CASE HISTORY

Restoring a Sludge Holding Tank at a Wastewater Treatment Plant Using High-Performance Coatings

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Faced with a serious hydrogen sulfide (H_2S) corrosion problem in two sludge holding tanks in 1993, the city of Concord, New Hampshire, repaired the deteriorating substrate by using a conventional acrylic-modified cementitious resurfacer and a coal tar epoxy (CTE) coating system. CTE failure occurred within 2 years, leading to more severe coating delamination. Restoration was delayed for 10 years, which caused extensive chemical attack on the concrete substrate—upwards of 2 in. (50 mm) of concrete loss. This article explains how one of these tanks was restored and prepared for another 15+ years of service.

One of two plants in Concord, New Hampshire, the Hall Street Wastewater Treatment Plant is capable of handling an average daily flow of 10.1 million gal. Its two sludge holding tanks were in a serious state of deterioration. Erected in 1980, the two 40-by-42-by-20-ft (12-by-13-by-6-m) underground sludge holding tanks contain the heavy biosolids removed in the preliminary treatment process by the primary clarifiers. These biosolids contain inorganic and partially decomposed organic matter, including pathogenic bacteria.

The Problem

The plant experienced a serious hydrogen sulfide (H_2S) corrosion problem in 1993 that was repaired using a conventional, acrylic-modified cementitious resurfacer and coal tar epoxy (CTE) coating. Failure of the CTE coating occurred within 2 years, leading to coating delamination. Frustrated by the lack of protection by an otherwise traditional product for these severe applications, the city elected to forego repair. This restoration delay caused extensive chemical attack of the concrete substrate—upwards of 2 in. (50 mm) of concrete loss—exposing some rebar and thereby raising structural concerns for the two sludge tanks (Figure 1).

CTEs have traditionally been utilized for wastewater exposures, but with this plant, as with most wastewater treatment plants across the country, the H_2S levels began to rise in the mid 1980s primarily because of the removal of heavy metals from the waste stream as required by the U.S. Environmental Protection Agency's (EPA) Clean Water Act. This unintentionally allowed for higher H_2S gas generation in the collection systems and treatment processes.

The root cause of odor and corrosion in collection and treatment systems is H_2S, which is produced through a reaction by sulfate-reducing bacteria residing in the anaerobic slime layer on the submerged portion of sewer pipes and structures. The sludge handling and dewatering processes taking place in the sludge tank produce

H_2S gas in a reaction from the waste water where odor and corrosion problems begin.

Another type of bacteria, *Thiobacillus* aerobic sulfur-oxidizing bacteria (SOB), oxidizes H_2S gas to produce sulfuric acid (H_2SO_4) that causes the destruction of concrete and steel within wastewater facilities. It is the H_2S gas and reaction derivatives that permeate the protective coating systems and allow the sulfur oxidizing bacteria and H_2SO_4 to follow and attack the lining and substrate.

CTEs generally have good H_2SO_4 resistance, especially at the low levels typically found in wastewater headspaces. At this plant, however, the increase in H_2S levels introduced another dimension to coating permeation that has been traditionally overlooked. The H_2S gas permeated the CTE film and attacked the acrylic cementitious resurfacer and concrete substrate. In other words, H_2S was oxidized by various factors including SOB and converted the H_2S into H_2SO_4, thus attacking the alkaline concrete.

Developing a Rehabilitation Plan

In November 2003, the plant superintendent asked the city's consulting engineers for a comprehensive plan to rehabilitate the two badly deteriorated sludge tanks, as the city needed a successful repair solution. A coating consultant specified a high-performance coating system that was proven in H_2S-rich environments. It was also specified that all contractors and applicators be prequalified and preapproved, and that an independent coatings inspection be conducted for quality assurance.

An epoxy-modified cementitious resurfacing mortar was specified to provide a contiguous concrete surface for the protective lining.

The top coatings specified were an aggregate reinforced, modified aliphatic amine epoxy mortar and a versatile, thick-film modified polyamine epoxy with good permeation resistance to H_2S, H_2SO_4, and water (H_2O).

FIGURE 1

Deterioration of concrete sludge holding tank after 10 years of H_2S corrosion.

FIGURE 2

Concrete surfaces after water jetting and hand chipping.

Restoring Sludge Storage Tank #1

The city's consulting engineer, coating consultant, application contractor, and coating inspector agreed on a specific course of action to repair and resurface the first of the two severely deteriorated holding tanks. The first job was to remove the failed lining system. This was accom-

FIGURE 3

Trowel application at 125 mils of 100% solids epoxy mortar system designed for elevated H_2S permeation.

FIGURE 4

Appearance of the finished coating.

plished with high-pressure water cleaning of 5,000 psi (35 MPa), and by chipping away damaged concrete by hand. Twenty percent of the tank's substrate had been damaged so severely that large areas of 1/2 to 3 in. (13 to 76 mm) of concrete had to be restored with shotcrete to provide the necessary rebar cover and to bring the surface back to the original plane. After curing for 7 days according to American Concrete Institute (ACI) Standards, the shotcrete was abrasive-blasted to remove the membrane curing compound and any laitance formed during troweling and curing according to NACE No. 6/SSPC-SP 13[1] (Figure 2). At this stage, the coating inspector evaluated the progress for quality control.

The next step was to apply a parge coat of the epoxy modified cementitious resurfacer mortar to the entire shotcreted surface at 1/16-in. (1.6-mm) thickness to close any of the shotcrete surface anomalies. Once again the inspector checked the work in progress.

When this substrate restoration was complete, the applicator trowel-applied at 125 mils (3 mm) of 100% solids epoxy mortar, especially designed for permeation resistance of elevated H_2S gas and reaction products (Figure 3). This coating was then backrolled to close the film and to make the lining pinhole free.

Upon completion and cure, the inspector evaluated the adhesion/pull-off tensile strength of the coating system at nine locations according to ASTM D4541.[2] The pull test yielded 100% substrate failure at 700 psi (4.8 MPa) average (300 to 400 psi [2 to 3 MPa] is typical), and the high adhesion result was attributed to the epoxy polymer modified cementitious resurfacer material. The inspector also performed high-voltage (spark) holiday testing at 12,500 V (100 V per mil of coating thickness according to NACE RP0188[3]).

Following holiday testing, the applicator completed the job with a final roll coat of a modified polyamine epoxy lining at 15 to 20 mils (0.4 to 0.5 mm) to seal the few holiday pinholes detected by the high voltage spark test (Figure 4).

Conclusions

There are liquid polymer linings available to handle the severe H_2S environments commonly found in wastewater collection systems and treatment plants. The thin film epoxy and CTE coatings of the past are no longer handling the severe H_2S environments they once were.

Providing the proper tank repair and lining system to tackle today's severe corrosion problems takes a high-performance coating system designed with good permeation resistance to H_2S, H_2SO_4, and H_2O. Close cooperation among engineers and the coating consultant, applicator, and inspector also is essential.

References

1. NACE No. 6/SSPC-SP 13, "Surface Preparation of Concrete" (Houston, TX: NACE International, 2003).

2. ASTM D4541, "Standard Test Method for Pull Off Strength of Coating Using Portable Adhesion Testers," Annual Book of ASTM Standards (West Conshohocken, PA: ASTM International).

3. NACE RP0188-99, "Discontinuity (Holiday) Testing of New Protective Coatings on Conductive Substrates" (Houston, TX: NACE, 1999).

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