

TECHNICAL REQUIREMENTS AND SPECIFICATIONS

REHABILITATION OF CONCRETE AND MASONRY MANHOLES OR UNDERGROUND VAULTS WITH A PROTECTIVE COATING (As Provided by Raven Lining Systems)

FOREWORD

This specification covers work, materials and equipment required for protecting and/or rehabilitating concrete and masonry manholes and other underground vaults by monolithic spray-application of a high-build, solvent-free epoxy coating to eliminate infiltration, provide corrosion protection, repair voids and enhance structural integrity. Procedures for surface preparation, cleaning, application and testing are described herein.

PART 1 - GENERAL

1.01 SECTION INCLUDES

- A. Requirements for surface preparation, repairs and solvent-free epoxy coating application to specified surfaces.

1.02 RELATED SECTIONS

- A. Concrete Repair.
- B. Environmental, Health and Safety.

1.03 REFERENCES

- A. ASTM D638 - Tensile Properties of Plastics.
- B. ASTM D790 - Flexural Properties of Unreinforced and Reinforced Plastics.
- C. ASTM D695 - Compressive Properties of Rigid Plastics.
- D. ASTM D4541 - Pull-off Strength of Coatings Using a Portable Adhesion Tester.
- E. ASTM D2584 - Volatile Matter Content.
- F. ASTM D2240 - Durometer Hardness, Type D.
- G. ASTM D543 - Resistance of Plastics to Chemical Reagents.
- H. ASTM C109 - Compressive Strength Hydraulic Cement Mortars.

- I. ACI 506.2-77 - Specifications for Materials, Proportioning, and Application of Shotcrete.
- J. ASTM C579 - Compressive Strength of Chemically Setting Silicate and Silica Chemical Resistant Mortars.
- K. ASTM - The published standards of the American Society for Testing and Materials, West Conshohocken, PA.
- L. NACE - The published standards of National Association of Corrosion Engineers (NACE International), Houston, TX.
- M. SSPC - The published standards of the Society of Protective Coatings, Pittsburgh, PA.

1.04 SUBMITTALS

- A. The following items shall be submitted:
 - 1 Technical data sheet on each product used, including ASTM test results indicating the product conforms to and is suitable for its intended use per these specifications.
 - 2 Material Safety Data Sheets (MSDS) for each product used.
 - 3 Project specific guidelines and recommendations.
 - 4 Applicator Qualifications:
 - a. Manufacturer certification that Applicator has been trained and approved in the handling, mixing and application of the products to be used.
 - b. Certification that the equipment to be used for applying the products has been manufactured or approved by the protective coating manufacturer and Applicator personnel have been trained and certified for proper use of the equipment.
 - c. Five (5) recent references of Applicator (projects similar size and scope) indicating successful application of a high-build solvent-free epoxy coating by plural component spray application.
 - d. Proof of any necessary federal, state or local permits or licenses necessary for the project.
 - 5 Design details for any additional ancillary systems and equipment to be used in site and surface preparation, application and testing.

1.05 QUALITY ASSURANCE

- A. Applicator shall initiate and enforce quality control procedures consistent with applicable ASTM, NACE and SSPC standards and the protective coating manufacturer's recommendations.
- B. (OPTIONAL) A NACE Certified Coating Inspector shall be provided by Owner. The Inspector will observe surface preparation, application and material handling procedures to ensure adherence to the specifications.

1.06 DELIVERY, STORAGE, AND HANDLING

- A. Materials are to be kept dry, protected from weather and stored under cover.
- B. Protective coating materials are to be stored between 50 deg F and 90 deg F. Do not store near flame, heat or strong oxidants.
- C. Protective coating materials are to be handled according to their material safety data sheets.

1.07 SITE CONDITIONS

- A. Applicator shall conform with all local, state and federal regulations including those set forth by OSHA, RCRA and the EPA and any other applicable authorities.
- B. Method statements and design procedures are to be provided by Owner when confined space entry, flow diversion or bypass is necessary in order for Applicator to perform the specified work.

1.08 WARRANTY

- A. Applicator shall warrant all work against defects in materials and workmanship for a period of one (1) year, unless otherwise noted, from the date of final acceptance of the project. Applicator shall, within a reasonable time after receipt of written notice thereof, repair defects in materials or workmanship which may develop during said one (1) year period, and any damage to other work caused by such defects or the repairing of same, at his own expense and without cost to the Owner.

PART 2 – PRODUCTS

2.01 EXISTING PRODUCTS

- A. Standard Portland cement or new concrete (not quick setting high strength cement) must be well cured prior to application of the protective coating. Generally, 28 days is adequate cure time for standard Portland. If earlier application is desired, compressive or tensile strength of the concrete can be tested to determine if acceptable cure has occurred. (Note: Bond strength of the coating to the concrete surface is generally limited to the tensile strength of the concrete itself. Engineer may require Elcometer pull tests to determine suitability of concrete for coating)

- B. Cementitious patching and repair materials should not be used unless their manufacturer provides information as to its suitability and procedures for topcoating with an epoxy coating. Project specific submittals should be provided including application, cure time and surface preparation procedures which permit optimum bond strength with the epoxy coating.
- C. Remove existing coatings prior to application of the new protective coating. Applicator is to maintain strict adherence to applicable NACE and SSPC recommendations with regard to proper surface preparation and compatibility with existing coatings.

2.02 MANUFACTURER

- A. Raven Lining Systems, Inc., Tulsa, Oklahoma 800-324-2810 or 918-584-2810 or FAX 918-582-4311.

2.03 REPAIR MATERIALS

- A. Repair materials shall be used to fill voids, structurally reinforce and/or rebuild surfaces, etc. as determined necessary by the engineer and protective coating applicator. Repair materials must be compatible with the specified epoxy coating and shall be applied in accordance with the manufacturer's recommendations.
- B. The following products may be accepted and approved as compatible repair basecoat materials for epoxy topcoating for use within the specifications:
 - 1 100% solids, solvent-free epoxy grout specifically formulated for epoxy topcoating compatibility. The epoxy grout manufacturer shall provide instructions for trowel or spray application and for epoxy topcoating procedures.
 - 2 Factory blended, rapid setting, high early strength, fiber reinforced, non-shrink repair mortar that can be trowelled or pneumatically spray applied may be approved if specifically formulated to be suitable for epoxy topcoating. Such repair mortars should not be used unless their manufacturer provides information as to its suitability for topcoating with an epoxy coating. Project specific submittals should be provided including application, cure time and surface preparation procedures which permit optimum bond strength with the epoxy coating.

2.04 PROTECTIVE COATING MATERIAL

- A. Raven Lining Systems' *{insert product name}* epoxy coating system - a 100% solids, solvent-free two-component epoxy resin system thixotropic in nature and filled with select fillers to minimize permeability and provide sag resistance acceptable to these specifications (up to *{depends on product}* mils in a single coat).

Product type	Amine cured epoxy
Color	<i>{see product data sheet}</i>
Solids Content (vol %)	100
Mix Ratio	1:1 <i>{Aquatapoxy}</i> 3:1 <i>{Raven}</i>
Compressive Strength	<i>{see product data sheet}</i>
Tensile Strength, psi	<i>{see product data sheet}</i>
Tensile Elongation, %	<i>{see product data sheet}</i>
Flexural Modulus, psi	<i>{see product data sheet}</i>
Hardness, Type D	<i>{see product data sheet}</i>
Bond Strength - Concrete	>Tensile Strength of Concrete
Chemical Resistance to:	
<i>{Examples}</i>	
Sulfuric Acid, 10%	Immersion Service
Sodium Hydroxide, 20%	Immersion Service
MEK	Incidental Contact
<i>{include reagents relevant to the project}</i>	

2.05 PROTECTIVE COATING APPLICATION EQUIPMENT

- A. Manufacturer approved heated plural component spray equipment shall be used in the application of the specified protective coating.

2.06 REPAIR MORTAR SPRAY APPLICATION EQUIPMENT (if spray applied)

- A. Spray applied repair mortars shall be applied with manufacturer approved equipment.

PART 3 - EXECUTION

3.01 ACCEPTABLE APPLICATORS

- A. Repair mortar applicators shall be trained to properly apply the cementitious mortar according to manufacturer's recommendations.
- B. Protective coating must be applied by a Certified Applicator of the protective coating manufacturer and according to manufacturer specifications.

3.02 EXAMINATION

- A. All structures to be coated shall be readily accessible to Applicator.

- B. Appropriate actions shall be taken to comply with local, state and federal regulatory and other applicable agencies with regard to environment, health and safety.
- C. Any active flows shall be dammed, plugged or diverted as required to ensure that the liquid flow is maintained below the surfaces to be coated. Flows should be totally plugged and/or diverted when coating the invert. All extraneous flows into the manhole or vaults at or above the area coated shall be plugged and/or diverted until the epoxy has set hard to the touch. As an option, hot air may be added to the manhole to accelerate set time of the coating.
- D. (Optional) Pipe joint seals shall be installed by others. No leaks may be present prior to commencing and during work.
- E. Installation of the protective coating shall not commence until the concrete substrate has properly cured in accordance with these specifications.
- F. Temperature of the surface to be coated should be maintained between 40 deg F and 120 deg F during application. Prior to and during application, care should be taken to avoid exposure of direct sunlight or other intense heat source to the structure being coated. Where varying surface temperatures do exist, care should be taken to apply the coating when the temperature is falling versus rising (ie. late afternoon into evening vs. morning into afternoon).

3.03 SURFACE PREPARATION

- A. Applicator shall inspect all surfaces specified to receive a protective coating prior to surface preparation. Applicator shall notify Owner of any noticeable disparity in the surfaces which may interfere with the proper preparation or application of the repair mortar and protective coating.
- B. All contaminants including: oils, grease, incompatible existing coatings, waxes, form release, curing compounds, efflorescence, sealers, salts, or other contaminants shall be removed.
- C. All concrete or mortar that is not sound or has been damaged by chemical exposure shall be removed to a sound concrete surface or replaced.
- D. Surface preparation method(s) should be based upon the conditions of the substrate, service environment and the requirements of the epoxy protective coating to be applied.
- E. Surfaces to receive protective coating shall be cleaned and abraded to produce a sound surface with adequate profile and porosity to provide a strong bond between the protective coating and the substrate. Generally, this can be achieved with a high pressure water cleaning using equipment capable of 5,000 psi at 4 gpm. Other methods such as high pressure water jetting (refer to NACE Standard No. 5/SSPC-SP12), abrasive blasting, shotblasting, grinding, scarifying or acid etching may also be used. Detergent water cleaning and hot water blasting may be necessary to remove oils, grease or other hydrocarbon residues from the concrete. Whichever method(s) are used, they shall be performed in a manner that provides a uniform, sound clean neutralized surface that is not excessively

damaged.

- F. Infiltration shall be stopped by using a material which is compatible with the specified repair mortar and is suitable for topcoating with the specified epoxy protective coating.
- G. The area between the manhole and the manhole ring and any other area that might exhibit movement or cracking due to expansion and contraction, shall be grouted with a flexible grout or gel.
- H. (OPTIONAL) Castings can be abrasive blasted and coated to prevent corrosion if desired.
- I. All surfaces should be inspected by the Inspector during and after preparation and before the repair material is applied.

3.04 APPLICATION OF REPAIR MATERIALS

- A. Areas where structural steel has been exposed or removed shall be repaired in accordance with the Project Engineer's recommendations.
- B. Repair materials shall meet the specifications herein. The materials shall be trowel or spray applied utilizing proper equipment on to specified surfaces. The material thickness shall be specified by the Project Engineer according to Owner's requirements and manufacturer's recommendations.
- C. If using approved cementitious repair materials, such shall be trowelled to provide a smooth surface with an average profile equivalent to coarse sandpaper to optimally receive the protective coating. No bugholes or honeycomb surfaces should remain after the final trowel procedure of the repair mortar.
- D. The repair materials shall be permitted to cure according to manufacturer recommendations. Curing compounds should not be used unless approved for compatibility with the specified protective coating.
- E. Application of the repair materials, if not performed by the coating certified applicator, should be inspected by the protective coating certified applicator to ensure proper finishing for suitability to receive the specified coating.
- F. After abrasive blast and leak repair is performed, all surfaces shall be inspected for remaining laitance prior to protective coating application. Any evidence of remaining contamination or laitance shall be removed by additional abrasive blast, shotblast or other approved method. If repair materials are used, refer to these specifications for surface preparation. Areas to be coated must also be prepared in accordance with these specifications after receiving a cementitious repair mortar and prior to application of the epoxy coating.
- G. All surfaces should be inspected during and after preparation and before the protective coating is applied.

3.05 APPLICATION OF PROTECTIVE COATING

- A. Application procedures shall conform to the recommendations of the protective coating manufacturer, including material handling, mixing, environmental controls during application, safety, and spray equipment.
- B. The spray equipment shall be specifically designed to accurately ratio and apply the specified protective coating materials and shall be regularly maintained and in proper working order.
- C. The protective coating material must be spray applied by a Certified Applicator of the protective coating manufacturer.
- D. Specified surfaces shall be coated by spray application of a moisture tolerant, solvent-free, 100% solids, epoxy protective coating as further described herein. Spray application shall be to a minimum wet film thickness of ___ mils and an average wet film thicknesses of _____ mils.
 - Concrete, New/Smooth: 80-100 mils for immersion, 60-80 mils for atmospheric, splash and spill exposure.
 - Concrete, Rough: 100-125+ mils Masonry/Brick: 125-150+ mils Steel: 16-80 mils for immersion, 16-40 mils for atmospheric, splash and spill exposure; also profile dependent.
 - Fiberglass Systems: 40-60 mils tack coat, 9 oz/yd² fabric, 40-60 mils top coat. Varies with circumstances.

(Thicknesses shown above are for general purposes only, each project should be evaluated independently and thickness of system determined upon product, service environment, protection and restoration requirements.)
- E. Airless spray application equipment approved by the coating manufacturer shall be used to apply each coat of the protective coating. Air assisted spray application equipment may be acceptable, especially for thinner coats (<10 mils), only if the air source is filtered to completely remove all oil and water.
- F. If necessary, subsequent topcoating or additional coats of the protective coating should occur as soon as the basecoat becomes tack free, ideally within 12 hours but no later than the recoat window for the specified products. Additional surface preparation procedures will be required if this recoat window is exceeded.
- G. (Optional) Fiberglass woven-roving fabric may be rolled into the resin or chopped glass spray applied with the resin for added tensile and flexural strength where desired. Sloped surfaces of the floor may be made non-skid by broadcasting aluminum oxide or silica sand into the surface prior to gelation.
- H. (Optional) Depending on flow levels and how long flow can be stopped, inverts may be lined with an approved 100% solids, fast setting epoxy coating material.

3.06 TESTING AND INSPECTION

- A. During application a wet film thickness gage, such as those available through Paul N. Gardner Company, Inc. meeting ASTM D4414 - Standard Practice for Measurement of Wet Film Thickness of Organic Coatings by Notched Gages, shall be used to ensure a monolithic coating and uniform thickness during

application.

- B. (Optional – Note that this procedure is sometimes difficult or impossible to perform in tight manhole or vault structures) After the protective coating has set hard to the touch it shall be inspected with high-voltage holiday detection equipment. Surface shall first be dried, an induced holiday shall then be made on to the coated concrete surface and shall serve to determine the minimum/maximum voltage to be used to test the coating for holidays at that particular area. The spark tester shall be initially set at 100 volts per 1 mil (25 microns) of film thickness applied but may be adjusted as necessary to detect the induced holiday (refer to NACE RPO188-99). All detected holidays shall be marked and repaired by abrading the coating surface with grit disk paper or other hand tooling method. After abrading and cleaning, additional protective coating material can be hand applied to the repair area. All touch-up/repair procedures shall follow the protective coating manufacturer's recommendations.
- C. Measurement of bond strength of the protective coating to the substrate can be measured in accordance with ASTM D4541. Any areas detected to have inadequate bond strength shall be evaluated by the Project Engineer. Further bond tests may be performed in that area to determine the extent of potentially deficient bonded area and repairs shall be made by Applicator in strict accordance with manufacturer's recommendations.
- D. Manhole Testing - Type A: Manholes lined in their entirety may be vacuum tested. All pipes entering the manhole should be plugged, taking care to securely place the plug from being drawn into the manhole. The test head shall be placed and the seal inflated in accordance with the manufacturer's recommendations. A vacuum pump of ten (10) inches of mercury shall be drawn and the vacuum pump shut off. With the valves closed, the time shall be measured for the vacuum to drop to nine (9) inches. Following are minimum allowable test times for manhole acceptance at the specified vacuum drop:

DEPTH (FEET)	TIME (SECONDS)		
	48" diameter	60" diameter	72" diameter
4	10	13	16
8	20	26	33
12	30	39	49
16	40	52	67
20	50	65	81
24	59	78	97

Add for 2ft. more depth: 5 6.66 8

Note: These numbers have been taken from ASTM C 1244-93 (reapproved 2000).

If the manhole fails the initial test, repairs and adjustments necessary due to extenuating circumstances (ie. pipe joint, liner, plug sealing) should be made. Retesting shall proceed until a satisfactory test is obtained.

Manhole Testing -Type B: Manholes lined in their entirety (including invert) may be subjected to an exfiltration test. Incoming and outgoing sewer and service lines

shall be plugged, the plugs restrained and the manhole filled with water to the top of the manhole frame. A soaking period of up to 1 hour will be allowed if bypassing of the sewage is not required or has been provided for. At the end of this optional soaking period, the manhole shall be refilled with water and the test begun. If the water loss exceeds that shown in the following table, the manhole will have failed the test. Repairs and adjustments necessary due to extenuating circumstances (ie. pipe joint, liner, plug sealing) should be made. Retesting shall proceed until a satisfactory test is obtained. Maximum Allowable Loss is determined assuming a standard 4 foot diameter manhole.

<u>Depth of Manhole</u>	<u>Maximum Allowable Loss</u>
under 8 feet deep	1 inch in 5 minutes
over 8 feet deep	1/8" per foot of depth in 5 minutes

- E. A final visual inspection shall be made by the Inspector and manufacturer's representative. Any deficiencies in the finished coating shall be marked and repaired according to the procedures set forth herein by Applicator.
- F. The municipal sewer system may be put back into non-severe operational service as soon as the final inspection has taken place. However, for severe corrosion duty such as high concentrations of acids, bases or solvents, 3 to 7 days and/or force cure by heat induction to the coated surfaces may be necessary prior to returning to service. Consult coating manufacturer for further details.

END OF SECTION