

**TECHNICAL REQUIREMENTS AND SPECIFICATIONS
REHABILITATION OF CONCRETE, METAL AND MASONRY
STRUCTURES
WITH A PROTECTIVE LINING FOR STRUCTURAL OR CORROSION
PROTECTION**

FOREWORD

This specification covers work, materials and equipment required for protecting and/or rehabilitating concrete, metal and masonry structures and other underground vaults by monolithic spray-application of a high-build, rigid and solvent-free polyurethane coating to eliminate infiltration, provide corrosion protection, repair voids and enhance structural integrity as required. 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 rigid polyurethane material 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 D 7234 (Concrete) - Pull-off Strength of Coatings Using a Portable
ASTM D 4541 (Steel) 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. SSPC - The published standards of the Society of Protective Coatings, Pittsburgh, PA.
- M. Los Angeles County Sanitation District – Evaluation of Protective Coatings for Concrete.
- N. ASTM F1216 (Including Appendix XI-X7): Design Parameters for Buried Structures (structural rehabilitation) utilizing the External Buckling Equation for thickness determination.
- O. ASTM D2990: Test Methods for Tensile, Compressive and Flexural Creep and Creep Rupture in Plastics
- P. SSPWC 210-2.3.3 - Chemical resistance testing published in the Standard Specifications for Public Works Construction, 1997 edition (otherwise known as “The Greenbook”).
- Q. NACE - The published standards of National Association of Corrosion Engineers (NACE International), Houston, TX.

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. Safety Data Sheets (SDS) 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. Certification letter shall be dated within six months of bid date.

- b. The Manufacturer shall provide four (4) references which demonstrate previous successful projects completed for the specified structural protective coating system or comparable, during the last two (2) years.
- c. 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. Certification letter shall be dated within six months of bid date.
- d. Proof of any necessary federal, state or local permits or licenses necessary for the project.

5. Structural Design:

a. Third party testing verifying the short term Modulus of Elasticity used on this project, minimum of 735,000 psi.

b. Third party testing verifying long term Flexural Modulus of Elasticity, minimum of 529,200 psi. This third party testing will verify the long term reduction factor (Creep Analysis) of a minimum of 28%. This long term reduction factor verification shall be conducted utilizing ASTM D2990-01 via a third party, independently certified laboratory.

1.05 Design Conditions

The following design conditions shall be assumed for all structures being rehabilitated with the approved resin system:

<u>Parameter</u>	<u>Design Requirement</u>
1. Structure Condition	Partially/Fully Deteriorated, based on condition of the existing structure.
2. Design Thickness	ASTM 1216-09 or Two Way Flat Wall Beam Analysis
3. Ovality	Not greater than 5%
4. Soil Load	120 lbs/cu. ft.
5. Traffic Load	AASHTO-HS-20-44 Highway
6. Soil Modulus	>500 psi.<1000 psi.
7. Safety Factor	2.0
8. Soil Cover	Distance from grade to crown of conduit
9. Water Table	Distance from invert to water table

Wall thickness design calculations for each structure to be rehabilitated utilizing the specified resin technology systems must be submitted with all qualified bids,

along with supporting formulas that document that version of formula used. Additionally, product specific strength values, including the short term flexural modulus and the long term flexural modulus strength, must be substantiated by third party testing which will be submitted with all qualified bids. The materials utilized for the contracted project shall be of a quality equal to or better than the materials used in the long term test with respect to the initial flexural modulus and the long term reduction factor used in design.

1.06 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.

1.07 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 safety data sheets.

1.08 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.

1.09 WARRANTY

- A. Applicator shall warrant all work against defects in materials and workmanship for a period of three (3) years, 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 three (3) 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 cement. 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 pull tests to determine suitability of concrete or metal for coating)
- B. Cementitious patching and repair materials should not be used unless their manufacturer provides information as to its compatibility and procedures for topcoating with the approved coating. Project specific submittals should be provided including application, cure time and surface preparation procedures which permit optimum bond strength with the approved 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. Sprayroq, Inc.

2.03 REPAIR MATERIALS

- A. Repair materials shall be used to; fill voids, bugholes, 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 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 approved topcoating for use within the specifications:
 - 1. 100% solids, solvent-free grout specifically formulated for approved topcoating compatibility. The grout manufacturer shall provide instructions for trowel or spray application and for approved topcoating procedures.
 - 2. Factory blended, rapid setting, high early strength, non-shrink cementitious or epoxy repair mortar that can be trowelled or pneumatically spray applied may be approved if specifically

formulated to be compatible for approved topcoating. Such repair mortars should not be used unless their manufacturer provides information as to its suitability for topcoating with the approved topcoating. Project specific submittals should be provided including application, cure time and surface preparation procedures which permit optimum bond strength with the approved coating.

3. In the case of excessive infiltration, a hydraulic cement or plug may be used to stop the flow of the infiltration. Approved manufacturer's include Strong, or approved equal. The hydraulic cement shall be compatible with the spray applied resin coating.

2.04 PROTECTIVE COATING MATERIAL

- A. 1. The resin based material shall be used to form the sprayed structurally enhanced monolithic liner covering all interior surfaces of the structure, including benches and inverts of manholes. The finished liner shall be 100% Solids polyurethane and conform to the minimum physical requirements listed below. The physical requirements must be verified by an independent, certified, third party testing laboratory within the last five years and **must be submitted with the bid package. Any bid package not including the verifiable, independent third party testing shall be ruled non-responsive and will be rejected.**

Compressive strength	ASTM D 695	> 18,000 psi
Tensile strength	ASTM D 638	> 7,450 psi
Bond (Concrete)	ASTM D7234 Or Substrate Failure	> 200 psi
Bond (Steel)	ASTM D4541	> 1,000 psi
Flexural Modulus (Initial)	ASTM D 790	> 735,000 psi
Flexural Modulus (Long Term)	ASTM D 2990	> 529,000 psi
Density		87 ± pcf
Chemical Resistance:	ASTM D543	
Severe Municipal Sewer:	All types of service	
Successful Pass:	Sanitation District of L.A. County Coating Evaluation Study or SSPWC 211-2	

2. When the wall of the resin based liner is to be structurally designed to withstand the hydraulic load generated by the groundwater table the long term (50yr) value of the flexural modulus of elasticity will be utilized to calculate the thickness of the structural liner. The initial flexural modulus of elasticity (short term) of the submitted resin material will be utilized with the long term deformation percentage as determined by ASTM D2990

(see below) in the design equations outlined in ASTM 1216-09, Appendix X1-X7 (Circular Geometries) or Flat Wall Beam Analysis for walled structures. No adhesion to the substrate is assumed in structural calculations. The value of the long term flexural modulus of the proposed product will be certified by an independent, certified, third party testing lab, independent of the Manufacturer and submitted with the bid package. **[The definition of long term value will be identified as initial flexural modulus of elasticity less the reduction in value caused by Creep over a fifty (50) year minimum period and verified by third party DMA testing (ASTM D2990).] All design submittals will include this certified third party DMA testing (ASTM D2990) value in their respective design calculations for each structure being rehabilitated.**

3. When groundwater loading is not an issue and only a corrosion barrier is required, the rehabilitation lining shall be installed to the thickness necessary to qualify as a monolithic (void free) liner. The roughness of the substrate will dictate the thickness needed to create the monolithic liner and eliminate any opportunity for voids in the lining. The minimum value for coating thickness for corrosion protection for non-structural rehabilitation shall be 125 mils and structural rehabilitation shall be a minimum of 250 mils or the design thickness determined by the proper design protocol.

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 coating has set hard to the touch. As an option, hot air may be added to the manhole and structures 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 70 deg F and 110 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.

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 metal that is not sound or has been damaged by chemical exposure shall be removed to a sound surface or replaced.
- D. Surface preparation method(s) should be based upon the conditions of the substrate, service environment and the requirements of the resin protective coating to be applied.
- E. Surfaces to receive protective coating shall be cleaned and abraded to produce a sound surface with profile to meet as a minimum ICRI CSP3 – CSP6 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 a minimum 4,500 psi at 4.5 gpm with a turbo head jet nozzle. Other methods such as high pressure water jetting (refer to SSPC-SP 13/NACE No.6), 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 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.
- I. Surfaces to receive protective coating shall be dry to the touch and or with no visible dampness. This is to insure maximum adhesion to the substrate. If required, drying may be accomplished by a minimum of 20 minutes of a heated, indirect forced air blower. The drying shall be to the specification dictated by the resin manufacturer and its trained applicator.
- J. Surfaces to receive protective coating utilizing Flat Wall Beam Analysis design shall be prepared with a series of grooves cut into the substrate at a spacing and depth determined by the manufacturer to "key" or lock the protective coating to the substrate. All coating termination edges shall be "locked" in to the substrate with a termination groove "key" cut into the substrate. The "key" shall be a minimum $\frac{1}{4}$ "w x $\frac{1}{4}$ "d and cut at a 45 degree angle.
- K. 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 60 grit sandpaper or a minimum ICRI CSP3-CSP6 profile 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 high pressure water blasting 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 approved coating.
- G. All surfaces should be inspected during and after preparation and before the protective coating is applied.

3.05 APPLICATION OF PROTECTIVE LINING

- 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 solvent-free, 100% solids, rigid structural lining as further described herein.
- E. Plural component spray application equipment approved by the coating manufacturer shall be used to apply each coat of the protective coating.
- F. If necessary, subsequent topcoating or additional coats of the protective coating should occur as soon as the basecoat becomes tack free, no later than the recoat window for the specified products. Additional surface preparation procedures will be required if this recoat window is exceeded as per Manufacturer's recommendation.
- G. When groundwater loading is not an issue and only a corrosion barrier is required, the rehabilitation lining shall be installed to the thickness necessary to qualify as a monolithic (void free) liner. The minimum value for coating thickness for corrosion protection for non-structural rehabilitation shall be 125 mils and structural rehabilitation shall be a

minimum of 250 mils or the design thickness determined by the proper design protocol.

3.06 TESTING AND INSPECTION

- A. **High Voltage Spark Test.** After the protective coating has set hard to the touch it shall be inspected with high-voltage holiday detection equipment. **This test is critical when applied to corrosion protection applications (i.e. mil coatings less than 250 mils).** Surface shall first be dried, an induced holiday shall then be made on to the coated concrete or metal 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 or D4787 Continuity Testing of Liquid or Sheet Liners On Concrete-Holidays). 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.
- B. **Adhesion Testing.** The adhesion tests shall be performed on a minimum of one or 10% of all rehabilitated structures, which ever is greater, or as shown on the Plan and/or specified in the Special Provisions. Adhesion testing shall be conducted after the lining or coating system has cured per manufacturer instruction and in accordance with ASTM D4541(Steel) or ASTM 7234(Concrete). **Adhesion is critical for proper performance of a corrosion barrier (i.e. < 250 mils).** A minimum of one 20 mm dolly shall be affixed to the lined surface of the structure at the upper section or cone area, mid section and at the bottom, unless otherwise specified in the Special Provisions. Each testing location shall be identified by the Engineer. The adhesive used to attach the dollies to the liner shall be rapid setting with tensile strength in excess of the liner material and permitted to cure in accordance with manufacturer recommendations. The lining material and dollies shall be adequately prepared to receive the adhesive. Prior to pull test, the Contractor shall utilize a scoring device to cut through the coating until the substrate is reached. Extreme care shall be required while scoring to prevent micro cracking in the coating, since cracks may cause failures at diminished strengths. Failure due to improper dolly adhesive or scoring shall require retesting. The pull tests in each area shall meet or exceed 200 psi. and shall include subbase adhered to the back of the dolly or no visual signs of coating material in the test hole. Pull tests with results between a minimum 150 psi and 200 psi shall be acceptable if more than 50% of the subsurface is adhered to the back of the dolly. A test result can be discarded, as determined by the Engineer, if there is a valid nonstatistical reason for discarding the test results as directed by Sections

8.4 and 8.5 of ASTM D4541 and ASTM D7234. If any test fails, a minimum of three additional locations in the section of the failure shall be tested, as directed by the Engineer. If any of the retests fail, all loosely adhered or unadhered liner in the failed area, as determined by the Engineer, shall be removed and replaced at the Contractor's expense. If a structure fails the adhesion test, one additional structure or 10% of the initial number of structures selected for testing shall be tested at the discretion of the Engineer and/or as specified in the Special Provisions.

NOTE: The mil thickness will be measured and confirmed with the scored and pulled test samples. In structural repairs (partially or fully deteriorated design assumptions), it is critical to confirm the design thickness with the pulled sample as adhesion is not assumed in the ASTM 1216-09 design. The primary purpose of the pull test in structural rehabilitation is to confirm applied thickness, not adhesion. Any derived adhesion is further enhancement to the final installation strength of the rehabilitated structure.

- C. 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.
- D. 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, 4 to 8 hours may be necessary prior to returning to service. Consult coating manufacturer for further details.

END OF SECTION