



Polyurea... Hydrogen Sulfide Resistant Industrial Sewage & Wastewater Coating for Rehabilitation of Concrete

Introduction

For years, polyurethane's and epoxy coatings have been utilized for corrosion protection in wastewater and sewage applications. However, with the advent of polyurea technology, the protection of concrete and steel in continual-immersed or occasional sewage conditions has been raised to a new level.

What is Sewage?

Sewage is the wastewater released by residences, businesses, and industries in a community. It is 99.94% water with only 0.06% of the wastewater dissolved and suspended solid material. The cloudiness of sewage is caused by suspended particles, which in untreated sewage, ranges from 100 to 350 mg/L. A measure of the strength of wastewater is biochemical demand (or BOD₅). The BOD₅ measures the amount of oxygen microorganisms require in five days to break down sewage. Pathogens and disease causing bacteria, such as Coliform, are also present in sewage. Sewage can also contain nutrients such as ammonia and phosphorus as well as minerals and metals. One byproduct of sewage is hydrogen sulfide gas. Hydrogen Sulfide gas is a highly corrosive and lethal substance. This gas coupled with several other items including pH changes, minerals used to treat sewage and temperature fluctuation has been the cause of many coating failures.

Aging Concrete in Sewage Plants

Concrete has traditionally been utilized as the material of choice for the construction of



Mike Kronz of Remote Orbital Installations Preparing a Manhole for a Polyurea Lining

sewage plants, manholes, sewage pipelines and sewage treatment basins and lagoons. However, because of the aging of our infrastructure, the concrete that was installed over 20 years ago now displays severe corrosion results. There is a large need for polyurea coatings to be utilized in this area of our infrastructure because of its outstanding corrosion resistance and rapid cure. The amount of monies that could be saved by rehabilitating of current sewage treatment facilities could be tremendous.

New Concrete Applications

There are probably hundreds of sewage treatment plants under construction today that are not utilizing the benefits of polyurea coatings. However, it is becoming more and more commonplace for engineers to specify polyurea coatings as a corrosion control coating for new construction applications. This specification is becoming so popular that one contractor has even invented a robotic polyurea application system for manholes and sewage pipe¹. This robotic system can be used in the concrete pre-cast yard (after proper curing of the concrete) or in the field on previously placed manholes to apply a seamless polyurea lining that is essentially pinhole free in a matter of minutes.

What about Epoxies?

Epoxy coatings have been used for years in sewage treatment plants as a corrosion control coating. Epoxy displays excellent adhesion to concrete or steel and can display good chemical resistance. However, there are several disadvantages to epoxy as it pertains to wastewater applications. The first disadvantage is epoxies generally do not display good elongation. This can cause cracking with the natural movement of the earth and will eventually lead to coating failure and/or water intrusion. Secondly, epoxies are generally slow curing. Slow cure is not a desirable property when hundreds of residents are waiting on a lift station, basin, or lagoon to be brought back into service. Thirdly, some epoxies contain solvents, which can leach out of the coating and cause undesirable surface interface properties. In one test performed by a public utility, only 5 of 63 epoxy coatings survived two years of simulated sewage immersion testing.

Polyurethane Comparison

Polyurethane coatings have been used somewhat sparingly in the wastewater industry. The issue with polyurethane's in sewage applications has been chemical

resistance to hydrogen sulfide gas. Although there are some polyurethane's that will resist the extremely corrosive and toxic gas, most of the coatings on the market have not shown excellent long-term chemical resistance to some of the commonly used wastewater chemicals and treatment byproducts. However, polyurethane's display good elongation and resistance to cracking and chipping because of their elastomeric nature. Furthermore, polyurethane's have curing temperature limitations as well as humidity limitations, which can be a serious issue during application in the field.

Polyurea, A Urethane/Epoxy Hybrid?

Originally developed by Texaco Chemical, a polyurea coating is the result of a chemical reaction between an isocyanate and an amine-terminated polyether. This reaction is different than a polyurethane reaction because the reaction of polyurethane involves an isocyanate and a polyol (i.e. no amines). The polyurea reaction is much more consistent, predictable, and thermally stable than a polyurethane. This allows a polyurea formulation to be sprayed at 100% humidity conditions or at conditions well below -20F with virtually the same dependable reaction speed. Another interesting aspect of polyurea is the fact that one of the main formulation ingredients is a high molecular weight epoxy hardener. This ingredient imparts epoxy-like qualities with a quasi pre-polymer isocyanate (which gives elastomeric properties). Therefore, the argument can be made that a polyurea could be considered a much improved hybrid of a polyurethane and an epoxy.

Why Polyurea in Sewage Applications?

Going back to the second paragraph, sewage breakdown requires a certain level of oxygen. Polyurea has very little oxygen in the reaction mechanism. The oxygen that is present in the isocyanate (i.e. NCO molecule) is reacted with the amines in the resin component. When

complete, this reaction is 100% inert and plays no role in the biochemical breakdown of wastewater. Another fact is that amine backbone of the polyurea reaction is very resistant to hydrogen sulfide gas as well as other caustics and acids generally associated with wastewater.

Polyurea Corrosion Resistance

The corrosion resistance of a coating is directly relatable to the coatings moisture vapor transmission rate (or MVT). Polyurea has shown an average of 0.002 perms at an average thickness of 80 mils DFT. Another determination of corrosion resistance is the field immersion testing of polyurea in simulated sewage conditions. Pure polyurea formulations hold up very well in these conditions and show no signs of degradation. Another excellent property of polyurea is its ability to resist hydrocarbons. Although undesirable, hydrocarbons such as gasoline and oil always seem to make their way to the wastewater system. It is imperative that a wastewater coating shows good hydrocarbon resistance.

Primers for Polyurea's

Polyurea functions well over several primers, however, the most compatible primers are generally epoxies and polyurethane's. The epoxies have an amine backbone, and usually display vigorous adhesion to concrete. They are also very high in tensile strength, which may improve concrete surface tensile strength. The disadvantage to epoxy primers is their cure times. Polyurethane primers are compatible as well because of the utilization of isocyanate. A solvented polyurethane primer will usually penetrate into the concrete substrate and react leaving very nice bonding sites, which remain "open" for coating for several hours.

UV Stability

Depending on the formulations, polyureas can be very stable in UV light. Because of

polyurea's aromatic nature, the surface will yellow but show little or no signs of degradation. Independent testing has shown that, using the proper UV additives, a polyurea will easily withstand 3000 hours in a Atlas Weatherometer and display only minor surface deficiencies and yellowing². Color-stable aliphatic polyureas are available on the market for applications demanding color fastness. An engineer may specify a color stable polyurea in a high profile area that requires some architectural beauty.

Polyurea Application Limitations

One of the problems generally associated with polyurea is the high cost of the required application equipment. The cost of a fully equipped spray application rig can certainly be upwards of \$50,000. However, the high cost of equipment tends to allow only the most successful applicators that can afford this equipment to apply these coatings. This tends to be coatings applicators of high quality since so much of an investment is placed upon application equipment. Most manufacturers have a "Certified Applicator" program that allows a contractor and manufacturer to place warranties on the application for maximum value to the municipalities and engineers.

A Final Thought

As you can imagine, not all polyurea's are created equal. An engineer should ask for references and prior applications of the manufacturer's polyurea. This thorough research will maximize the opportunity for a successful polyurea application. When attempting to specify a corrosion resistant coating for sewage applications and rehabilitation, there is one thing that is certain; polyurea has been a proven winner in these applications for over 12 years.

1- Remote Orbital Systems
Madison, WI

2- Independent Testing performed by
Bayer Corp. Coatings Division