



Standard Practice for Installing a Protective Cementitious Liner System in Sanitary Sewer Manholes¹

This standard is issued under the fixed designation F2551; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon (ϵ) indicates an editorial change since the last revision or reapproval.

INTRODUCTION

A sanitary sewer manhole may be repaired or rehabilitated by applying a prepackaged cementitious liner to the interior surface after it has been properly prepared and cleaned. Sanitary sewer manholes can be damaged by dynamic loading, abrasion, erosion, and corrosion.

1. Scope

1.1 This specification describes all the work required to structurally reinforce, seal, and protect sanitary sewer manholes. Applications include applying a prepackaged cementitious liner that can function as a full depth restoration or a partial depth repair. A uniform high-strength, fiber-reinforced cementitious mortar should be manually sprayed and hand troweled or centrifugally cast in a uniform, prescribed thickness to all cleaned, interior surfaces from the bottom of the frame to the bench. The cementitious liner may be applied to manholes constructed of brick, concrete, block, and various other materials.

1.2 A manufacturer's approved applicator shall furnish the complete application of the protective, prepackaged cementitious liner material. All of the cleaning, preparation, and application procedures shall be in accordance with the manufacturer's recommendations.

1.3 The values stated in inch-pound units are to be regarded as standard. The values given in parentheses are mathematical conversions to SI units that are provided for information only and are not considered standard.

1.4 *This standard does not purport to address all of the safety concerns, if any, associated with its use. It is the responsibility of the user of this standard to establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use. Manholes are permit required confined spaces in accordance with OSHA definition and should be treated as such, requiring confined*

space entry permits, appropriate monitoring equipment, and the associated personal protective equipment.

2. Referenced Documents

2.1 ASTM Standards:²

- C39/C39M Test Method for Compressive Strength of Cylindrical Concrete Specimens
 - C109/C109M Test Method for Compressive Strength of Hydraulic Cement Mortars (Using 2-in. or [50-mm] Cube Specimens)
 - C309 Specification for Liquid Membrane-Forming Compounds for Curing Concrete
 - C494/C494M Specification for Chemical Admixtures for Concrete
 - C969 Practice for Infiltration and Exfiltration Acceptance Testing of Installed Precast Concrete Pipe Sewer Lines
 - C1140/C1140M Practice for Preparing and Testing Specimens from Shotcrete Test Panels
 - C1244 Test Method for Concrete Sewer Manholes by the Negative Air Pressure (Vacuum) Test Prior to Backfill
 - C1315 Specification for Liquid Membrane-Forming Compounds Having Special Properties for Curing and Sealing Concrete
 - F2414 Practice for Sealing Sewer Manholes Using Chemical Grouting
- #### 2.2 ACI Standards:³
- ACI 301-05 Specifications for Structural Concrete
 - ACI 305R-99 Hot Weather Concreting
 - ACI 306R-88 Cold Weather Concreting
 - ACI 308R Practice for Curing Concrete

¹ This practice is under the jurisdiction of ASTM Committee F36 on Technology and Underground Utilities and is the direct responsibility of Subcommittee F36.20 on Inspection and Renewal of Water and Wastewater Infrastructure.

Current edition approved April 1, 2016. Published May 2016. Originally approved in 2009. Last previous edition approved in 2009 as F2551-09. DOI: 10.1520/F2551-09R16.

² For referenced ASTM standards, visit the ASTM website, www.astm.org, or contact ASTM Customer Service at service@astm.org. For *Annual Book of ASTM Standards* volume information, refer to the standard's Document Summary page on the ASTM website.

³ Available from American Concrete Institute (ACI), 38800 Country Club Dr., Farmington Hills, MI 48331-3439, <http://www.concrete.org>.

ACI 506R Guide to Shotcrete

2.3 *ICRI Technical Guidelines*.⁴

Guideline No. 03732 Selecting and Specifying Concrete Surface Preparation for Sealers, Coatings, and Polymer Overlays

Guideline No. 03737 Guide for the Preparation of Concrete Surfaces for Repair Using Hydro-demolition Methods

3. Ordering Information

3.1 *Submittals*—Orders for all prepackaged materials listed under this practice shall include the following:

- 3.1.1 Product data, including manufacturer and brand name;
- 3.1.2 Technical data stipulating physical characteristics of applied liner material; and
- 3.1.3 Manufacturer's Safety Data Sheets.

3.2 *Delivery, Storage, and Handling*:

3.2.1 The prepackaged cementitious materials should be stored according to the manufacturer's recommendations. No modification should be made to the manufacturer's recommendations for handling and delivery of these products.

4. Materials and Manufacture

4.1 All prepackaged materials shall be designed, manufactured, and intended for sewer manhole rehabilitation and the specific application in which they are used. Each material shall be designed for application over damp surfaces without degradation of the final product or the bond between the product and the manhole surface.

4.2 *Materials for Substrate Repairs*—All voids and irregularities of the substrate should be filled or repaired with structurally sound materials before applying the cementitious liner material.

4.2.1 *Cementitious Repair Materials*—Hand mix and apply for filling voids and reforming benches and resurfacing the brick, concrete walls, and bench surfaces of the sewer manhole. Mix the cement repair material and apply according to the manufacturer's instructions. The cementitious liner material can be used as the repair material.

4.3 *Infiltration Water Control Materials*—Specifically formulated for stopping water leaks and minor infiltration.

4.3.1 *Cementitious Water Control Materials*—Used to stop flowing water leaks in concrete and masonry structures. This material may be applied in dry form directly to the leak area or mixed with potable water to a soft putty consistency for larger active leaks. This material is held in place until it sets and the leak stops. Mix and use according to the manufacturer's instructions.

4.3.2 No modification should be made to the products recommendations for handling, mixing, placing, and finishing without the manufacturers prior written approval.

4.4 *Chemical Grout Material*—To stop water leaks and infiltration with chemical grout, refer to Practice **F2414**.

4.5 *Lining Material*—Prepackaged cementitious lining materials are specifically designed to repair or rehabilitate sewer manhole.

4.6 *Other Materials*—No other material shall be used with or added to the prepackaged cementitious liner materials without prior written approval from the manufacturer.

5. Surface Preparation, Cleaning, and Repair

5.1 The applicator is responsible to ensure that the manhole is properly cleaned and prepared.

5.2 Place wooden or plastic covers or other protective devices over the sewer manhole invert while cleaning the manhole wall and bench sections before applying the prepackaged cementitious liner. Wire mesh and fabric filters allowing water to pass are also acceptable.

5.3 Remove all foreign materials from the manhole wall and bench sections. Remove all loose and protruding bricks, mortar, and concrete. Remove metal, plastic, or brick stairs, if required, before applying the new liner. Fill any large voids with fast setting cementitious repair material.

5.4 *Surface Cleaning Procedures*:

5.4.1 *High Pressure Cleaning*—Properly cleaning the surface of the structure is critical to the success of this rehabilitation method. Use a high-pressure washer delivering a minimum of 3500 psi (2413 MPa). A minimum of two and a half gallons per minute (9.46 litres per minute) should be delivered through the spray tip. The spray tip should be kept between 6 and 12 in. (15.24 and 30.48 cm) from the surface and be held at an angle between 45° and 90° to the surface being cleaned. The spray tip should be directed across the surface at a speed of no more than one foot per second (0.3 metres per second). If the surface is especially dirty or greasy, cleaning agents may be added to the pressure washer water or the water may be heated. When hot water is required, it should be heated to 210°F (99°C). Care should be taken to clean the frame sealing surface where the lid fits into the frame, removing any debris or other materials that negatively impact the lids ability to seal against the frame. Cleaning should begin with the frame surface and progress down to and include the bench. A rotating spray nozzle may be used for cleaning, if it meets pressure and flow requirements. Care should be taken to avoid further structural damage to the existing surface.

5.4.2 In some situations, when removing existing coatings or linings, pneumatic hammers, hydro-demolition, or sand blasting may be required. Refer to Guideline No. 03732 or Guideline No. 03737.

5.4.3 Some substrates may require more surface preparation including acid washing. If acid washing is performed, the acid cleaned surface should be neutralized.

5.4.4 Remove any loose material after all preparations and cleaning has been completed. Do not allow soil, sand, debris, or runoff to enter the sewer system. Properly dispose of any deleterious materials removed from the manhole according to local, state, and federal guidelines.

5.5 *Surface Repair*:

5.5.1 *Repair the Invert and Bench Sections*—Repair any invert and bench section that exhibits visible damage,

⁴ Available from the International Concrete Repair Institute, Inc. (ICRI), 1000 Westgate Drive, Suite 252, St. Paul, Minnesota 55114, <http://www.icri.org>.

degradation, or water infiltration. Remove obstructions and loose materials from benches prior to shaping inverts. Form smooth, u-shaped channels across the floor of the manhole. Use a high-strength, fast-setting cementitious repair material. Control or divert the flow to allow sufficient setting time for the material used. Make finished benches and inverts smooth without defects. Allow no accumulation of debris.

6. Mixing of Prepackaged Cementitious Repair Materials

6.1 The applicator shall bear complete responsibility for mixing of the materials, applying, and finishing of the sewer manhole repair system.

6.1.1 The prepackaged cementitious liner material should be mixed with water in accordance with the manufacturer's recommendations. Tempering of the material above the manufacturer's published limits should not be allowed.

6.1.2 Use clean and potable water for mixing.

6.1.3 No modifications or changes should be made to the product without prior written approval of the manufacturer.

6.1.4 During hot weather, the cementitious liner material should be mixed at temperatures below 90°F (32.2°C) in order to avoid rapid loss of workability, to decrease water evaporation, and to prevent premature set time. Retarding admixtures Type A, B, or D that meet Specification **C494/C494M** may be used to allow work in hotter weather. However, applicators should obtain manufacturer's permission or use products recommended by manufacturer. Apply admixtures in accordance with ACI 305R-99 recommendations for hot weather conditions.

6.1.5 If work is to be performed near 40°F (4.4°C), preheat the water and keep prepackaged material warm. The mix should be kept near 70°F (21.1°C). Apply in accordance with ACI 306R-88 recommendations for cold weather concreting. Some liner materials are capable of setting in cold weather; consult with manufacturer for suitability.

7. Execution—Application of the Cement Liner

7.1 *Spray Application—Manual Surface Sealing:*

7.1.1 Dampen the manhole wall surface. Surface must be damp without noticeable free water droplets or running water (surface, saturated, dry). Spray or apply the cementitious liner material to a uniform thickness as specified. Use a hand trowel to hand work and compact the manhole cementitious liner material into all the voids and crevices but do not over trowel. Allow the cementitious liner material to set as recommended by the manufacturer.

7.1.2 Spray the cementitious liner material to a nominal thickness of ½ in. (1.25 cm) in one or more passes. The thickness of the cementitious lining material applied to the surface depends on a wide array of variables. These variables include overall condition of the manhole, depth, construction materials, location, dynamic traffic load, source and state of corrosion, diameter, hydrostatic pressure, soil type, and any other factors that might impact the design of the cementitious liner. The design engineer should determine appropriate liner thickness and liner material properties and may be prepared to include the addition of protective coatings or other methods used to limit or eliminate corrosion factors. Use a wet gauge to measure applied cementitious liner material thickness at three

sections of the manhole: the cone/corbel section, middle of barrel, and the barrel near the invert. The liner shall be even and uniform with a troweled, brushed, or natural finish.

7.1.3 Not all manufacturers recommend the use of a protective coating over the cementitious liner material. If the liner is to receive a top coating, then an anchor tooth finish is recommended and shall be free of curing or similar compounds. For dry gunite applications, finish in accordance with ACI 506R, using the recommended trowel.

7.1.4 Apply the prepackaged cementitious liner material from the top of the manhole down to the bench. Overlay the bench with a gradual slope from the wall to the edge of the channel. The wall and bench intersection should have a rounded and uniform radius. The thickness of the bench shall be no less than ½ in. (1.25 cm) at the edge of the channel and shall increase in the direction of the wall so as to provide the required slope.

7.2 *Spray Application—Centrifugal Process:*

7.2.1 Position the high-speed, bi-directional, rotating applicator within the center of the manhole at the lowest point desired for the new wall and commence pumping the mixed prepackaged cementitious liner material. Man-entry may be required to assure the lining has been effectively applied, as on the underside of any brickwork or around laterals. As the cementitious liner material begins to be centrifugally cast evenly around the interior, retrieve the applicator head at the prescribed speed for applying the thickness that has been selected. Controlled multiple passes in both clockwise and counterclockwise directions are made until the desired thickness is attained.

7.2.2 If the procedure is interrupted for any reason, simply arrest the retrieval of the applicator head until flows are recommenced. Verify the desired thickness with a wet gage. The liners shall be even and uniform with a brushed or natural finish. If the liner is to receive a top coating refer to 7.1.3. Benches and channels are finished by hand as in 7.1.4.

8. Curing of Freshly Applied Cementitious Liner Material

8.1 Protect the freshly applied cementitious liner from extreme weather conditions. According to ACI 301-05, ACI 305R-99, ACI 306R-88, and ACI 308R, curing compounds should be used to minimize the loss of moisture to ensure the continuation of the cement hydration process. Curing compounds are used to obtain adequate and specified strength gain of the applied material. Liquid membrane curing compounds that are specified in Specifications **C309** or **C1315** should be used for these purposes.

8.2 During hot, dry weather conditions, protect the finished cementitious liner material at early ages to prevent rapid water loss. Use an accepted liquid membrane curing compound in accordance with Specifications **C309** or **C1315** on the finished cementitious liners to limit water loss. Apply curing compounds according to manufacturer's specification. Protect liner materials in accordance with ACI 305R-99.

8.3 During cold weather application provide protection of the cementitious liner at early ages to prevent damage from

freezing. Do not apply prepackaged liner, when ambient temperature falls below 40°F (4.4°C) or freezing temperatures are expected within 24 h, or both. Protect liner materials in accordance with ACI 306R-88. Some liner materials are capable of setting in cold weather; consult with manufacturer for suitability.

8.4 The sewer manhole rehabilitation system is acceptable for day, nighttime, or continuous 24-h work schedules in the proper environment.

9. Sampling

9.1 Use cylinders as in accordance with Test Method **C39/C39M**, cubes as in accordance with Test Method **C109/C109M**, or shotcrete panels as in accordance with Practice **C1140/C1140M**, or as specified by the manufacturer or engineer document for testing compressive strength. Make cylinders, cubes, or panels from each day's work and label each with the date, location, project, and product batch numbers. The product batch numbers are located on each cement material bag or on the pallet. Send the cylinder, cube, or panel to a third-party laboratory or the manufacturer for verification. Test the cementitious liner material for compliance with specified strengths at 28 days or in accordance with the engineer's instructions. Retain one sample for further instructions should the others fail to meet the 28-day requirement. Field samples should not be moved for a minimum of the first 24 h and should be maintained according to ASTM specifications.

9.2 The engineer should approve the inspection and quality control protocol before project startup.

10. Manhole Verification and Testing

10.1 At the owner's option, one or more of the following procedures may be employed to verify the quality of the applied liner.

10.1.1 Vacuum testing in accordance with Test Method **C1244**.

10.1.2 The water ex-filtration method in accordance with Practice **C969**.

10.1.3 A visual inspection which may be recorded in still or video digital format.

10.1.4 Other methods as specified by the project engineer.

11. Quality Assurance

11.1 The engineer should verify that the repaired manhole meets specifications.

11.2 If the repaired manhole does not comply with the prescribed standards, the applicator should make corrections and repeat the test procedures until design specifications are met.

12. Keywords

12.1 cement liner; cementitious liner; corrosion protection; manhole rehabilitation; manhole renewal; sanitary sewer manhole; sewer manhole; stopping water infiltration; structural enhancement; structural rehabilitation

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