SSPC-Paint 44

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

www.sspc.org

Presentation Agenda

- Principal Service Environments
- Concrete as a Construction Substrate
- Concrete Test Methods (ASTM)
- Concrete Conditions and Contaminants
- Corrosive Treatment Methods
- Type and Extent of Deterioration
- Suitable Lining Systems
- Minimum Coating Performance

www.sspc.org

Introduction

This presentation will provide an overview on performance requirements for coatings and linings used on **sound concrete substrates** in principal service environments of areas in municipal wastewater treatment facilities.

www.sspc.org

Principal Service Environments

- Collection Systems
- Preliminary Treatment Systems
- Primary Treatment Systems
- Secondary Treatment Systems
- Advanced Treatment Systems
- Solids Handling Areas
- Secondary Containment Structures

www.sspc.org

Collection Systems

- Series of laterals, manholes, interceptors, and pump stations

www.sspc.org

Preliminary Treatment Systems

- First steps of processing municipal wastewater, which consists of monitoring flow, screening debris, and removing grit (heavy inorganic solids)

www.sspc.org

Secondary Treatment Systems

- Structures that consist of the process by which microorganisms are used to absorb and oxidize organic substances

www.sspc.org

Advanced Treatment Systems

- Structures that are used for the specialized process that removes specific organic and inorganic contaminants

www.sspc.org

Solids Handling Areas

- Structures that consist of the process by which wastewater sludge (settled solids) is removed from the wastewater treatment process and treated to remove excess water

Secondary Containment Structures

- Provide chemical spill containment should the primary means of chemical storage fail or leak

Concrete as a Substrate

- Most widely used construction material in wastewater treatment plants
- Restoring concrete with coatings and linings require considering performance properties of the existing concrete
- Some properties that are considered are:
  - Surface tensile strength
  - Moisture content
  - Contaminants (e.g., laitance and efflorescence)
  - Porosity

Surface Tensile Strength

- A weak surface layer can be a result of poor installation procedures or from extended exposure to a corrosive environment
- Evaluated by measuring the pull-off adhesion of the coating applied to the concrete per ASTM D7234

Surface Tensile Strength (cont'd)

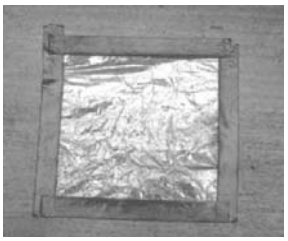
- Minimum recommended surface tensile strength will vary by coating manufacturer and specific lining systems as well as by the service conditions of the structure
- Consult the manufacturer's PDS for concrete strength requirements

Moisture Content

- Porous Substrate
  - Absorbs and retains water
- Tests available for determining level of moisture
  - ASTM D4263
  - ASTM F1869
  - ASTM F2170

ASTM D4263

- Standard Test Method for Indicating Moisture in Concrete by the Plastic Sheet Method
  - Used to indicate the presence of capillary moisture in concrete



ASTM F1869

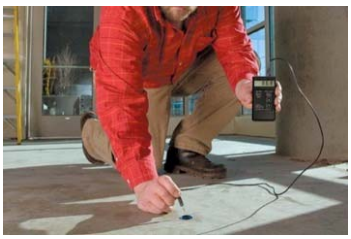
- Standard Test Method for Measuring Moisture Vapor Emission Rate of Concrete Subfloor Using Anhydrous Calcium Chloride
  - Covers the quantitative determination of the rate of moisture vapor emitted from below-grade, on-grade, and above-grade (suspended) concrete floors

ASTM F1869

www.sspc.org

ASTM F2170

- Standard Test Method for Determining Relative Humidity in Concrete Floor Slabs Using In-Situ Probes
  - Covers the quantitative determination of percent relative humidity in concrete slabs for field or laboratory tests



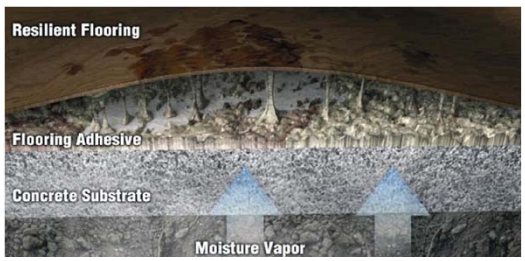
www.sspc.org

MVE

- Moisture Vapor Emission (MVE)
  - Defined as the measurement of moisture vapor movement through a concrete slab
  - ASTM F1869 describes how this is accomplished by absorbing moisture on anhydrous calcium chloride

MVE (cont'd)

- Porosity of concrete affects MVE
- The capillary action of the concrete draws in moisture or contaminants



Laitance

- Thin, weak, brittle layer of cement and aggregate fines on a concrete surface
  - Degree of severity is based on the amount of admixtures, the degree of working, and the amount of water in the concrete

Efflorescence

- White crystalline or powdery deposit on the surface of the concrete
  - Results from leaching of lime or calcium hydroxide out of a permeable concrete mass over time by water, followed by the reaction with carbon dioxide and acidic pollutants

Efflorescence

www.sspc.org

Other Contaminants

- Concrete surfaces at wastewater treatment facilities can have extensive contamination from greases, fats, and oils
  - Visually inspect prior to surface preparation
  - Remove using steam or pressure washing with a cleaning compound or detergent capable of dissolving the contamination
  - Inspect
    - Black light test
    - Waterbreak test
      - ASTM F22

www.sspc.org

Permeation

- The steady water vapor flow in unit time through unit area of body induced by unit vapor pressure difference between two surfaces of a coating
- Hydrostatic conditions occurring when ground water is present on the earth side of the concrete wall or when water is present on the backside of a common concrete wall

Permeation

- The coating or lining can disband and osmotic blisters may form if the water pressure exceeds the tensile adhesion

Corrosive Environment

- Naturally occurring corrosives common to most wastewater facilities include:
  - Acidic wastewater
  - Hydrogen sulfide
  - Sulfuric acid
  - Carbon dioxide

Corrosive Treatment Methods and Chemicals

- Treatment chemicals that can corrode concrete are:
  - Granular activated carbon
  - Chlorine solution (hypochlorus acid)
  - Ferric chloride
  - Sodium/calcium hypochlorite
  - Aluminum sulfate (alum)
  - Ferrous sulfate
  - Sulfuric acid

Corrosives

- The most severe deterioration from these corrosives occurs on the exposed wall and slab underside surfaces at and above the flow line in enclosed or covered spaces
  - Dissolved sulfides are released from turbulent wastewater as hydrogen sulfide
    - Hydrogen sulfide is converted to sulfuric acid by aerobic microbial oxidation

ASTM G210

- Standard practice for operating the severe wastewater analysis testing apparatus
  - Test simulates the pertinent attributes of a typical domestic severe wastewater headspace (sewer) environment

Type and Extent of Deterioration

- Understanding the type and extent of deterioration on equipment or a structure is critical when selecting a rehabilitation coating or lining system

Type and Extent of Deterioration (cont'd)

- Can range from slight etching or partial loss of the surface cement binder to complete loss of the cement binder
  - Coarse aggregate with corroded reinforcing steel is exposed
    - Spalling and cracking

Suitable Lining Systems

- Some generic lining systems that have demonstrated varying performance from testing or field experience include:
  - Polyester
  - Vinyl ester
  - Epoxy
  - Coal tar epoxy
  - Polyurea
  - Polyvinyl chloride liner with mastic or urethane
  - Urethane
  - Sulfur concrete
  - Potassium silicate concrete
  - Calcium aluminum concrete

Suitable Lining System (cont'd)

- Many of organic resin linings systems have shown enhanced performance when installed in a mortar form
  - Sand extended or filled
  - Reinforced with fabric or mat

Minimum Coating Performance Requirements, Specific Wastewater Treatment Facility Areas

TABLE 1
MINIMUM PERFORMANCE REQUIREMENTS
WHEN EVALUATED ACCORDING TO ASTM TESTS LISTED BELOW

Row Number System or Area	Adhesion to Substrate per ASTM D7234[1]	Abrasion Resistance per ASTM D4060	Water Vapor Transmission of Organic Coating Films (WVT)[2] per ASTM D1653, Method B (wet cup) used with condition A	Water Vapor Permeance (WVP)[2] per ASTM E96, water method at 21 to 24 °C (69 to 75 °F) and 50 to 70% RH[3]	Linear Expansion per ASTM C531	Absorption of Chemical Resistant Mortars, Grouts, Monolithic Surfacings and Polymer Concretes per ASTM C413	Tensile Strength per ASTM D2370 or C307 as specified	Description of Exposure Duration and Environments for Chemical Resistance per ASTM D6943[4], and/or ASTM C267[4] as specified
1. Collection Systems	Not less than 200 psi and 100% substrate failure for Light Service No less than 300 psi and 100% substrate failure for Severe Service	Abrasion loss not to exceed 80 mg when tested with CS 17 wheel with 1,000 gm load for 1000 cycles	WVT = <2.00 g/m² per 24 hrs	WVP = <0.19 metric perms	<5.6 X 10⁻⁶/F	No greater than 1.5% in 30 days following 7 days of cure per section 7.3 of ASTM C413	N/A	20% H_2SO_4 immersion of at least 6 months
2. Preliminary Treatment	Not less than 200 psi and 100% substrate failure for Light Service No less than 300 psi and 100% substrate failure for Severe Service	Abrasion loss not to exceed 80 mg when tested with CS 17 wheel with 1,000 gm load for 1000 cycles	WVT = <2.00 g/m² per 24 hrs	WVP = <0.19 metric perms	<5.6 X 10⁻⁶/F	No greater than 1.5% in 30 days following 7 days of cure per section 7.3 of ASTM C413	N/A	20% H_2SO_4 immersion of at least 6 months
3. Primary Treatment Systems	Not less than 200 psi and 100% substrate failure for Light Service No less than 300 psi and 100% substrate failure for Severe Service	N/A	WVT = <2.00 g/m² per 24 hrs	WVP = <0.19 metric perms	<5.6 X 10⁻⁶/F	No greater than 1.5% in 30 days following 7 days of cure per section 7.3 of ASTM C413	N/A	20% H_2SO_4 immersion of at least 6 months
4. Secondary Treatment Systems	Not less than 200 psi and 100 % substrate failure for Light Service No less than 300 psi and 100% substrate failure for Severe Service	N/A	WVT = <2.00 g/m² per 24 hrs	WVP = <0.19 metric perms	<5.6 X 10⁻⁶/F	No greater than 1.5% in 30 days following 7 days of cure per section 7.3 of ASTM C413	N/A	20% H_2SO_4 1% Ferric Sulfates 1.25% Sodium Hypochlorite 0.5% Sodium Bisulfate 1% Aluminum Sulfate Chlorine Gas 1% Ferric Chloride Immersion of at least 6 months

www.sspc.org

Minimum Coating Performance Requirements, Specific Wastewater Treatment Facility Areas

TABLE 1
MINIMUM PERFORMANCE REQUIREMENTS
WHEN EVALUATED ACCORDING TO ASTM TESTS LISTED BELOW

Row Number System or Area	Adhesion to Substrate per ASTM D7234[1]	Abrasion Resistance per ASTM D4060	Water Vapor Transmission of Organic Coating Films (WVT)[2] per ASTM D1653, Method B (wet cup) used with condition A	Water Vapor Permeance (WVP)[2] per ASTM E96, water method at 21 to 24 °C (69 to 75 °F) and 50 to 70% RH[3]	Linear Expansion per ASTM C531	Absorption of Chemical Resistant Mortars, Grouts, Monolithic Surfacings and Polymer Concretes per ASTM C413	Tensile Strength per ASTM D2370 or C307 as specified	Description of Exposure Duration and Environments for Chemical Resistance per ASTM D6943[4], and/or ASTM C267[4] as specified
5. Advanced Treatment Systems	Not less than 200 psi and 100% substrate failure for Light Service No less than 300 psi and 100% substrate failure for Severe Service	N/A	WVT = <2.00 g/m² per 24 hrs	WVP = <0.19 metric perms	<5.6 X 10⁻⁶/F	No greater than 1.5% in 30 days following 7 days of cure per section 7.3 of ASTM C413	Greater than 2000 psi	1% Sodium Hypochlorite immersion of at least 6 months
6. Solids Handling	Not less than 200 psi and 100% substrate failure for Light Service No less than 300 psi and 100% substrate failure for Severe Service	Abrasion loss not to exceed 100 mg when tested with CS 17 wheel with 1,000 gm load for 1000 cycles	WVT = <2.00 g/m² per 24 hrs	WVP = <0.19 metric perms	<5.6 X 10⁻⁶/F	No greater than 1.5% in 30 days following 7 days of cure per section 7.3 of ASTM C413	N/A	Wastewater sludge, immersion of at least 6 months
7. Chemical Storage	Not less than 200 psi and 100% substrate failure for Light Service No less than 300 psi and 100% substrate failure for Severe Service	Abrasion loss not to exceed 100 mg when tested with CS 17 wheel with 1,000 gm load for 1000 cycles	WVT = <2.00 g/m² per 24 hrs	WVP = <0.19 metric perms	<5.6 X 10⁻⁶/F	No greater than 1.5% in 30 days following 7 days of cure per section 7.3 of ASTM C413	N/A	Chemicals being stored, immersion of at least 72 hours
8. Secondary Containment	Not less than 200 psi and 100% substrate failure for Light Service No less than 300 psi and 100% substrate failure for Severe Service	Abrasion loss not to exceed 100 mg when tested with CS 17 wheel with 1,000 gm load for 1000 cycles	WVT = <2.00 g/m² per 24 hrs	WVP = <0.19 metric perms	<5.6 X 10⁻⁶/F	No greater than 1.5% in 30 days following 7 days of cure per section 7.3 of ASTM C413	No less than 1000 psi	Chemical Spill containment, immersion of at least 72 hours

[1] Disregard results of an adhesion test pull that causes 100 percent substrate failure prior to achieving minimum required psi for the service condition (see Section 4.2).
[2] Values of water vapor transmission rate and water vapor permeance can be used in the relative rating of coatings only if the coatings are tested under the same closely controlled conditions of temperature and relative humidity and if their thicknesses are equal. See ASTM E96 for guidance on coating thickness.
[3] See ASTM E96 for guidance on coating thickness.
[4] The chemical solution concentrations are made by volume.

www.sspc.org

Solution

- The deteriorated concrete in wastewater facilities can be rehabilitated with protective coatings and linings. Selection of effective coating and lining systems require consideration of many factors, including:
  - Original materials of construction
  - Corrosive environment
  - Type and extent of deterioration
  - Suitability of specific lining systems
  - Lining installation requirements
  - Plant operating conditions
  - Regulatory issues

SSPC The Society For Protective Coatings

www.sspc.org