

SSPC: The Society for Protective Coatings

TECHNOLOGY GUIDE 27

Recommended Performance Properties for Liquid-Applied Organic Polymeric Coatings and Linings for Concrete Structures in Municipal Wastewater Facilities

1. Scope

This guide provides recommendations for laboratory test and field performance properties used in selecting coatings and linings used to protect sound concrete substrates in municipal wastewater collection systems and treatment plant facilities. Exposure environments include immersion and headspace service areas. Minimum recommended acceptance criteria are also included.

Performance recommendations for interior linings and exterior coatings for concrete sewage pipe (RCP, CCP or PCCP), interceptors, tunnels in wastewater collection systems, and chemical secondary containment applications are addressed in other technical publications. Concrete repair products and resurfacing material requirements are beyond the scope of this guide.

Units of Measure: This guide provides both ASTM⁽¹⁾/IEEE SI 10, "American National Standard for Metric Practice" International System Units (SI) units and U.S. Customary units. The measurements are not exact equivalents; therefore each system must be used independently of the other without combining in any way. Where both sets of units are shown, U.S. Customary units are presented first, with approximate SI conversions shown in parentheses.

2. Referenced Standards

2.1 The date of the referenced standard in effect at the time of publication of this guide was used in the development of the Guide unless otherwise noted. Standards marked with an asterisk (*) are referenced only in the Notes.

2.2 American Society for Testing and Materials (ASTM) Standards:

- * D562 Standard Test Method for Consistency of Paints Measuring Krebs Unit (KU) Viscosity Using a Stormer-Type Viscometer
- * D1475 Standard Test Method For Density of Liquid Coatings, Inks, and Related Products

⁽¹⁾ ASTM International, 100 Barr Harbor Drive, West Conshohocken, PA 19380-2959, phone int+1-610-832-9500 or referenced ASTM standards, visit the ASTM website <<http://www.astm.org>>

This standard developed by the SSPC C 1.14 Committee on Coatings for Concrete in Wastewater Facilities was first issued as SSPC-Paint 44 in 1913 and was revised into SSPC-Guide 27 in September 2019

- * D1640 Standard Test Methods for Drying, Curing, or Film Formation of Coatings at Room Temperature
- D1653 Standard Test Methods for Water Vapor Transmission of Organic Coating Film
- * D2369 Standard Test Method for Volatile Content of Coatings
- * D2621 Standard Test Method for Infrared Identification of Vehicle Solids From Solvent-Reducible Paints
- D4060 Standard Test Method for Abrasion Resistance of Organic Coatings by the Taber Abraser
- D6943 Standard Practices for Immersion Testing of Industrial Protective Coatings
- D7234 Standard Test Method for Pull-Off Adhesion Strength of Coatings on Concrete Using Portable Pull-Off Adhesion Testers
- E96 Standard Test Methods for Water Vapor Transmission of Materials
- G210 Standard Practice for Operating the Severe Wastewater Analysis Testing Apparatus.

3. Definitions

Advanced Treatment: Specialized processes that remove specific organic and inorganic contaminants from wastewater, e.g. phosphorous and ammonia.

Aggressively Corrosive Environments: Headspace or immersion exposures or service conditions under which concrete is rapidly degraded due to acidic attack or to expansive chemical deterioration or to cracking or spalling promoted by the corrosion of reinforcing steel within the concrete (related to high chloride ion ingress into the concrete).

Aqueous Phase Carbonation: The corrosion mechanism that occurs below the waterline in wastewater treatment plant structures in which dissolved carbon dioxide (CO₂) evolves as carbonic acid and causes gradual pH reduction of the alkaline, hardened cement paste in concrete which can, in turn, be dissolved and washed away leaving

exposed coarse aggregate. The main reaction compound from carbonation is calcium carbonate, which is the reason for the term carbonation.

Biogenic Sulfide Corrosion: The corrosion mechanism that occurs in the aerated spaces of structures in wastewater systems in which sulfur oxidizing bacteria (SOB), mainly thiobacillus, metabolize hydrogen sulfide to form sulfuric acid while, in turn, causes acidic attack of the alkaline cement paste in concrete.

Coating: A liquid, liquefiable, or mastic composition that is converted to a solid protective, decorative, or functional adherent film after application as a thin layer.

Collection Systems: The series of laterals, manholes, interceptors and pump stations through which municipal wastewater is transported to the treatment facility.

Damage Mechanism: For the purposes of this document, this refers to a specific chemical corrosion process that results in the degradation of concrete.

Headspace: Enclosed portions of concrete structures in wastewater applications in which the concrete substrate would be exposed to corrosive gases such as H_2S , CH_4 , and CO_2 .

Headworks: The entrance structures for wastewater treatment plants in which wastewater from the collection system is brought together to be conveyed to preliminary or primary treatment in the wastewater treatment plant..

Lining: A material used to protect the interior of a container against corrosion and/or to protect the contents of the container from contamination by the container shell material. Sprayable linings, sheet liners, and drop-in liners can be used to accomplish these purposes,

Preliminary Treatment Systems: The first steps in processing municipal wastewater, which consists of monitoring flow, screening debris, and removing grit (heavy inorganic solids).

Primary Treatment: The process by which contaminants that either float or settle are removed from the wastewater (e.g., oils, greases, solids etc.).

Secondary Containment: Structures (often concrete dikes) that provide chemical spill containment should the primary means of chemical storage fail or leak.

Secondary Treatment: The process by which microorganisms are used to absorb and oxidize organic substances from the wastewater.

Severe Service (concrete): Environments in which surfaces and applied coatings have significant exposure to traffic, chemicals, or changes in temperature.

Solids Dewatering and Handling: The process by which wastewater sludge (settled solids) is removed from the wastewater treatment process and treated to remove excess water.

Wastewater Sludge: Solid, semisolid, or liquid material generated from a wastewater treatment process. A biologically active mix of water, organic matter (derived from human wastes, food wastes, etc.), inorganic solids (including trace elements), dead and alive microorganisms (including pathogens), and trace contaminants (e.g., chemicals). Wastewater sludge is generated in primary settling tanks ("clarifiers") and secondary settling tanks and, in most cases, is a slightly viscous, gray-brown liquid.

4. Locations of Aggressive Corrosion Damage Mechanisms in Municipal Wastewater Collection Systems and Treatment Plants

The most aggressive corrosion damage mechanisms that concrete encounters in municipal wastewater collection systems and treatment plants (excluding the exceptions identified in the Scope) are:

4.1 ACIDIC ATTACK MECHANISMS

4.1.1 Biogenic Sulfide Corrosion: This occurs in the headspaces of pipelines, interceptors, tunnels, pump stations, lift stations, headwork structures, grit chambers, screening structures, primary clarifiers, aeration tanks, trickling filters, and other structures. Its level of aggressiveness is influenced by length of wastewater transit time, biosolids septicity, wastewater temperature, turbulent flow conditions at the point of H_2S gas liberation, ventilation (air changes), wastewater velocity and flow rates upstream of the structure, and many other factors.

Coating or lining resistance to biogenic sulfide corrosion is a function of several properties. The most important of these properties are chemical resistance to sulfuric acid (H_2SO_4) and good permeation resistance to H_2S , CO_2 , and CH_4 gases.

Biogenic sulfide metabolism of sulfides to form acids also causes acidic attack of concrete in immersion service areas such as biofilters. In these areas, the acid formed on the filter media is washed down onto concrete surfaces where the filtrate is collected and conveyed. The acid attacks the alkaline cement paste in these immersion exposure areas, rather than in a headspace.

4.1.2 Aqueous Phase Carbonation: This occurs in all collection system and treatment plant structures exposed to low pH or near-neutral pH water or wastewater that is low in alkalinity and hardness. The effects are made more

aggressive in pure oxygen reactors (in Secondary Biological Treatment) where pressurized headspaces force more CO_2 (a by-product of bacterial respiration in the treatment process) to remain in solution. This causes more of the CO_2 to evolve as carbonic acid, depressing the pH of the wastewater, and promoting promotes acidic attack of calcium hydroxide and other calcium silicate hydrates in the concrete's cement paste.

Coating or lining performance relative to resistance to aqueous phase carbonation has been shown to be mainly based on good permeation resistance to water, water vapor, and chemical resistance to waters having a pH in the 4.0 to 6.0 range.

4.1.3 Exposure to organic acids in sludge (biosolids) digestion and handling processes also causes acidic attack of concrete substrates. This can occur when "upset operating conditions" occur in anaerobic digesters as well as in the handling of decant in sludge processing. In both scenarios, acidic acid, carbonic acid, and other organic volatile acids are present and can cause aggressive attack of the hydrated cement paste in concrete. Acidic attack in these applications, (including other structures beyond digesters or decant handling equipment), occurs in immersion exposures. Coating or lining properties that are essential for good performance in volatile acid exposure include requisite chemical resistance and good permeability resistance to water, water vapor, and gases such as CO_2 , H_2S , and methane (CH_4).

4.2 EXPANSIVE DETERIORATION OF CONCRETE:

Chloride Induced Reinforcing Steel Corrosion can also cause aggressive concrete deterioration. When concrete is placed around reinforcing bars, the steel surface initially corrodes. Then, a tightly adherent oxide film forms over the surface to protect it from further corrosion, provided it remains intact. This passive protection film is maintained by the highly alkaline environment of the hydrated Portland cement in the concrete.

The protective film is compromised when moisture, chloride ions, and oxygen penetrate through pores or cracks in the concrete to reach the steel surface, establishing local corrosion cells. The result is the formation of large amounts of iron oxide with concurrent volume expansion. If the expansive forces exceed the relatively low tensile strength of the concrete covering the steel bars, the concrete cracks, allowing further ingress of chloride ions, water, and oxygen. Rust bleeding, cracking, and spalling are all manifestations of chloride-induced corrosion.

This damage mechanism occurs primarily in collection system structures along sea coastal environments in which a great deal of brackish water or seawater infiltrates the collection system. It also occurs frequently in chlorine contact chambers and structures and where sodium hypochlorite and ferric chloride are present in wastewater in treatment facilities. Note that ferric chloride attack of concrete is both

an acidic damage mechanism (due to its very low pH) and a chloride-related damage mechanism.

Good coating or lining performance for preventing chloride induced corrosion in concrete requires the requisite chemical resistance to chlorine and chlorides as well as good permeation resistance to water and water vapor.

5. Matching Aggressive Corrosion Damage Mechanisms to Coating and Lining Performance Requirements

5.1 Table 1 lists the minimum coating or lining properties recommended for resistance to the aggressive corrosion damage mechanisms commonly encountered by concrete in service environments such as wastewater collection systems and treatment plant structures. All values listed in Table 1 are laboratory test results and should not be interpreted as field test values.

- Column 1, "System or Area" lists the area of the facility where the coating will be used.
- Column 2, "Damage Mechanisms" describes the damage mechanism for which the coating or lining should provide protection.
- Columns 3 through 9 list the ASTM test standard procedures and minimum performance requirements for the coatings or linings to be selected for use for protecting concrete against the specific damage mechanisms.
- The number of replicate specimens required for testing should be as recommended by the relevant ASTM test method. Should the ASTM test method not include a recommended number of replicate specimens, at least three (3) replicate specimens should be prepared and tested to determine compliance with the recommendations of this guide, unless otherwise required by the specifier.

5.2 The result of any adhesion pull that causes 100 percent substrate failure prior to reaching the minimum pull value (psi) for the specified service condition should be disregarded and that pull should be repeated. Test substrates (panels) that fail consistently below the minimum required psi should be discarded.

5.3 ANALYTICAL TEST DATA: To ensure batch-to-batch consistency, it is recommended that purchasers retain records of chemical and physical analysis of qualified coating batches (see Note 8.1).

6. Guidance on Field Performance Properties Recommended for Selecting Coatings and Linings.

Table 2 presents some key minimum field performance properties for coatings and linings to ensure good performance to resist the aggressive corrosion damage