

Standard Practice for Rehabilitation of Concrete and Masonry Structures With a Protective Epoxy Coating System

Introduction

The specification describes the work, materials and equipment to restore the structural integrity in concrete and masonry brick structures by application of a sprayable, monolithic, microsilica cement liner and high-build epoxy coating to stop water infiltration and protect concrete and steel components against deterioration in sewer manholes, Fiberglas structures, lift station chambers, pipes, and water treatment plant workings.

PART 1 - GENERAL

- 1.0 The requirements include surface preparation, concrete repair, and application of a cement liner coat and epoxy coating system to protect against hydrogen sulfide (H₂S) corrosion attack and abrasion in sewers.
- 1.1 This standard does not purport to address all of the safety concerns, if any, and associated with its use. It is the responsibility of the user to establish the correct safety and health practices and determine the applicability of regulatory limitations prior to use. Sewer structures are permit required confined spaces and need appropriate permits in accordance with OSHA definition.
- 1.2 The manufacturer or an approved applicator shall apply the cement and epoxy coating materials in accordance with the manufacturer's recommendation.

1.3 REFERENCES

A. ASTM C 150	Standard Specifications for Portland Type I.
B. ASTM C 109M	Test Method for Compressive Strength of Hydraulic Cement Mortars (2-in Cubes).
C. ASTM C 267	Test Methods for Chemical Resistance of Mortars, Grouts, and Monolithic Surfacing and Polymer Concretes.
D. ASTM C 309	Specification for Liquid Membrane-Forming Compounds for Curing Concrete.
E. ASTM C 321	Test Method for Bond Strength of Chemical-Resistant Mortars.
F. ASTM C 494-86	Standard Specifications for Chemical Admixtures for Concrete.
G. ASTM C 49C/ 49M	Test Method for Splitting Tensile Strength for Cylindrical Concrete Specimens.
H. ASTM C 882	Test Methods for Bond Strength of Epoxy Coatings Used With Concrete by Slant Shear.
I. ASTM D 4541; IV	Standard Test Method for Pull-Off Strength of Coatings Using Portable Adhesion Testers.
J. ASTM D 695	Compressive Strength Properties of Rigid Plastics.
K. ASTM D 2240	Durometer Hardness, Shore D.
L. ASTM D 638; I	Tensile Strength of Rigid Plastics.

- M. ASTM D 790 Flexural Strength of Rigid Plastics.
- N. ASTM G 20 Chemical Resistance of Rigid Plastics.
- O. ASTM D 4060 Abrasion Resistance of Rigid Plastics.
- P. ASTM C 109 Compressive Strength of Hydraulic Cement Mortars.

1.3.1 ACI STANDARDS

- A. ACI 201.2R-93 Guide for Durable Concrete
- B. ACI 302 Guidelines for Concrete Floors and Slab Construction
- C. ACI 308 Practice for Curing Concrete

1.3.2 DEPARTMENT OF TRANSPORTATION STANDARDS¹

- A. AASHTO T 277 Rapid Determination of the Chloride Permeability of Concrete

1.4 SUBMITTALS

- A. Technical product data on each product; include brand name and manufacturer.
- B. Provide laboratory tests results to verify 28-day compressive strength in accordance with ASTM C-39, ASTM C-109, ASTM D 695 or ACI 318, and as specified.
- C. Provide satisfactory test results that confirm conformance to ASTM C 267, Test Methods for Chemical Resistance of Mortars, Grouts and Monolithic Surfaces and Polymer Concretes.
- D. Provide a product certification stating the chloride ion content of the cement liner material.
- E. Provide a list of similar sewer manhole rehabilitation projects with a 10-year history. Include the owner's name, contact information, project name, description and date.
- F. Provide the Engineers Design Calculations indicating the cement and epoxy coating repair material conforms, meets or exceeds AASHTO T – 277 HS-20 Traffic Loading Requirements; Federal Highway Administration Transportation Department Standard.
- G. Provide an independent third party 15-Year Long Term Performance Study of the Microsilica Cement Liner in Aggressive Sewer Manhole Wastewater Environments; CIGMAT, Department of Civil Engineering, University of Houston, 2006.
- H. Provide the Engineers EPA Environmental Technology Verification Statement [NSF International] and the Water Quality Protection Center indicating the epoxy coating repair material is verified in accordance with EPA standards for use in wastewater sewer systems to control the deterioration of concrete and clay infrastructure facilities; CIGMAT, University of Houston, 2008.
- I. Provide a Patent number for the cement liner material.

1.5 QUALITY CONTROL

- A. Inspection Services: The Owner shall appoint a NACE Certified Coating Inspector or inspector to represent the City and observe the daily procedures, tests and services specified in individual Specification sections, and the final epoxy coating product application.
 - 1. The Owner may also appoint, employ, and pay an independent firm to provide additional inspection or construction management services.
 - 2. The independent firm will submit reports to Project Manager indicating observations and results of tests and indicating compliance or noncompliance with Contract requirements.

3. Contractor shall assist and cooperate with the inspector, furnish samples of materials, design mix, equipment, tools, and storage.
- B. The epoxy coating manufacturer shall provide a technical representative for on-site observation of the daily procedures, recommendations for handling of the epoxy coating, application and curing of the products.
- C. Provide a procedure that meets applicable ASTM, NACE and SSPC inspection standards and quality assurance control that meets the manufacturer's procedures. The engineer shall approve the procedure before start up.

1.6 CONTRACTOR REQUIREMENTS

- A. Provide a manufacturer's certification verifying the applicator has been trained [approved] for handling, mixing and is qualified to apply the cement liner material and epoxy coating product; and application of the product(s) to be used.
- B. Provide ten (10) recent references indicating successful application of the composite cement and epoxy coating system within a municipal wastewater environment in accordance with 1.05 Submittals.
- C. The approved applicator shall furnish all of the labor, equipment and materials to rehabilitate the manhole. The application equipment shall be capable of spraying the cement as required by the manufacturers printed recommendation.
- D. The applicator shall use a Sewer Manhole Masters® Repair Trailer [or approved equal] to apply the cement and a Graco Hydracat pump to apply the epoxy coating materials.

1.7 DELIVERY, STORAGE AND HANDLING

Store the materials in a dry area and protected from weather. Keep open flame, heat and strong oxidants away. Handle according to the material safety data sheet information.

1.8 WARRANTY

The applicator shall warrant all work to be free of defects, be of good quality and perform as specified for a one (1) year period, unless otherwise stated, after completion and acceptance of the work. The applicator shall repair defects in materials or workmanship during the one-year period; and any damage to other work caused by such defects or discovered within the same period at no additional cost to the owner.

PART 2 - PRODUCTS

2.1 CONCRETE SUBSTRATE

Remove all existing coatings before applying the new epoxy coating system. The applicator shall maintain a strict surface preparation procedure that is suitable and provides the greatest compatibility for the epoxy top coating. The applicator shall follow all applicable ASTM, NACE and SSPC surface preparation guidelines.

2.2 MANUFACTURER

- A. Standard Cement Materials Inc; Houston Texas, 888. 278.1337 at www.sales@standardcement.com.

- B. The manufacturer shall provide a representative for on-site consultation and make recommendations for surface preparation, handling of the materials, application and curing of the epoxy coating material.

2.3 REPAIR MATERIALS

- A. Use a factory blended, fiber reinforced cement repair material to provide structural restoration [fill voids], stop water infiltration, and protect the concrete against hydrogen sulfide deterioration, and eliminate water vapor transmission pressure through the substrate. A single source manufacturer shall provide the cement and epoxy coating material system.
- B. Approved products:
 - 1. Reliner MSP® Cement — a high strength, polymer-modified factory blend of finely divided cementitious, microsilica-based ingredients, and polypropylene fibers.
 - 2. LG 68 Heavy Duty Concrete Cleaner or abrasive sand blasting to clean and etch the concrete or new cement liner in each case.
 - 3. Fast Set Bench Mix — cement patcher, fill or repair voids and irregularities with the shrink compensating grout. Mix the cement patcher by hand and make repairs in concrete, masonry sewer manholes and other structures.
 - 4. Custom Plug Hydraulic Cement — a rapid setting cement to stop all active water leaks.
 - 5. 4553™ Epoxy Coating — a 100% solids, solvent-free, two-component, epoxy coating with increased bond strength and board range chemical resistance to protect concrete and masonry structures in moist and damp environments.

2.4 CONDITIONS

- A. The Engineer shall determine the repair method according to the following conditions and the manufacturer will provide instructions and a procedure for applying the cement and epoxy coating system.

Condition 1: A new, structurally sound, smooth poured in place concrete structure or precast sewer manhole with no indications of settlement, cracking or other signs of structural fatigue. All joints are tight with no sign of infiltration or exfiltration. The structure should be able to pass a standard pressurized vacuum test.

Repair Method: Clean the sewer manhole to a sound condition. Use a citrus based concrete cleaner and high-pressure water blaster with a zero degree rotating nozzle at 3500 – 5000 psi, wet sand injection cleaning process, or dry sand blast cleaning process. Fill the voids, bug holes, recessed joints, honeycombs and pipe penetrations with a rapid set cement repair material. Allow the repair material to set for 30-minutes to 24-hours. Saturate the repair surface with the citrus based concrete wash and allow it to set for approximately 5 minutes. Wash the entire structure with clean water to remove the laitance. Blow the substrate damp dry and apply the epoxy coating material at an 80 to 100 mil thickness.

Condition 2: An existing damaged, poured in place, rough structure, precast, or masonry brick sewer manhole with no indications of settlement, cracking or other signs of structural fatigue.

The structure has infiltration or exfiltration through concrete joints, cement mortar joints or around pipe connections and has mild corrosion or deterioration (less than ½ inch in depth). The structure will not pass a standard vacuum test.

Repair Method: Clean the sewer manhole to a sound condition. Use a citrus based concrete cleaner and high-pressure water blaster with a zero degree rotating nozzle at 3500 – 5000 psi, wet sand injection cleaning process, or dry sand blast cleaning process. Fill the voids, bug holes, recessed joints, honeycombs and pipe penetrations with a rapid set cement repair material. Allow the repair material to set for 30-minutes to 24-hours. Saturate the repair surface with the citrus based concrete wash and allow it to set for approximately 5 minutes. Wash the entire structure with clean water to remove the laitance. Blow the substrate damp, dry and apply the epoxy coating material at 100 to 125 mil thickness.

Condition 3: An existing damaged, poured in place structure, precast, or masonry brick sewer manhole that has early signs of structural fatigue and apparent minor cracks, loss of mortar or bricks with moderate to severe corrosion (less than 1 inch in depth), the manholes cross sectional distortion is minor; that is less than 10%, however, the existing structure is currently supporting the soil and a live load.

Repair Method: Clean the sewer manhole to a sound condition. Use a citrus based concrete cleaner and high-pressure water blaster with a zero degree rotating nozzle at 3500 – 5000 psi, wet sand injection cleaning process, or dry sand blast cleaning process. Fill the voids, bug holes, recessed joints, honeycombs and pipe penetrations with a rapid set cement repair material. Allow the repair material to set for 30-minutes to 24-hours. Saturate the repair surface with the citrus based concrete wash and allow it to set for approximately 5 minutes. Wash the entire structure with clean water to remove the laitance. Blow the substrate damp, dry and apply the epoxy coating material at 125 to 150 mil thickness.

Condition 4: An existing damaged, poured in place structure, precast, or masonry brick sewer manhole that is failing and exhibits structural fatigue, has signs of severe deterioration and collapse is possible (mortar loss of 1 inch or greater), the manholes cross sectional distortion is beyond 10%, it shows signs of exposed reinforcement, and evidence of loose or missing brick.

Repair Method: Clean the sewer manhole to a sound condition. Use a citrus based concrete cleaner and high-pressure water blaster with a zero degree rotating nozzle at 3500 – 5000 psi, wet sand injection cleaning process, or dry sand blast cleaning process. Fill the voids, bug holes, recessed joints, honeycombs and pipe penetrations with a rapid set cement repair material. Allow the repair material to set for 30-minutes to 24-hours. Saturate the repair surface with the citrus based concrete wash and allow it to set for approximately 5 minutes. Wash the entire structure with clean water to remove the laitance. Blow the substrate damp, dry and apply the epoxy coating material at a minimum 150 to 250 mil thickness.

2.5 APPLICATION EQUIPMENT

- A. Specifically designed, use a SEWER MANHOLE MASTERS™ CEMENT [and EPOXY] TRAILER and pump for this application, approved for use by the manufacturer, use a heated plural component spray pump [equipment].

PART 3 - EXECUTION

3.1 APPLICATORS

- A. The cement mortar applicator shall be trained in the handling, mixing and proper application of the Reliner MSP® Cement product.
- B. The epoxy coating applicator shall be trained in the handling, mixing and proper application of the 4553™ epoxy coating product.
- C. All active flows shall be dammed, plugged or diverted to lower the flow of water and maintained below the intended surface to be coated.
- D. The intended surface temperature (surface to be coated) should be kept between 40° F and 120° F during the application process. Protect, prevent and avoid exposure to direct sunlight or other heat source to the structure being coated. When varying surface temperatures do exist, then care should be taken to apply the epoxy coating when the surface temperature is falling versus rising.

3.2 SURFACE PREPARATION

- A. The applicator shall examine the lift stations wet well substrate surface prior to applying the epoxy coating and inform the owner of any disparity in the surface which may interfere with its preparation or the application of the repair materials. Remove all unsound concrete that has been damaged by corrosion exposure. Clean the existing lift station wet well chamber to a suitable and sound surface. Use abrasive sand blasting, wet abrasive sand blasting, or high-pressure washing at 3500-5000 psi, minimum.
- B. Remove dirt, oil, loose concrete, any previously applied coatings or other deleterious materials. Continue the cleaning procedures until a uniform and sound profile is obtained. The surface shall be cleaned and properly abraded to create a good firm surface with a suitable profile to produce the strongest adhesion between the protective epoxy coating and the concrete surface.
- C. Remove the corroded cement mortar (that has a light white tint color) which has experienced excessive deterioration and erosion greater than 1 inch. Replace or prepare the exposed steel reinforcement, repair cracks, stops active water leaks and provide joint treatment to prevent water infiltration and exfiltration through the structure.
- D. Repair the damaged areas with the Reliner MSP™ Cement. Fill bug holes, joints sections, honeycombs and around pipe penetrations. Allow the repair material to dry for a minimum of 24 hours, or as specified. Wash the entire structure with LGL 68P Heavy Duty Concrete Cleaner to achieve a raised aggregate profile and wash the surface again.

3.3 APPLICATION OF THE CEMENT REPAIR MATERIALS

- A. Use Standard Plug™ Hydraulic Cement (Custom) to stop active water leaks. Use fast setting cement specifically designed for that purpose. Get help from the sales representative for selecting the right cement product to stop the leak.
- B. Use the Fast Set Bench Mix™, FSR™, Cement patcher a non-metallic shrink compensating grout to fill voids and make repairs in concrete bottoms, walls and masonry structures.

1. Mix a small amount of FSR™ patcher with cold water to the consistency of pancake batter. Brush the neat mixture over the area as a “primer”. Carefully work the primer into the surface pores and voids. Then mix additional FSR™ patcher to the consistency of soft putty to fill the void. Mix thoroughly for one minute, work quickly, the FSR™ begins to stiffen in about eight minutes, sets in fifteen minutes and reaches final set in thirty minutes.
 2. Apply by gloved hand or with a trowel, level and smooth the patcher. Keep the patch damp. By spraying lightly with water or by covering with a damp cloth for at least one hour. Protect the mortar from wind changes, freezing and temperature extremes.
- C. Mix the Reliner MSP™ Cement liner material with cold water in accordance with the manufacturers printed data. Finish with a stainless steel trowel to a smooth or brush finish surface. Apply the cement liner from the top down, along the walls to the floor. Spray apply in such a manner so as to produce a smooth, level surface. Produce a cove finish at the wall to wall interface and the ceiling to floor interface. Contact the manufacturer for recommendations when more than 24 hours have passed between starting and finishing the application.
1. No application shall be made when ambient temperatures are less than 40° F and when freezing temperature is expected within 24 hours. If the ambient temperature is in excess of 90° F, precautions shall be taken to keep mixing water below 85 degrees F. Use ice if necessary.

3.4 APPLICATION OF THE PROTECTIVE EPOXY COATING

- A. The protective epoxy coating shall be applied by a trained certified applicator. The applicator shall furnish all of the labor, equipment, materials and application as required by the manufacturer. The application procedure shall conform to the recommendations of the epoxy coating manufacturer.
- B. Coat the new concrete surface or apply over the repair material as soon as possible. Use the solvent-free, 100% solids, self- priming epoxy protective coating as described herein. Apply the epoxy coating material to a nominal wet film thickness, DFT, between 20 to 250 mils as specified.
- C. Use an airless, plural component spray pump designed specifically for this purpose. The pump unit will utilize a 2:1 material mix ratio manifold with maximum fluid operating pressure of 4500 psi and 100 psi inbound air. The pump unit will incorporate two 25-gallon stainless steel material hoppers with air driven agitators, water jackets and heated with 300 watt 220 volt thermostat controlled immersion heaters, and fluid outlet manifold with 5000 psi gauges and proportion the material mixing automatically. The pump unit will be powered by a 30-amp breaker control complete with a Chromalux temperature controlled hose with a digital temperature readout and mixer manifold with dual material valves. The pump unit will be completely assembled and tested before use. Contact your Standard Cement Materials representative for details about the spray equipment.
1. Keep all pipe penetrations plugged for a minimum of 4 to 8 hours after the coating installation. Avoid damage to the uncured epoxy coating. Allow the epoxy coating to cure 8 to 24 hours before being subjected to active flow.

3.5 INSPECTION

A. Coating Thickness Inspection

1. Use a wet film thickness gage to measure the epoxy coating thickness during application, such as P. N. Gardner Company, meeting ASTM D 4414; Standard Practice for measurement of wet Film Thickness of Organic Coatings by Notched Gages.

B. Operator

2. The hand-held high-voltage holiday detector equipment should be operated by a responsible, trained and authorized person. Do not make contact with the tester electrode, wearing of rubber gloves is recommended.

a. The operator should enjoy good health and not suffer from cardiac condition. If the operator has a pacemaker, then they should not use this equipment.

C. Inspection and Equipment

1. The applied coating should be cured, thickness tested, and visually inspected – before high voltage porosity testing is administered. The operator shall inspect the epoxy coating after it has cured hard to the touch using a PCWI Compact, High-voltage DC30 Porosity Holiday Detector by Precision Instrumentation. The Porosity Holiday Detector shall comply with PCWI's Laboratory and the general requirements of ISO/IEC 17025, AS3894.1-2002, ASTM G62-07, ASTM D5162-08, ASTM D4748-08, NACE RP0274-04, NACE SP0490-07, NACE SP0188-06, ANSI/AWWA C214-07, ANS/AWWA C213-07 and ISO 2746;98 for testing and calibration compliance. Connect the probe and earth leads, and attach the earth clamp to the metallic substrate item to be tested – the substrate should be earthed to ground. Check the probe near the metal substrate. Make a definite flaw in the coated surface and locate the flaw with the designated test voltage, proving the unit is locating the type of fault to be found, one may proceed. Set the holiday detector at 100 volts per 1 mil (25 microns) of film thickness applied, adjustments may be necessary to detect the induced holiday. Operate the detector by placing the probe on the coated surface and moving in a horizontal sweeping motion [direction] at approximately (1) one meter per four seconds. Keep the probe in full contact with the surface, gaps in or between the probe and the coating may result in flaws going undetected. The wire brushes, rubber and coil spring probes should be kept in good condition. All holidays shall be marked for repair, abrade using a hand tool, sand paper or grit disk. After the area has been abraded, apply additional epoxy coating material to the repair area. All hand applied, touch-up repairs shall be in accordance with the manufacturers recommendations.
2. Wet and contaminated coatings should not be tested until dry and clean.
3. Safety Precautions: earth ground the item to be tested when the item is not grounded, a ground rod must be attached.

END OF SECTION