systems.

What is the difference between coatings and liners?

The McGraw-Hill Dictionary of Scientific and Technical Terms generally defines a coating as any material that will form a continuous film over a surface. A lining is sometimes referred to as a material used to protect the inner surfaces—for instance, a tunnel or pipe. By the National Association of Corrosion Engineers' (NACE) definition, a coating is a material that is applied up to 0.125 inches (<125 mils) in thickness that develops an adhesive bond with the surface of the material to be protected. If the material is applied to a thickness of more than 0.125 inches (>125 mils), it is designated to be a liner, whether in a bonded or an un-bonded condition.

While their purpose is largely the same, these subtle differences could be detrimental when considering a polymer coating for your cementitious surfaces, as adhesive bonding may be critical. The infographic below differentiates the two.

Protective Coating:
A polymer monolithic coating applied at any thickness and **has a mechanical bond** to the host substrate.

Protective Liner:
A polymer material designed to protect the structure as a barrier from a corrosive environment. A liner **can be bonded or un-bonded** to the substrate based on its design.

Why are they used?

A polymer coating or liner is applied to a substrate to serve as a functional protective barrier as it is chemical, abrasion, impact, and water resistant. It is also used because it is monolithic, provides infiltration control, and aids in visual-anniversary inspections.

1. **Chemical, Abrasion, and Impact Resistant –** polymers are stable, tough, and resistant to corrosive chemicals such as sulfuric acid, sodium, sulfates, ammonium, and chlorine. Although corrosion is the leading cause of asset failure – costing the U.S. nearly $300 billion each year – a coating or lining provides the substrate protection to in-service impact and abrasion as well.
2. **Water Resistant –** polymers properly formulated to resist water vapor from permeating through the film to the host substrate.
3. **Monolithic –** used for coatings when they adhere directly to the cementitious surface to form an integral protective barrier that eliminates voids.
4. **Infiltration Control –** polymer coatings and liners seal and prevent groundwater from entering systems, saving entities from treating this extraneous water.
5. **Visual- Anniversary Inspections –** part of a well-planned Quality Control Program is to ensure the structure's condition and the service life is maximized.

Why are they effective for cementitious surfaces?

Although cement is a strong and hard substrate, it is subject to deterioration when bare. Concrete is porous, allowing chemicals to penetrate the pores. This allows it to be worn down by physical impact and abrasion. Water can also penetrate the concrete. Water will freeze and expand inside when the temperature drops, ultimately weakening the concrete. If the concrete has rebar to provide additional strength, the rebar can corrode if moisture, oxygen, and chloride ions penetrate the concrete. Corrosion on the rebar contributes to the deterioration of concrete.

Therefore, polymer coatings or liners are used to protect the substrate from chemical and physical attack. It's also ideal for improving its appearance and ease of maintenance. As long as the lining or coating is properly applied to an adequately prepared concrete surface, the structure's life is prolonged.

Polymer coating and liner comparison

A wide range of polymer coating and lining systems are available to protect cementitious surfaces in wastewater collection systems and treatment facilities. These systems typically range between epoxies, polyurethanes, and polyurea. Each one offers a high-build option.

Epoxy | High-Build Reinforced | (80 – 250+ mils)

Pros

- Excellent chemical resistance
- Strong physical properties
  - Resistant to hydrostatic pressure due to groundwater
- Application to wet saturated surface-dry (SSD) concrete
- Excellent adhesion (bond) to the host structure
- Fast return to wastewater service (2-24 hours)
- No volatile organic compounds (VOCs)
- Capable of high builds in a single coat
- Single coat systems prevent intercoat adhesion issues

Cons

- Rigid (elongation 2%-10%)
- Potential for outgassing creating film defects/holidays
- *Expert/trained applicators for application is a must*

Epoxy | Thin-Film | (20 – 60 mils)

Pros

- Long established coating with excellent performance properties to protect structures in industrial environments
- Thin-film systems applied at 20.0 – 60.0 mils dft
- Long pot life and can be applied by a single leg, conventional airless equipment

Cons

- Physical properties at the low end of what is normally required for the protection of concrete structures
- Multiple coats to meet higher film build requirements
- Can be sensitive to moisture and temperature during application
- Long return to service in wastewater immersion (>24 hours)
- Potential for outgassing creating film defects/holidays
- Increased risk of health and environmental hazards with solvent use
- Beware of the applicator – training, lack of surface preparation knowledge, and use of safety equipment can be critical

Polyurethane | High-Build | (80 – 300+ mils)

Pros

- Chemical resistant
- High abrasion resistance
- Can be flexible and crack bridging
- Fast cure to service (some are cured in minutes)
- High-build (80-300+ mils)

Cons

- Sensitive to moisture (must be dry)
- Fair adhesion (bond) to the host structure
  - Primers are recommended for underground structures
- Low physical properties compared to high-build epoxies
- Some are very rigid and can crack during curing
- Risk of health issues associated with isocyanate exposure
- Potential for outgassing creating film defects/holidays
- *Expert/trained applicators for application is a must*

Polyurea | Pure

Pros

- Rapid setting (tack-free 10-30 seconds)
- Flexible and crack bridging (100%-500% tensile elongation)

- Flexible and crack bridging (100%-300% tensile elongation)
- Fast return to service
- High-build (60-500+ mils)
- Good chemical resistance
- Can be applied at any ambient temperature (-20°F to 200°F+)

Cons

- Fair adhesion to primed concrete (must be dry)
- Sensitive to moisture during application
- Equipment can spray off-ratio without proper set-up and maintenance
- Poor moisture vapor transmission resistance
- Difficult to apply in tight areas because of the size of the gun and hose bundle
- Potential for outgassing creating film defects/holidays
- *Expert/trained applicators for application is a must*

Polyurea | Hybrid

Pros

- Rapid setting (tack-free 10-30 seconds)
- Flexible and crack bridging (100%-400+% tensile elongation)
- Fast return to service
- High-build (60-300+ mils)
- Good chemical resistance
- Slower cure allows air to escape and reduce pinholes in the film

Cons

- Fair adhesion to primed concrete
- Sensitive to moisture during application
- Poor moisture vapor transmission resistance
- Risk of health issues associated with isocyanate exposure
- Potential for outgassing creating film defects/holidays
- *Expert/trained applicators for application is a must*

PRODUCT COMPARISON

CHARACTERISTICS	EPOXY (HIGH-BUILD)	EPOXY (THIN-FILM)	POLYUREA	POLYURETHANE
Adhesion to Dry Concrete	**Excellent**	Good	Good	Good
Moisture Filled	**Excellent**	Not recommended	Good (with Primer)	Good (with Primer)
Wet (SSD)	**Excellent**	Not recommended	Not recommended	Not recommended
Tensile Strength (ASTM D638)	**5,000 - 8,000 psi**	Up to 7,000 psi	2,000 - 3,500 psi	2,000 - 3,000 psi (Flex) Up to 7,000 psi (Rigid)
Tensile Elongation (ASTM D638)	**2% - 5%**	4% - 10%	75% - 400%	5% - 100%
Chemical Resistence 20% Sulfuric Acid	**Excellent**	Poor/Fair	Good	Good
Max mils per coat	**500 mils**	Up to 50 mils dft.	300+ mils	300+ mils

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How to choose the correct polymer liner or coating for your concrete structure

Selecting the suitable polymer coating or liner depends on various factors, but the most important will be understanding the environment to which the concrete substrate is exposed to. When seeking protection within a wastewater system, specifying products designed for use in wastewater exposure will be critical; therefore, verifying the selected products have the physical properties and the chemical resistance to withstand the service demands. In new construction, the concrete surfaces' ambient conditions and cleanliness are not as difficult to control to ensure proper application and curing of the coating or lining system. When rehabilitating structures, products that provide tolerance to moisture and high humidity along with other existing conditions should be considered to avoid costly downtime.

Due to the number of considerations and the complexity of your project or specific structure, it is often helpful to engage with a protective coatings specialist. Their focus is to provide a thorough assessment of your current coating conditions and service life requirements to determine the best coating or lining for your facility or collection system.

Unfortunately, if the right polymer coating or liner is not chosen wisely, then the following results may occur:

- Disbonding
- Aggressive corrosion after failure
- Pinholes and thin coating voids
- Groundwater infiltration
- Catastrophic failure of the structure

The reasons for these occurrences stem from an unsuitable coating or liner for the given environment, poor or deficient surface

preparation/application, or insufficient coating thickness. Much of these can be prevented if trained, certified, or approved applicators are used for the selected product. Certified or approved applicators by the manufacturer are typically vetted and continuously trained in the handling, mixing, application, and inspection of the coating or liner products. They are diligent in performing application procedures per recommendations by the manufacturer.

Seeking an independent third-party NACE or SSPC certified coatings inspector is also recommended for completing quality assurance and control for your project. As they perform their inspections, they will look at every aspect of your work with an objective viewpoint, thus more likely to find any potential problems that need to be resolved. This level of objectivity is crucial to ensure the issues mentioned above do not occur with your next coating project.

Polymer coatings or liners can perform well to protect cementitious substrates and should be seen as a cost-effective method of enhancing concrete structures' performance. However, it is important that the selection and preparation of concrete are carefully considered. Proper selection, application, and quality control of the coating or lining system are vital for an effective lifetime of service.

Are you interested in learning more about this topic?

Register for our upcoming webinar presented by John McGill, PCS.

Protection of Wastewater Structures with Polymer Coatings and Linings

Wednesday, April 28, 2021 | 12:00 – 1:00 PM EST

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